



# **Study on the Competitiveness of the EU Engineering Industries and the Impact of Digitalisation**

Final Report

CSES, KMU Forschung Austria, IDEA Consult, Prognos AG,  
DECISION Etudes & Conseil  
November 2020



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Luxembourg: Publications Office of the European Union, 2020

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|-----|-------------------------|---------------------|-------------------|
| PDF | ISBN: 978-92-9460-077-6 | doi: 10.2826/020261 | EA-02-20-498-EN-N |
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## GLOSSARY AND LIST OF ACRONYMS

| Acronyms | Full meaning                                                                                                                                                          |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AI       | Artificial intelligence                                                                                                                                               |
| ATI      | Advanced Technologies for Industry                                                                                                                                    |
| B2B      | Business-to-business                                                                                                                                                  |
| B2C      | Business-to-consumer                                                                                                                                                  |
| BaU      | Business as Usual costs (costs that could be incurred anyway by business regardless as to whether there is new legislation).                                          |
| BEA      | US Bureau of Economic Analysis                                                                                                                                        |
| BERD     | Business expenditure on R&D                                                                                                                                           |
| BRIC     | Grouping acronym for the countries of Brazil, Russia, India and China                                                                                                 |
| CEE      | Central and Eastern Europe                                                                                                                                            |
| COSME    | EU programme for the Competitiveness of Enterprises and Small and Medium-Sized Enterprises (2014-2020)                                                                |
| CPS      | Cyber-physical systems                                                                                                                                                |
| CRD      | Capital Requirements Directive                                                                                                                                        |
| CRR      | Capital Requirements Regulation                                                                                                                                       |
| CSA      | Cybersecurity Act (voluntary security certification schemes for the ICT and other IT/ telephony/ communications sectors). Being rolled out on sector by sector basis. |
| CVTS     | Continuing Vocational Training Survey                                                                                                                                 |
| DDI      | Digital Density Index                                                                                                                                                 |
| DESI     | Digital Economy and Society Index, EU                                                                                                                                 |
| DIH      | Digital Innovation Hubs                                                                                                                                               |
| DLT      | Distributed Ledger Technology                                                                                                                                         |
| DSM      | Digital Single Market                                                                                                                                                 |
| EASME    | Executive Agency for Small and Medium-sized Enterprises                                                                                                               |
| ECHA     | European Chemicals Agency                                                                                                                                             |
| EEE      | Electrical and electronic engineering industries (the EEI includes electrical devices, radio equipment and the telecommunications industries)                         |
| EEMEI    | Electronic Electrical Mechanical Engineering Industries                                                                                                               |
| EGD      | European Green Deal                                                                                                                                                   |
| EIP      | European innovation partnership                                                                                                                                       |
| EMCD     | Electromagnetic Compatibility Directive (2014/30/EU)                                                                                                                  |
| EO       | Economic operators (firms in the value chain covering manufacturers, service providers, distributors, authorised representatives).                                    |
| EPC      | European Patent Convention                                                                                                                                            |
| EPO      | European Patent Office                                                                                                                                                |
| ERDF     | European Regional Development Fund                                                                                                                                    |
| ESF      | European Social Fund                                                                                                                                                  |
| ESIFs    | European Structural and Investment Funds                                                                                                                              |
| ESO      | European Standardisation Organisations                                                                                                                                |
| EU       | European Union                                                                                                                                                        |
| EU MS    | European Union Member State                                                                                                                                           |
| e-PD     | ePrivacy Directive (Directive 2002/58/EC concerning the processing of personal data and the protection of privacy in Electronic Communications)                       |
| e-PR     | ePrivacy Regulation (Proposal for a Regulation of the European Parliament and of the Council concerning the respect for private life and the protection of            |

| Acronyms                | Full meaning                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                         | personal data in electronic communications. COM/2017/010 final - 2017/03 (COD)                                                                                                                                                                                                                                                                                                                                                                                                                        |
| EVs                     | Electric vehicles                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| FDI                     | Foreign Direct Investment                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| FTA                     | Free trade agreement                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| GAR                     | Gas Appliances Regulation (2016/426/EU)                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| GDPR                    | General Data Protection Regulation (EU) 2016/679 (GDPR)                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| GERD                    | Gross domestic expenditure on R&D                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Gold-plating            | Concept whereby some Member States may go beyond compliance with existing EU legislation and introduce additional national requirements. May be especially prevalent in the case of minimum harmonisation Directives, where MS may go beyond the minimum.                                                                                                                                                                                                                                             |
| GVA                     | Gross Value Added                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| GVC                     | Global Value Chains                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| HPC                     | High Performance Computing                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| ICB                     | Industry Classification Benchmark                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Industry 4.0            | The fourth industrial revolution is a trend towards automation and data exchange in manufacturing technologies and processes which include cyber-physical systems (CPS), the internet of things (IoT), industrial internet of things (IIOT) cloud computing, cognitive computing and artificial intelligence.                                                                                                                                                                                         |
| IoT (and IIoT)          | Internet of Things. The IoT involves connecting different internet-connected devices and products, sensors and cyber-physical systems together, with potential improvements in the efficiency of industrial and manufacturing processes. IoT system architecture is generally divided into three layers: the perception layer, the network layer and service layer (or application layer). The industrial IoT (IIoT) extends the concept to IoT devices designed and deployed in industrial contexts. |
| IPCEI                   | Important Project of Common European interest                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| ISIC                    | International Standard Industrial Classification of All Economic Activities                                                                                                                                                                                                                                                                                                                                                                                                                           |
| KETs                    | Key Enabling Technologies (investments in technologies that will allow European industries to retain competitiveness and capitalise on new markets).                                                                                                                                                                                                                                                                                                                                                  |
| LEDs                    | Light-emitting diodes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| LQ                      | Location Quotient                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| LVD                     | Low Voltage Directive (2014/35/EU)                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| MD                      | Machinery Directive (2006/42/EC)                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| MSA                     | Market Surveillance Authority                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| NACE                    | <i>Nomenclature des Activités Économiques dans la Communauté Européenne</i> ) is a European industry standard classification system similar in function to Standard Industry Classification (SIC) and North American Industry Classification System (NAICS) for classifying business activities.                                                                                                                                                                                                      |
| NGEU                    | Next Generation EU Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| NLF                     | New Legislative Framework                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| NUTS                    | Nomenclature of Territorial Units for Statistics                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| OECD                    | Organisation for Economic Co-operation and Development                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| OSH Framework Directive | Framework Decision on Occupational Health and Safety (Directive 1989/391/EEC)                                                                                                                                                                                                                                                                                                                                                                                                                         |
| PATSTAT                 | EPO Worldwide Patent Statistical Database                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| PCT                     | Patent Cooperation Treaty                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| PED                     | Pressure Equipment Directive (2014/68/EU)                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

| Acronyms       | Full meaning                                                                                                                                                                                                                                                                                       |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PPE Regulation | Personal Protective Equipment Regulation (EU/2016/425)                                                                                                                                                                                                                                             |
| PPP            | Public Private Partnership                                                                                                                                                                                                                                                                         |
| PRODCOM        | <i>PRODUCTION COMMUNAUTAIRE (Community Production)</i> . Prodcom provides statistics on the production of manufactured goods carried out by enterprises on the national territory of the reporting countries.                                                                                      |
| REACH          | Registration, Evaluation, Authorisation and Restriction of Chemicals. The REACH Regulation (EC) No 1907/2006 (aims to improve the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry). |
| RED            | Radio Equipment Directive (2014/53/EU)                                                                                                                                                                                                                                                             |
| RIO            | Research and Innovation Observatory                                                                                                                                                                                                                                                                |
| RoHS Directive | Restriction of Hazardous Substances Directive (2011/65/EU)                                                                                                                                                                                                                                         |
| SAAS           | Software as a service                                                                                                                                                                                                                                                                              |
| SAR            | Specific Absorption Rate                                                                                                                                                                                                                                                                           |
| SBS            | Eurostat's Structural Business Statistics (SBS), which shed light on relevant classes of connected Radio Equipment and Wearables.                                                                                                                                                                  |
| SDS            | Safety Data Sheet                                                                                                                                                                                                                                                                                  |
| SIP            | Strategic implementation plan                                                                                                                                                                                                                                                                      |
| SPVD           | Simple Pressure Vessels Directive (2014/29/EU)                                                                                                                                                                                                                                                     |
| STAN           | STructural ANalysis Database, OECD                                                                                                                                                                                                                                                                 |
| SVHC           | Substances of Very High Concern                                                                                                                                                                                                                                                                    |
| SWOT           | Strengths, Weaknesses, Opportunities, and Threats                                                                                                                                                                                                                                                  |
| UN             | United Nations                                                                                                                                                                                                                                                                                     |
| UNCTAD         | United Nations Conference on Trade and Development                                                                                                                                                                                                                                                 |
| UNIDO          | United Nations Industrial Development Organization                                                                                                                                                                                                                                                 |
| USPTO          | United States Patent and Trademark Office                                                                                                                                                                                                                                                          |
| V2X            | Vehicle-to-Everything communication                                                                                                                                                                                                                                                                |
| WEEE Directive | Waste Electrical and Electronic Equipment Directive (2012/19/EU)                                                                                                                                                                                                                                   |
| WEF            | World Economic Forum                                                                                                                                                                                                                                                                               |
| WIOD           | World Input-Output Database                                                                                                                                                                                                                                                                        |
| WIPO           | World Intellectual Property Organisation                                                                                                                                                                                                                                                           |
| WTO            | World Trade Organisation                                                                                                                                                                                                                                                                           |

## 1. INTRODUCTION

This document contains the Final Report for the **Study on the Competitiveness of the EU Engineering Industries and the Impact of Digitalisation**, which was managed by EASME on behalf of the European Commission's DG GROW.<sup>1</sup> The study was led by CSES, with inputs from consortium partners IDEA Consult, KMFA and Prognos, supported by DECISION. The study was undertaken between June 2019 and September 2020.

### 1.1 STUDY OBJECTIVES AND SCOPE

The study's overall objective is to provide an up-to-date assessment of the **competitiveness of the electrical, electronic and mechanical engineering sectors at European level** and across the 27 Member States (+ the UK), and of the comparative situation internationally through benchmarking with major global competitor countries. The specific aims are to:

- **Update the 2013 competitiveness studies** on the engineering industries (electrical, mechanical and electronic);
- Provide an **assessment of the current level competitiveness** of the European engineering industries (electronic, electrical and mechanical), by mapping and analysing the current baseline situation (e.g. market size and structure, competitiveness drivers and inhibitors);
- **Assess the impact of digitalisation and Industry 4.0** on the competitiveness of the European engineering industry overall, and at a sub-sectoral level;
- **Inform EU policy-making** by updating the assessment of engineering competitiveness and EU policy framework, taking into account trends (e.g. digitalisation, Industry 4.0);
- Identify **future scenarios for the next 10 years** in terms of how the competitiveness situation is likely to evolve, the evolution in the regulatory situation, and the degree of take-up of digitalisation; and
- Analyse the **impacts of COVID-19 on the EU engineering industries** in the short and medium term.

The following research topics are examined through the study:

- To what degree has the EU engineering industry digitalized compared to its main competitors internationally;
- The effect of digitalisation on the EU engineering industry's global market position;
- Comparative level of investments in digitalisation innovation;
- Links between changes to the EU regulatory framework pertinent to the European engineering industries to reflect technological developments; and
- The effect of digitalisation on the reshoring of engineering activities.

The **sectoral study scope** covers the definition of the EU engineering industries (2-digit NACE level codes in the statistical revision NACE Rev. 2 business nomenclature 25, 26, 27, 28, 33 and 3-digit 32.5). Specifically, it covers the metal products, mechanical engineering, electrical engineering, electronics and ICT and the instruments sectors. It also covers the Installation and repair services sector, chapter 33 of NACE Rev. 2. In Annex 2 - Detailed tables and figures, more detailed NACE codes are presented.

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<sup>1</sup> The study was commissioned as part of Framework Contract (FWC) 575/PP/2016/FC.

The **geographic scope** was the EU-27 + the UK, which was an EU Member State during the study time scope. It should be noted that the data does not refer to EFTA countries, as these countries were outside the study scope. Selected third country competitor countries were also included for the purpose of international benchmarking, namely the US, Japan, South Korea and the BRICs (Brazil, Russia, India and China). A comparative assessment was undertaken of the relative competitiveness compared with global competitors across the three main branches of the EU engineering industries (electrical, electronic and mechanical engineering).

The **study time scope** for the retrospective part of the study was 2008-2017, although where possible, more recent structural business statistics data for 2018 was included (e.g. on enterprises, turnover and employment) and for trade and production statistics, annual data for 2019. Given the sizable impacts of COVID-19 on short to medium-term industrial competitiveness, the pandemic's impacts to date were assessed making use of short-term structural business statistics available monthly for 2020 (trade and production data only).

## 1.2 STUDY BACKGROUND

Maintaining and strengthening the economic competitiveness of the EU engineering industries is of crucial importance, as the EU engineering industries are Europe's second biggest sector, and account for a significant share (28%) of total manufacturing output. Moreover, this study is timely as digitalisation and Industry 4.0-related developments, such as the rise of the industrial internet of things (IoT), the growing use of artificial intelligence (AI) and machine learning to optimise production processes, as well as increased automation and robotisation. These mega trends are having an increasingly significant impact on the engineering industries not just in Europe, but globally.

The background to the study is that the European Commission requested a follow-up assessment to two earlier competitiveness studies (2012, 2013) on the competitiveness of different branches of the EU engineering industries. The first study covered mechanical engineering and the second one the electrical engineering, electronics and components industries.

Earlier competitiveness studies carried out in 2012-2013 (but published December 2013 and April 2014) found that Europe retains some competitive strengths that enable it to be able to compete globally, especially in sectors such as mechanical engineering (machinery production). However, the studies also pointed to a gradual loss of competitiveness in other sectors, such as semi-conductors, a trend that the present study finds has continued in the period 2013-2020 (i.e. since the previous studies were published).

### Box 1-1: Key findings from the earlier competitiveness studies

The ***Study on the Competitiveness of the Electrical and Electronic Engineering Industry (December 2013)***<sup>2</sup> found that as regards market size and structure, the electrical and electronic engineering industry (EEI) is one of the largest EU industries with a gross output of € 703 billion, equal to a share of total manufacturing (TM) gross output of 10%. The EU EEI's performance in international markets was found to be strong, especially EE1 (the downstream industry) and in sectors such as machinery and transport equipment. Patenting activities were used to assess the EU EEI's position in technology competition. A key finding was that the EU share of granted patents had declined for all three subsectors within EEE. The growing capital intensity of the semiconductors industry, and the fact that less labour was required than previously due to major investment in technology (e.g. automation, robotisation) were noted.

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<sup>2</sup> <https://ec.europa.eu/docsroom/documents/15348/attachments/1/translations/en/renditions/native>

The ***Study on the Competitiveness of the Mechanical Engineering Industry (April 2014)***<sup>3</sup> concluded that the EU mechanical engineering industries have a number of global competitive advantages compared with major competitor countries. They were also found to have a comparatively strong performance in terms of market share in international trade (which has continued until 2020, according to the findings from the present study). However, less positively, the EU mechanical engineering industries perform less well as regards price competitiveness.

This study is ambitious in scope, as it covers all three branches of the engineering industries. The study consists of three parts:

- **Part 1** – Economic and competitiveness analysis of the EU electronic, electrical and mechanical engineering industries.
- **Part 2** – Regulatory analysis between the EU and its key competitors.
- **Part 3** – Analysis of the extent, impacts, challenges and opportunities of digitalisation.

Whilst each of the three parts covers a range of study issues in their own right, the interlinkages between these were analysed. For example, EU legislation evidently has an influence on industrial competitiveness and innovation, and will also have an impact on the pace and extent of take-up of digitalisation by EU engineering firms.

Section 5 provides a dedicated section on the topic of the impact of COVID-19 on the EU engineering industries. A short overview of the type of issues explored is provided below:

#### **The impact of COVID-19 on the EU engineering industries**

The EU engineering industries are facing unprecedented challenges in light of the COVID-19 pandemic, as a result of global market dislocations of supply chains and export markets. This may demand rethinking global supply chains to strengthen their resilience. This presents an opportunity for the EU engineering industries due to the opportunities presented by greater recourse to reshoring elements of production and / or near-shore outsourcing (e.g. in lower cost-locations in central and eastern Europe). There has also been a significant impact on demand, with a major reduction in EU engineering exports to third countries.

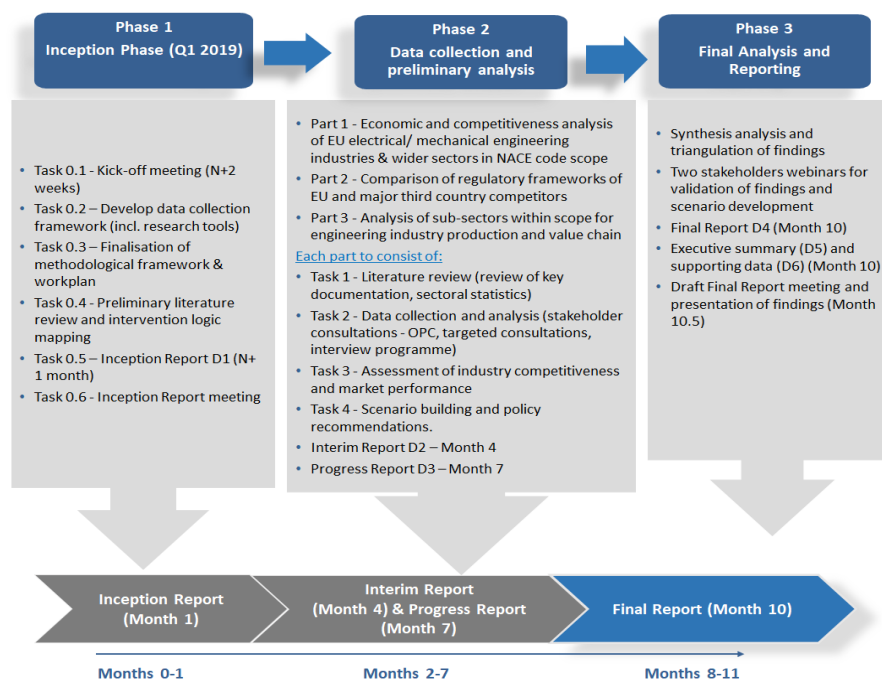
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<sup>3</sup><https://op.europa.eu/en/publication-detail/-/publication/19d533d8-f9d4-4259-b229-1aeed0d16338/language-en/format-PDF>

### 1.3 METHODOLOGICAL APPROACH (SUMMARY OVERVIEW)

A robust methodology was used to carry out this study assignment. A short summary of the methodology is provided in this section and a detailed methodological technical note is provided in standalone Annex 8. An overview of the workplan is provided in the following Figure:

**Figure 1-1: Methodology overview**



#### 1.3.1 Common methodology by Task

The three study parts followed a common approach to conducting the research and tasks required, namely:

- **Task 1** – Literature review (desk research of key documentation, sectoral statistics);
- **Task 2** – Data collection and analysis (stakeholder consultations - OPC, targeted consultations, and an interview programme);
- **Task 3** – Assessment of industry competitiveness and market performance; and
- **Task 4** – Scenario building and policy recommendations.

#### 1.3.2 Stakeholder consultations

The stakeholder consultations consisted of: (1) desk research to review position papers by key stakeholders (2) an interview programme (3) three online surveys, and (4) the holding of two webinars with relevant stakeholders in May 2020. A summary of the level of participation in the stakeholder consultations is provided below:

##### The interview programme

An interview programme with relevant stakeholders was undertaken. The categories of EU and international stakeholders interviewed has included: industry associations, individual manufacturers (including SMEs), cluster organisations, organisations focusing on Industry 4.0, Market Surveillance Authorities and Notified Bodies. A total of 87 stakeholders were interviewed from across a representative sample of these stakeholder groups.



## **Interactive webinars**

Two webinars were held in May 2020. The webinars were successful and generated considerable interest. The first webinar covered the impact of legislation on the EU engineering industries – current state of play and future scenarios to 2030. In total, 33 participants attended, including our study team and representatives from the European Commission and EASME, as well as industry associations, individual manufacturers, and a notified body.

The second webinar focused on the competitiveness and digitalisation in the European engineering industries – current state of play and future scenarios. In total, 41 participants attended this virtual meeting, including our study team and representatives from the European Commission and EASME, as well as industry and business associations, manufacturers, and cluster organisations. Slides were prepared for these webinars and circulated to all participants.

## **The online surveys**

Three online surveys were conducted, with several follow-up email reminders to encourage prospective respondents. The response to these surveys is now summarised.

- Survey of industry associations - 47 responses;
- Survey of testing and certification laboratories, Market Surveillance Authorities (MSAs) and Notified Bodies (NBs) - 41 responses; and
- Survey of individual manufacturers and other economic operators – 32 responses.

The response rate was positive in that the EU and national industry associations concerned represent a significant share of the EU engineering industries, as all the major industry associations responded. Likewise, the response from testing labs, MSAs and NBs was also broadly representative. However, the survey response from manufacturers was below initial expectations, reflecting the very broad scope of the study.

## **Methodological approach by part**

As the methodology for each of the three study parts was quite complex and multifaceted, the detailed description of the approach is summarised in a supporting annex, Annex 8.

## **1.4 REPORT STRUCTURE**

This report has been structured as follows:

- **Section 1** – Introduction (this section) reiterates the study objectives, overall methodology and common tasks;
- **Section 2** – Economic and competitiveness analysis of the EU electronic, electrical and mechanical engineering industries;
- **Section 3** – Regulatory analysis of legislation applicable to the EU engineering industries;
- **Section 4** – Analysis of the extent, impacts, challenges and opportunities of digitalisation;
- **Section 5** – Impact of COVID-19 on the EU engineering industries;
- **Section 6** – Future scenario analysis and strategic outlook; and
- **Section 7** – Overall conclusions and recommendations.



The **supporting annexes** include:

- **Annex 1** – Bibliography;
- **Annex 2** – Detailed tables and figures (detailed statistical tables related to the analysis of the competitiveness of the EU engineering industries);
- **Annex 3** – Statistical sources (detailed statistical tables related to the analysis of the competitiveness of the EU engineering industries);
- **Annex 4** – definition of advanced digital technologies;
- **Annex 5** – a review of the availability of public data for assessing the effect of digitalisation on the EU engineering sector's competitiveness;
- **Annex 6** – Monitoring digitalisation by the OECD, UN, WTO and BEA;
- **Annex 7** – Additional figures on the endogenous digital innovation potential;
- **Annex 8** – Detailed methodology (standalone publication); and
- **Annex 9** – Survey analysis (standalone publication).

## 2. ECONOMIC AND COMPETITIVENESS ANALYSIS OF THE EU'S ELECTRONIC, ELECTRICAL AND MECHANICAL ENGINEERING INDUSTRIES

The objective of this chapter is to undertake an economic and competitiveness analysis of the EU electrical and mechanical engineering industries. This will focus on the NACE Rev. 2 codes within scope, namely chapters 25 (metal products), 26 (electronic products and equipment), 27 (electrical engineering), 28 (mechanical machinery and equipment), 32.5 (medical and dental instruments and supplies) and 33 (Installation, repair and maintenance of mechanical, electrical and electronic engineering equipment).

The focus is on analysing the performance of the European engineering industry across the six subsectors that constitute the three main branches (electronic, electrical and mechanical) against its major competitors globally, i.e. US, Japan, South Korea and the BRICs (Brazil, Russia, India and China)<sup>4</sup>, covering the period 2008-2018 (and the latest year of data availability wherever more recent data was available).

### 2.1 STRUCTURAL ANALYSIS OF THE ENGINEERING SECTOR

This section provides a structural analysis of the EU engineering industries. It should be noted that the latest available data has been used, which is 2017/2018 for some indicators (e.g. enterprises, persons employed, turnover and value added), and 2019 for production and international trade data (annualised), with the latter two indicators also available monthly for 2020 to assess the preliminary impacts of COVID-19. The following table provides a summary overview in this regard:

**Table 2-1: Overview of data availability by source and time series**

| Data source                                                                                                                                          | Latest available year                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| <b>Structural Business Statistics:</b> <ul style="list-style-type: none"> <li>Number of enterprises</li> <li>Employment</li> <li>Turnover</li> </ul> | 2018                                                                         |
| <b>Structural Business Statistics:</b><br>Data by enterprise size                                                                                    | 2017                                                                         |
| <b>Short-term Business Statistics:</b>                                                                                                               | 2018                                                                         |
| <b>National accounts:</b><br>Value added                                                                                                             | 2017                                                                         |
| <b>PRODCOM:</b><br>Production                                                                                                                        | 2019 (annual). Note monthly data also analysed for impacts of COVID for 2020 |
| <b>Business Demography:</b><br>Enterprise births                                                                                                     | 2017                                                                         |
| <b>International trade in goods</b><br>Exports<br>Imports                                                                                            | 2019 (annual). Note monthly data also analysed for impacts of COVID for 2020 |
| <b>OECD Balanced International Merchandise Trade Statistics</b>                                                                                      | 2016                                                                         |
| <b>World Input-Output Database</b>                                                                                                                   | 2014                                                                         |
| <b>Statistics on research and development</b>                                                                                                        | GERD: 2018<br>BERD: 2017                                                     |

<sup>4</sup> And, where appropriate, further countries that are emerging players in particular areas of engineering.

More detailed information on statistical sources is provided in Annex 2 - detailed tables and figures (supporting competitiveness analysis).

### 2.1.1 Sectoral structure of the EU engineering industries

In the European Union (EU-27 + UK), in 2018<sup>5</sup>, approximately 853,500 enterprises can be assigned to the engineering industries (definition according to the NACE Rev. 2 codes within scope<sup>6</sup>). These enterprises employ more than 11 million people. The turnover of the sector amounts to circa € 2,300 billion, while the value added is about € 687 billion (in 2017). In 2019, the production value of the engineering industries of the 27 EU countries plus UK accounts for approx. € 1,600 billion. In 2017<sup>7</sup>, in the engineering industries, approximately 60,500 enterprises were newly created.<sup>8</sup>

Overall, the engineering industries constitute 3% of all enterprises in 2017 and 8% of all persons employed, 7% of the turnover, 9% of the value added and 2% of the enterprise births in the total EU business economy<sup>9</sup>.

Compared to the entire manufacturing sector<sup>10</sup> of the EU (incl. the UK), the share of the engineering industries is 40% of all manufacturing enterprises, 36% of the persons employed, 28% of the turnover, 34% of the value added, 28% of the total production value and 36% of the enterprise births.

**Table 2-2: Structure of the engineering industries in the EU-27 + UK, 2018<sup>1</sup>**

|                                      | EU-27      | UK      | EU-28      |
|--------------------------------------|------------|---------|------------|
| Enterprises (number)                 | 792,322    | 61,147  | 853,469    |
| Persons employed (number)            | 10,591,309 | 853,958 | 11,445,267 |
| Turnover in € million                | 2,117,682  | 173,893 | 2,291,575  |
| Value added in € million             | 627,107    | 59,709  | 686,816    |
| Production value in € million (2019) | n/a        | n/a     | 1,574,989  |
| Births of enterprises <sup>2</sup>   | 54,005     | 6,525   | 60,530     |

<sup>1</sup> Value added, births of enterprises: latest available year 2017; enterprises, persons employed and turnover: 2018, production value: 2019

<sup>2</sup> including NACE 24 (Manufacture of basic metals), excluding NACE 32.5 (Manufacture of medical and dental instruments and supplies) as data from the Business Demography statistics are not published for every NACE code according to the definition

Source: Eurostat, Structural Business Statistics: enterprise, persons employed, turnover, gross value added; Statistics on the production of manufactured goods (PRODCOM): production value; Status: August 2020

<sup>5</sup> Latest available year (status March 2020)

<sup>6</sup> In this study, the term "engineering industries" refers to the following NACE Rev. 2 codes: 25 (Fabricated metal products), 26 (Computer, electronic and optical products), 27 (Electrical equipment), 28 (Machinery and equipment n.e.c.), 32.5 (Medical and dental instruments and supplies) and 33 (Installation, repair and maintenance of mechanical, electrical and electronic engineering equipment). Please see Annex 3 for a "Definition of engineering industries according to the NACE Rev. 2 classification" for a detailed list of industry segments that fall under these NACE codes.

<sup>7</sup> Latest available year (status March 2020)

<sup>8</sup> A detailed list of top-selling companies in the EU-27+UK by NACE 3-digit-code can be found in Annex 2 "Key players in the EU engineering industries by NACE Rev. 2 classification"

<sup>9</sup> Total business economy according to Structural Business Statistics: NACE Rev. 2 section B to N +S95 excluding section K; latest available year 2017

<sup>10</sup> NACE Rev. 2 section C

Since 2008, the number of enterprises has grown by 6.7%, while the number of persons employed has decreased by 2.3%. The level of turnover increased in real terms by 6.7%, the gross value added by 3.9% and the production value by 0.6%.

The average annual change rate demonstrates the different development in the periods 2008 to 2013 and 2013 to the latest year available (2017, 2018 or 2019 depending on the type of business statistics concerned).<sup>11</sup> While the number of enterprises increased slightly in both periods, all the other indicators show a decline in the period 2008 to 2013 and a growth between 2013 and the latest available year.

**Table 2-3: Development of the engineering industries in the EU-27 + UK , 2008-2018/19<sup>1</sup>**

|                                            | Change 2008-2017/18 <sup>1</sup> in % | Average annual change 2008-2013 in % | Average annual change 2013-2017/18/19 <sup>1</sup> year in % |
|--------------------------------------------|---------------------------------------|--------------------------------------|--------------------------------------------------------------|
| Enterprises                                | 6.7                                   | 0.4                                  | 0.9                                                          |
| Persons employed                           | -2.3                                  | -1.6                                 | 1.2                                                          |
| Turnover in € million <sup>2</sup>         | 6.7                                   | -2.1                                 | 3.4                                                          |
| Value added in € million <sup>2</sup>      | 3.9                                   | -1.4                                 | 2.7                                                          |
| Production value in € million <sup>2</sup> | 0.6                                   | -2.4                                 | 1.9                                                          |
| Births of enterprises <sup>3</sup>         | n/a                                   | n/a                                  | 2.6                                                          |

<sup>1</sup> Value added, births of enterprises: latest available year 2017; enterprises, persons employed and turnover: 2018, production value: 2019

<sup>2</sup> Development is in 2015 prices: Price index gross value added (National accounts) and (if not available for specific sectors) Total output price index (Short-term business statistics for industry) for value added; Total output price index (Short-term business statistics for industry, excluding NACE 33 (Repair and installation of machinery and equipment) for turnover, production value

<sup>3</sup> including NACE 24 (Manufacture of basic metals), excluding NACE 32.5 (Manufacture of medical and dental instruments and supplies) as data from the Business Demography statistics are not published for every NACE code according to the definition

Source: Eurostat, Structural Business Statistics: enterprise, persons employed, turnover; National accounts: value added; Statistics on the production of manufactured goods (PRODCOM): production value; Status: September 2020

The following graph illustrates the distribution of enterprises and the persons employed by size category of enterprises. The great majority of enterprises (82%) in the EU engineering industries are micro enterprises, employing up to nine people. A further 8% of enterprises employ 10 to 19 persons, 5% between 20 and 49 persons and 3% between 50 and 249 persons. In total, 99% of EU engineering firms are classified small and medium-sized enterprises (SMEs). Only 1% are large enterprises with 250 or more persons employed. This corresponds approximately to the distribution of enterprises in the manufacturing sector as a whole. Compared to the total business economy, enterprises in the engineering industries tend to be larger: while the share of enterprises with less than ten persons is 93% in the total economy, it is much lower in the engineering industries (82%).

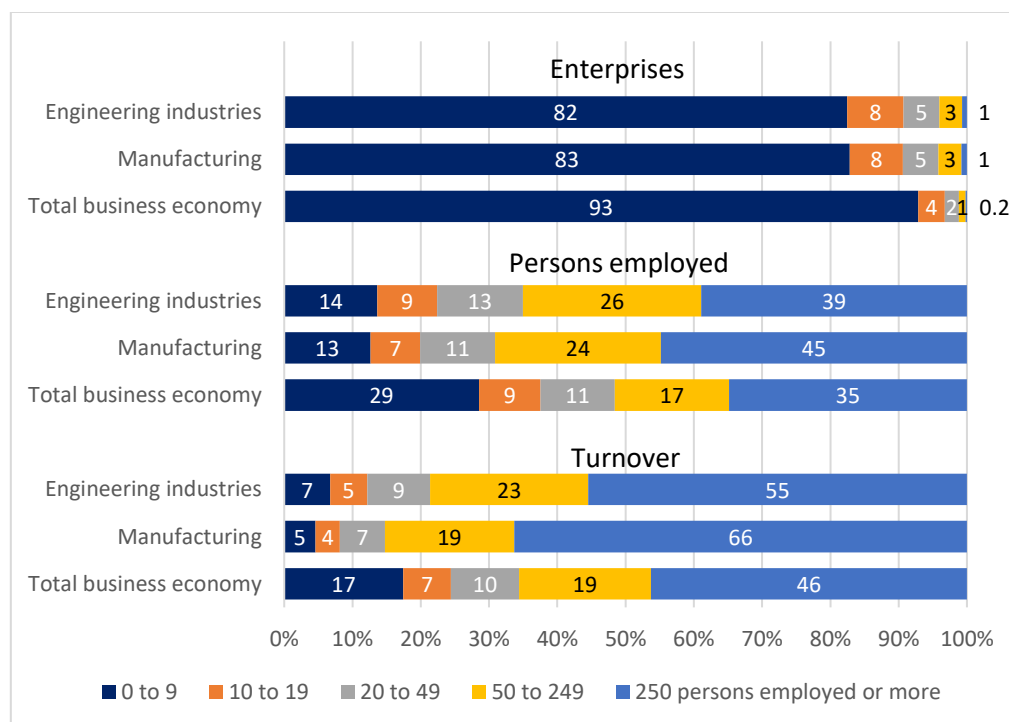
With regard to employment, large enterprises with more than 250 employees account for 39% of the persons employed in the EU engineering industries (61% work in SMEs, mostly in enterprises with between 50 and 249 persons employed. On average, the enterprises in the engineering industries are smaller than in the total manufacturing sector (45% in

<sup>11</sup> The development from 2008 to 2018 cannot be shown for EU-27 as data for this aggregate is only available since 2011.

large enterprises), which means that the engineering industries are less concentrated than the manufacturing sector as a whole. Also, they are bigger than in the total business economy (35% in large enterprises).

Large enterprises generate more than half of the turnover of the EU engineering industries. 23% can be attributed to enterprises with 50 to 249 persons employed. In total, SMEs account for 45% of the sales volume. On average, the share of turnover generated by large enterprises in the EU engineering industries (55%) is lower than in manufacturing (66%) and higher than in the total business economy (46%).

**Figure 2-1: Enterprises and persons employed by size<sup>1</sup> in the EU-27 + UK in %, 2017<sup>2</sup>, engineering industries, manufacturing and total business economy<sup>3</sup>**



<sup>1</sup> based on the number of persons employed

<sup>2</sup> latest available year

<sup>3</sup> according to the Structural Business Statistics: NACE Rev.2 section B to N + S95 excluding section K

Source: Eurostat, Structural Business Statistics; own calculations; Status: August 2020

The largest sectors within the EU engineering industries are manufacturers of fabricated metal products and manufacturers of machinery and equipment. In contrast, manufacturers of medical and dental instruments and supplies can be counted among the smaller sectors.

**Table 2-4: Sectoral structure of the engineering industries in the EU-27 + UK, 2018<sup>1</sup>**

|                                                           | Enterprises | Persons employed | Turnover in € million | Value added in € million |
|-----------------------------------------------------------|-------------|------------------|-----------------------|--------------------------|
| Fabricated metal products, except machinery and equipment | 400,332     | 3,846,275        | 530,043               | 184,136                  |
| Computer, electronic and optical products                 | 41,003      | 1,104,050        | 406,666               | 85,500                   |
| Electrical equipment                                      | 44,985      | 1,515,222        | 326,597               | 96,000                   |

|                                                    | Enterprises    | Persons employed  | Turnover in € million | Value added in € million |
|----------------------------------------------------|----------------|-------------------|-----------------------|--------------------------|
| Machinery and equipment n.e.c.                     | 87,592         | 3,146,677         | 764,819               | 224,748                  |
| Medical and dental instruments and supplies        | 65,400         | 531,065           | 84,062                | 33,432                   |
| Repair and installation of machinery and equipment | 214,157        | 1,301,978         | 179,388               | 63,000                   |
| <b>Engineering industries total</b>                | <b>853,469</b> | <b>11,445,267</b> | <b>2,291,575</b>      | <b>686,816</b>           |

<sup>1</sup> Latest available year; data on value added is available only for 2017

Source: Eurostat, Structural Business Statistics; own calculations; Status: August 2020

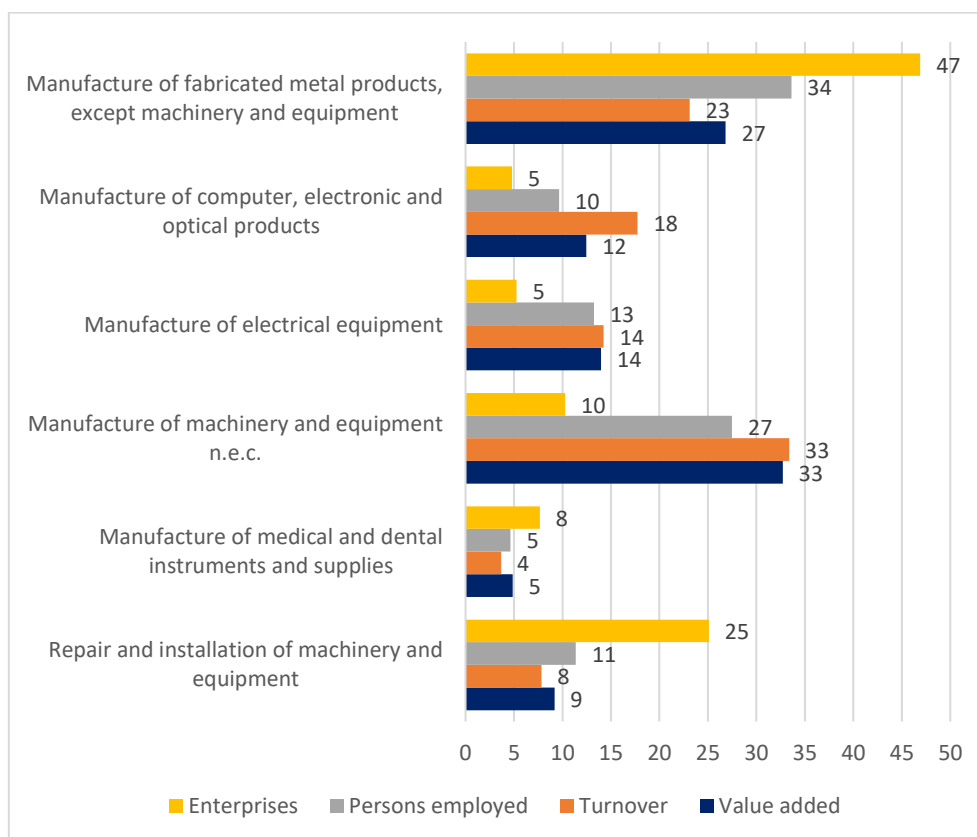
In 2018, the sector comprising manufacturers of fabricated metal products had the highest number of enterprises, accounting for 47% of all enterprises in the engineering industries. Repair and installation of machinery and equipment (25%) ranks second, followed by manufacturers of machinery and equipment n.e.c. (10%).

The sectors with the highest number of persons employed included manufacturers of fabricated metal products (34%), and manufacturers of machinery and equipment n.e.c. (27%). Together they account for more than 60% of the employment in the engineering industries.

The two sectors are also responsible for approximately 60% of the total turnover and value added of the engineering industries within scope. The sector comprising manufacturers of machinery and equipment is the main contributor to the total turnover (33%) and value added (33%) in the EU engineering industries (incl. the UK). Manufacturers of fabricated metal products rank second in terms of turnover (23%) and value added (27%).

Although having 25% of all enterprises in the engineering industries, repair and installation of machinery and equipment only accounts for 11% of the employment, 8% of the turnover and 9% of the value added. Manufacturers of medical and dental instruments and supplies rank at the end of the list, with a contribution of approximately 5% to the employment as well as 4% to the total turnover and 5% to the value added of the engineering industries.

**Figure 2-2: Sectoral structure of the engineering industries in the EU-27 + UK in %, 2018<sup>1</sup>**

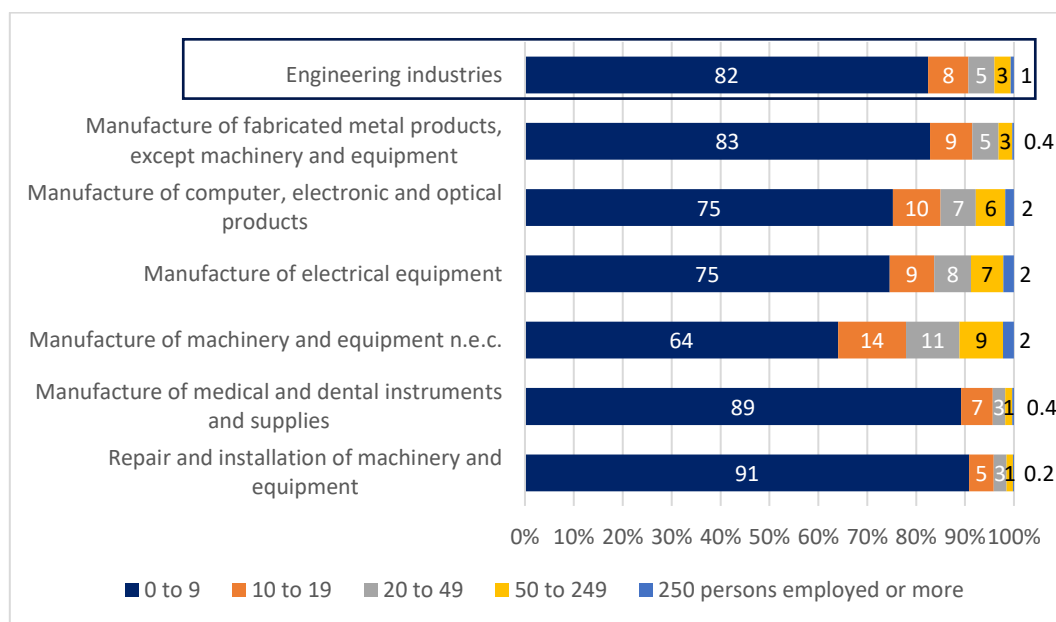


<sup>1</sup> Latest available year; data on value added is available only for 2017

Source: Eurostat, Structural Business Statistics; own calculations; Status: August 2020

The majority of enterprises in the EU engineering industries (82%) are micro-enterprises with less than 10 employees. However, the structure of the industries by enterprise size class differs between sectors: for instance, the proportion of micro-enterprises is highest in the repair and installation of machinery and equipment (91%), as well as the manufacture of medical and dental instruments and supplies (89%). In the sectors related to the manufacture of machinery and equipment n.e.c. (64%), manufacture of electrical equipment (75%) and manufacture of computer, electronic and optical products (75%), the proportion of these enterprises is much lower – here we find more SMEs and large companies (2 % each) than in other sectors of the engineering industries.

**Figure 2-3: Enterprises by size class<sup>1</sup> for the sectors of the engineering industries in the EU-27 + UK in %, 2017<sup>2</sup>**

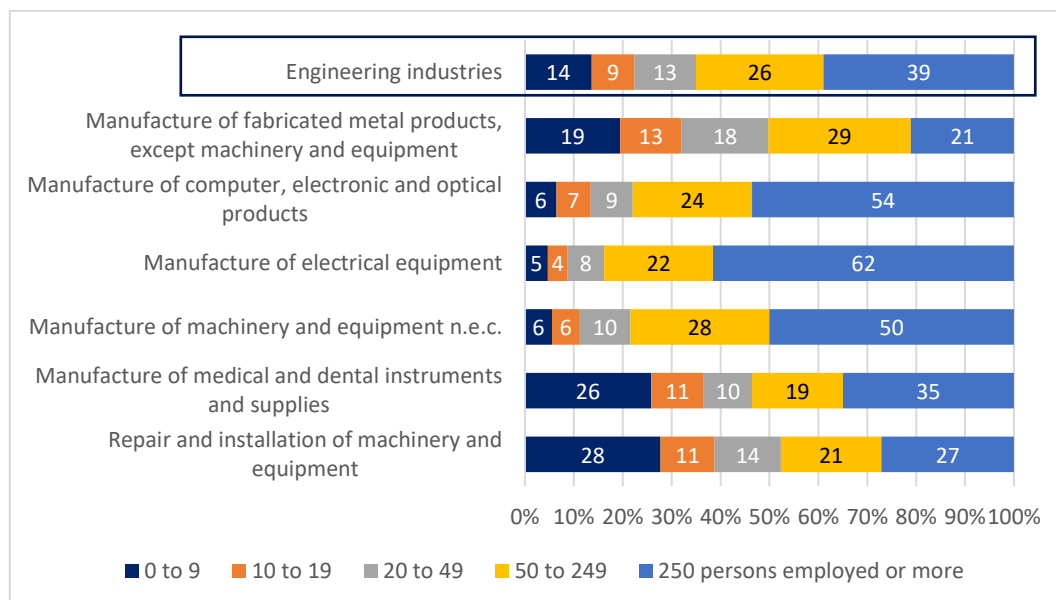


<sup>1</sup> based on the number of persons employed

<sup>2</sup> latest available year

Source: Eurostat, Structural Business Statistics; own calculations; Status: August 2020

**Figure 2-4: Persons employed by size class<sup>1</sup> for the sectors of the engineering industries in the EU-27 + UK in %, 2017<sup>2</sup>**



<sup>1</sup> based on the number of persons employed

<sup>2</sup> latest available year

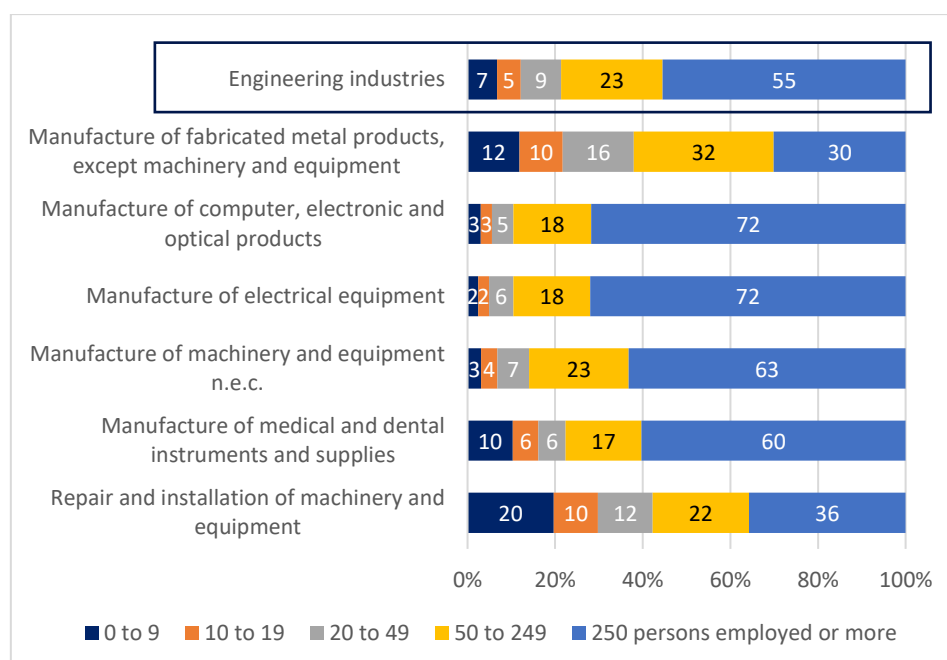
Source: Eurostat, Structural Business Statistics; own calculations; Status: August 2020



The distribution of persons employed across the different enterprise size classes shows a similar picture. At least half of all persons employed in the sectors related to the manufacture of electrical equipment (62%), manufacture of computer, electronic and optical products (54%) and manufacture of machinery and equipment n.e.c. (50%) work in large enterprises. In contrast, more than a quarter of all employees in the sectors repair and installation of machinery and equipment (28%) as well as the manufacture of medical and dental instruments and supplies (26%) work in micro enterprises.

With regard to turnover, in four of the six engineering sectors, more than half of the sales can be attributed to large enterprises with 250 and more persons employed. The manufacture of computer, electronic and optical products and manufacture of electrical equipment have the highest share of turnover dominated by large enterprises (72% each). In contrast, medium-sized enterprises generate one-third of the total turnover of the sector in the manufacture of fabricated metal products.

**Figure 2-5: Turnover by size class<sup>1</sup> for the sectors of the engineering industries in the EU-27 + UK in %, 2017<sup>2</sup>**



<sup>1</sup> based on the number of persons employed

<sup>2</sup> latest available year

Source: Eurostat, Structural Business Statistics; own calculations; August 2020

The following table demonstrates different developments across different sub- sectors in the EU engineering industries regarding the average annual changes across key structural business statistics metrics in the 2008 to 2013 period, and then the 2013 to 2018 period respectively (value added: 2017). In smaller sectors, including the manufacture of medical and dental instruments and supplies, as well as the repair and installation of machinery and equipment, the number of enterprises and persons employed increased in both periods. In larger sectors, such as the manufacture of machinery and equipment n.e.c., there was mostly unfavourable trends in both periods regarding the number of enterprises, while the number of persons employed decreased in the period between 2008 and 2013 and grew between 2013 and 2018.

Turnover and value added declined in the period 2008 to 2013, and grew between 2013 and 2017/18 in most sectors: The repair and installation of machinery and equipment is

the only sector within the EU engineering industries where a slight downturn in value added was experienced in the 2013 to 2017 period in real terms.

**Table 2-5: Sectoral development of the engineering industries in the EU-27 + UK in %, 2008 – 2017/2018<sup>1</sup>**

|                                       | Average annual change 2008-2013 in %                             | Average annual change 2013-2017/18 <sup>1</sup> in % | Average annual change 2008-2013 in %               | Average annual change 2013-2017/18 <sup>1</sup> in % | Average annual change 2008-2013 in %                      | Average annual change 2013-2017/18 <sup>1</sup> in % |
|---------------------------------------|------------------------------------------------------------------|------------------------------------------------------|----------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------|
|                                       | <b>Fabricated metal products, except machinery and equipment</b> |                                                      | <b>Computer, electronic and optical products</b>   |                                                      | <b>Electrical equipment</b>                               |                                                      |
| Enterprises                           | 0.2                                                              | 1.2                                                  | -2.1                                               | -0.5                                                 | -0.6                                                      | -1.7                                                 |
| Persons employed                      | -2.3                                                             | 1.5                                                  | -2.7                                               | -0.3                                                 | -1.8                                                      | 0.9                                                  |
| Turnover (real terms) <sup>2</sup>    | -2.3                                                             | 2.1                                                  | -3.3                                               | 7.2                                                  | -2.1                                                      | 1.8                                                  |
| Value added (real terms) <sup>3</sup> | -2.4                                                             | 3.5                                                  | -1.3                                               | 2.2                                                  | -1.7                                                      | 2.4                                                  |
|                                       | <b>Machinery and equipment n.e.c.</b>                            |                                                      | <b>Medical and dental instruments and supplies</b> |                                                      | <b>Repair and installation of machinery and equipment</b> |                                                      |
| Enterprises                           | -2.2                                                             | -1.0                                                 | 1.1                                                | 0.6                                                  | 3.9                                                       | 2.3                                                  |
| Persons employed                      | -1.6                                                             | 1.5                                                  | 0.3                                                | 1.7                                                  | 0.7                                                       | 0.9                                                  |
| Turnover (real terms) <sup>2</sup>    | -1.5                                                             | 3.2                                                  | 0.1                                                | 4.4                                                  | n/a                                                       | n/a                                                  |
| Value added (real terms) <sup>3</sup> | -0.9                                                             | 3.2                                                  | 0.5                                                | 4.8                                                  | -0.6                                                      | -0.7                                                 |

<sup>1</sup> Latest available year; data on value added is available only for 2017

<sup>2</sup> For turnover, no data is available for NACE 33 (Repair and installation of machinery and equipment); development is in 2015 prices (Total output price index (Short-term business statistics for industry))

<sup>3</sup> Development is in 2015 prices: Price index gross value added (National accounts, excluding NACE 32.5 (Manufacture of medical and dental instruments and supplies)) and (if not available for specific sectors) Total output price index (Short-term business statistics for industry); latest available data from 2017

Source: Eurostat, Structural Business Statistics, Short-term business statistics for industry, National accounts; own calculations; Status: August 2020

In 2019, according to PRODCOM data on industrial production, the production value of the engineering industries<sup>12</sup> of the 27 EU countries plus UK amounted to approx. € 1,600 billion. The largest share of production value for the EU engineering industries can be attributed to the manufacture of machinery and equipment n.e.c (34%), followed by the manufacture of fabricated metal products (24%).

While the production value decreased taking the annual average for the period 2008 to 2013 in real terms in most sectors, all sectors experienced positive annual growth between 2013 and 2019. Between 2008 and 2013, the manufacture of computer, electronic and

<sup>12</sup> Although PRODCOM and the NACE classification correspond to each other, the basis/units of both classifications different. PRODCOM is a classification of goods where the unit is the product, while NACE is a classification of economic activities of enterprises, where the unit is an enterprise that has its main activity in a specific NACE code (according to its value added). Therefore, production data cannot be fully compared with data from the Structural Business Statistics that operate with NACE codes.

optical products had the highest decline among the sectors of the engineering industries. It had also the highest increase between 2013 and 2019.

**Table 2-6: Production value of the engineering industries in the EU-27 + UK by sectors, 2019**

|                                                           | Value in € million 2019 | Share in Engineering industries in % 2019 | Average annual change 2008-2013 in % <sup>1</sup> | Average annual change 2013-2019 in % <sup>1</sup> |
|-----------------------------------------------------------|-------------------------|-------------------------------------------|---------------------------------------------------|---------------------------------------------------|
| Fabricated metal products, except machinery and equipment | 372,621                 | 24                                        | -3.0                                              | 2.3                                               |
| Computer, electronic and optical products                 | 209,386                 | 13                                        | -3.7                                              | 2.5                                               |
| Electrical equipment                                      | 226,409                 | 14                                        | -2.2                                              | 1.9                                               |
| Machinery and equipment n.e.c.                            | 535,515                 | 34                                        | -1.7                                              | 1.3                                               |
| Medical and dental instruments and supplies               | 51,426                  | 3                                         | 1.4                                               | 2.3                                               |
| Repair and installation of machinery and equipment        | 179,632                 | 11                                        | n/a                                               | 0.9                                               |
| <b>Engineering industries total</b>                       | <b>1,574,989</b>        | <b>100</b>                                | <b>-2.4</b>                                       | <b>1.9</b>                                        |

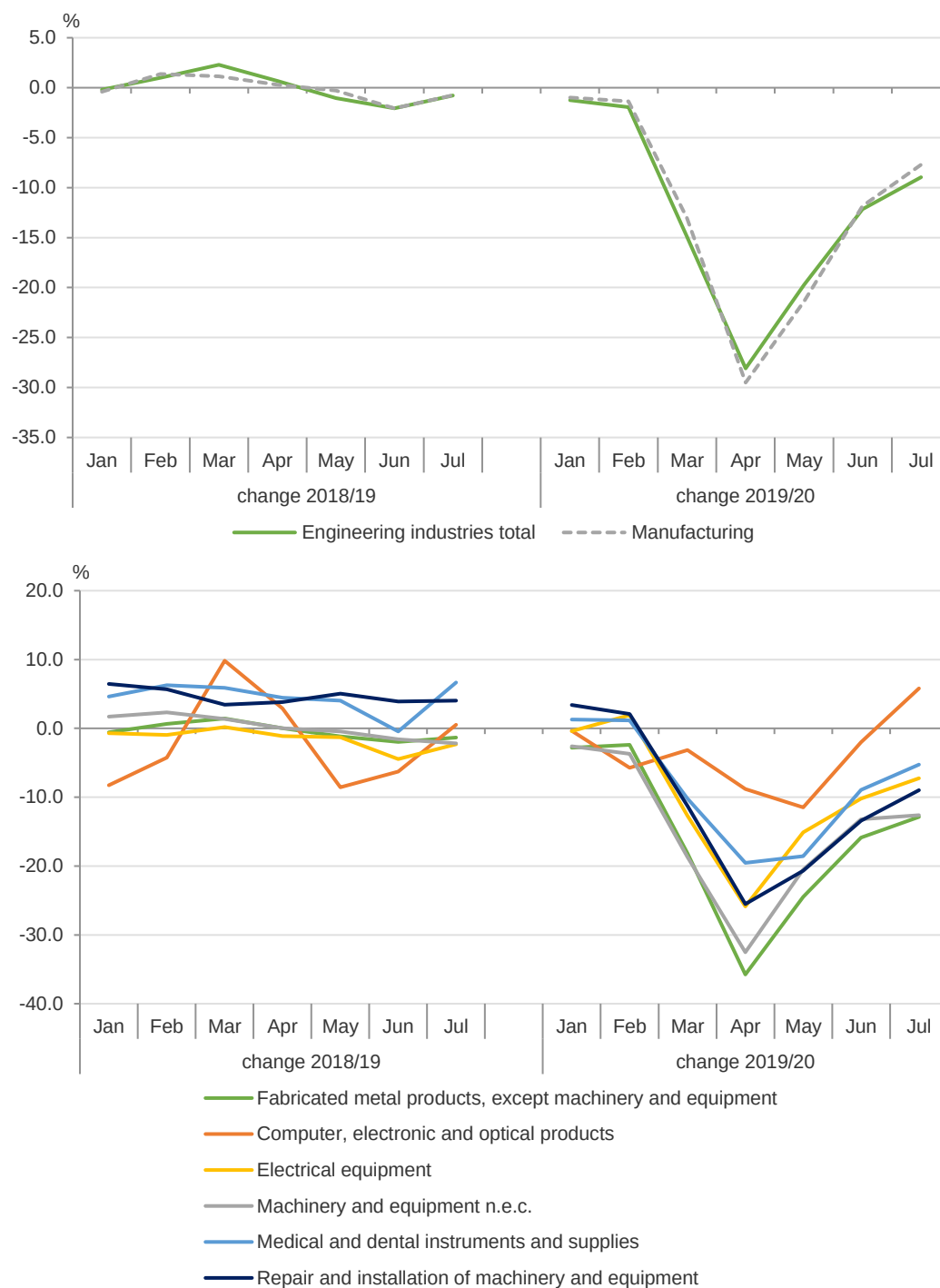
<sup>1</sup> Development is in 2015 prices: Total output price index (Short-term business statistics for industry, excluding NACE 33 (Repair and installation of machinery and equipment))

Source: Eurostat, Statistics on the production of manufactured goods (PRODCOM); own calculations; September 2020

The following graphs show the development of the production volume in the EU-27 (excl. the UK) in the periods January to July 2019 compared to January to July 2018 and the same period 2020 compared to 2019 in order to reflect the adverse economic impacts caused by the global COVID-19 pandemic. Whereas production in the EU engineering industries increased between February and April 2019, there has been a decline in May to July 2019. There was already a slight decrease in January and February 2020 in production, reflecting global supply chain dislocations caused by the pandemic due to widespread regional and national lockdowns in China and elsewhere in Asia. Subsequently, production has declined sharply with the beginning of the COVID-19 pandemic in Europe in March 2020. The downturn was highest in April 2020 with nearly -30% compared to April 2019. The declines were still significant in the following months between May and July 2020, although the rate of decline was less pronounced than in April 2020. Across the manufacturing sector in total, the development of production was similar to that of the EU engineering industries.

Regarding the sectors in the EU engineering industries, production grew in (almost) every month between January and July 2019 in the manufacture of medical and dental instruments and supplies as well as in the repair and installation of machinery and equipment. Since the beginning of the COVID-19 pandemic in March 2020 in Europe, the only sector that was not hit so hard than the others was the manufacture of computer, electronic and optical products. This is also the only sector in the engineering industries with an increase in July 2020.

**Figure 2-6: Development<sup>1</sup> of production in the engineering industries and manufacturing in the EU-27 (excl. UK), January – July, change 2018/19 and 2019/20**



<sup>1</sup> Development is in 2015 prices, calendar adjusted data: Volume index of production (Short-term business statistics for industry)

Source: Eurostat, Short-term business statistics for industry; own calculations; September 2020

According to Eurostat's Business Demography statistics, approx. 60,500 enterprises in the engineering industries of the EU (incl. the UK) were newly created in 2017. More than half of enterprise births (53 %)<sup>13</sup> can be assigned to the manufacture of basic metals and fabricated metal products, approx. one third (31%) to the repair and installation of machinery and equipment. The enterprise birth rate in the EU was at 7.0%, which means that 7.0% of all active enterprises in this year were newly-established enterprises. The birth rate was highest in the repair and installation of machinery and equipment (9.0%), and lowest in the manufacture of machinery and equipment (4.2%). The enterprises in the total business economy in the EU were more dynamic in terms of enterprise births (9.6%) than in the engineering industries, while the enterprise birth rate of the total manufacturing sector was similar (7.2%).

51% of the enterprises in the engineering industries in the EU that were established in 2012 survived the first five years until 2017. The survival rate was highest in the manufacture of machinery and equipment (56%) and lowest in the manufacture of basic metals and fabricated metal products, except machinery and equipment (50%). In the total business economy, only 44% of enterprises survived the first five years.

**Table 2-7: Births of enterprises of the engineering industries<sup>1</sup> in the EU-27 + UK by sectors, 2017<sup>2</sup>**

|                                                                            | Number 2017   | Share in Engineering industries in % | Birth rate <sup>3</sup> | Average annual change 2013-2017 in % | Five year survival rate in % <sup>4</sup> |
|----------------------------------------------------------------------------|---------------|--------------------------------------|-------------------------|--------------------------------------|-------------------------------------------|
| Basic metals and fabricated metal products, except machinery and equipment | 32,100        | 53                                   | 7.0                     | 5.3                                  | 50                                        |
| Computer, electronic and optical products; electrical equipment            | 5,390         | 9                                    | 5.3                     | 1.4                                  | 51                                        |
| Machinery and equipment n.e.c.                                             | 4,040         | 7                                    | 4.2                     | -1.6                                 | 56                                        |
| Repair and installation of machinery and equipment                         | 19,000        | 31                                   | 9.0                     | -0.2                                 | 51                                        |
| <b>Engineering industries total</b>                                        | <b>60,530</b> | <b>100</b>                           | <b>7.0</b>              | <b>2.6</b>                           | <b>51</b>                                 |

<sup>1</sup> including NACE 24 (Manufacture of basic metals), excluding NACE 32.5 (Manufacture of medical and dental instruments and supplies) as data from the Business Demography statistics are not published for every NACE code

<sup>2</sup> latest available year

<sup>3</sup> Number of enterprise births divided by the number of enterprises active as a percentage

<sup>4</sup> Number of enterprises newly born in t-5 (2012) having survived to t (2017) divided by the number of enterprise births in t-5 (2012) as a percentage

Source: Eurostat, Business Demography; own calculations; Status: August 2020

<sup>13</sup> Including NACE 24 (Manufacture of basic metals) as data from the Business Demography statistics are not published for every single NACE code

### 2.1.2 Comparison of the structure of the EU engineering industries with major competitor countries

In this chapter, we compare the EU engineering sector (incl. the UK)<sup>14</sup> in terms of employment and value added with its major competitors: Brazil, China, India, Israel, Japan, Korea, Taiwan, Thailand and USA.

With regard to employment, among all the countries within scope, China has the highest absolute number of employees in 2018, with more than 25 million people employed in the engineering industries. However, employment actually decreased in the period 2013-2018 in China. The EU-27 plus UK ranks second with more than 10 million employees<sup>15</sup>, ahead of the USA with more than 3.6 million persons employed in the engineering industries.

**Table 2-8: Employment<sup>1</sup> in the Engineering industries and manufacturing in major competing countries and the EU-27 + UK**

| Country                  | Engineering Industries (EI) |                            |               | Manufacturing |               | Share of EI in Manufacturing<br>2018 in % |
|--------------------------|-----------------------------|----------------------------|---------------|---------------|---------------|-------------------------------------------|
|                          | Employment<br>in 2018       | Annual average change in % |               |               |               |                                           |
|                          |                             | 2008-<br>2013              | 2013-<br>2018 | 2008-<br>2013 | 2013-<br>2018 |                                           |
| Brazil                   | 1,198,732                   | 3.4                        | -5.4          | 2.9           | -2.8          | 17.0                                      |
| China                    | 25,324,000                  | 1.6                        | -1.6          | 0.9           | -3.6          | 35.7                                      |
| Taiwan                   | 1,602,234                   | 0.7                        | 1.7           | 0.7           | 1.4           | 56.3                                      |
| India                    | 2,474,325                   | 2.6                        | 3.5           | 3.5           | 3.8           | 15.9                                      |
| Israel                   | 151,589                     | -0.3                       | 0.4           | -0.1          | 0.6           | 39.7                                      |
| Japan                    | 2,821,897                   | -2.9                       | 2.8           | -1.9          | 2.4           | 35.8                                      |
| Republic of Korea        | 1,239,488                   | 2.2                        | 1.2           | 1.8           | 1.1           | 43.0                                      |
| Russian Federation       | 1,974,117                   | -4.0                       | 0.7           | -3.8          | -0.3          | 26.6                                      |
| Thailand                 | 943,527                     | -4.9                       | 3.6           | -2.0          | 1.2           | 23.2                                      |
| United States of America | 3,654,570                   | -4.9                       | 0.4           | -2.8          | 1.4           | 30.8                                      |
| EU-27 + UK               | 10,172,104                  | -2.2                       | 1.2           | -2.4          | 1.5           | 33.8                                      |

<sup>1</sup> The data covers employees and not persons employed (employees plus self-employed persons), therefore values are lower than for total employment data presented in chapter 2.1.1.

<sup>2</sup> Data based on ISIC Rev. 3. The codes within scope (28 – 33) were chosen based on concordance with the ISIC Rev. 4 classification 25-28, 32.5 and 33.

Source: UNIDO INDSTAT 2 Database, calculations by Austrian Institute for SME Research

**Employment** in the EU engineering industries declined in five countries as well as at an EU level (incl. the UK) in the period 2008-2013 due to the effects of the financial crisis since 2008/09. However, Brazil, India and South Korea showed relatively strong average annual growth rates in employment during this period. In the period 2013-2018, most

<sup>14</sup> The UK is included for the purposes of the international comparisons as the UK was an EU Member State during the period the comparative international statistics relate to.

<sup>15</sup> Data are based on employees, while the data presented in chapter 2.1.1 refer to persons employed (employees plus self-employed persons).

countries show average annual growth rates in employment, with the exception of China and Brazil. In terms of employment, the importance of the engineering industries measured as the share of total manufacturing differs among competitor countries: the highest percentage share can be observed in Taiwan (56.3%), followed by the Republic of Korea (43.0%) and Israel (39.7%).

In terms of **value added**, the engineering industries in the EU had the second highest value added in nominal terms, ranked behind China, but again ahead of the USA. However, as values are shown in nominal terms due to the lack of data available for value added in real terms makes it difficult to make a direct like for like comparison between countries. A quite different picture emerges when the share of engineering industries of total manufacturing is considered. The engineering industry in Taiwan accounts for a very significant percentage (60.7 %) of the total manufacturing industries in that country. Engineering also accounts for a reasonably significant share of total manufacturing in South Korea (45.8 %) and Israel (43.3 %). The EU-28 (31.8 %) ranks fifth behind Japan (32.7 %) and ahead of China (28.1 %).

**Table 2-9: Value added in nominal terms in the engineering industries<sup>1</sup> and manufacturing in major competing countries and the EU-27 + UK**

| Country                  | Engineering Industries (EI)            |                            |                  | Manufacturing |                  | Share of EI in Manufacturing 2018 in % |
|--------------------------|----------------------------------------|----------------------------|------------------|---------------|------------------|----------------------------------------|
|                          | Value added 2018 in € Mio <sup>2</sup> | Annual average change in % |                  |               |                  |                                        |
|                          |                                        | 2008-2013                  | 2013-2018        | 2008-2013     | 2013-2018        |                                        |
| Brazil                   | 28,423                                 | 5.5                        | -10.4            | 3.9           | -7.6             | 16.1                                   |
| China                    | 790,416                                | 14.8                       | 2.5              | 14.7          | 2.5              | 28.1                                   |
| Taiwan                   | 96,125                                 | 5.4                        | 5.5 <sup>3</sup> | 5.3           | 5.1 <sup>3</sup> | 60.7                                   |
| India                    | 29,903                                 | 1.4                        | 5.7              | 4.6           | 5.5              | 15.9                                   |
| Israel                   | 12,634                                 | 4.6                        | 2.0              | 2.7           | 2.6              | 43.3                                   |
| Japan                    | 258,362                                | -3.3                       | 0.7              | -1.2          | 0.2              | 32.7                                   |
| Republic of Korea        | 196,920                                | 7.5                        | 4.3              | 6.1           | 3.0              | 45.8                                   |
| Russian Federation       | 24,240                                 | 2.5                        | -5.5             | 0.9           | -6.3             | 15.2                                   |
| Thailand                 | 19,938                                 | 4.8                        | -0.3             | 9.6           | -0.2             | 24.7                                   |
| United States of America | 543,151                                | -3.5                       | 1.0              | 0.8           | 2.1              | 24.6                                   |
| EU-27 + UK               | 657,628                                | -2.7                       | 0.7              | -3.1          | 2.4              | 31.8                                   |

<sup>1</sup> Data based on ISIC Rev. 3. The codes within scope (28 – 33) were chosen based on concordance with the ISIC Rev. 4 classification 25-28, 32.5 and 33.

<sup>2</sup> Calculation based on yearly average exchange rates from Eurostat for 2018 (Taiwan 2017), Austrian Institute for SME Research Austria

<sup>3</sup> Values for Taiwan 2013-2017

Source: UNIDO INDSTAT 2 Database, calculations by Austrian Institute for SME research Austria

The evolution in value added in the engineering industries in international competitor countries, as well as in manufacturing more broadly differed between countries. China had by far the strongest growth rates of all countries between 2008 and 2013 in both the engineering industries as well as in manufacturing. This however is in stark contrast to the low increase in employment in these sectors in China in the same period (see Table 2.6). The USA as well as the EU (incl. the UK) experienced a decline in the value added of the

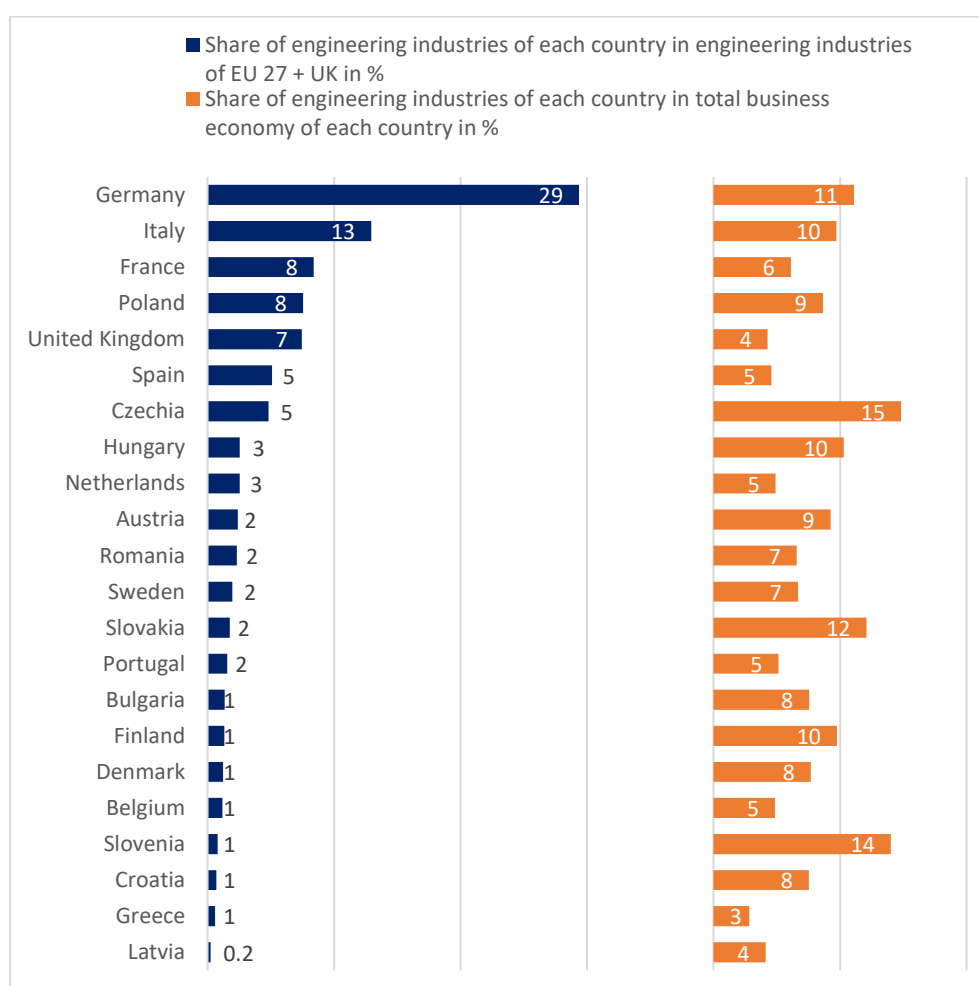
engineering industries as well as in total manufacturing in 2008-2013, followed by a weaker growth in the engineering industries than in total manufacturing from 2013-2018. Interestingly, in most of the observed countries (with the exception of Japan, USA and the EU), the engineering industries experienced an increase in value added in nominal terms in 2008-2013 despite the financial crisis.

### 2.1.3 Engineering industries in the EU Member States

There is a strong market concentration in the EU engineering industries as only five countries account for two-thirds (66 %) of the persons employed. Germany is by far the largest employer in the EU engineering industries. 29% of all persons employed in this sector work in German enterprises. 13% of persons employed in engineering are in Italy, and 8% each in France and in Poland.

With regard to the employment share of the EU engineering industries of each country in relation to the total business economy, the highest rate can be found in the Czech Republic (15%) and Slovenia (14%), followed by Slovakia (12%) and Germany (11%).

**Figure 2-7: Persons employed in the engineering industries in the EU-27 + UK by countries<sup>1</sup>, 2018<sup>2</sup>**



<sup>1</sup> For Estonia, Ireland, Cyprus, Lithuania, Luxembourg, Malta data is not available for all sectors of the engineering industries.

<sup>2</sup> The share of Engineering industries of each country in the total business economy (NACE Rev.2 section B to N + S95 excluding section K) of each country refers to 2017.

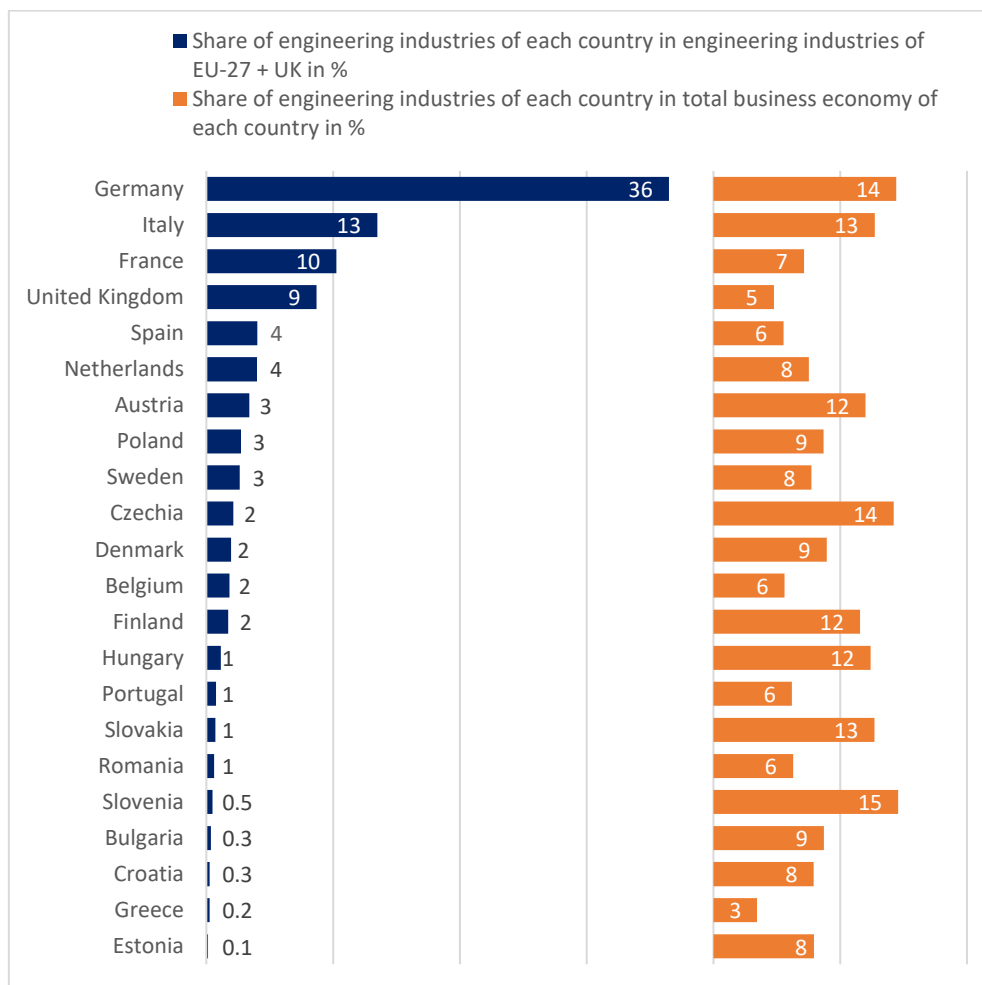
Source: Eurostat, Structural Business Statistics; own calculations; Status: August 2020



Four countries account for a concentrated share (69 %) of **total value added**: Germany is by far the largest contributor to the value added in the engineering industries (36%). Among the second and third ranked Member States with the highest value added, Italy is responsible for 13% of value added, and France for 10%.

In terms of value added, the share of the engineering industries in relation to the total business economy of each country is highest in Slovenia (15%) as well as in Germany and Czech Republic (14% each), followed by Italy and Slovakia (13% each).

**Figure 2-8: Value added of the engineering industries in the EU-27 + UK by countries<sup>1</sup>, 2017**



Note: Total business economy is defined as NACE Rev.2 section B to N + S95 excluding section K

<sup>1</sup> For Ireland, Cyprus, Latvia, Lithuania, Luxembourg, Malta data is not available for all sectors of the engineering industries.

Source: Eurostat, Structural Business Statistics; own calculations; Status: August 2020

## 2.1.4 Regional distribution of engineering industries in the EU

### 2.1.4.1 Regional industrial specialisation in the engineering industries in European regions

An initial indication of the regional distribution of engineering activities throughout the EU has been provided in the previous chapter 2.3.1 (Engineering industries in the EU Member States). Employment and value added in the EU engineering industries are to a great extent concentrated in Germany, Italy, France, the UK, Poland, Spain and the Czech Republic.

This section focuses at the subnational level and considers the extent of **concentration of the engineering industries<sup>16</sup> across different regions** of the European Union. The **location quotient (LQ)** is a way of quantifying how concentrated a particular industry is in a region as compared to a larger geographic unit. It is an indicator of self-sufficiency, or relative strength, of a particular industry. It can reveal what makes a particular region “unique” in comparison to the national or EU average.<sup>17 18</sup> The LQ is computed as an industry’s share of a regional total for some economic statistic, in this case employment<sup>19</sup>, divided by the industry’s share of the larger geographic unit for the same statistic. In this study, it measures a NUTS 2 region’s industrial specialisation in relation to the EU (incl. the UK).

$$LQ = \frac{\text{Regional employment in specific industry}}{\text{Regional total employment}} \bigg/ \frac{\text{EU employment in specific industry}}{\text{EU total employment}}$$

According to Miller et al. (1991), Sentz (2011) and Deller (n/a), the LQ can be interpreted as follows:

- **LQ < 1:** The region has a lower concentration in a specific industry as compared to the EU-28 as a whole. An LQ < 0.7 indicates the industry is very underrepresented, an LQ > 0.7 and < 0.9 that the industry is moderately underrepresented.
- **LQ = 1** means the region has the same proportion of economic activity (i.e. employment) in a specific industry as the EU-. It is not specialised in the given industry. Values around 0.9 and 1.1 can therefore be interpreted as average representation.
- **LQ > 1:** The region has a larger proportion of its economy in a specific industry than the EU, and the excess can potentially be exported. Values > 1.1 and < 1.3 indicate a moderate overrepresentation, all values > 1.3 that the industry is very overrepresented.
- **LQ = 2:** means that the given industry is represented by a 100% bigger share of employment in the given region than the industry’s share of employment on the level of all European regions. This indicates that the region is specialised in the industry and that it is export-oriented.

The **location quotients for European regions in the engineering industries** (excl. manufacture of medical and dental instruments) show that there is a high concentration of engineering with an LQ > 2 in German and Czech regions, followed by regions in Slovakia, Hungary, Italy as well as one region each in France (Franche-Comté), Slovenia

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<sup>16</sup> Regional data is only available for the NACE 2-digit-level. Therefore, data for manufacture of medical and dental instruments (C32.5) is not available.

<sup>17</sup> Sentz, R. (2011): Understanding location quotient.

<https://www.economicmodeling.com/2011/10/14/understanding-location-quotient-2/>, queried 15 January 2020

<sup>18</sup> Deller, S. (n/a): Location-Quotients and Targeted Regional Economic Development.

<https://aeese.psu.edu/nercrd/economic-development/tred/basic-tools/location-quotients>, queried 15 January 2020

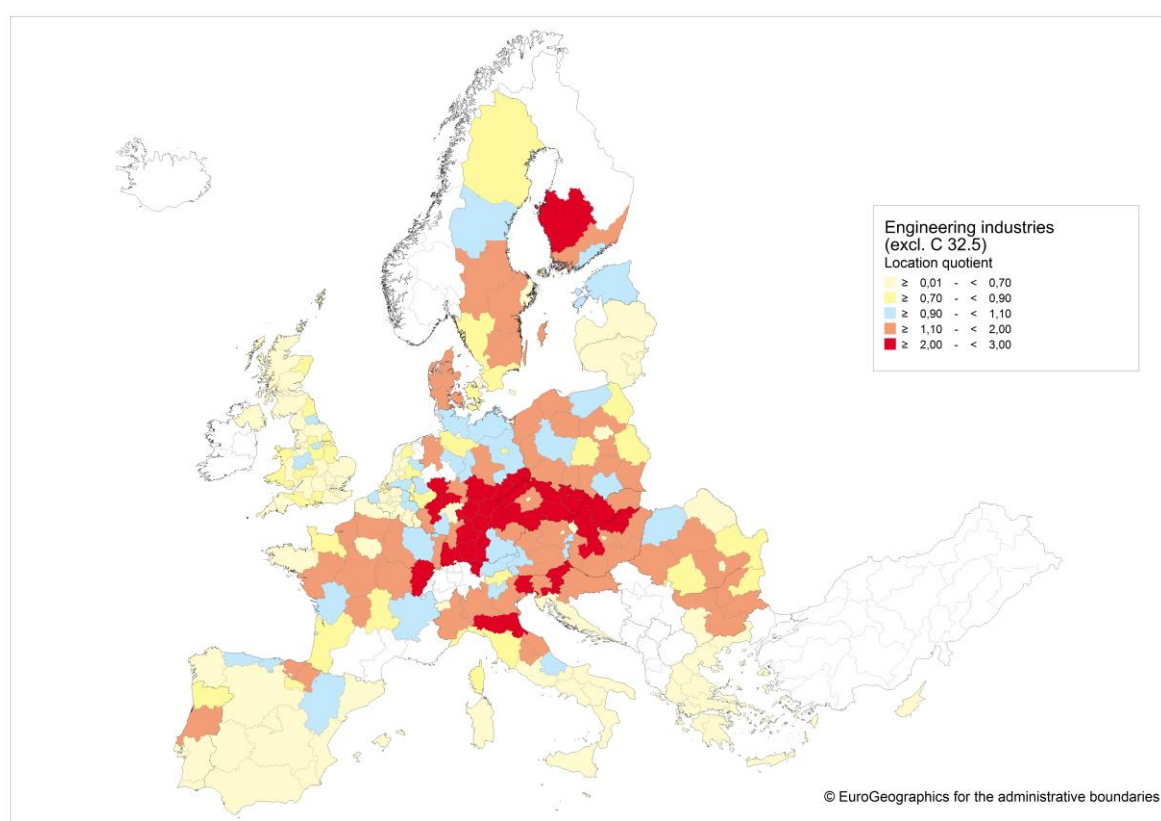
<sup>19</sup> Data for other possible economic statistics, such as value added, imports or exports, are not available on NUTS 2 level.

(Vzhodna Slovenija), Austria (Vorarlberg) and Finland (Länsi-Suomi). The highest LQ among the EU regions has Strední Morava in the Czech Republic (3.0), followed by the German regions Tübingen, Freiburg and Oberpfalz (2.8 each).

An underrepresentation of engineering industries ( $LQ < 0.9$ ) can generally be observed in urban agglomerations (e.g. London, Stockholm, Bucarest, Île de France, Vienna, Bratislava, Budapest, Hamburg, Prague, Berlin) as well as in rural touristic areas (e.g. Algarve in Portugal, many regions in Greece, Highlands and Islands in Scotland).

Figures on the industrial specialisation in each subsector of the engineering industries can be found in the Annex (Annex 2, Industrial specialisation in subsectors of the engineering industries).

**Figure 2-9: Industrial specialisation<sup>1</sup> in engineering industries<sup>2</sup> in the EU by NUTS 2 regions, 2017<sup>3</sup>**



<sup>1</sup> Industrial specialisation: the location quotient measures a region's industrial specialisation relative to the EU (incl. UK) as a whole. Values below 1 (0-0.7; 0.7-0.9) show an underrepresentation of the industry's employment in the region as compared to the EU, values around 1 (0.9-1.1) show an equal specialisation and values above 1 show a spatial concentration of the industry's employment in the region compared to the EU. Values above 2 show a specialisation of the region in the industry.

<sup>2</sup> excl. manufacture of medical and dental instruments (C32.5)

<sup>3</sup> latest available year

Source: Regional Structural Business Statistics; SBS data by NUTS 2 regions and NACE Rev. 2 [sbs\_r\_nuts06\_r2]; Status: August 2020

#### 2.1.4.2 Shifts in regional employment in the European engineering industries

Between 2008, 2013 and 2017, shifts in the regional employment in the engineering industries and its subsectors can be observed. These shifts are shown by dividing the total employment in the EU engineering industries into the Northern, Western, Central and Eastern and Southern economies, calculate their respective shares and compare employment shares over time.<sup>20</sup>

**Table 2-10 : Regional employment shares in the engineering industries in the EU-27 + UK, 2008-2017<sup>1</sup>**

|                                                    | Northern economies | Western economies | Central and Eastern economies | Southern economies | EU-27 + UK total |
|----------------------------------------------------|--------------------|-------------------|-------------------------------|--------------------|------------------|
| <b>2017</b>                                        |                    |                   |                               |                    |                  |
| Fabricated metal products                          | 4.3                | 45.4              | 26.4                          | 24.0               | 100.0            |
| Computer, electronic and optical products          | 5.2                | 59.8              | 23.1                          | 11.8               | 100.0            |
| Electrical equipment                               | 3.4                | 52.4              | 27.6                          | 16.6               | 100.0            |
| Machinery and equipment                            | 5.7                | 58.7              | 16.0                          | 19.7               | 100.0            |
| Repair and installation of machinery and equipment | 4.2                | 48.6              | 24.5                          | 22.7               | 100.0            |
| <b>Engineering industries total</b>                | <b>4.7</b>         | <b>52.1</b>       | <b>23.0</b>                   | <b>20.3</b>        | <b>100.0</b>     |
| <b>2013</b>                                        |                    |                   |                               |                    |                  |
| Fabricated metal products                          | 4.7                | 47.2              | 23.3                          | 24.8               | 100.0            |
| Computer, electronic and optical products          | 7.7                | 59.9              | 19.4                          | 13.0               | 100.0            |
| Electrical equipment                               | 4.0                | 54.1              | 24.8                          | 17.2               | 100.0            |
| Machinery and equipment                            | 6.4                | 58.6              | 15.3                          | 19.7               | 100.0            |
| Repair and installation of machinery and equipment | 4.3                | 51.9              | 23.2                          | 20.6               | 100.0            |
| <b>Engineering industries</b>                      | <b>5.4</b>         | <b>53.5</b>       | <b>20.7</b>                   | <b>20.4</b>        | <b>100.0</b>     |
| <b>2008</b>                                        |                    |                   |                               |                    |                  |
| Fabricated metal products                          | 5.1                | 41.2              | 22.9                          | 30.8               | 100.0            |
| Computer, electronic and optical products          | 8.7                | 54.5              | 21.6                          | 15.2               | 100.0            |
| Electrical equipment                               | 4.5                | 48.2              | 27.1                          | 20.2               | 100.0            |
| Machinery and equipment                            | 7.3                | 52.7              | 18.0                          | 22.1               | 100.0            |
| Repair and installation of machinery and equipment | 4.9                | 47.3              | 24.2                          | 23.7               | 100.0            |
| <b>Engineering industries</b>                      | <b>6.0</b>         | <b>47.6</b>       | <b>22.1</b>                   | <b>24.3</b>        | <b>100.0</b>     |

<sup>1</sup> latest year available

<sup>2</sup> Northern economies: DK (2016), FI, SE

<sup>3</sup> Western economies: BE, DE, IE, FR, LU, NL, AT, UK

<sup>4</sup> Central and Eastern economies: BG, CZ, EE, HR, LV, LT, HU, PL, RO, SI, SK

<sup>5</sup> Southern economies: EL, ES, IT (2016), CY, MT, PT

Source: Regional Structural Business Statistics, Eurostat; Status: August 2020

<sup>20</sup> Due to major changes and restructuring of NUTS 2 regions in 2006, 2010 and 2013 throughout the EU, the shifts cannot be shown on NUTS 2 level.

In 2017, based on the total EU employment in engineering (incl. the UK), more than half (52.1%) can be attributed to the economies of **Western Europe**, including Germany, France, the United Kingdom, the Netherlands, Austria, Ireland, Belgium and Luxembourg. Western economies have particularly high employment shares in the manufacture of computer, electronic and optical products (59.8%) as well as the manufacture of machinery and equipment (58.7%).

The economies of **Central and Eastern Europe**, such as Poland, the Czech Republic, Romania, Hungary, Slovakia, Slovenia, Bulgaria, Croatia, Lithuania, Estonia and Latvia constitute the second largest group with 23.0% of the total employment in engineering and particularly in the manufacture of electrical equipment (27.6%) and manufacture of fabricated metal products (26.4%).

One fifth of employment (20.3%) can be attributed to the economies of **Southern Europe**, such as Italy, Spain, Portugal, Greece, Cyprus and Malta. The Southern economies have high employment shares in the manufacture of fabricated metal products (24.0%).

**Table 2-11 : Changes in the regional employment shares in the engineering industries in the EU-27 + UK, 2017<sup>1</sup>**

|                                                    | Northern economies <sup>2</sup> | Western economies <sup>3</sup> | CEE economies <sup>4</sup> | Southern economies <sup>5</sup> |
|----------------------------------------------------|---------------------------------|--------------------------------|----------------------------|---------------------------------|
| <b>Change 2013-2017 in %-points</b>                |                                 |                                |                            |                                 |
| Fabricated metal products                          | -0.5                            | -1.8                           | 3.1                        | -0.8                            |
| Computer, electronic and optical products          | -2.5                            | -0.1                           | 3.7                        | -1.1                            |
| Electrical equipment                               | -0.5                            | -1.7                           | 2.9                        | -0.6                            |
| Machinery and equipment                            | -0.7                            | 0.0                            | 0.7                        | 0.0                             |
| Repair and installation of machinery and equipment | -0.1                            | -3.3                           | 1.3                        | 2.2                             |
| <b>Engineering industries total</b>                | <b>-0.7</b>                     | <b>-1.4</b>                    | <b>2.2</b>                 | <b>-0.1</b>                     |
| <b>Change 2008-2013 in %-points</b>                |                                 |                                |                            |                                 |
| Fabricated metal products                          | -0.4                            | 5.9                            | 0.5                        | -6.0                            |
| Computer, electronic and optical products          | -1.0                            | 5.5                            | -2.2                       | -2.3                            |
| Electrical equipment                               | -0.5                            | 5.9                            | -2.4                       | -3.0                            |
| Machinery and equipment                            | -0.8                            | 6.0                            | -2.7                       | -2.4                            |
| Repair and installation of machinery and equipment | -0.6                            | 4.6                            | -1.0                       | -3.1                            |
| <b>Engineering industries total</b>                | <b>-0.6</b>                     | <b>5.9</b>                     | <b>-1.4</b>                | <b>-3.9</b>                     |

<sup>1</sup> latest year available

<sup>2</sup> Northern economies: DK (2016), FI, SE

<sup>3</sup> Western economies: BE, DE, IE, FR, LU, NL, AT, UK

<sup>4</sup> CEE economies: BG, CZ, EE, HR, LV, LT, HU, PL, RO, SI, SK

<sup>5</sup> Southern economies: EL, ES, IT (2016), CY, MT, PT

Note: The calculation is based on the regional employment shares of the country groups in the EU-28 total engineering employment in 2008, 2013 and 2017. The table represents the changes of the regional shares in total EU-27 + UK employment in engineering in %-points.

Source: Regional Structural Business Statistics, Eurostat; Status: August 2020

4.7% of the total employment in engineering can be observed in the Northern economies such as Sweden, Finland and Denmark, with higher shares in manufacture of machinery and equipment (5.7%) as well as manufacture of computer, electronic and optical products (5.2%).

When comparing the employment distribution throughout the years, the following table shows that there were **shifts in the regional employment** shares: The Western economies could gain employment shares in all engineering industries between 2008 and 2013, with an increase of 5.9%-points on average, while the shares of the other economies decreased in the same time period. Between 2013 and 2017, the employment distribution shifted towards the CEE economies in all engineering industries, in particular in the manufacture of computer, electronic and optical products (+3.7%-points), but also manufacture of fabricated metal products (+3.1%-points). The Southern economies could not increase their employment share except for the repair and installation of machinery and equipment (+2.2%-points).

## **2.2 KEY COMPETITIVENESS FACTORS FOR THE EU ENGINEERING INDUSTRIES**

The assessment of the competitiveness and overall performance of the EU engineering industry are based on analysing the key determinants of competitiveness based on a review of key performance indicators. This chapter analyses international trade performance, global value chains (GVCs), access to, and trade in raw materials, technological competition (technologies, R&D, patents), access to skilled labour, performance and price competitiveness, investments, foreign direct investments (FDI), as well as financial performance and access to finance.

### **2.2.1 International trade performance**

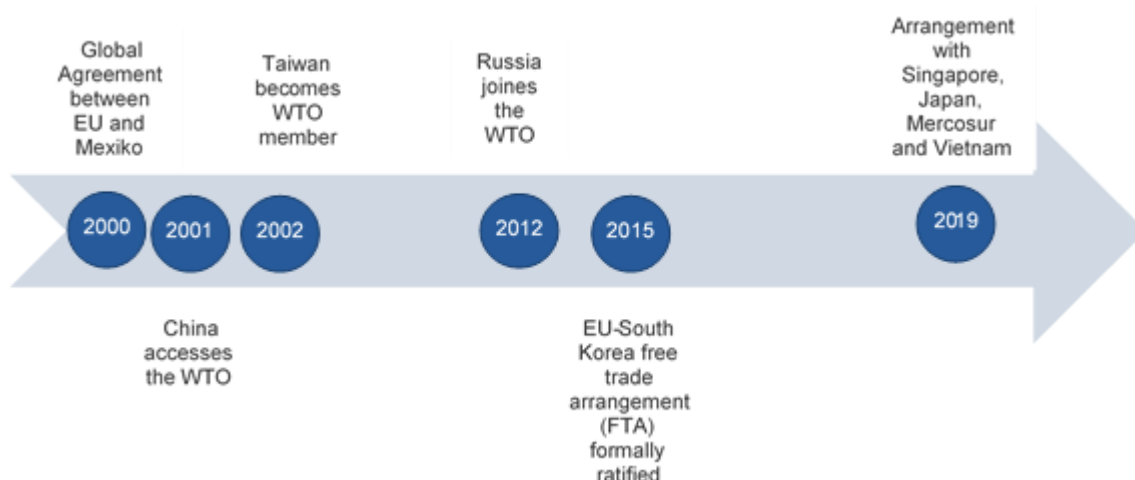
It is widely acknowledged that trade is a powerful engine of growth and job creation. Trade outside the EU is an exclusive EU competence, which means that EU institutions make laws on trade matters, as well as negotiate and conclude international trade agreements.

There are three main types of trade agreements with third countries:

1. Customs Unions, which abolish customs duties in bilateral trade, and create a joint customs tariff for foreign importers.
2. Association Agreements, Stabilisation Agreements, (Deep and Comprehensive) Free Trade Agreements and Economic Partnership Agreements, that eliminate or reduce customs tariffs in bilateral trade.
3. Partnership and Cooperation Agreements, which provide a general framework for bilateral economic relations, leaving customs tariffs unaffected.

The following figure provides a review of the effective dates of trade arrangements between the EU and its main partner countries. It should be noted that these agreements apply to trade in general, and not specifically to the EU engineering industries.

**Figure 2-10: Trade arrangements between the European Union and main trade partners**



Source: European Commission

In 1997, the EU and **Mexico** signed an Economic Partnership, Political Coordination and Cooperation Agreement, known as the Global Agreement. The part on trade, which mostly opened up trade in goods, came into force in 2000. **China** joined the WTO in 2001 and in 2016, the EU adopted a new five year strategy to refine its trading relationship with China. The strategy also includes a trade agenda with a strong focus on improving market access opportunities - including negotiations on a Comprehensive Agreement on Investment. Separate Negotiations with China for an upgrade of the 1985 Trade and Economic Cooperation Agreement were launched in 2007 but have been stalled since 2011 due to divergences between the mandates and expectations of the parties. The **EU-South Korea** free trade agreement (FTA) was formally ratified in 2015, but has provisionally applied since July 2011. In 2019, Trade and Investment Protection Agreements between the EU and **Singapore** came into force.<sup>21</sup> Such an agreement with **Vietnam** has been approved but still needs to be ratified.<sup>22</sup> Also 2019, the Economic Partnership Agreement 'EPA' between EU and **Japan** entered into force.<sup>23</sup>

Negotiations with the **United States** to secure a trade agreement through the Transatlantic Trade and Investment Partnership (TTIP) were launched in 2013 and ended without conclusion at the end of 2016. Negotiations on a new trade agreement between EU and **India** and the EU and **Thailand** started in 2007 and lasted until 2013, when they were put on hold. However, at the end of 2018, the EU adopted a strategy on India, "aimed at reinforcing the strategic partnership, with a focus on sustainable modernisation and on collaboration in a multilateral context".<sup>24</sup> Two annual EU-India summits took place in 2016 and 2017, and engineering was one of the sectors where the scope for cooperation was identified.

As only some of the dates when the trade deals became effective are within the study time frame (2008-19), the effects of trade arrangements on actual trade developments have not been assessed within this study, as this would not be possible across all competitor countries.

<sup>21</sup> <https://ec.europa.eu/trade/policy/in-focus/eu-singapore-agreement/>

<sup>22</sup> <https://ec.europa.eu/trade/policy/in-focus/eu-vietnam-agreement/>

<sup>23</sup> <https://ec.europa.eu/trade/policy/in-focus/eu-japan-economic-partnership-agreement/>

<sup>24</sup> Cost of Non-Europe Report, European Parliament, Cecilia Navarra, European Added Value Unit, (June 2020) - Assessing the potential impact of an EU-India trade agreement, [https://www.europarl.europa.eu/RegData/etudes/STUD/2020/642841/EPRS\\_STU\(2020\)642841\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2020/642841/EPRS_STU(2020)642841_EN.pdf)

The following section provides an assessment of trade performance of the EU-27 plus UK in the market of engineering goods<sup>25</sup>. The analysis draws on Eurostat's international trade in goods data. The following table provides an overview of the development of trade flows within (intra-EU) and outside (extra-EU) the EU-27 + UK. In 2019, the total import value of engineering goods of the EU (intra-EU and extra-EU) amounted to € 1,530 billion. The majority of imports (€ 930 billion) are between EU countries (incl. UK), whereas around 40% of import flows cross EU external borders.

Exports to third countries (€ 635 billion) exceed imports of EU member states from third countries (€ 600 billion), leading to a positive trade balance of € 35.6 billion in 2019. Domestic demand – defined as the sum of EU-27 + UK production and extra-EU imports deducting exports from third countries – increased on average by 2.9% annually in the past 6 years and amounted to € 1,291,913 million in 2019. The export quota reveals that 42% of total EU engineering production is exported to third countries.

**Table 2-12: Trade performance: International trade of engineering goods of the EU-27 + UK, 2008-19**

|                             | Value in € million | Average annual change <sup>1</sup> 2008-13 in % | Average annual change <sup>1</sup> 2013-19 in % |
|-----------------------------|--------------------|-------------------------------------------------|-------------------------------------------------|
|                             | 2019               |                                                 |                                                 |
| <b>Intra-EU<sup>2</sup></b> |                    |                                                 |                                                 |
| Imports                     | 929,541            | -0.5                                            | 4.1                                             |
| Exports                     | 997,419            | -0.4                                            | 4.4                                             |
| <b>Extra-EU</b>             |                    |                                                 |                                                 |
| Imports                     | 600,403            | 0.5                                             | 4.9                                             |
| Exports                     | 635,968            | 2.2                                             | 2.2                                             |
| Trade Balance               | 35,565             | -                                               | -                                               |
| Production                  | 1,395,357          | -2.4                                            | 1.9                                             |
| Domestic Demand             | 1,291,913          | -2.7                                            | 2.9                                             |
| Export quota                | 42%                | -                                               | -                                               |
| <b>Total</b>                |                    |                                                 |                                                 |
| Imports                     | 1,529,944          | -0.2                                            | 4.4                                             |
| Exports                     | 1,633,387          | 0.6                                             | 4.2                                             |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study. Domestic demand=production of EU-28 countries plus imports minus exports.

<sup>1</sup> Annual changes are based on 2015 prices.

<sup>2</sup> The CIF/FOB approach makes it impossible that the intra-EU trade balance is zero.

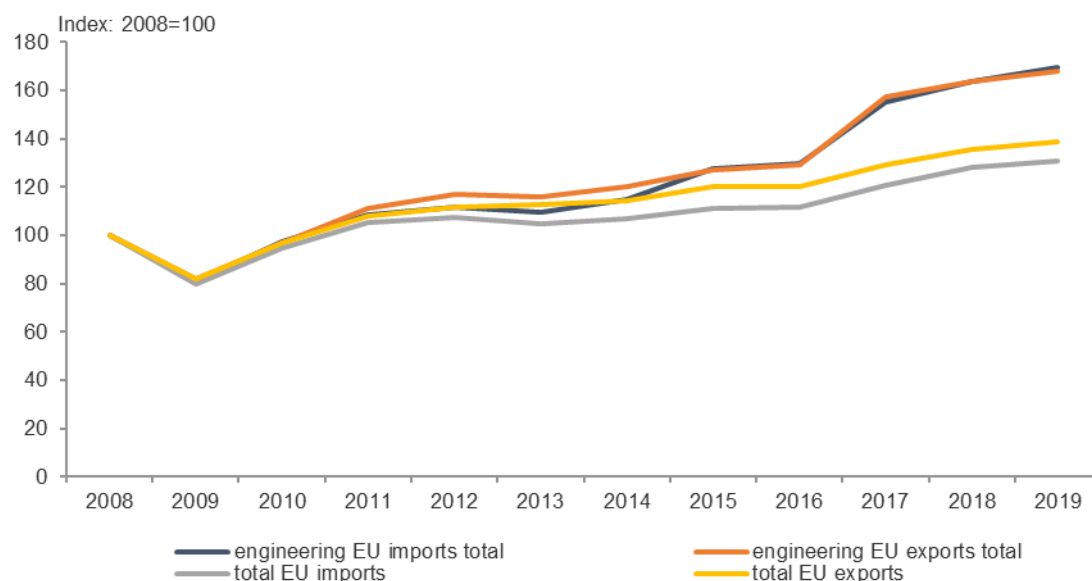
Source: Eurostat, International trade in goods; Statistics on the production of manufactured goods (PRODCOM); own calculations

As shown in the figure below, until 2010, imports and exports of all goods showed a similar trajectory to those of engineering goods. In 2011, the trends started to differ: Imports and exports of engineering goods performed better than those of all commodities, with a noticeable increase in 2016 for both EU engineering exports and imports.

<sup>25</sup> Engineering goods based on the CN-classification; via correspondence tables provided by Eurostat (RAMON), NACE codes can be translated into PRODCOM codes (goods classification) and, consequently, into CN-codes (goods classification).



**Figure 2-11: Development of the international trade of engineering goods and in total of the EU-27 + UK, 2008-19 (index: 2008=100)**

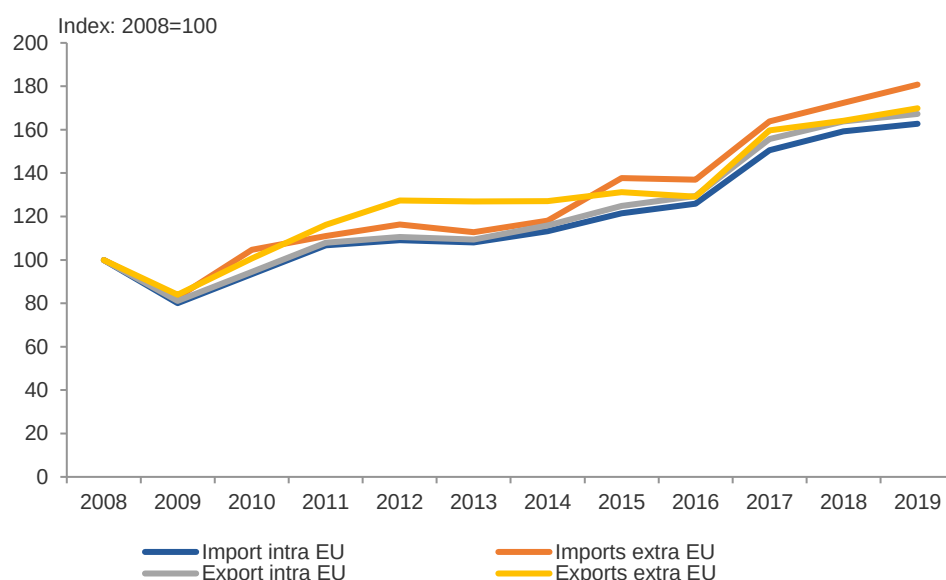


Note: Data are based on the CN-classification and engineering goods as defines in the frame of the present study.

Source: Austrian Institute for SME Research; Eurostat, International trade in goods.

The following figure examines trade in engineering goods more closely, and distinguishes further between flows intra- and extra-EU-27 + UK. Again, there is a decline between 2008 and 2009 due to the economic and financial crisis. Thereafter, extra-EU trade performed better than intra-EU trade. Extra-EU exports have been mainly stable between 2012 and 2016. Again, very positive economic growth in 2016 affects all trade flows.

**Figure 2-12: Detailed development of the international trade of engineering goods of the EU-27 + UK, 2008--19 (index: 2008=100)**

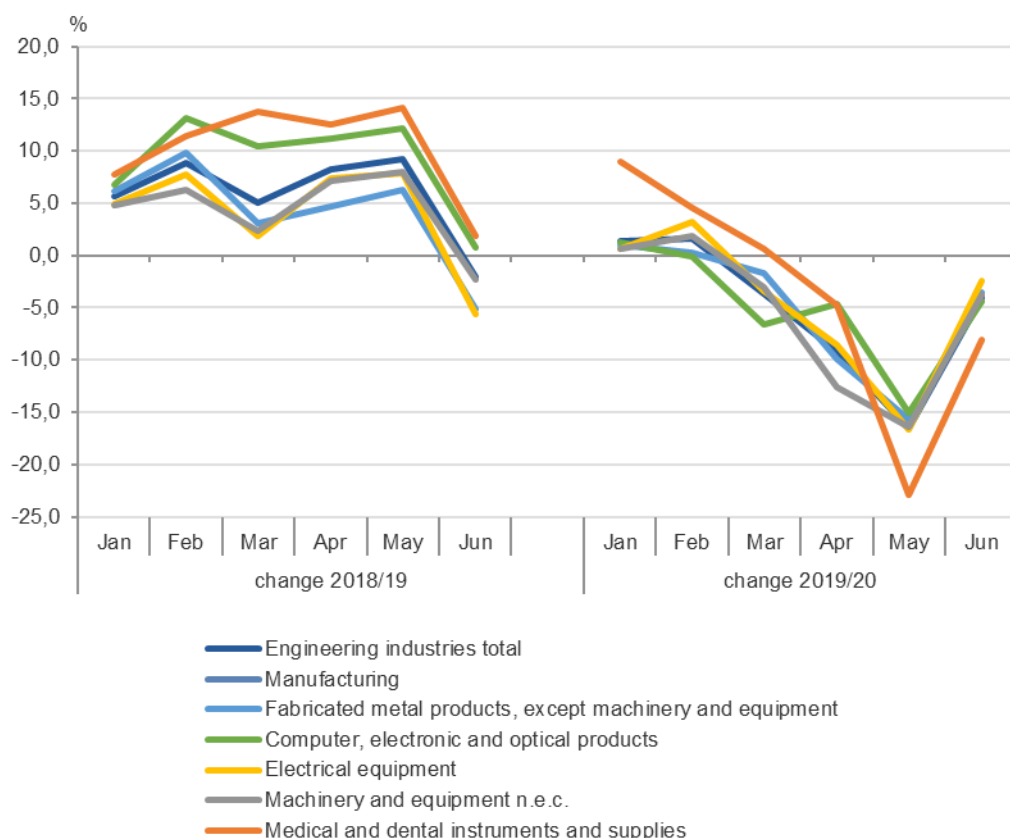


Note: Data is based on the CN-classification and engineering goods as defines in the frame of the present study.

Source: Austrian Institute for SME Research; Eurostat, International trade in goods

The following figure shows how deeply extra-EU exports have been affected by the COVID-19 crisis: All engineering product groups experienced a sharp decrease in extra-EU exports compared to the year before. The slump was reached in May 2020 when all sectors suffer an export-shrinkage in the range of 15-17%, the sector medical and dental instruments and supplies even sustaining a fall of 23%. In June 2020, the year-on-year change on extra-EU-27 exports was still negative, but showing an upward trend.

**Figure 2-13 : Recent developments in extra-EU exports of the EU-27 (annual changes 2018/19 vs. 2019/20)**



Source: Eurostat international trade in goods data.

Table 2-13 provides an overview of intra-EU trade flows: the two categories computer, electronic and optical products as well as machinery and equipment each constitute nearly one third of intra-EU imports and -exports of engineering goods. Moreover, these two segments also exhibited the highest annual growth rates within the past five years.

**Table 2-13: International trade (intra-EU) of engineering goods of the EU-27 + UK, 2008-2019**

|                                                           | 2019<br>(Value in<br>€ million) | Share in<br>engineerin<br>g goods in<br>% | Average<br>annual<br>change <sup>1</sup><br>2008-13 in<br>% | Average<br>annual<br>change <sup>1</sup><br>2013-19 in<br>% |
|-----------------------------------------------------------|---------------------------------|-------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------|
| <b>Intra-EU imports</b>                                   |                                 |                                           |                                                             |                                                             |
| Tube or pipe fittings of iron or steel                    | 3,872                           | 0.4                                       | -4.4                                                        | 1.2                                                         |
| Fabricated metal products, except machinery and equipment | 103,622                         | 11.1                                      | 1.3                                                         | 3.3                                                         |

|                                                                       | 2019<br>(Value in<br>€ million) | Share in<br>engineerin<br>g goods in<br>% | Average<br>annual<br>change <sup>1</sup><br>2008-13 in<br>% | Average<br>annual<br>change <sup>1</sup><br>2013-19 in<br>% |
|-----------------------------------------------------------------------|---------------------------------|-------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------|
| Computer, electronic and optical products                             | 301,064                         | 32.3                                      | -0.4                                                        | 4.4                                                         |
| Electrical equipment                                                  | 178,427                         | 19.1                                      | 0.0                                                         | 4.0                                                         |
| Machinery and equipment                                               | 298,303                         | 32.0                                      | -2.6                                                        | 4.3                                                         |
| Medical and dental instruments and supplies                           | 48,124                          | 5.2                                       | 7.0                                                         | 2.8                                                         |
| <b>Engineering Industries total<br/>(incl. tube or pipe fittings)</b> | <b>933,413</b>                  | <b>100.0</b>                              | <b>-0.6</b>                                                 | <b>4.1</b>                                                  |
| <b>Intra-EU exports</b>                                               |                                 |                                           |                                                             |                                                             |
| Tube or pipe fittings of iron or steel                                | 3,529                           | 0.4                                       | 0.3                                                         | -2.1                                                        |
| Fabricated metal products, except machinery and equipment             | 115,615                         | 11.5                                      | 1.7                                                         | 2.9                                                         |
| Computer, electronic and optical products                             | 323,961                         | 32.3                                      | -0.3                                                        | 4.9                                                         |
| Electrical equipment                                                  | 189,361                         | 18.9                                      | 0.1                                                         | 4.2                                                         |
| Machinery and equipment                                               | 318,656                         | 31.8                                      | -2.5                                                        | 4.9                                                         |
| Medical and dental instruments and supplies                           | 49,826                          | 5.0                                       | 7.0                                                         | 2.9                                                         |
| <b>Engineering Industries total<br/>(incl. tube or pipe fittings)</b> | <b>1,001,474</b>                | <b>100.0</b>                              | <b>-0.4</b>                                                 | <b>4.4</b>                                                  |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study; tube or pipe fittings have been added

<sup>1</sup> Annual changes are based on 2015 prices.

Source: Eurostat, International trade in goods; own calculations

Table 2-14 focuses on trade of engineering goods with third countries. Computer, electronic and optical products is the most relevant category of extra-EU imports, constituting almost half (48.3%) of all imported engineering goods. Regarding exports to third countries, machinery and equipment reveal the highest share (42.4%), amounting to € 270,778 million in 2019. Over the past six years (2013-19), extra-EU imports grew on average faster (4.9% p.a.) than did exports (2.2%). Although medical instruments constitute only a small segment (6.5%) of extra-EU exports, they are a dynamic product category exhibiting comparatively high annual growth rates of 7.8% (2013-18).

**Table 2-14: International trade (extra-EU) of engineering goods of the EU-27 + UK. 2008-2019**

|                                        | 2019<br>(Value in<br>€ million) | Share in<br>engineerin<br>g goods in<br>% | Average<br>annual<br>change <sup>1</sup><br>2008-13 in<br>% | Average<br>annual<br>change <sup>1</sup><br>2013-19 in<br>% |
|----------------------------------------|---------------------------------|-------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------|
| <b>Extra-EU imports</b>                |                                 |                                           |                                                             |                                                             |
| Tube or pipe fittings of iron or steel | 1,682                           | 0.3                                       | -2.8                                                        | 2.5                                                         |

|                                                                        | 2019<br>(Value in<br>€ million) | Share in<br>engineerin<br>g goods in<br>% | Average<br>annual<br>change <sup>1</sup><br>2008-13 in<br>% | Average<br>annual<br>change <sup>1</sup><br>2013-19 in<br>% |
|------------------------------------------------------------------------|---------------------------------|-------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------|
| Fabricated metal products. except<br>machinery and equipment           | 46,201                          | 7.7                                       | 3.8                                                         | 5.5                                                         |
| Computer. electronic and optical<br>products                           | 290,655                         | 48.3                                      | -0.4                                                        | 4.2                                                         |
| Electrical equipment                                                   | 106,072                         | 17.6                                      | 3.4                                                         | 6.2                                                         |
| Machinery and equipment                                                | 125,709                         | 20.9                                      | -1.7                                                        | 6.0                                                         |
| Medical and dental instruments<br>and supplies                         | 31,766                          | 5.3                                       | 7.0                                                         | 3.3                                                         |
| <b>Engineering Industries total<br/>(incl. tubes or pipe fittings)</b> | <b>602,085</b>                  | <b>100.0</b>                              | <b>0.5</b>                                                  | <b>4.9</b>                                                  |
| <b>Extra-EU exports</b>                                                |                                 |                                           |                                                             |                                                             |
| Tube or pipe fittings of iron or<br>steel                              | 2,616                           | 0.4                                       | -1.1                                                        | -4.5                                                        |
| Fabricated metal products. except<br>machinery and equipment           | 51,358                          | 8.0                                       | 6.2                                                         | 0.1                                                         |
| Computer. electronic and optical<br>products                           | 167,196                         | 26.2                                      | 0.2                                                         | 4.4                                                         |
| Electrical equipment                                                   | 105,303                         | 16.5                                      | 1.7                                                         | 1.8                                                         |
| Machinery and equipment                                                | 270,778                         | 42.4                                      | 2.0                                                         | 1.2                                                         |
| Medical and dental instruments<br>and supplies                         | 41,333                          | 6.5                                       | 8.6                                                         | 4.3                                                         |
| <b>Engineering Industries total<br/>(incl. tubes or pipe fittings)</b> | <b>638,584</b>                  | <b>100.0</b>                              | <b>2.1</b>                                                  | <b>2.2</b>                                                  |

Note: Data is based on the CN-classification and engineering goods as defined in the frame of the present study; tube or pipe fittings have been added

<sup>1</sup> Annual changes are based on 2015 prices.

Source: Eurostat. International trade in goods; own calculations

The EU-27+ UK external trade balance is characterised by two different observations. On the one hand, extra-EU trade shows a strongly positive trade balance in the field of machinery and equipment. This means that the EU-27 + UK exports more to third countries than it imports. Medical instruments, metal products and electrical equipment also show a positive trade balance in 2019. On the other hand, the EU-27 + UK has a strong negative trade balance in the field of computer, electronic and electrical products.

**Table 2-15: International trade balance (extra-EU) of engineering goods of the EU-27 + UK, 2008-2019**

|                                                           | Value in<br>€ million<br>2019 |
|-----------------------------------------------------------|-------------------------------|
| Tube or pipe fittings of iron or steel                    | 933                           |
| Fabricated metal products, except machinery and equipment | 5,158                         |
| Computer, electronic and optical products                 | -123,460                      |
| Electrical equipment                                      | -768                          |

|                                                                        | Value in<br>€ million<br>2019 |
|------------------------------------------------------------------------|-------------------------------|
| Machinery and equipment                                                | 145,069                       |
| Medical and dental instruments and supplies                            | 9,566                         |
| <b>Engineering industries total<br/>(incl. tubes or pipe fittings)</b> | <b>36,499</b>                 |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study; tube or pipe fittings have been added

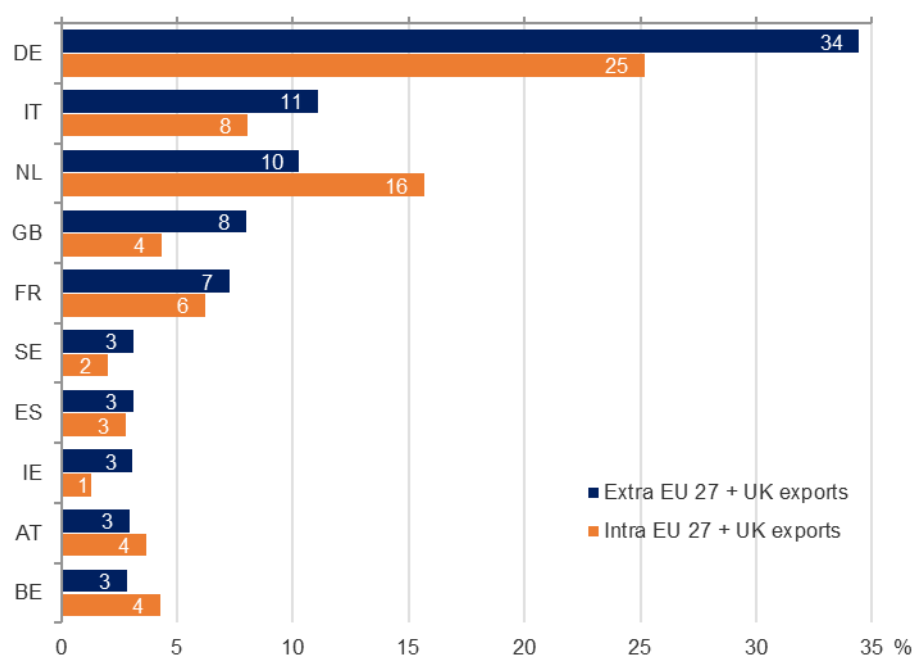
Trade balance = exports minus imports

Source: Eurostat, International trade in goods; own calculations

The following figure depicts the ten best-performing countries of the EU-27 and the UK, which collectively account for 85% of intra-EU exports and 83% of extra EU-exports of engineering products.

In 2019, Germany was by far the largest exporter of engineering goods among the EU-27+ UK – 25% of all intra-EU and 34% of total extra-EU exports can be assigned to Germany. The Netherlands (16% of intra-EU exports; 10% of extra-EU exports) and Italy (8% of intra-EU exports; 11% of extra-EU exports) are placed second and third in the export rankings.

**Figure 2-14: Export of engineering goods by TOP 10-countries, share of EU-27 + UK export value in %, 2019**



Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

Table 2-16 ranks the most important global players in the engineering industries regarding their reported export values. In 2016, China is in the leading position: its exports amount to US \$ 1,030,853 Mio and are therefore, almost double the level of extra-EU exports (exports from EU-27 + UK). Germany ranks third regarding the exports of engineering products: Its export values are US \$ 422,347 Mio, which surpasses even the United States.

**Table 2-16 : World exports<sup>1</sup> of main global players- shares of EEI sectors on total EEI and reported export values for EEI in Mio US\$, 2016**

|                       | Shares on Engineering total in %                          |                                           |                      |                                | Reported export values in Mio US\$ |
|-----------------------|-----------------------------------------------------------|-------------------------------------------|----------------------|--------------------------------|------------------------------------|
|                       | Fabricated metal products, except machinery and equipment | Computer, electronic and optical products | Electrical equipment | Machinery and equipment n.e.c. | Engineering total                  |
| China                 | 7                                                         | 58                                        | 19                   | 16                             | 1,030,853                          |
| <b>EU 27 + UK</b>     | <b>10</b>                                                 | <b>27</b>                                 | <b>19</b>            | <b>45</b>                      | <b>498,180</b>                     |
| <i>Germany</i>        | <i>10</i>                                                 | <i>26</i>                                 | <i>19</i>            | <i>44</i>                      | <i>422,347</i>                     |
| United States         | 8                                                         | 45                                        | 15                   | 33                             | 419,115                            |
| Hong Kong             | 1                                                         | 82                                        | 12                   | 6                              | 335,991                            |
| Japan                 | 5                                                         | 34                                        | 16                   | 45                             | 253,953                            |
| Korea                 | 6                                                         | 60                                        | 15                   | 19                             | 224,961                            |
| Chinese Taipei        | 7                                                         | 76                                        | 7                    | 11                             | 173,193                            |
| Singapore             | 2                                                         | 72                                        | 9                    | 18                             | 170,169                            |
| <i>Italy</i>          | <i>14</i>                                                 | <i>11</i>                                 | <i>17</i>            | <i>59</i>                      | <i>140,459</i>                     |
| Mexico                | 6                                                         | 50                                        | 23                   | 21                             | 139,105                            |
| <i>Netherlands</i>    | <i>7</i>                                                  | <i>50</i>                                 | <i>11</i>            | <i>32</i>                      | <i>122,641</i>                     |
| <i>France</i>         | <i>10</i>                                                 | <i>32</i>                                 | <i>20</i>            | <i>39</i>                      | <i>100,368</i>                     |
| <i>United Kingdom</i> | <i>8</i>                                                  | <i>36</i>                                 | <i>15</i>            | <i>41</i>                      | <i>86,706</i>                      |
| Malaysia              | 3                                                         | 73                                        | 11                   | 12                             | 86,385                             |
| Thailand              | 8                                                         | 51                                        | 18                   | 23                             | 73,532                             |
| Vietnam               | 4                                                         | 83                                        | 9                    | 4                              | 70,603                             |
| <i>Czech Republic</i> | <i>14</i>                                                 | <i>34</i>                                 | <i>23</i>            | <i>30</i>                      | <i>65,208</i>                      |
| Switzerland           | 8                                                         | 46                                        | 14                   | 32                             | 65,192                             |
| <i>Austria</i>        | <i>17</i>                                                 | <i>24</i>                                 | <i>20</i>            | <i>39</i>                      | <i>56,608</i>                      |
| India                 | 24                                                        | 14                                        | 20                   | 42                             | 27,825                             |
| Brazil                | 20                                                        | 8                                         | 16                   | 56                             | 15,286                             |
| Russia                | 15                                                        | 33                                        | 22                   | 30                             | 9,682                              |

Note: Data are based on CPA classification

<sup>1</sup> For the EU-27 + UK, only extra-EU exports are reported, while for the individual EU member states total exports (intra-EU and extra-EU) are displayed.

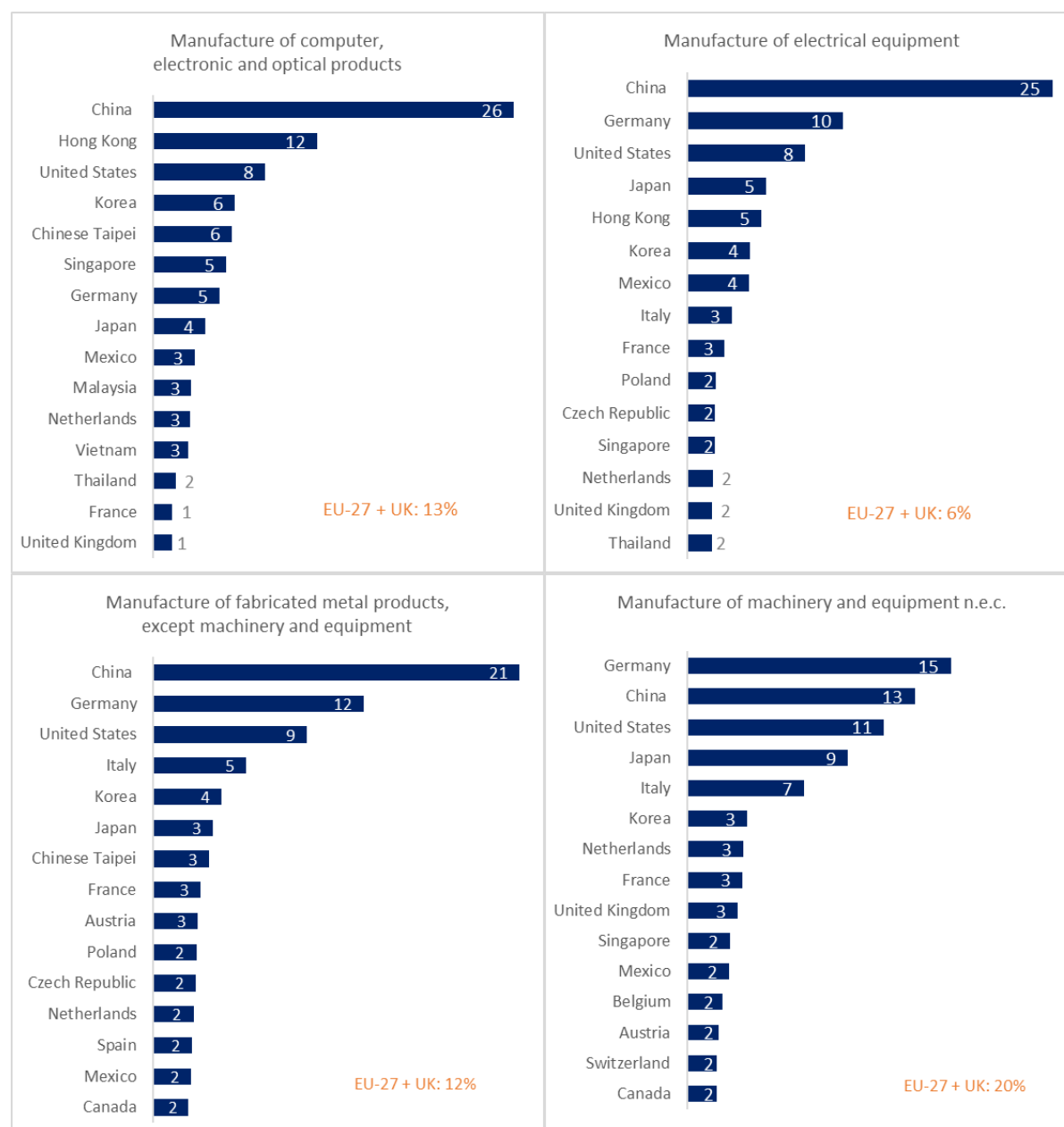
Source: OECD Balanced International Merchandise Trade Statistics (by CPA), own calculations; Status: August 2020

Between the different comparator countries, the importance of the EEI sectors varies considerably. For example, Asian countries (e.g. Chinese Taipei, Malaysia, Vietnam and Singapore) focus mainly on computers, electronic and optical products, whereas in the EU (incl. UK), sectoral strengths are concentrated in machinery and equipment. Among the EU's main competitors, Brazil exhibits the highest proportion of machinery and equipment (56%) of the reported EEI export values in 2016. Fabricated metal products comprise 10%

of EU extra-EU exports (exports from EU-27 + UK), but have above-average shares in India (24%), Austria (17%), Russia (15%), the Czech Republic and Italy (14% each).

Figure 2-15 rates the top-15 countries by market share in world exports for each of the engineering sectors. The market share of the EU (incl. UK) is highest in the manufacturing of machinery and equipment sector, where the EU accounts for one-fifth of all exports. However, in the two sectors manufacturing of computers, electronic and optical products as well as the manufacturing of electrical equipment, about a quarter of global exports are from China. The United States is the third biggest exporter in each category, with a share of global exports ranging between eight and eleven percent.

**Figure 2-15: Market shares on global exports<sup>1</sup> by sectors of EEI in %, Top-15 countries, 2016**



<sup>1</sup> For EU-27 + UK only extra-EU exports are reported, while for the individual EU countries total exports are displayed.

Source: OECD Balanced International Merchandise Trade Statistics (by CPA), own calculations; Status: August 2020

### **2.2.2 Global value chains (GVCs)**

Indications on GVCs in the EU engineering industries can be derived from the data of the World Input-Output Database (WIOD)<sup>26</sup>. The WIOD is based on a combination of more than 40 national input-output tables in which the use of products is broken down according to their origin. In contrast to the national input-output tables, this information is made explicit in the World Input-Output Tables. For each country, flows of products both for intermediate and final use are split into domestically produced or imported. In addition, the WIOD shows for imports in which foreign industry the product was produced (see also Timmer et al., 2012). Therefore, the database provides information on intermediate trade on a sectoral level between more than 40 countries. It allows the calculation of value-added flows, i.e. it can be determined where value added from the EU engineering industry is finally used and where value added used for final production in the EU engineering industry originally comes from.

#### **2.2.2.1 EU engineering industries value added exports**

Across the EU engineering industries as a whole, 75% of value added exports (EU-27 + UK), are used in EU final production (particularly in Germany, France and Italy), while 25% are used in final production outside the EU. This means that there are strong intra-EU trade relationships between key EU Member States in the EU engineering industries. From total EU engineering value added used in final production outside the EU, the main target countries are the USA (17% of EU engineering industries' value-added exports), China (15%), Russia (6%), Switzerland and South Korea (4% each). Further notable target countries for European exports include Brazil, Canada, Japan, Norway and Turkey (3% each).

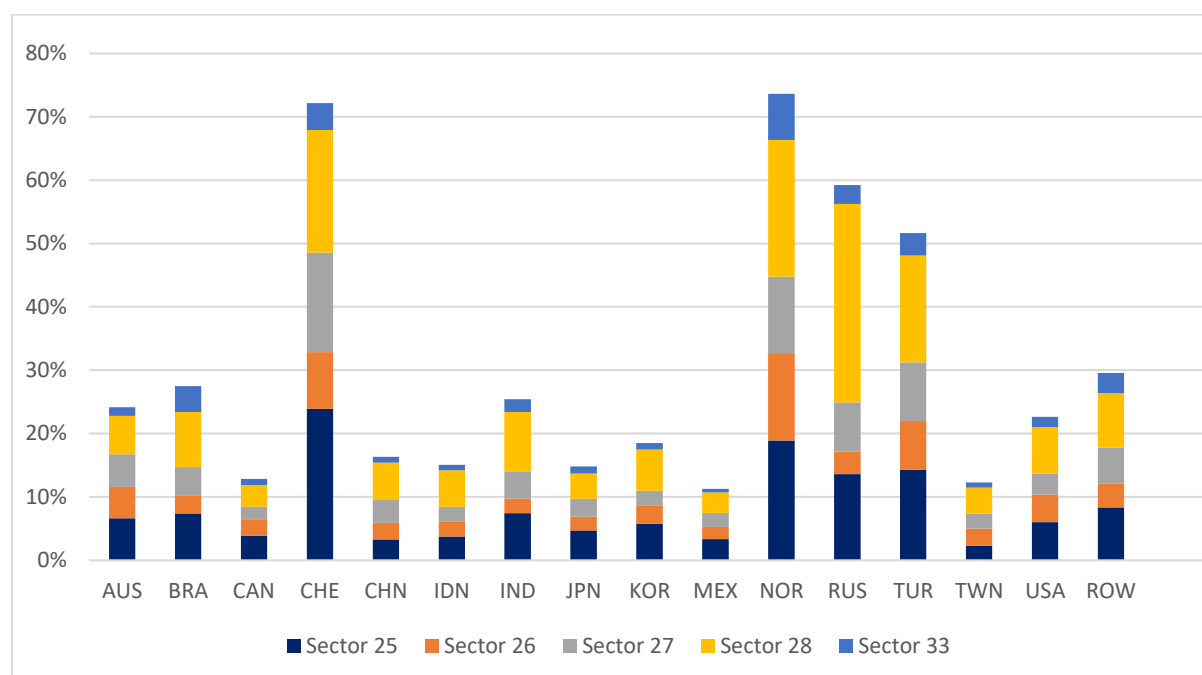
For the extra-EU target countries, the EU engineering value added exports contribute to more than 70% of all imported engineering value added in Norway and Switzerland, especially in the manufacture of fabricated metal products, but also in the manufacture of machinery and equipment. The EU engineering value added also contributes to a considerable extent to engineering value added imports in Russia (especially machinery and equipment) and Turkey (machinery and equipment, metal products).

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<sup>26</sup> The latest available data point refers to the year 2014 (Status: August 2020). The WIOD is an outcome of an EU-financed project. The first version of the World Input-Output Database was constructed within the official WIOD Project, funded by the European Commission as part of the 7th Framework Programme, Theme 8: Socio-Economic Sciences and Humanities. This project ran from May 2009 and ended in April 2012. The database was officially launched on April 16, 2012 in Brussels.



**Figure 2-16: Share of EU engineering industries value added exports to the engineering value added imports of the target country/region, by sector**

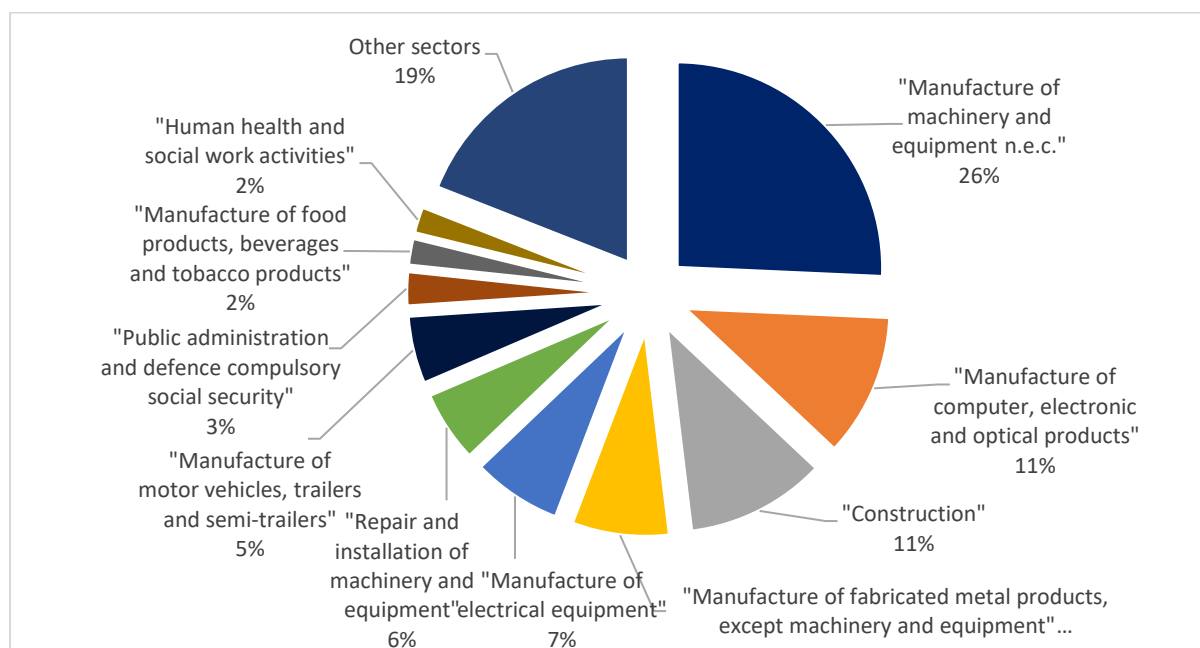


Sector 25: Fabricated metal products; Sector 26: Computer, electronic and optical products; Sector 27: Electrical equipment, Sector 28: Machinery and equipment, Sector 33: Repair and installation of machinery and equipment

Source: World Input-Output Database; most recent data from 2014, Status: August 2020

From the perspective of global final production, the EU value added exports are particularly used for the final production in machinery and equipment (26%), followed by manufacture of computer, electronic and optical products as well as construction (11% each). Nearly half of EU value added exports is used for final production in these sectors. Apart from other engineering subsectors (6-8%), 5% also go into the final production of motor vehicles etc.

**Figure 2-17: Share of EU engineering industries value added used in global final production, by sector**



Source: World Input-Output Database; most recent data from 2014, Status: August 2020

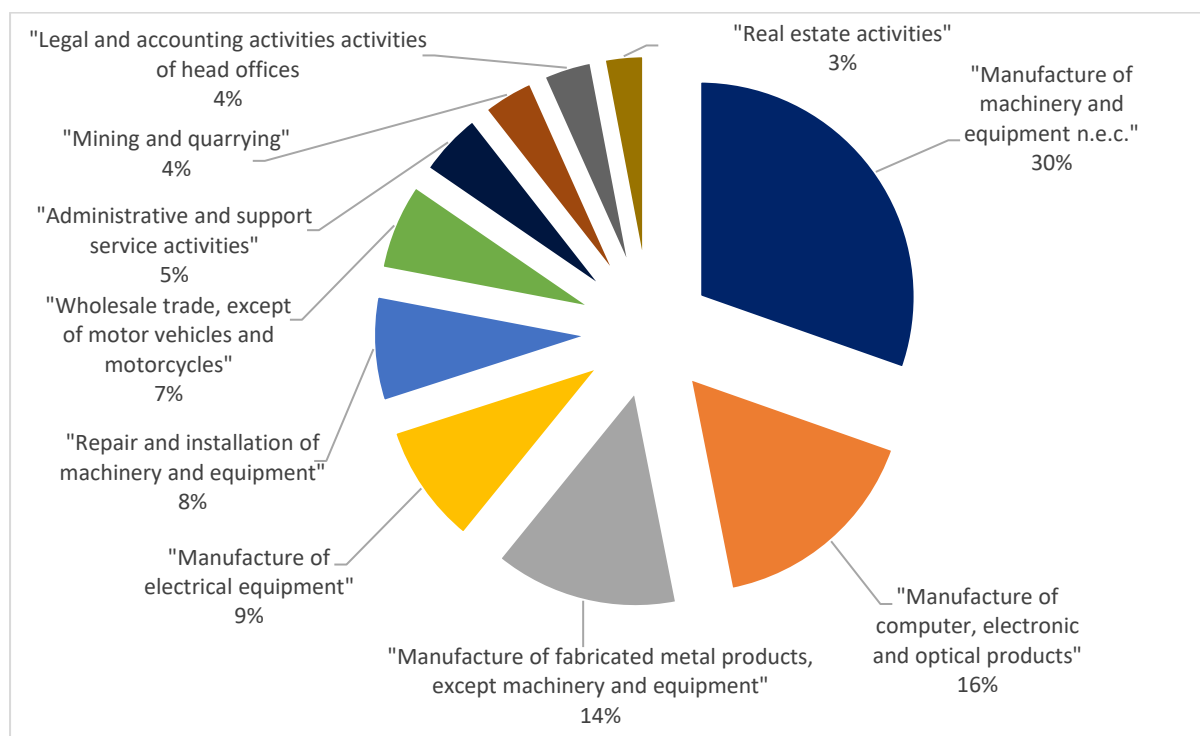
A drawback of the data provided in the World Input-Output Database however is that the most recent data dates only from 2014, as input-output data is not updated sufficiently frequently, due to the complex nature of the underlying national account data.

#### **2.2.2.2 Value added imports for the final production in the EU engineering industries**

80% of the value added used for final production in the EU engineering industries (EU-27 + UK) is from the EU itself, whereas 20% of value added is from outside the EU. Again, this demonstrates evidence of the strong linkages between EU countries in production processes. In terms of the market share for all value added imports to the EU coming from outside the EU, China ranks first with a 20% share, followed by the USA (16%), Russia (6%), Japan and Switzerland (5% each), as well as South Korea (4%). Further notable countries include Norway and Turkey (3% each).

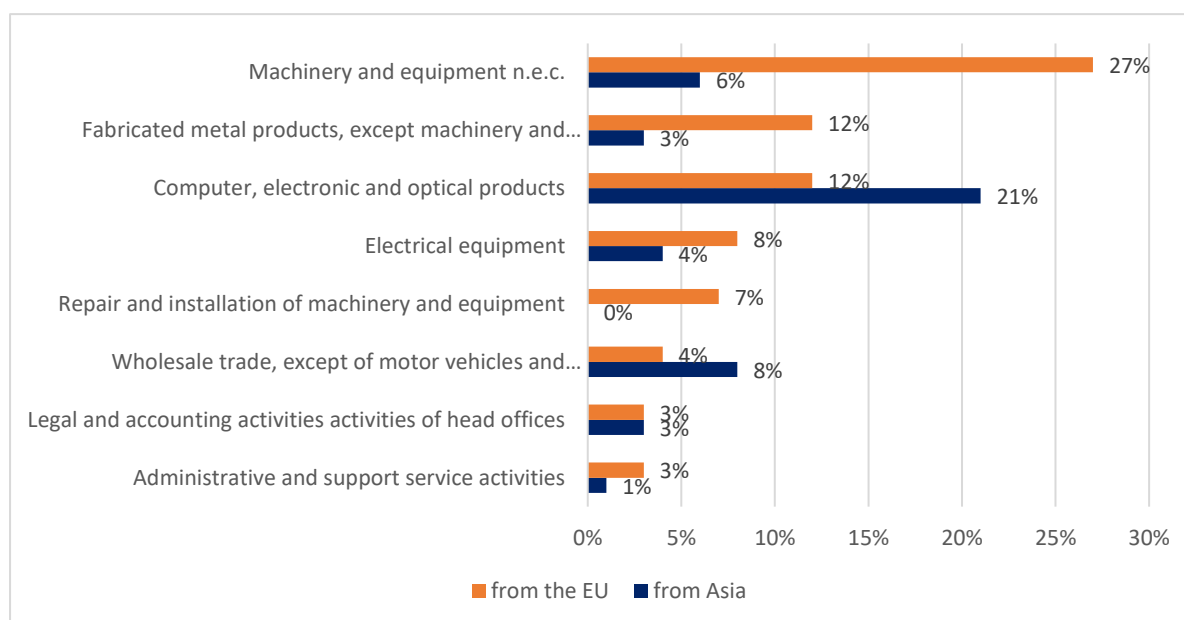
30% of the value added used in the EU engineering industries final production comes from the manufacturing of machinery and equipment sector, followed by the manufacture of computer, electronic and optical products (16%) and manufacture of fabricated metal products (14%).

**Figure 2-18: Source of value added used for the final production in the EU engineering industries, by sector**



Source: World Input-Output Database; most recent data from 2014, Status: August 2020

**Figure 2-19: Share of value added to EU engineering industries final production, from the EU and Asia**



Source: World Input-Output Database; most recent data from 2014, Status: August 2020

When distinguishing the value added used in the EU engineering industries final production (EU-27 + UK) by regions of origin, the following differences can be observed: 27% of the EU value added used in final production in engineering comes from the manufacture of machinery and equipment, followed by the manufacture of fabricated metal products and

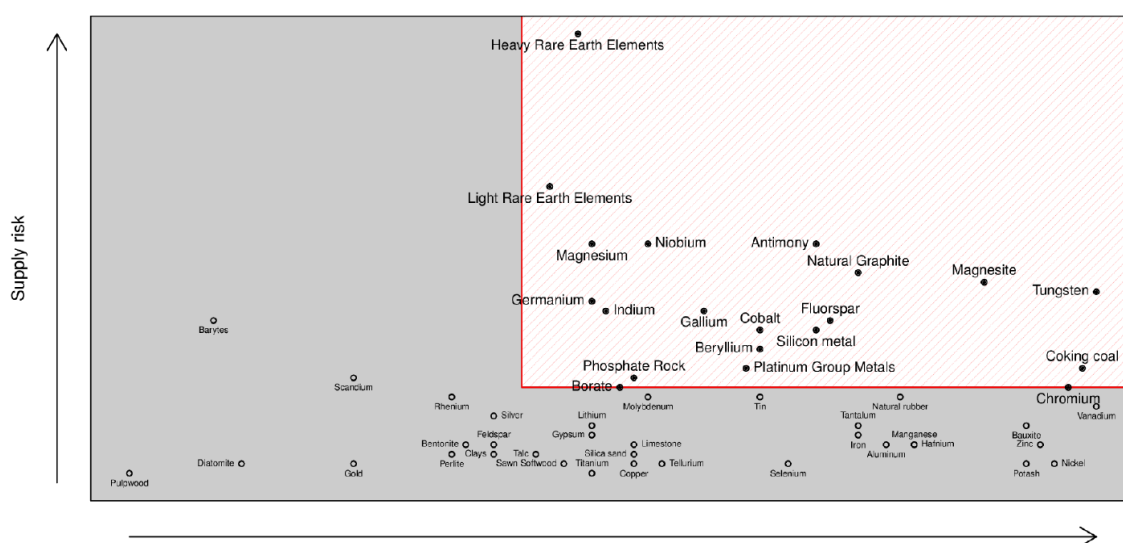
computer, electronic and optical products (12% each). However, 21% from the value-added originating from Asia and used in the final production in engineering, is from the manufacture of computer, electronic and optical products, followed by wholesale trade (8%) and the manufacture of machinery and equipment (6%).

### 2.2.3 Access to raw materials

Ensuring access to raw materials (including rare earths), i.e. securing reliable, sustainable and undistorted access to crucial non-energy raw materials, has been of growing concern in economies such as those of the EU, US and Japan. The European Commission's "Raw Materials Initiative: meeting our critical needs for growth and jobs in Europe" from 2008 called for a coherent EU policy response.<sup>27</sup>

In 2014, in its "Report on critical raw materials for the EU", the European Commission emphasised the importance of non-energy raw materials as being intrinsically linked to all industries across all supply chain stages. Sectors rely on these materials as direct inputs, for instance, metals refining relies on metallic ores as well as on industrial minerals. This primary industry underpins downstream sectors, which utilise processed materials in their products and services. Europe is especially dependent on non-energy raw materials to sustain businesses and the economy. In the 2008 Communication on the raw materials initiative, the Commission estimated that 30 million jobs in the EU are directly reliant on access to raw materials. However, very little primary production occurs within the Member States themselves, with the majority being produced and supplied from third countries. An exception is that France, Germany and Italy are ranked the highest, due to industrial mineral production.

**Figure 2-20 – Raw materials – criticality assessments for the EU for 2013**



Source: European Commission (2014), Report on critical raw materials for the EU. Report of the Ad hoc Working Group on defining critical raw materials

According to the same report, only approximately 9% of raw material supply is indigenous to the EU, with the remainder of the EU's supply of raw materials being dependent on third countries. Indigenous supply of industrial minerals includes large supplies of hafnium (47%, linked to refining), clays (37%), perlite (37%), silica sand (35%), feldspar (35%), diatomite (28%) and sawn softwood (26%). For critical raw materials, however, the supply situation is more limited. Total supply across all twenty critical raw materials has been

<sup>27</sup> The raw materials initiative — meeting our critical needs for growth and jobs in Europe, Brussels, 4.11.2008 COM(2008) 699 final, {SEC(2008) 2741} <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52008DC0699&from=EN>

estimated at under 3%, with over half having either no, or very limited production within the EU. The critical raw materials with the highest production in the EU are gallium (12%), magnesite (12%), silicon metal (8%) and germanium (6%). The result of a supply-demand forecast is that certain critical raw materials have been identified as having a risk of market deficit.

These include antimony, coking coal, gallium, indium, platinum group metals, heavy rare earths and silicon metal. However, care is required when interpreting these results, and readers are directed towards the material profiles for a more complete and specific understanding of the circumstances for each critical material.

**Figure 2-21: Forecast market balance for critical raw materials to 2020**

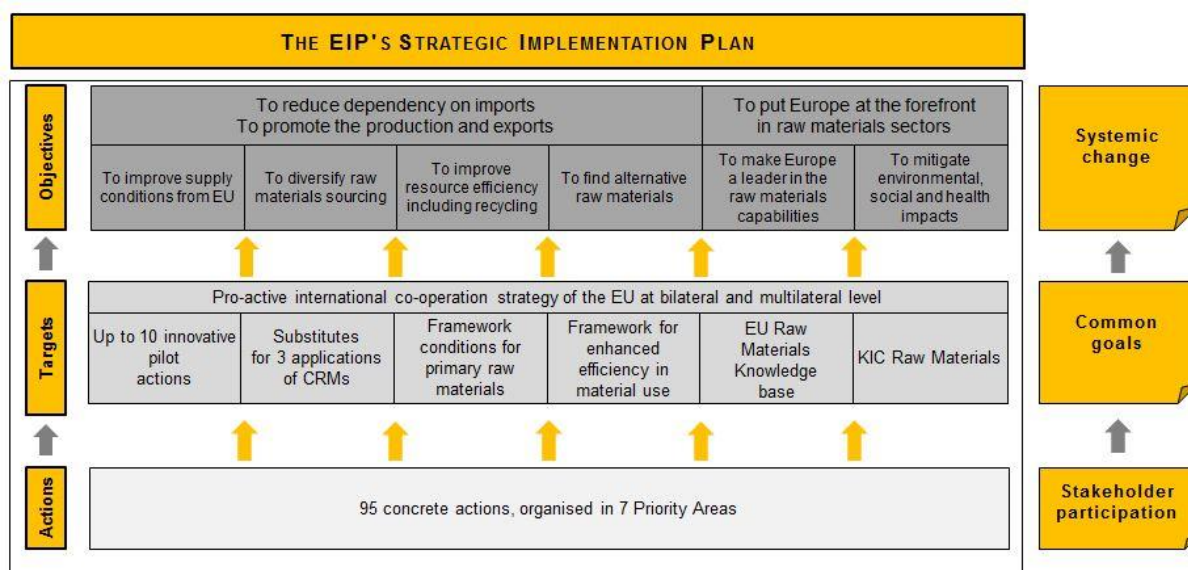
| Critical raw material       | 2012 | 2015 | 2020 |
|-----------------------------|------|------|------|
| Antimony                    |      |      |      |
| Borates                     |      |      |      |
| Chromium                    |      |      |      |
| Cobalt                      |      |      |      |
| Coking Coal                 |      |      |      |
| Fluorspar                   |      |      |      |
| Gallium                     |      |      |      |
| Germanium                   |      |      |      |
| Indium                      |      |      |      |
| Magnesite                   |      |      |      |
| Magnesium                   |      |      |      |
| Natural Graphite            |      |      |      |
| Niobium                     |      |      |      |
| Phosphates                  |      |      |      |
| Platinum Group Metals       |      |      |      |
| Rare Earth Elements – Light |      |      |      |
| Rare Earth Elements – Heavy |      |      |      |
| Silicon Metal               |      |      |      |
| Tungsten                    |      |      |      |

Colours indicate deficits (red), balance (yellow) and surplus (green)

Source: European Commission (2014), Report on critical raw materials for the EU. Report of the Ad hoc Working Group on defining critical raw materials

Following the establishment of the EU's **Raw Materials Initiative**, a number of activities have been launched. One of the main players in Europe is the **European Innovation Partnership (EIP) on raw materials**: a stakeholder platform launched in 2012 bringing together representatives from industry, public services, academia and NGOs with the mission to provide guidance to the European Commission, EU countries and private actors on innovative approaches to the challenges related to raw materials. The EIP follows a strategic implementation plan (SIP) detailing the objectives to be achieved by 2020:

**Figure 2-22: EIP's Strategic Implementation Plan**



Source: Strategic Implementation Plan (SIP), part of the EIP's action plan.<sup>28</sup>

As a contribution to the objectives of the EU's industrial policy, the EIP aims to achieve the following two main objectives:

- Reducing import dependency and promoting production and exports by improving supply conditions from the EU, diversifying raw materials sourcing, improving resource efficiency (including recycling) and finding alternative raw materials; and
- Putting Europe at the forefront in raw materials sectors and mitigating the related negative environmental, social and health impacts.

To this end, the SIP lists 95 concrete actions ranging from technology, such as the innovative extraction of raw materials or the substitution of certain raw materials to establishing Global Raw Materials Governance and fostering dialogue.

One of the initiatives set out in the EIP on raw material is **"The Raw Materials Scoreboard"**.<sup>29</sup> The Scoreboard presents monitoring information for governments, industry, and other stakeholders and is published every two years. The 2018 Scoreboard is the most recent and second edition of the series. As an overview of the current state of the global market of primary raw materials, the report states that whilst globally supply has increased rapidly, this increase was mainly driven by increased production of raw materials in Asia (especially in China) and, in the case of precious metals, a production increase in South America. In terms of global production, the EU's contribution is relatively small for most raw materials, except for industrial roundwood and industrial minerals.

The same report highlights the EU's relatively high dependency on the imports of raw materials, which is generally high for metals and natural rubber, but very low for several non-metallic minerals and industrial roundwood. The following table gives an overview of the EU's import reliance for selected raw materials.

<sup>28</sup> [https://ec.europa.eu/growth/sectors/raw-materials/eip/strategic-implementation-plan\\_en#documents](https://ec.europa.eu/growth/sectors/raw-materials/eip/strategic-implementation-plan_en#documents)

<sup>29</sup> <https://op.europa.eu/en/publication-detail/-/publication/117c8d9b-e3d3-11e8-b690-01aa75ed71a1>

**Table 2-17: EU's import reliance for selected raw materials**

| Raw material        | Import reliance | Critical raw material? |
|---------------------|-----------------|------------------------|
| Cobalt              | 32              | Y                      |
| Zinc                | 61              |                        |
| Iron ore            | 74              |                        |
| Chromium            | 75              |                        |
| Tin                 | 78              |                        |
| Copper              | 82              |                        |
| Vanadium            | 84              | Y                      |
| Bauxite             | 85              |                        |
| Manganese           | 89              |                        |
| Platinum            | 98              | Y                      |
| Titanium            | 100             |                        |
| Tantalum            | 100             | Y                      |
| Rare Earth Elements | 100             | Y                      |
| Niobium             | 100             | Y                      |
| Natural rubber      | 100             | Y                      |
| Molybdenum          | 100             |                        |
| Antimony            | 100             | Y                      |

Source: European Commission (2018a): Raw Materials Scoreboard 2018, Brussels.

Regarding rare earths, there is a particularly high dependency on supply from China, and if this supply were to be interrupted, it could have negative effects on the competitiveness of strategic industries of European importance mentioned in the EU's new industrial strategy. For instance, Europe is dependent on rare earths for the manufacturing of batteries for electric vehicles (EV), which in turn is crucial for the growth of the EV industry. The Raw Materials Scoreboard 2018 mentions (pg.3) that "Many new enabling technologies rely on materials that are predominantly produced outside of the European Union, such as cobalt for Lithium-Ion batteries powering low-emission mobility or rare-earth elements for energy-saving electronics".

The aforementioned Scoreboard also includes the topic of raw materials as part of a circular economy and suggests the reuse, remanufacturing, recycling as well as increasing material efficiency as a way to ensure a more secure and sustainable supply of raw materials in Europe. The circular use of raw materials in the EU economy is, however, relatively low (below 10%). The report expects that the supply of secondary raw materials will continue to increase (albeit at a gradual rate and from a relatively low base). Therefore, primary extraction will continue to be the main means of satisfying demand for raw materials. Recycling rates for certain materials are relatively high (e.g. for some widely used metals) but there are many factors limiting recycling's potential contribution to materials demand, such as: dissipative material losses, design of products that impede recycling and/or lack of suitable recycling infrastructure.

The management of waste from electrical and electronic equipment (WEEE) is potentially of special relevance to the engineering industries producing any type of electronic equipment. The Raw Materials Scoreboard mentions that around 3.5 million tonnes of WEEE containing valuable raw materials are collected yearly in the EU. However, a large amount of this waste is not properly collected and/or leaves Europe and does not contribute directly to the circularity of the European economy. Net exports of several waste



flows increased significantly in the last decade, with net exports in 2016 more than doubling compared to 2004. However, capturing the complexity of waste management requires looking at both volume and value of waste and scrap. China's recent ban on the import of waste and scraps provides an opportunity for Europe to ensure more circularity and keep the raw materials from these streams in the economy.

EU trade (of raw materials) is analysed using product group codes. It is possible that materials are part of product groups also containing other materials and/or being subject to re-export.

In 2018, Cobalt, which is crucial in the production of lithium batteries used in EV was mined in 18 countries, among which the largest producing country is the Democratic Republic of Congo. The trade code used for the import analysis is suboptimal, as it comprises 'cobalt mattes and other intermediate products of cobalt metallurgy' that contain only a minor fraction of cobalt, as well as 'unwrought cobalt and cobalt powders' that are supposed to be of pure cobalt. The originating countries for these EU-28 imports are mainly the United States, the Democratic Republic of Congo as well as Canada.

Global production of Vanadium amounted to around 84,000 t in 2018, those of Niobium 58,000 tonnes and Tantalum around 1,600 tonnes. In Eurostat's Comext database, tantalum ores and concentrates are reported in a single category along with niobium and vanadium, which make a separate examination of trade flows for those raw materials difficult.

Platinum is one of the six chemical elements referred to as the platinum-group metal (PGM), which are six rare metals that occur together naturally and are generally co-products from the same deposits. Global supply is dominated by South Africa, which is also the main source of EU27 imports.

The world mine production of antimony was about 156,000 tonnes in 2018. Antimony is traded in a number of forms (e.g. ores and concentrates, antimony trioxide and unwrought antimony metal and powders). The trade of unwrought antimony and antimony powders metal is dominated by China, which accounts for almost 45 % of EU-27 plus UK imports, followed by Vietnam and Tajikistan.

Overall, there is an ongoing over-dependency on third countries for the supply of raw materials generally and of rare earths in particular. This remains a challenge and a potential threat to the future competitiveness of the EU engineering industries, and for the manufacturing sector as a whole. The most recent **Communication on Critical Raw Materials Resilience**<sup>30</sup> sums up the current challenges:

- Access to resources is a strategic security question for Europe's ambition to deliver the Green Deal;
- Europe's transition to climate neutrality could replace today's reliance on fossil fuels with one on raw materials;
- There is a need of diversified and undistorted access to global markets for raw materials;
- In order to decrease external dependencies and environmental pressures, there is a need to reduce and reuse materials before recycling them.
- The COVID-19 crisis has revealed just how fast and how deeply global supply chains can be disrupted.

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<sup>30</sup> Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability COM/2020/474 final, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0474>



The secure and sustainable supply of critical raw materials requires knowledge on the demand and availability of critical raw materials. It is crucial to develop resilient value chains for EU industrial ecosystems, to further develop the circular use of resources, sustainable products and innovation, to strengthen the sustainable domestic sourcing and processing of raw materials from the European Union and to intensify diversified sourcing from third countries.

#### **2.2.4 Technological competition (technologies, R&D, patents)**

##### **2.2.4.1 Technological competition – overview of state of play and Industry 4.0 readiness**

The 2017 Communication of the European Commission highlights the importance of “Investing in a smart, innovative and sustainable Industry. A renewed EU Industrial Policy Strategy” states that the future of industry lies in its digital transformation, which is at the core of the ongoing 4<sup>th</sup> industrial revolution (commonly referred to as Industry 4.0).<sup>31</sup> Progress made through advancements in technologies such as big data, artificial intelligence and robotics, the Internet of Things and high-performance computing is impacting the very nature of work and society as a whole. The combined economic impact of the automation of knowledge, work, robots and autonomous vehicles is estimated to reach up to € 12 trillion annually by 2025, including gains in productivity. The digital transformation highlights the service component of industries.

Europe is a global leader in many manufacturing industries and its companies are often at the forefront of digitalisation and automation in key industry sectors. However, Europe’s role in the data and platform economy is limited and the uptake of digital technology by SMEs is low. Only a fifth of companies in the EU are highly-digitised. Companies in turn must do their part by shouldering the initial investment in digital technologies and then seize the productivity gains and innovation advantages they offer. Business models and processes may change; managers and staff may have to gain new skills; and the transformative pace may pick up, but forgoing digitalisation will also bring change with the likely loss of competitiveness, market share and ultimately jobs, in the worst case threatening the existence of the firm itself.

Technologically driven transformations are usually linked to a number of ICT-heavy innovations and digital technologies. IT systems are already at the heart of production system, a trend likely to continue and accelerate in future. In Industry 4.0, those systems will be far more connected to all sub-systems, processes, internal and external objects, the supplier and customer networks. Complexity will be much higher and will require sophisticated marketplace offerings. IT systems will be built around machines, storage systems and supplies that adhere to a defined standard and are linked up as cyber-physical systems (CPS). These can be controlled in real time. As industrial plants are already producing increasingly large amounts of data, these need to be saved, processed and analysed. Innovative methods to handle big data and to tap the potential of cloud computing will create new ways to leverage information. In general, digital technologies are dominated by non-European players (e.g. the three largest providers of commercial cloud solutions are Amazon, Google and IBM).

Off-the-shelf solutions enabling companies to handle big data in meaningful way are available primarily as proprietary Software as a Service (SAAS) solutions from large software companies such as SAP (their current enterprise resource planning software S4/HANA has been available since 2015), Oracle or Microsoft. While large companies have already switched or are in the midst of switching to software systems able to deal with big data, the necessary digital competencies and capacities are much harder to obtain for SMEs. However, there is wide variety of ready-to-use solutions that are cloud-based

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<sup>31</sup> Investing in a smart, innovative and sustainable Industry A renewed EU Industrial Policy Strategy COM/2017/0479 final, <https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:52017DC0479>

and/or open source eliminating some of the barriers for SMEs. The increasing variety of such solutions naturally increases the cost of identifying the right tools. Moreover, the issue of compatibility and processability has to be observed and creates additional demand for skilled labour and resources.

A study by Roland Berger Strategy Consultants (2014) shows that robots are already replacing human workers. The number of multipurpose industrial robots developed by players in the Industry 4.0 supplier segment and used in European manufacturing has almost doubled since 2004. In countries such as Czech Republic or Hungary, the increase is even higher. Industrial robots will become intelligent, i.e. able to adapt, communicate and interact. Thus, they will enable further productivity leaps for companies, having a profound change on cost structures, skills landscape and production sites. Smart robots will not only replace humans in simply structured workflows within closed areas. In Industry 4.0, smart robots and humans will work together on tasks and using smart sensors in human-machine interfaces. The use of robots is widening to include various functions: production, logistics, office management (to distribute documents).

The advancement of (digital) technologies results in a number of challenges inherent in the technologies themselves and the processes these technologies are being integrated into. The Industry 2030 high-level industrial roundtable in its report "A vision for the European industry until 2030" lists a number of challenges linked to scientific and technological developments:<sup>32</sup>

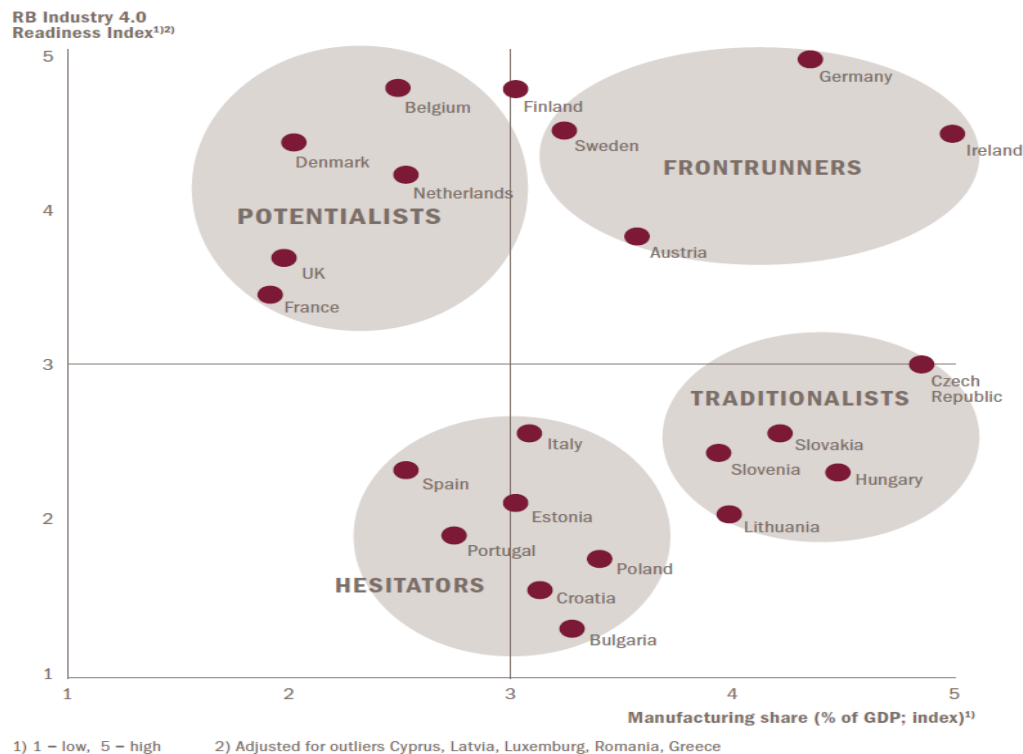
- Slow rollout of new technologies to the large majority of SMEs and other companies and insufficient translation of European R&D and knowledge base into marketable goods and services
- Risk of innovation gap in Europe, leaving some territories and communities behind
- Carbon footprint from digitisation
- General security awareness, education, and understanding of the related vulnerabilities for industry and for the society (ethical, legal liability and data-ownership issues raised by new technologies)

The Roland Berger study (2014) also shows that Europe's nation states are not equally prepared for the digital transformation of their manufacturing/engineering industries. The following figure summarises these assessments by classifying countries into frontrunners, countries with potential "potentialists", "traditionalists" and "hesitators". Therein, it becomes evident that Europe's digital transformation is likely to face difficulties in some areas, among which there are a number with a comparably strong overall importance of (engineering) industries especially in Eastern and Southern Europe.

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<sup>32</sup> These findings were also confirmed in the interviews conducted in the context of the study.

**Figure 2-23: Industry 4.0 readiness by country**



The underlying RB (Roland Berger) Industry 4.0 readiness indicator is calculated as follows: production process sophistication, degree of automation, workforce readiness and innovation intensity are bundled together in a category called "industrial excellence". A second category labelled "value network" combines data on high value added, industry openness, innovation network and Internet sophistication. Each category was measured using a 5-point scale, with "5" indicating that a country is excellently prepared for the Industry 4.0 landscape. The combination of these two categories determines a country's position in the RB 4.0 Readiness Index.

Source: Roland Berger (2014), *Industry 4.0. The new industrial revolution. How Europe will succeed*

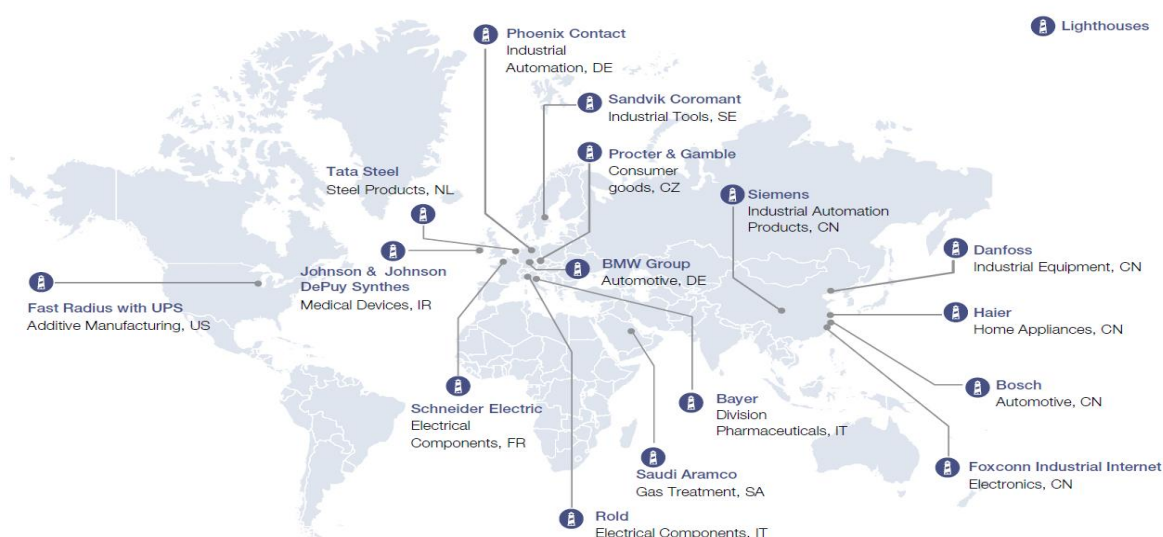
At the centre of Industry 4.0 – or more precisely, one of the main technologies – is Artificial Intelligence. However, according to the European Commission's Communication on Artificial Intelligence for Europe (COM(2018) 237), Europe is lagging behind in respect of private investments in AI which totalled around € 2.4 to 3.2 billion in 2016, compared with € 6.5 to 9.7 billion in Asia and € 12.1 to 18.6 billion in North America. Another main challenge for the EU to be competitive is to ensure the take-up of AI technology across its economy. Presently, only a fraction of European companies has already adopted digital or new technologies. This trend is particularly acute in small and medium-sized businesses. In 2017, 25% of EU large enterprises and 10% of small and medium-sized enterprises used big data analytics. Only one in five small and medium-sized enterprises was highly digitised, while one third of the workforce still does not possess basic digital skills. At the same time, the benefits of adopting AI are widely recognised. In 2016 however, the McKinsey Global Institute reported that Europe's international competitors are investing 3 to 7 times more than Europe in AI. Unless this trend is being reversed or otherwise mitigated through increased public and private investments, the potential positive impact of developing and applying AI will be much smaller for Europe compared to the US and China.

In 2019, the World Economic Forum (WEF) published a report on industry 4.0 "lighthouses". Those were defined as factories that have taken industry 4.0 technologies from pilot schemes to integration at scale, realizing significant financial and operational benefits. In order to be ranked among these "lighthouses" factories/production sites had to meet high standards in four categories: significant impact achieved; successful integration of several use-cases; a scalable technology platform; and strong performance

on critical enablers such as managing change, building capability and collaborating with a Fourth Industrial Revolution community. The following map shows the global distribution of 16 of these “lighthouses”, indicating a real European strength in this field:

- 9 out of 16 are located in Europe. From these, three belong to non-European companies, i.e. Procter & Gamble - USA, DePuy Synthes (part of Johnson & Johnson) - USA and Tata Steel - India.
- Three of the factories located outside Europe are European-owned, i.e. Siemens - Germany, Bosch - Germany and Danfoss - Denmark.
- In total, irrespective of the location, 9 out of 16 “lighthouses” are European-owned, i.e. Phoenix Contact - Germany, Sandvik Coromant - Sweden, BMW Group - Germany, Siemens - Germany, Danfoss - Denmark, Bosch - Germany, Bayer Division Pharmaceuticals - Germany, Rold - Italy and Schneider Electric - France.

**Figure 2-24: Lighthouse factories**



Source: World Economic Forum (2019), *Fourth Industrial Revolution. Beacons of Technology and Innovation in Manufacturing*

Following the 2019 report “Towards better monitoring of innovation strengths, regional specialisation and industrial modernisation in the EU”<sup>33</sup> the main factors affecting the ability for industrial modernisation include:

- Innovation capacity to develop new and improve existing products (goods and services) and processes, including the generation of new knowledge (e.g. R&D), the adoption and usage of advanced technologies, in particular digital and key enabling technologies, and investment in new equipment, infrastructures and intangible assets;
- Managerial and organisational capabilities to master new challenges, including the disruptive transformation of industries (e.g. through the emergence of digital-based platforms), servitisation, changes in markets and customer demands, such capabilities include reactivity and anticipation, flexibility, and fast decision-making;
- Skills development in order to prepare the workforce for new requirements and new models of production and collaboration, ranging from education to vocational training and on-the-job learning and including human resource management practices such as

<sup>33</sup> European Commission (2019c): Towards better monitoring of innovation strengths, regional specialisation and industrial modernisation in the EU, Brussels.

improving workplace environments;

- Openness and the capacity to cooperate, build and develop clusters and networks along value chains, and to engage in joint activities with academia and the wider research and innovation community both on a regional and global scale;
- Industrial sustainability, including energy saving, resource-efficient, environmentally-friendly production processes and eco-innovative solutions.

Technological change is additionally highlighting the international dimension of technology-driven competition. According to the 2016 report<sup>34</sup> of the German Bertelsmann Foundation, more than 50% of managers interviewed stated that their Asian competitors improved their innovation capacities. Next to China, the main competitors with the highest innovation-based performance are India and Malaysia. Apart from the ICT sector, the competition increased especially in the manufacturing of electronic equipment, medical devices, mechanical engineering and automotive.

#### **2.2.4.2 R&D expenditures**

When considering innovative activities to develop new or improve existing products or services, both an input and output view are necessary. According to the Frascati Manual (OECD, 2015), **research and development (R&D)** is increasingly viewed as an input to innovation in the context of the overall efforts made in a knowledge-based global economy, but continues to play a crucial part and be a major focus of government policies because of their unique features. Moreover, innovative activities can also be measured by the outputs of R&D processes, e.g. the number of patent applications or publications.

It is widely acknowledged that R&D is a key factor in technological progress and thus the engine of economic growth (European Commission, 2019a). The main aggregate statistic used to describe a country's R&D activities is **gross domestic expenditure on R&D (GERD)**, which covers all expenditure for R&D performed at national level, during a specific reference period. GERD or the GERD/GDP ratio is the principal R&D indicator at country level and used for international comparisons<sup>35</sup>.

In total<sup>36</sup>, intramural R&D expenditure (GERD) in the EU-27 + UK in 2018 was at € 336 billion<sup>37</sup>. The majority, i.e. 67% or € 225 billion, can be assigned to the business sector and 22% or € 73 billion to the higher education sector. The private non-profit sector accounts for € 2.6 billion or less than 1% of the total GERD.

When comparing the European Union and the UK with major competitors in terms of **R&D intensity (R&D expenditure as % of the GDP)**, the shares of South Korea, Japan and the US remain considerably higher than the EU average: In 2017, Europe lagged slightly behind China (EU-27 + UK: 2.08%, China: 2.15%) and only ranked 5<sup>th</sup>. Since 2008, South Korea has outperformed Japan and ranked 1<sup>st</sup> in 2017 with an R&D intensity of 4.29% (Japan: 3.20%). Throughout the period of 2008 to 2017, the R&D intensity of the US has remained stable at approx. 2.75% (2017: 2.78%). China has caught up from an R&D intensity of 1.44% in 2008 to 2.15% in 2017. The data show very clearly that the R&D intensity in the EU has been growing too slowly over the years to meet the Europe 2020 target of 3%.

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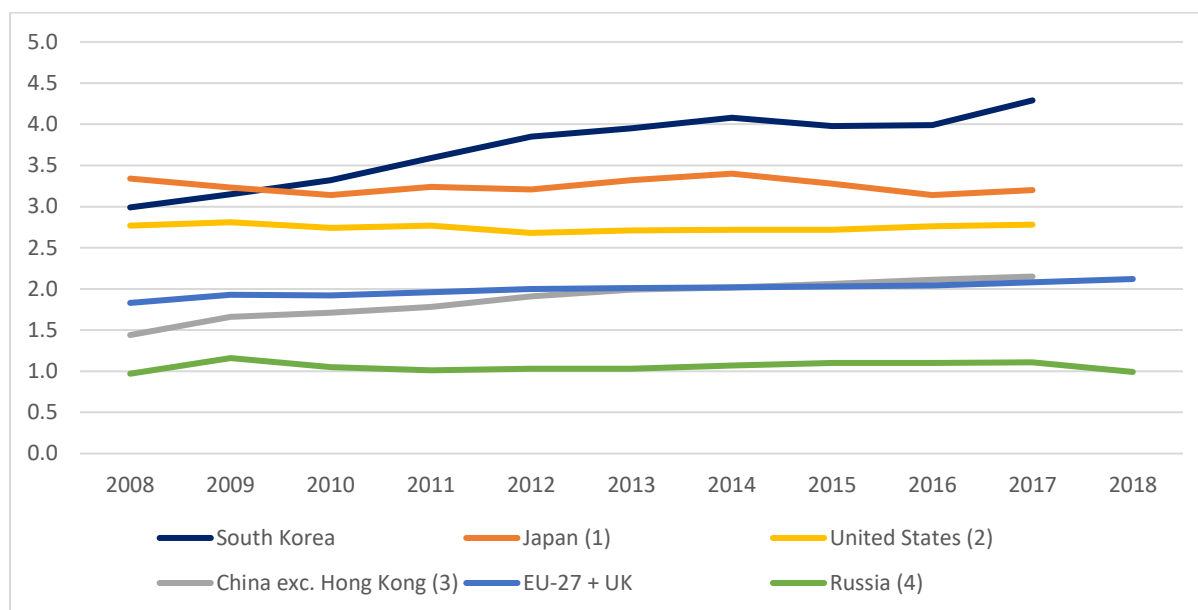
<sup>34</sup> Bertelsmann Stiftung (2016), Innovationsfaktor Asien. Wie Europas Unternehmen auf den Innovationsdruck der neuen asiatischen Wirtschaftsmächte reagieren, Gütersloh.

<sup>35</sup> However, at Eurostat and OECD, data on GERD by relevant science fields in engineering and technology or by socio-economic objective are only scarcely available by country (e.g. no data at all for bigger countries like Germany, France and UK); also, the data have not been updated since 2014/15.

<sup>36</sup> Covering all fields of sciences and all socio-economic objectives

<sup>37</sup> Eurostat, Intramural R&D expenditure (GERD) by sectors of performance [rd\_e\_gerdtot]

**Figure 2-25: Gross domestic expenditure on R&D (GERD) as % of the GDP, 2008-2018**



<sup>1</sup> 2008 and 2010: break in series

<sup>2</sup> Excludes most or all capital expenditure, definition differs; 2016: provisional

<sup>3</sup> 2009: break in series

<sup>4</sup> No data available for 2016 (interpolated)

Source: Eurostat, Statistics on research and development, [rd\_e\_gerdtot], Status: August 2020

R&D intensity differs across the EU: EU Member States with an R&D intensity above the European average in 2018<sup>38</sup> include Sweden (3.32%), Austria (3.17%), Germany (3.13%), Denmark (3.03%), Belgium (2.76%), Finland (2.76%), France (2.19%) and the Netherlands (2.16%). All other Member States have an R&D intensity below the EU-28 average.

From the € 225 billion GERD invested in the business sector by the EU in 2018, approximately 22% can be specifically assigned to the engineering industries<sup>39</sup>. According to the SME Performance Review (European Commission, 2019a), the sectors comprising the engineering industries are also amongst those with the highest R&D intensity scores in the EU. On a scale between (1) – very low and (5) – very high R&D intensity, the sectors manufacture of computer, electronic and optical products, manufacture of electrical equipment, manufacture of machinery and equipment as well as other manufacturing (including medical and dental instruments) score very high (5). The remaining sectors manufacture of fabricated metal products as well as repair and installation of machinery and equipment score average (3) in R&D intensity.

In 2017<sup>40</sup>, the **business expenditure on R&D (BERD) in the engineering industries in the EU-27 + UK** was approximately € 49 billion, which is 37% of all business expenditure on R&D in the manufacturing sector (NACE C) and 23% of business expenditure on R&D in all economic sectors.

According to Eurostat, businesses in the US and China invest more in R&D than the EU-27 + UK: The US businesses invested € 98 billion in R&D in 2017, while China invested € 67

<sup>38</sup> Provisional data for Belgium, Denmark, Germany, Netherlands, Austria; estimated data for France (May 2020)

<sup>39</sup> By NACE Rev. 2 activity, i.e. C25, C26, C27, C28, C32.5 and C33

<sup>40</sup> 2018 data are not available yet for all Member States (Status: August 2020)

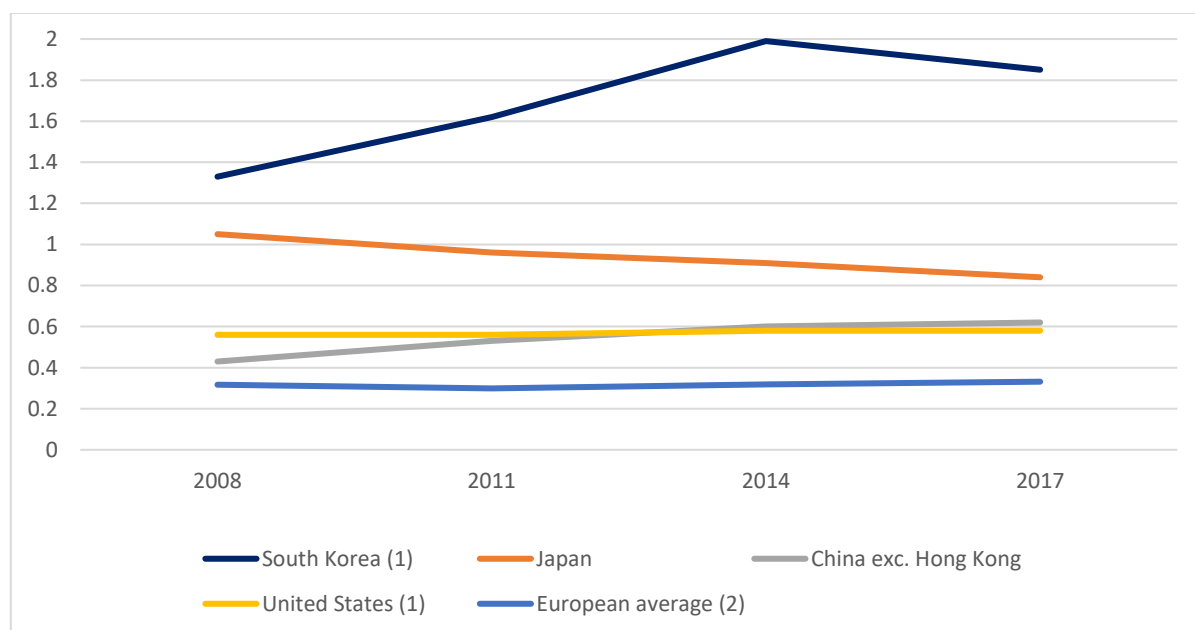


billion. The EU follows with € 49 billion in total, thereby investing more in absolute numbers than Japan (€ 36 billion) and South Korea (€ 24 billion).

The following Figure shows the evolution in business expenditure on R&D (BERD) in the EU engineering industries as a % of GDP: Throughout the time period of the study scope (2008-2017), South Korea has had the highest level of investment in R&D as a share of GDP, with nearly 2 % for the engineering industries in 2014 (1.99%) and 1.85% in 2017. This means that 43% of South Korea's total R&D expenditure (GERD) goes into the BERD in engineering. Japan ranks second, however with a declining share from 1.05% (2008) to 0.84 % (2017). China is third ranked, having overtaken the US in 2013 and increasing to 0.62% in 2017. Both the US and European shares of engineering BERD in GDP remain relatively stable over time: the US share is around 0.56 %, whilst the European average is around 0.32 %.

This means that the R&D intensity of China and the US in the field of engineering in terms of BERD is approximately twice as high as the European average. South Korean businesses invest nearly six times more in R&D in engineering industries than the European average.

**Figure 2-26: Business expenditure on R&D (BERD) in engineering industries as % of GDP, 2008-2017**



Note: data are not available for all years; no data available for Russia

<sup>1</sup> latest available data for South Korea from 2015 and for US from 2016

<sup>2</sup> no data available for EU-27 + UK; average (weighted by the countries' GDP) calculated from the top 9 performing EU Member states in engineering industries in terms of value added and persons employed (i.e. over 80% of the EU-28 engineering industries)

Source: Eurostat, Statistics on research and development, [rd\_e\_berdindr2], Status: August 2020

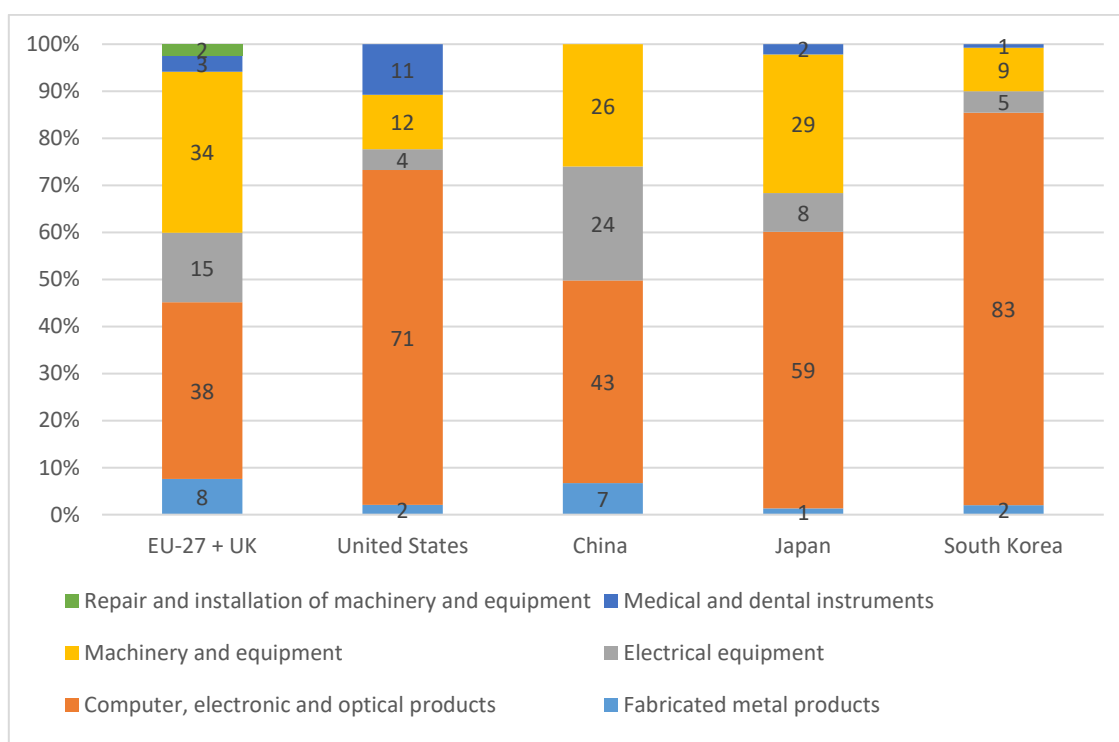
When breaking down BERD by NACE activity within the engineering industries, differences in the focus of R&D investments can be observed: in South Korea (83%), the US (71%) and Japan (59%), the majority of expenditures goes into manufacture of computer, electronic and optical products. In addition, China (43%) and the EU-27 + UK (38%) invest to a considerable extent in this sector. Despite the fact that manufacture of computer, electronic and optical products is one of the smaller sectors within engineering industries in the EU (see chapter 2.1.1), there is a high percentage of the EU BERD in this sector. A reason for this might be that – particularly in this sector – R&D takes place in Europe whereas a significant proportion of production takes place in other countries. Most business

R&D in the manufacturing of computer, electronic and optical products takes place in Germany, followed by France, Sweden and UK.

R&D expenditure in the manufacture of machinery and equipment is particularly relevant in the EU (34%) and Japan (29%) as well as in China (26%), as compared to the US (12%) and South Korea (9%). China invests to a much higher extent in manufacture of electrical equipment (24%) than the EU (15%) or the other main competitors Japan (8%), South Korea (5%) and the US (4%).

In comparison, the US invests much more in the manufacture of medical and dental instruments (11%) than its major competitors. In turn, the share of BERD going into the manufacture of fabricated metal products is highest in the EU (8%) and China (7%).

**Figure 2-27: Distribution of business expenditure on R&D (BERD) within engineering industries by NACE Rev. 2 activity, 2017**



Note: latest data available from 2017; data for US from 2016 and for South Korea from 2015; no data available for Russia

Source: Eurostat, Statistics on research and development, [rd\_e\_berdindr2], Status: August 2020

In order to illustrate the **R&D activities in the business sector at firm level** directly, the **EU Industrial R&D Investment Scoreboard**<sup>41</sup> - comprised of the 2,500 companies investing the largest sums in R&D in the world - provides some interesting insights as regards R&D expenditure, sales, R&D intensity<sup>42</sup>, employees and profitability<sup>43</sup>. The Scoreboard also provides an analysis by sectors of activity<sup>44</sup>.

<sup>41</sup> <https://iri.jrc.ec.europa.eu/data>, queried October 2019

<sup>42</sup> R&D intensity: R&D as percentage of sales

<sup>43</sup> Profitability: Profit as percentage of sales

<sup>44</sup> The Scoreboard uses the ICB (Industry Classification Benchmark) classification, a tool basically designed by FTSE-Russell for the financial analysis of the stock market, and incompatible with the NACE classification used in this study. In particular the NACE sectors covered by this study (25, 26, 27, 28, and 32.5) are split up between "technology hardware and equipment" and "electronic and electrical equipment", which include some of the activities covered under NACE 26, 27 and 28 and no other activities, as well as into other ICB sectors



Although Robert Bosch is basically an automotive supplier and manufacturer, it has been included in the analysis because Bosch is one of the few European companies to have a significant activity in semiconductors, and is – in 2020 – investing one billion euros in a very big 300 mm wafer fab in Dresden due to go on stream in 2021. The company also ranks first for R&D expenditure among the European companies concerned by the EEMEI sectors. Furthermore, Medtronic and Seagate have been considered as American companies, although they have transferred their fiscal headquarters to Ireland, retaining their operational headquarters in the US.

The following table ranks the top 60 EEMEI (Electronic Electrical Mechanical Engineering Industries) companies in the world according to their R&D expenditure in 2018. Europe ranks third among the top 60 EEMEI R&D investors, with 11 European EEMEI companies among the world top 60, behind the US with 24 companies and Japan with 14. The other leading R&D investing countries in EEMEI are China (5 companies), South Korea (3) and Taiwan (3).

Among the top 60, R&D intensity (R&D investment as a percentage of sales) varies between 1.7% and 24.5%, but fairly high, considering that the average for all the 2500 companies in the database is 4.5%. Only 14 of the top 60 EEMEI R&D investing companies fall below that average.

**Table 2-18: Top 60 worldwide R&D ranking of companies in EEMEI (Electronic, Electrical, Mechanical Engineering industries), 2018**

| Overall Rank | EEMEI Rank | EEMEI in Europe rank | Company           | Country   | R&D 2018 in € million | R&D intensity <sup>2</sup> (%) | Profitability <sup>3</sup> (%) |
|--------------|------------|----------------------|-------------------|-----------|-----------------------|--------------------------------|--------------------------------|
| 1            | 1          |                      | Samsung           | RK        | 13,437                | 7.2                            | 22.4                           |
| 5            | 2          |                      | Huawei            | CN        | 11,334                | 14.7                           | n/a                            |
| 6            | 3          |                      | Intel             | US        | 10,921                | 20.9                           | 27.8                           |
| 7            | 4          |                      | Apple             | US        | 9,656                 | 5.1                            | 26.8                           |
| <b>19</b>    | <b>5</b>   | <b>1</b>             | <b>R Bosch</b>    | <b>DE</b> | <b>5,939</b>          | <b>7.6</b>                     | <b>6.2</b>                     |
| <b>20</b>    | <b>6</b>   | <b>2</b>             | <b>Siemens</b>    | <b>DE</b> | <b>5,538</b>          | <b>6.7</b>                     | <b>9.1</b>                     |
| 25           | 7          |                      | Cisco Systems     | US        | 5,052                 | 12.6                           | 26.5                           |
| <b>27</b>    | <b>8</b>   | <b>3</b>             | <b>Nokia</b>      | <b>FI</b> | <b>4,916</b>          | <b>21.2</b>                    | <b>0.5</b>                     |
| 28           | 9          |                      | Qualcomm          | US        | 4,557                 | 24.5                           | 21.9                           |
| 34           | 10         |                      | General Electric  | US        | 4,005                 | 4.0                            | -2.8                           |
| 35           | 11         |                      | Dell Technologies | US        | 3,963                 | 6.0                            | -4.1                           |
| 36           | 12         |                      | Panasonic         | JP        | 3,706                 | 6.3                            | 5.0                            |
| 39           | 13         |                      | Sony              | JP        | 3,386                 | 5.4                            | 8.6                            |
| <b>43</b>    | <b>14</b>  | <b>4</b>             | <b>Ericsson</b>   | <b>SW</b> | <b>3,261</b>          | <b>15.9</b>                    | <b>-18.9</b>                   |
| 52           | 15         |                      | Broadcom          | US        | 2,745                 | 18.7                           | 15.2                           |
| 53           | 16         |                      | LG Electronics    | RK        | 2,637                 | 5.5                            | 4.0                            |
| 55           | 17         |                      | Hitachi           | JP        | 2,459                 | 3.6                            | 7.5                            |

such as “construction materials”, “defence”, “industrial engineering”, “automobiles and parts”, “household goods”, “leisure goods” and “personal goods”, where they are mixed with other products that do not concern the engineering industries as defined for this study. For the purpose of the study, the Scoreboard database on the 2500 top world companies for R&D investment has been revised, changing the sector allocation of the companies, reassigning a number of them to our NACE compatible EEMEI (Electronic Electrical Mechanical Engineering Industries) sector from other ICB sectors. Please see Annex 2 for a correspondence table between NACE and ICB for the fields concerning the present study.

# Study on the Competitiveness of the EU Engineering Industries and the Impact of Digitalisation

| Overall Rank | EEMEI Rank | EEMEI in Europe rank | Company                   | Country   | R&D 2018 in € million | R&D intensity <sup>2</sup> (%) | Profitability <sup>3</sup> (%) |
|--------------|------------|----------------------|---------------------------|-----------|-----------------------|--------------------------------|--------------------------------|
| 56           | 18         |                      | Canon                     | JP        | 2,438                 | 8.1                            | 8.1                            |
| 59           | 19         |                      | Hon Hai Precision         | TW        | 2,285                 | 1.7                            | 2.5                            |
| 60           | 20         |                      | Taiwan Semiconductor      | TW        | 2,255                 | 8.3                            | 39.6                           |
| 64           | 21         |                      | Western Digital           | US        | 2,035                 | 12.8                           | 11.4                           |
| 67           | 22         |                      | SK Hynix                  | RK        | 1,937                 | 8.3                            | 45.6                           |
| 70           | 23         |                      | Medtronic                 | US        | 1,879                 | 7.5                            | 23.2                           |
| 76           | 24         |                      | ZTE                       | CN        | 1,798                 | 12.9                           | 7.0                            |
| <b>79</b>    | <b>25</b>  | <b>5</b>             | <b>Philips</b>            | <b>NL</b> | <b>1,740</b>          | <b>7.0</b>                     | <b>10.3</b>                    |
| 83           | 26         |                      | Mediatek                  | TW        | 1,597                 | 24.0                           | 4.3                            |
| 85           | 27         |                      | Caterpillar               | US        | 1,588                 | 4.2                            | 13.1                           |
| 89           | 28         |                      | Mitsubishi Electric       | JP        | 1,553                 | 4.7                            | 7.2                            |
| 91           | 29         |                      | Honeywell                 | US        | 1,530                 | 4.5                            | 16.9                           |
| 92           | 30         |                      | Micron Technology         | US        | 1,521                 | 9.0                            | 29.0                           |
| 94           | 31         |                      | Nvidia                    | US        | 1,498                 | 18.5                           | 33.0                           |
| 95           | 32         |                      | Applied Materials         | US        | 1,478                 | 12.2                           | 26.9                           |
| 106          | 33         |                      | Toshiba                   | JP        | 1,319                 | 4.5                            | 1.6                            |
| <b>109</b>   | <b>34</b>  | <b>6</b>             | <b>NXP Semiconductors</b> | <b>NL</b> | <b>1,296</b>          | <b>16.8</b>                    | <b>26.4</b>                    |
| 111          | 35         |                      | Texas Instruments         | US        | 1,257                 | 10.1                           | 42.9                           |
| 114          | 36         |                      | Fujifilm                  | JP        | 1,228                 | 6.8                            | 5.4                            |
| <b>115</b>   | <b>37</b>  | <b>7</b>             | <b>ABB</b>                | <b>CH</b> | <b>1,197</b>          | <b>4.2</b>                     | <b>8.8</b>                     |
| <b>119</b>   | <b>38</b>  | <b>8</b>             | <b>ASML</b>               | <b>NL</b> | <b>1,156</b>          | <b>12.8</b>                    | <b>28.4</b>                    |
| 122          | 39         |                      | John Deere                | US        | 1,140                 | 4.6                            | 14.0                           |
| 128          | 40         |                      | Midea                     | CN        | 1,088                 | 3.8                            | 9.4                            |
| <b>129</b>   | <b>41</b>  | <b>9</b>             | <b>STMicroelectronics</b> | <b>NL</b> | <b>1,066</b>          | <b>15.4</b>                    | <b>12.3</b>                    |
| 134          | 42         |                      | Seagate                   | US        | 1,027                 | 11.4                           | 9.8                            |
| 140          | 43         |                      | HP                        | US        | 992                   | 2.3                            | 7.7                            |
| 141          | 44         |                      | LAM Research              | US        | 992                   | 10.7                           | 28.6                           |
| 143          | 45         |                      | Lenovo                    | CN        | 973                   | 2.9                            | 0.9                            |
| 146          | 46         |                      | AMD                       | US        | 967                   | 21.8                           | 2.7                            |
| 149          | 47         |                      | Danaher                   | US        | 941                   | 6.2                            | 17.4                           |
| 151          | 48         |                      | Renesas                   | JP        | 938                   | 16.3                           | 9.9                            |
| <b>154</b>   | <b>49</b>  | <b>10</b>            | <b>Schneider</b>          | <b>FR</b> | <b>904</b>            | <b>3.7</b>                     | <b>12.6</b>                    |
| 160          | 50         |                      | Sumitomo Electric         | JP        | 869                   | 3.8                            | 5.5                            |
| 164          | 51         |                      | Mitsubishi Heavy I        | JP        | 846                   | 2.8                            | 3.0                            |

| Overall Rank | EEMEI Rank | EEMEI in Europe rank | Company               | Country   | R&D 2018 in € million | R&D intensity <sup>2</sup> (%) | Profitability <sup>3</sup> (%) |
|--------------|------------|----------------------|-----------------------|-----------|-----------------------|--------------------------------|--------------------------------|
| 165          | 52         |                      | Boston Scientific     | US        | 831                   | 11.0                           | 18.3                           |
| <b>167</b>   | <b>53</b>  | <b>11</b>            | <b>CNH Industrial</b> | <b>NL</b> | <b>822</b>            | <b>2.9</b>                     | <b>4.8</b>                     |
| 169          | 54         |                      | Juniper Networks      | US        | 818                   | 19.5                           | 18.2                           |
| 170          | 55         |                      | Ricoh                 | JP        | 812                   | 5.3                            | -6.2                           |
| 171          | 56         |                      | Analog Devices        | US        | 808                   | 19.0                           | 21.5                           |
| 173          | 57         |                      | NEC                   | JP        | 799                   | 3.8                            | 2.4                            |
| 178          | 58         |                      | TDK                   | JP        | 764                   | 8.1                            | 6.4                            |
| 182          | 59         |                      | Byd                   | CN        | 760                   | 5.8                            | 6.9                            |
| 187          | 60         |                      | Sharp                 | JP        | 743                   | 4.1                            | 16.7                           |

Countries: CN=China, JP=Japan, RK=South Korea, TW=Taiwan, US=United States, European countries: CH=Switzerland, DE=Germany, FI=Finland, FR=France, NL=Netherlands, SW=Sweden

<sup>2</sup> R&D Intensity: R&D/sales ratio

<sup>3</sup> Profitability: Profit/sales ratio

Source: DECISION, and EU Industrial R&D Investment Scoreboard database, 2018

The overall average profitability for the 2,500 companies in the database is 9.5%. This is similar for the EEMEI top 60 R&D investors, as just 30 of them are above this average and 30 below. It should be noted however that nearly all (13 out of 16) the companies whose profitability is above 20% are companies supplying semiconductors or semiconductor production equipment.

**Table 2-19: Top R&D investing EEMEI companies with profitability exceeding 20% in 2018**

| Company                   | Country   | R&D 2018 in € million | R&D intensity (%) | Profitability (%) | Segment               |
|---------------------------|-----------|-----------------------|-------------------|-------------------|-----------------------|
| SK Hynix                  | RK        | 1,937                 | 8,3               | 45,6              | Semiconductors        |
| Texas Instruments         | US        | 1,257                 | 10,1              | 42,9              | Semiconductors        |
| Taiwan Semiconductor      | TW        | 2,255                 | 8,3               | 39,6              | Semiconductors        |
| Nvidia                    | US        | 1,498                 | 18,5              | 33,0              | Semiconductors        |
| Micron Technology         | US        | 1,521                 | 9,0               | 29,0              | Semiconductors        |
| LAM Research              | US        | 992                   | 10,7              | 28,6              | Semiconductors        |
| <b>ASML</b>               | <b>NL</b> | <b>1,156</b>          | <b>12,8</b>       | <b>28,4</b>       | <b>Semiconductors</b> |
| Intel                     | US        | 10,921                | 20,9              | 27,8              | Semiconductors        |
| Applied Materials         | US        | 1,478                 | 12,2              | 26,9              | Semiconductors        |
| Apple                     | US        | 9,656                 | 5,1               | 26,8              | Consumer              |
| Cisco Syst                | US        | 5,052                 | 12,6              | 26,5              | Communications        |
| <b>NXP Semiconductors</b> | <b>NL</b> | <b>1,296</b>          | <b>16,8</b>       | <b>26,4</b>       | <b>Semiconductors</b> |
| Medtronic                 | US        | 1,879                 | 7,5               | 23,2              | Health                |
| Samsung                   | RK        | 13,437                | 7,2               | 22,4              | Semiconductors        |

| Company    | Country | R&D 2018<br>in<br>€ million | R&D<br>intensity<br>(%) | Profitability<br>(%) | Segment        |
|------------|---------|-----------------------------|-------------------------|----------------------|----------------|
| Qualcomm   | US      | 4,557                       | 24,5                    | 21,9                 | Semiconductors |
| Analog Dev | US      | 808                         | 19,0                    | 21,5                 | Semiconductors |

Countries: CN=China, JP=Japan, RK=South Korea, TW=Taiwan, US=United States,  
European countries: CH=Switzerland, DE=Germany, FI=Finland, FR=France, NL=Netherlands, SW=Sweden

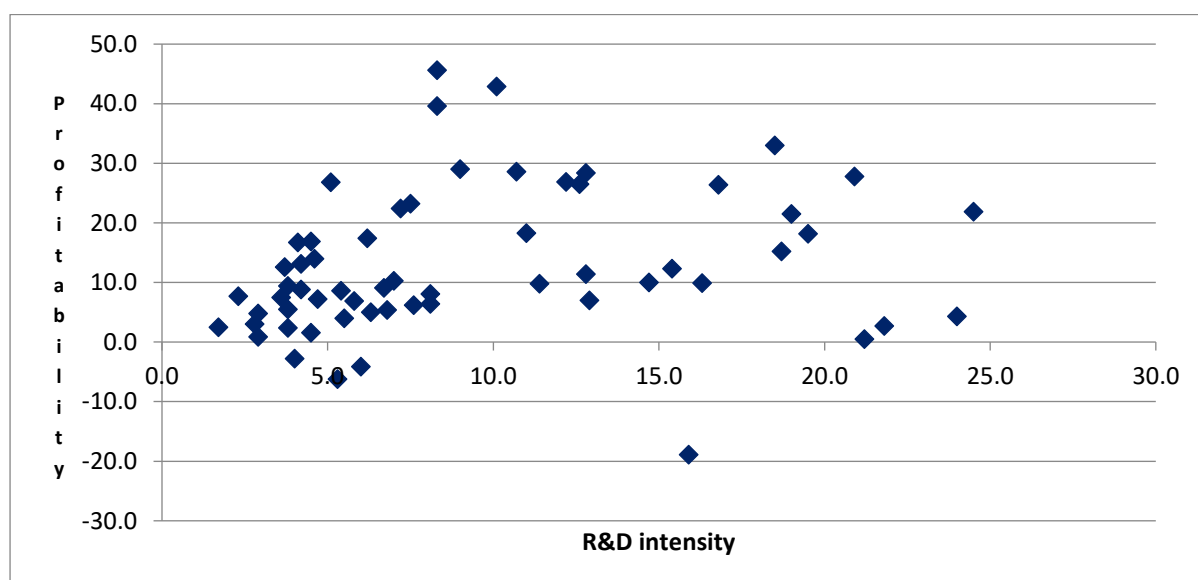
<sup>2</sup> R&D Intensity: R&D/sales ratio

<sup>3</sup> Profitability: Profit/sales ratio

Source: DECISION, and EU Industrial R&D Investment Scoreboard database, 2018

There seems to be no clear correlation between profitability and R&D intensity in the top 60 EEMEI R&D investors, although heavy R&D should, at least ultimately, enhance profitability and on the other hand investing heavily in R&D and in high-tech production facilities could initially impair profitability.

**Figure 2-28: R&D intensity against profitability, top 60 EEMEI R&D investors, 2018**



Source: DECISION and EU Industrial R&D Investment Scoreboard database, 2018

The R&D activities in the business sector at firm level described above mainly refer to large enterprises. However, also **SMEs** play an important role when it comes to **R&D activities**. According to the most recent EU SME Performance Review (European Commission, 2019a, 2019b) with a specific focus on innovation, SMEs play a critical role for technological change and in the innovation system because they represent a large share of economic activity in most economies. Smaller firms are said to have “behavioural advantages” in terms of rapid decision-making and flexibility. In contrast, the relative strengths of large businesses are predominantly material, as large firms have advantages linked to economies of scale and the availability of financial and technological resources (Vossen, 1998).

According to the SME Performance Review, SMEs in OECD economies are on average less innovative than large companies. However, at the same time, the contribution of SMEs to innovation has increased in recent decades thanks to changes in the way innovation takes place. They introduce advances in products, methods of production and management processes by making breakthrough innovation themselves or by adopting incremental innovations generated by large firms (OECD, 2010). Increasing niche market demand,

shorter product life cycles and changing technologies (Chesbrough, 2006; Spithoven et al., 2013) have enabled SMEs to strengthen their comparative advantages.

Some SMEs are among the most innovative firms, especially in science-driven sectors. They are often the source of radical innovations, thanks to their flexibility and to their ability of working outside of dominant knowledge paradigms (OECD, 2018). These firms exploit technological or commercial opportunities that have been neglected by larger firms (Talbot, 2018).

As compared to all other economic sectors, SMEs in the manufacturing sector – to which all engineering industries are counted – are most likely to conduct R&D “continuously”. Medium-sized SMEs are more likely to have permanent R&D staff in-house than Small SMEs. SMEs that are part of an enterprise group, or that have exported are more likely to conduct R&D on a consistent basis (European Commission, 2019b).

According to the SME Performance Review 2019, the innovation rate<sup>45</sup> among all SMEs in the manufacturing sector is 52%, compared with 82% among all large enterprises in this sector. In total, SMEs constitute 49% of all innovators within the manufacturing sector.

As acknowledged by the European 2020 strategy (European Commission, 2010), **Research and Development (R&D)** is a key driver for achieving the objectives of smart, sustainable and inclusive growth. In order to foster progress in the field of R&D and innovation, the Europe 2020 strategy in particular put forward the “Innovation Union” flagship initiative aiming at improving framework conditions and access to finance for research and innovation in order to ensure that innovative ideas, can be turned into products and services that create growth and jobs.

#### **2.2.4.3 Modernisation of state aid for R&D&I and the role of the IPCEIs**

Therefore, in 2014, State Aid for R&D and innovation (R&D&I)<sup>46</sup> was modernised. Since then, a number of IPCEIs, Joint Undertakings, as well as contractual Public Private Partnerships (cPPPs) (the latter under the European Research and Innovation Programme Horizon 2020) have been implemented. The following coordinated initiatives provide ongoing examples that are of high relevance to strengthening the competitiveness of the EU engineering industries and their value chains (see also European Commission, 2019f):

- **IPCEI on Microelectronics<sup>47</sup>:** Since the end of 2018, the IPCEI on Microelectronics has been in effect. The (then) four Member States France, Germany, Italy and UK jointly support research and innovation in transnational cooperation projects with major synergies in microelectronics. The project's overall objective is to enable research and develop innovative technologies and components (e.g. chips, integrated circuits, and sensors) that can be integrated in a large set of downstream applications, such as consumer and industrial devices, Internet of Things and connected or driverless cars. France, Germany, Italy and the United Kingdom are using state aid to promote the development of new microelectronic products across industry and national borders. The funding comes from the participating countries themselves, not the EU. With France providing up to €355 million, Germany up to €820 million, Italy up to €524 million and UK up to €48 million, in total €1.75 billion is available for this project that aims to unlock an additional €6 billion in private investment. The integrated research and innovation project involves 29 direct participants, headquartered both in and

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<sup>45</sup> Innovation rate: proportion of businesses that have innovated

<sup>46</sup> According to the Communication on “Framework for State aid for research and development and innovation” (2014/C 198/01), state aid for R&D&I is considered compatible with the internal market in order to promote the execution of an Important Project of Common European Interest (IPCEI) or to facilitate the development of certain economic activities within the Union, provided that such aid does not adversely affect trading conditions to an extent which goes contrary to the common interest.

<sup>47</sup> IPCEI on Microelectronics: <https://ipcei-me.eu/>, 14 May 2020; European Commission, Press Release, Brussels 18 December 2018

outside the EU. They are mostly industrial actors but also two research organisations, carrying out 40 closely interlinked sub-projects. These direct participants will work in collaboration with a large number of partners, such as other research organisations or small and medium-sized enterprises (SMEs), also beyond the four participating countries. The focus is on five different technology areas: energy efficient chips, power semiconductors, smart sensors, advanced optical equipment and compound materials (instead of silicon). The project should be completed by 2024 (with differing timelines for each sub-project).

- **IPCEI on Batteries**<sup>48</sup>: The IPCEI was set up in October 2019. Belgium, Finland, France, Germany, Italy, Poland and Sweden jointly support research and innovation in the common European priority area of batteries. The project supports the development of highly innovative and sustainable technologies for lithium-ion batteries (liquid electrolyte and solid state) that last longer, have shorter charging times, are safer and more environmentally friendly than those currently available. The R&D activities include innovation across the batteries value chain, from mining and processing the raw materials, production of advanced chemical materials, the design of battery cells and modules and their integration into smart systems, to the recycling and repurposing of used batteries. In the coming years, the seven Member States will provide up to approximately €3.2 billion in funding for this project, which is expected to unlock an additional €5 billion in private investments. The project will involve 17 direct participants, mostly industrial actors, including small and medium-sized enterprises (SMEs), some of which with activities in more than one Member State. The direct participants will closely cooperate with each other and with over 70 external partners, such as SMEs and public research organisations across Europe. The focus is on four areas: raw and advanced materials, cells and modules, battery systems, as well as repurposing, recycling and refining. The completion of the overall project is planned for 2031 (with differing timelines for each sub-project). In addition, in the field of IPCEI, in 2019, the Strategic Forum for Important Projects of Common European Interest has identified further strategic value chains that require actions: Clean, Connected and Autonomous Vehicles; Cybersecurity; Hydrogen technologies and systems; Industrial IoT; Low CO<sub>2</sub> Emissions Industry; Smart Health. Moreover, additional strategic value chains that have been prioritised include: Additive manufacturing, Bio-based materials, Critical raw materials for innovative applications, Net zero energy building construction and renovation, Smart vessels, Space – launchers, wired and wireless networks.
- **Joint Undertaking EuroHPC** (High-Performance Computing)<sup>49</sup>: EuroHPC aims at deploying a world-class supercomputing infrastructure and a competitive innovation ecosystem in supercomputing technologies, applications and skills in Europe. It pools EU-level and national resources as well as participating associated states of the Horizon 2020 programme and private stakeholders. Located in Luxembourg, the Joint Undertaking started operating in November 2018 and will remain operational until the end of 2026. EuroHPC Joint is jointly funded by its public members with a budget of around €1 billion. The EU's financial contribution is €486 million. This budget will be matched by a similar amount from the participating countries. The private members will also provide additional contributions to the value of over €400 million, through participation in the Joint Undertaking's activities. The Joint Undertaking will provide financial support in the form of procurement or research and innovation grants to participants following open and competitive calls.

**ECSEL Joint Undertaking** (Electronic Components and Systems for European Leadership)<sup>50 51</sup>: In 2014, ECSEL was established for the implementation of the Joint Technology Initiative (JTI) on "Electronic Components and Systems for European

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<sup>48</sup> European Commission, Press Release, Brussels 9 December 2019

<sup>49</sup> <https://eurohpc-ju.europa.eu/>, 15 May 2020

<sup>50</sup> <https://www.ecsel.eu/>, 15 May 2020

<sup>51</sup> European Commission (2017): Interim Evaluation of the ECSEL Joint Undertaking (2014-2016) Operating under Horizon 2020–Final Report. Luxembourg, Publications Office of the European Union



Leadership”, thereby merging the previous Joint Undertakings ARTEMIS and ENIAC from 2008. The ECSEL JU, operating under Horizon 2020, establishes a new generation JTI, encompassing areas of embedded/cyber-physical systems, nanoelectronics as well as smart systems, that are crucial for sectors such as automotive, rail, aerospace, manufacturing and health. The key role of the ECSEL JU is to keep Europe at the forefront of technology development in the area of Electronic components and systems. The total budget of ECSEL is approx. €5 billion for 2014-2024 (2020 for EU financial commitments), from which €1.185 billion comes from the EU (including €15 million administration costs), €1.170 billion come from participating States (Member States + Associated Countries) and €2.340 billion come from industry (at least, of which €1.657 billion from private members including maximum €48 million administration costs).

In 2017, the mid-term evaluation acknowledged that ECSEL has been highly successful in supporting the interests of the micro/nanoelectronics sector such as in supporting the development of FDSOI, a key advanced low-power technology, and in keeping production capabilities for advanced silicon processes as well as the resulting know-how in Europe. However, it was also recommended that the involvement of system industries should be strengthened, by ensuring that Lighthouse projects are driven by systems companies. Furthermore, the Member States participation rules, funding rates and procedures wherever possible should be harmonised. Additionally, the evaluation recommends the development of an industry driven top-down overarching strategy concentrating on the integration of Cyber-Physical Systems (CPS), smart systems and electronics with a focus on the key application domains such as automotive, health, energy, etc. Also, a focus should be on capitalising on the innovation capabilities of start-ups and SMEs by fully integrating them into innovation ecosystems for the key targeted market segments organised around Lighthouse projects, such as by developing open platforms. Up to 2020, 10 calls have been carried out, resulting in 64 projects with more than 2.100 participants.

- **FCH Joint Undertaking** (Fuel cells and Hydrogen)<sup>52 53</sup>: Established in 2008 under FP7, FCH JU is a public private partnership (PPP) supporting research, technological development and demonstration (RTD) activities in fuel cell and hydrogen energy technologies in Europe. Its aim is to accelerate the market introduction of these technologies, realising their potential as an instrument in achieving a carbon-clean energy system. The phase 2014-2020 (under Horizon 2020) has a total budget of €1.33 billion, provided on a matched basis between the EU represented by the European Commission, industry, and research. The FCH JU is set up for a period lasting until 31 December 2024. It brings public and private interests together in a new, industry-led implementation structure, ensuring that the jointly defined research programme better matches industry’s needs and expectations, while focusing on the objective of accelerating the commercialization of fuel cell and hydrogen technologies, based on the main pillars transport and energy. According to the latest available Programme Review Report from 2018, throughout all calls from 2008-2017, in total 227 projects have been funded by FCH JU, with a total budget of €844 million complemented by more than €886 million from other sources.
- **Contractual public-private partnerships (cPPP)**<sup>54 55</sup>: The EU contributes with €7.1 billion to the cPPPs, while the industry is also committed to leverage further investments in research and innovation, work on cutting-edge technologies and ensure the competitive edge of the European industry. 10 cPPPs have been implemented, all of them of high relevance for the EU engineering industries: Factories of the Future (FoF), Energy-efficient Buildings (EeB), European Green Vehicles Initiative (EGVI),

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<sup>52</sup> <https://www.fch.europa.eu/>, 15 May 2020

<sup>53</sup> FCH Joint Undertaking Programme Review Report 2018, available from [https://www.fch.europa.eu/sites/default/files/EGAA19001ENN\\_002\\_ONLINE%20VERSION%20%28ID%207214731%29.pdf](https://www.fch.europa.eu/sites/default/files/EGAA19001ENN_002_ONLINE%20VERSION%20%28ID%207214731%29.pdf), 15 May 2020

<sup>54</sup> <https://ec.europa.eu/programmes/horizon2020/en/contractual-public-private-partnerships>, 15 May 2020

<sup>55</sup> European Commission (2017): Mid-term review of the contractual Public Private Partnerships (cPPPs) under Horizon 2020. Report of the Independent Expert Group. Brussels: European Commission

Sustainable Process Industry (SPIRE), Photonics, Robotics, High Performance Computing (HPC), Advanced 5G networks for the Future Internet (5G), Cybersecurity, and Big Data Value. According to the mid-term review of 2017, 412 cPPP projects have been funded for about € 2.1 billion in the period 2014-2016. Among others, one recommendation of the mid-term review is to improve the governance of cPPPs, in particular enhancing transparency and systematic dissemination of results, developing studies of exploitation and transferring technical solutions within the same sector and along the supply chain. Furthermore, the links between the cPPPs and the other European Commission instruments should be strengthened.

#### 2.2.4.4 **Patent applications/publications**

Another important indicator for possible R&D activities of businesses are patent application filings or patent publications, strongly relating to the output of R&D activities. According to the World Intellectual Property Organization (WIPO, n.d., p.5), "a patent is an exclusive right granted for an invention – a product or process that provides a new way of doing something, or that offers a new technical solution to a problem. A patent provides patent owners with protection for their inventions. Protection is granted for a limited period, generally 20 years."

#### **Box 2-1: Possibilities of registering a patent**

##### **Individual applications**

Individual applications with the given national patent offices, covering only the country/countries where the patent was registered.

##### **Collective applications**

Collective applications for covering the European area or keeping options open, in order to save the effort of filing individual national applications.

##### *European patent applications*

A European patent application (EP) is a collective application filed with the European Patent Office, which grants a bunch of national patents. Within the European patent procedure, patents are granted centrally. The granted European patent is valid in up to the 42 countries that are member of (38) or affiliated with (6) the European Patent Convention (EPC), as designated by the patent applicant. (<https://www.epo.org>)

##### *Patent Cooperation Treaty (PCT)*

The PCT is an international treaty with more than 150 contracting states<sup>1</sup>. The PCT makes it possible to seek patent protection for an invention simultaneously in a large number of countries by filing a single "international" patent application instead of filing several separate national or regional patent applications. The granting of patents remains under the control of the national or regional Patent Offices in what is called the "national phase". (<https://www.wipo.int/pct/en/>)

##### *Unitary patent*

Unitary Patents (enhanced cooperation between 26 EU Member States, not yet in force and not ratified by all EU states as of February 2020) will make it possible to get a single patent protection for inventions in up to 26 EU Member States by submitting a single request to the EPO, making the procedure simpler and more cost effective for applicants. ([https://ec.europa.eu/growth/industry/intellectual-property/patents/unitary-patent\\_en](https://ec.europa.eu/growth/industry/intellectual-property/patents/unitary-patent_en))

<sup>1</sup> e.g. Taiwan is not member of PCT

Source: European Patent Office, World Intellectual Property Organization, 2019



### Patent applications in Europe

The European Patent Office (EPO) provides data on European patents<sup>56</sup> that are granted for some or all of the contracting states to the European Patent Convention (EPC), regardless as to whether the applicant is European or Non-European<sup>57</sup>. Patent application data are available by fields of technology<sup>58</sup>, being the following most relevant in relation to engineering industries: electrical engineering, instruments (optical, medical technology) and mechanical engineering.

From all 173,958 patent applications (all technologies) at EPO in 2018, the share of patent applications in the field of engineering industries is 60.6%. This share has remained relatively stable since 2009 (59.2%). Patent applications in the field of electrical engineering constitute 27.9% of all patent applications, while the share of mechanical engineering is at 22.4% and the share of instruments (optical, medical technology) is at 10.3%. Again, this distribution remained stable since 2009.

**Table 2-20: Patent applications<sup>1</sup> at EPO by field of technology<sup>2</sup>, 2009-2018**

| Field of technology <sup>2</sup>                  | 2009          | 2018          | Change 09-18 in % | Average annual change 09-13 in % | Average annual change 13-18 in % |
|---------------------------------------------------|---------------|---------------|-------------------|----------------------------------|----------------------------------|
| <b>Electrical engineering:</b>                    | <b>37,045</b> | <b>48,612</b> | <b>31.2</b>       | <b>3.3</b>                       | <b>2.9</b>                       |
| Electrical machinery, apparatus, energy           | 7,658         | 10,722        | 40.0              | 7.3                              | 1.1                              |
| Audio-visual technology                           | 4,678         | 4,171         | -10.8             | -3.9                             | 0.9                              |
| Telecommunications                                | 5,254         | 3,819         | -27.3             | -8.6                             | 0.8                              |
| Digital communication                             | 6,478         | 11,940        | 84.3              | 9.7                              | 4.9                              |
| Basic communication processes                     | 1,072         | 932           | -13.1             | -3.9                             | 0.4                              |
| Computer technology                               | 7,780         | 11,718        | 50.6              | 4.2                              | 5.1                              |
| IT methods for management                         | 1,237         | 2,378         | 92.2              | 8.0                              | 7.2                              |
| Semiconductors                                    | 2,888         | 2,932         | 1.5               | 2.7                              | -1.8                             |
| <b>Instruments (optical, medical technology):</b> | <b>13,259</b> | <b>17,852</b> | <b>34.6</b>       | <b>1.6</b>                       | <b>4.8</b>                       |
| Optics                                            | 3,280         | 4,057         | 23.7              | 0.4                              | 4.0                              |
| Medical technology                                | 9,979         | 13,795        | 38.2              | 2.0                              | 5.1                              |
| <b>Mechanical engineering:</b>                    | <b>29,104</b> | <b>38,928</b> | <b>33.8</b>       | <b>3.4</b>                       | <b>3.2</b>                       |
| Handling                                          | 3,628         | 4,747         | 30.8              | 1.2                              | 4.5                              |
| Machine tools                                     | 3,172         | 3,600         | 13.5              | 2.3                              | 0.7                              |
| Engines, pumps, turbines                          | 4,310         | 5,433         | 26.1              | 6.3                              | -0.2                             |

<sup>56</sup> Information on patents can be searched in the free database of EPO: <https://worldwide.espacenet.com/>

<sup>57</sup> A European patent application may be filed by any natural or legal person, or any body equivalent to a legal person, irrespective of nationality and place of residence or business (EPO, 2018)

<sup>58</sup> The definition of the fields is based on the WIPO IPC technology concordance. The table is available at: [http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/xls/ipc\\_technology.xls](http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/xls/ipc_technology.xls)

| Field of technology <sup>2</sup>      | 2009          | 2018           | Change 09-18 in % | Average annual change 09-13 in % | Average annual change 13-18 in % |
|---------------------------------------|---------------|----------------|-------------------|----------------------------------|----------------------------------|
| Textile and paper machines            | 2,413         | 2,701          | 11.9              | -2.4                             | 4.3                              |
| Other special machines                | 3,826         | 6,379          | 66.7              | 4.1                              | 7.3                              |
| Thermal processes and apparatus       | 2,152         | 2,673          | 24.2              | 3.6                              | 1.5                              |
| Mechanical elements                   | 3,490         | 4,356          | 24.8              | 2.6                              | 2.4                              |
| Transport                             | 6,113         | 9,039          | 47.9              | 5.0                              | 4.0                              |
| <b>Engineering industries (total)</b> | <b>79,408</b> | <b>105,392</b> | <b>32.7</b>       | <b>3.0</b>                       | <b>3.3</b>                       |

Note: data available only from 2009 onwards (no data available for 2008)

<sup>1</sup> European patent applications include direct European applications and international (PCT) applications that entered the European phase during the reporting period.

<sup>2</sup> The definition of the fields is based on the WIPO IPC technology concordance.

Source: EPO Statistics, 2019

In 2018, there were more than 105,000 patent applications in the field of engineering industries at the EPO. Thereof, 46% were patent applications in electrical engineering, 37% in mechanical engineering and 17% in instruments (optical, medical technology). The highest growth rates in patent applications since 2009 can be observed in IT methods for management, computer technology, digital communication, other special machines, electrical machinery/apparatus/energy, as well as medical technology. The highest annual average growth rates since 2014 can be found in other special machines (+7.8%), medical technology (+5.3%) and computer technology (+4.6%).

Detailed data from EPO by geographic origin of the patent applications<sup>59</sup> show that the share of patent applications originating in the EU-28 (country of residence of the first applicant listed on the application form) have decreased between 2009 and 2018 from 43.7% to 39.0% (-4.7%-points). During the same time, particularly the share of patent applications at EPO originating in China (+5.2%-points) and South Korea (+1.0%-points) have increased.

**Table 2-21: Share of patent applications<sup>1</sup> in the field of engineering industries<sup>2</sup> at EPO by geographic origin<sup>3</sup>, 2009-2018**

| Geographic origin <sup>3</sup> | Share of patent applications at EPO 2009 | Share of patent applications at EPO 2018 | Change 09-18 in %-points |
|--------------------------------|------------------------------------------|------------------------------------------|--------------------------|
| <b>EU-27 + UK</b>              | <b>43.7</b>                              | <b>39.0</b>                              | <b>-4.7</b>              |
| United States                  | 24.4                                     | 25.1                                     | 0.7                      |
| Japan                          | 17.0                                     | 14.3                                     | -2.7                     |
| China                          | 1.6                                      | 6.8                                      | 5.2                      |
| South Korea                    | 3.9                                      | 4.9                                      | 1.0                      |
| Taiwan                         | 1.0                                      | 1.2                                      | 0.2                      |

<sup>59</sup> Geographic origin of the natural or legal person, or the body equivalent to a legal person that has filed the patent application: The geographic origin is based on the country of residence of the first applicant listed on the application form (first-named applicant principle). In cases where several applicants are mentioned on the application form, the country of residence of the first applicant listed applies.

| Geographic origin <sup>3</sup> | Share of patent applications at EPO 2009 | Share of patent applications at EPO 2018 | Change 09-18 in %-points |
|--------------------------------|------------------------------------------|------------------------------------------|--------------------------|
| Israel                         | 0.8                                      | 0.9                                      | 0.1                      |
| Canada                         | 1.7                                      | 0.9                                      | -0.8                     |
| Australia                      | 0.5                                      | 0.5                                      | 0.0                      |
| Turkey                         | 0.1                                      | 0.3                                      | 0.2                      |
| All other countries            | 1.5                                      | 2.3                                      | 0.8                      |

Note: data available only from 2009 onwards (no data available for 2008)

<sup>1</sup> European patent applications include direct European applications and international (PCT) applications that entered the European phase during the reporting period.

<sup>2</sup> Electrical engineering, Instruments - optics, medical technology, Mechanical engineering; the definition of the fields is based on the WIPO IPC technology concordance.

<sup>3</sup> The geographic origin is based on the country of residence of the first applicant listed on the application form (first-named applicant principle). In cases where several applicants are mentioned on the application form, the country of residence of the first applicant listed applies.

Source: EPO Statistics, 2019

### *Patent publications worldwide*

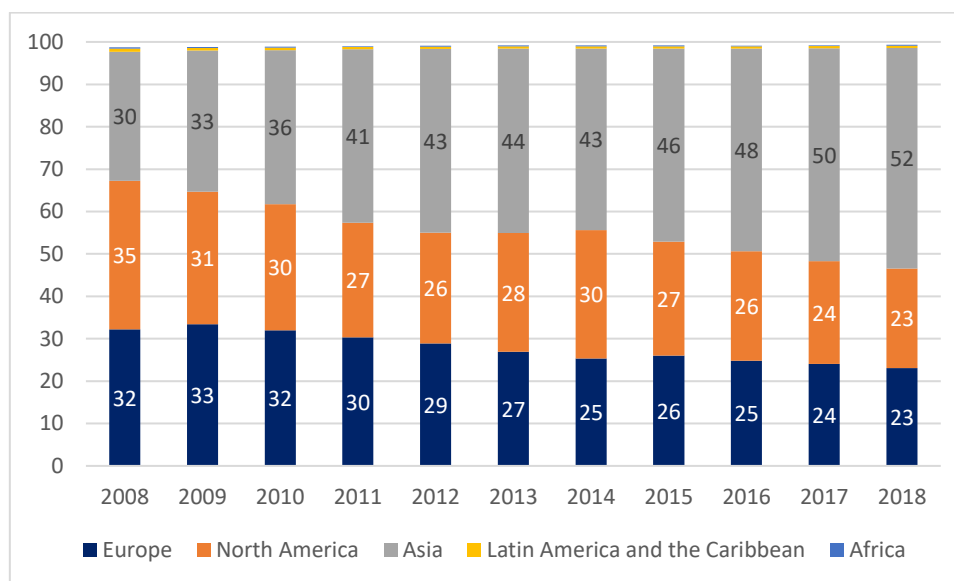
In order to reflect the global development in terms of patents in the years since 2008, PCT filings, in particular PCT patent publications by technology<sup>60</sup> have been analysed. Patent applications are generally published 18 months after the date of filing or earliest priority date. The data provide insight in the origin of a patent publication, i.e. the country of origin of the applicant.<sup>61</sup>

In 2018, more than half (52%) of all engineering patent publications in the world originated in Asia, particularly in the field of digital communication (approx. 12,400), computer technology (approx. 10,200), electrical machinery, apparatus, energy (approx. 9,900) and audio-visual technology (approx. 5,800). 46% of all patent publications originated in North America and in Europe (23% each). Important technology fields in Europe include electrical machinery, apparatus, energy (approx. 2,900 patent publications), medical technology (approx. 2,800) as well as digital communication (approx. 2,000). In North America, the highest numbers in patent publications were in computer technology (approx. 4,500) medical technology (approx. 4,200) and digital communication (approx. 2,700). The world regions Latin America and the Caribbean as well as Africa do not play a significant role as regions of origin when it comes to patent publications.

<sup>60</sup> As data on patent applications by technology are not available in the WIPO IP Statistics Data Center, patent publications by technology have been analysed. The publication date is the date on which a patent application is first published. It is the date on which the document is made available to the public, thereby making it part of the state of the art.

<sup>61</sup> For statistical purposes, the origin of an application means the country or territory of residence (or nationality, in the absence of a valid residence) of the first named applicant in the application.

**Figure 2-29: PCT patent publications in engineering industries<sup>1</sup> by region of origin<sup>2</sup>, 2008-2018**



Note: Indicator 5a: PCT publications by technology and origin

<sup>1</sup> Engineering industries: Electrical engineering, Instruments - optics, medical technology, Mechanical engineering; the definition of the fields is based on the WIPO IPC technology concordance.

<sup>2</sup> Origin: For statistical purposes, the origin of an application means the country or territory of residence (or nationality, in the absence of a valid residence) of the first named applicant in the application.

Source: WIPO statistics database. Last updated: September 2019

The origin of patent publications in engineering industries have changed very much since 2008: The share of patent publications from applicants with residence in Asia have increased from 30% in 2008 to 52% in 2018, while the shares of North America and Europe have decreased considerably.

Despite the decrease of patent publications originating from North America, US is still the country with the most patent publications in engineering industries (approx. 34,900) in 2018, followed by China (approx. 33,900) and Japan (approx. 32,900). The EU (including UK) ranks 4<sup>th</sup> with 32,250 patent publications in 2018. Germany, ranking fifth with 12,120 publications in 2018, is responsible for nearly one third of the patent publications of the EU-28. South Korea follows on rank 6 with 10,100 patent publications.

China and South Korea have the highest growth rates between 2008 and 2018. Further countries with high growth rates, especially since 2013, are Turkey (+14.7%), India (+9.8%), Ireland (+7.9%) and Norway (+7.6%), however starting from a lower level of number of patent publications. Considering all EU based patent publications in engineering industries since 2008 (incl. UK), only a moderate growth can be observed (08-13: +1.1%, 13-18: +1.1%) – however, the growth was higher than in the US.

**Table 2-22: PCT patent publications in engineering industries<sup>1</sup> by country of origin<sup>2</sup>, 2008-2018**

| Rank 2018 | Country of origin      | 2008          | 2018          | Change 08-18 in % | Average annual change 08-13 in % | Average annual change 13-18 in % |
|-----------|------------------------|---------------|---------------|-------------------|----------------------------------|----------------------------------|
| 1         | United States          | 32,448        | 34,873        | 7.5               | 0.4                              | 1.0                              |
| 2         | China                  | 4,129         | 33,872        | 720.3             | 25.5                             | 21.4                             |
| 3         | Japan                  | 18,692        | 32,906        | 76.0              | 10.6                             | 1.3                              |
| <b>4</b>  | <b>EU27 + UK total</b> | <b>28,932</b> | <b>32,250</b> | <b>11.5</b>       | <b>1.1</b>                       | <b>1.1</b>                       |
| 5         | Germany                | 10,728        | 12,120        | 13.0              | 1.3                              | 1.1                              |
| 6         | South Korea            | 4,721         | 10,099        | 113.9             | 10.7                             | 5.2                              |
| 7         | France                 | 3,980         | 4,594         | 15.4              | 2.1                              | 0.8                              |
| 8         | Sweden                 | 2,739         | 2,935         | 7.2               | 0.5                              | 0.9                              |
| 9         | United Kingdom         | 2,809         | 2,903         | 3.3               | -3.2                             | 3.9                              |
| 10        | Netherlands            | 2,492         | 2,392         | -4.0              | -2.3                             | 1.5                              |
| 11        | Switzerland            | 1,621         | 2,062         | 27.2              | 3.6                              | 1.3                              |
| 12        | Italy                  | 1,576         | 1,734         | 10.0              | 0.3                              | 1.6                              |
| 13        | Canada                 | 1,627         | 1,302         | -20.0             | 0.1                              | -4.5                             |
| 14        | Finland                | 1,604         | 1,286         | -19.8             | 1.5                              | -5.8                             |
| 15        | Israel                 | 1,146         | 1,105         | -3.6              | -3.9                             | 3.3                              |
| 16        | Australia              | 1,050         | 908           | -13.5             | -4.1                             | 1.3                              |
| 17        | Austria                | 517           | 856           | 65.6              | 8.2                              | 2.3                              |
| 18        | Denmark                | 623           | 755           | 21.2              | 0.9                              | 3.0                              |
| 19        | India                  | 255           | 749           | 193.7             | 13.0                             | 9.8                              |
| 20        | Belgium                | 385           | 632           | 64.2              | 6.8                              | 3.4                              |
| 21        | Spain                  | 634           | 630           | -0.6              | 5.1                              | -5.0                             |
| 22        | Turkey                 | 197           | 559           | 183.8             | 7.4                              | 14.7                             |
| 23        | Russia                 | 346           | 526           | 52.0              | 9.4                              | -0.6                             |
| 24        | Singapore              | 319           | 466           | 46.1              | 7.4                              | 0.5                              |
| 25        | Norway                 | 279           | 384           | 37.6              | -0.9                             | 7.6                              |
| 26        | Ireland                | 249           | 340           | 36.5              | -1.3                             | 7.9                              |
| 27        | Brazil                 | 240           | 293           | 22.1              | 5.7                              | -1.5                             |

Note: Countries of origin with more than 200 patent publications either in 2008 and/or in 2018

Indicator 5a: PCT publications by technology and origin

<sup>1</sup> Engineering industries: Electrical engineering, Instruments - optics, medical technology, Mechanical engineering; the definition of the fields is based on the WIPO IPC technology concordance.

<sup>2</sup> Origin: For statistical purposes, the origin of an application means the country or territory of residence (or nationality, in the absence of a valid residence) of the first named applicant in the application.

Source: WIPO statistics database. Last updated: September 2019

The focus of the engineering **PCT patent publications by field of technology** differs from country to country<sup>62</sup>: For instance, 58% of the PCT publications of the US (leader in absolute numbers in engineering patent publications) are in the field of electrical engineering, 22% in mechanical engineering and 20% in instruments (optics, medical technology). However, the Chinese engineering patent publications (ranked 2<sup>nd</sup> in absolute numbers) focus much more on electrical engineering (73%), while 17% are in mechanical engineering and “only” 10% are in optical and medical instruments. In comparison, Japan has a greater focus on mechanical engineering than the US and China: 50% of Japan’s patent publications (ranked 3<sup>rd</sup> in absolute numbers) are in electrical engineering, 34% in mechanical engineering and 16% in optical and medical instruments.

The EU-27 (plus the UK) in total (ranking 4<sup>th</sup> in terms of engineering patent publications) has a high share in mechanical engineering patent publications (48%), followed by nearly 38% in electrical engineering and nearly 15% in instruments (optics, medical technology). The strong focus on mechanical engineering in Europe can be attributed to a high share in patent publications in this technology field in Germany (56%), France (50%), Italy (67%), Denmark (63%) and Austria (57%).

Just like China, South Korea (ranked 6<sup>th</sup> in engineering patent publications), has a strong focus on electrical engineering patent publications (67%). Other countries with a considerable share of patent publications in this field include Singapore (68%) as well as Sweden and Finland (65% each).

Countries with patent publications in optical and medical instruments above average include in particular the Netherlands (38%), Israel (35%) and Ireland (32%).

### **2.2.5 Access to skilled labour**

Innovation is an extremely important factor of success in mechanical electronic, electrical and mechanical engineering. It often supports clear market position and differentiation among competitors. Fundamental research and new technologies make it possible to produce highly complex products with efficient processes. In this context, the **competencies required for continuous adaptation of the production system is a critical success factor in manufacturing**. Fernandez-Miranda et.al. (2017) identified organisations’ ability to permanently adapt their operations to the requirements of changing products on dynamic markets and innovative technologies as the main competitiveness factor for manufacturing. According to their analysis, employers need personnel with creativity and decision-making skills as well as relevant technical expertise. Engineers need to be increasingly well trained and highly skilled.

This need may be even more pronounced in advanced manufacturing settings with an ever-increasing utilisation of digital technologies and where big data analysts and cyber-security experts are required. According to European Commission (2020), 9 out of 10 **jobs will require significant digital skills** in the near future. However, according to McKinsey 2016, many manufacturers perceive that they lack the necessary skills and expertise to make new Industry 4.0 applications work (next to an inherent scepticism to cooperate with third-party providers of industry 4.0 related services). Similarly, according to the 2017 EY Global Construction & Engineering Survey, identifying the top five challenges for companies’ digital transformation, the lack of trained staff ranked as 2<sup>nd</sup> most important obstacle behind the lack of integration between systems. Companies included in this survey also stated their industry might not be attractive enough to the staff needed for digital transformation. According to the European Digital Skills Survey, manufacturing constitutes the sector reporting the largest digital skills gaps.

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<sup>62</sup> Complete table by Top 27 countries and technology field is listed in Annex 2

As the following table shows, engineering enterprises employ ICT specialists more frequently than enterprises in the business economy as a whole (29% of enterprises vs. 19%). This points to an above-average skills level in engineering industries, although the prevalence of ICT specialists in enterprises stagnated since 2014 – both in engineering as well as overall.

**Table 2-23: Percentage of enterprises that employ ICT specialists, EU-27**

| Year | All enterprises<br>(without financial sector) | Engineering industries |
|------|-----------------------------------------------|------------------------|
| 2014 | 19%                                           | 28%                    |
| 2015 | 20%                                           | 30%                    |
| 2016 | 20%                                           | 29%                    |
| 2017 | 19%                                           | 27%                    |
| 2018 | 19%                                           | 27%                    |
| 2019 | 19%                                           | 29%                    |

Only enterprises with 10 or more persons employed

Engineering industries = NACE 26 to 33

Source: Eurostat ICT Statistics, [isoc\_ske\_itspen2], Status: August 2020

Another indicator for the level of expertise and knowledge of the workforce is the share of researchers. This is displayed in the table below for the engineering industries, showing stark country variations of the share of researchers. Engineering industries in Northern European countries, Austria, the Netherlands, France and Denmark have clearly more researchers among their staff (more than 4%) than those in Eastern European countries and Spain, where researchers account for less than 1.5% of the workforce.

**Table 2-24: Share of researchers in engineering industries' total employment, 2017**

| Country            | Share of researchers in % |
|--------------------|---------------------------|
| <b>Belgium</b>     | <b>4.35</b>               |
| Bulgaria           | 0.86                      |
| Czech Republic     | 1.03                      |
| <b>Denmark</b>     | <b>6.30</b>               |
| Germany            | 2.86                      |
| Estonia            | 1.41                      |
| Spain              | 1.38                      |
| <b>France</b>      | <b>5.40</b>               |
| Croatia            | 0.44                      |
| Italy              | 1.55                      |
| Latvia             | 0.67                      |
| Lithuania          | 1.46                      |
| Hungary            | 0.89                      |
| <b>Netherlands</b> | <b>5.76</b>               |
| <b>Austria</b>     | <b>5.35</b>               |
| Portugal           | 2.12                      |
| Romania            | 0.12                      |

| Country        | Share of researchers in % |
|----------------|---------------------------|
| Slovakia       | 0.47                      |
| <b>Sweden</b>  | <b>4.46</b>               |
| United Kingdom | 2.00                      |
| Iceland        | 3.70                      |
| <b>Norway</b>  | <b>4.14</b>               |

Note: No data available for Finland, Cyprus, Malta, Ireland, Greece, Luxembourg, Poland, Slovenia

Engineering industries = NACE 25, 26, 27, 28, and 33

Source: Eurostat SBS and Statistics on Research and Development, [rd\_p\_bempoccr2], Status: August 2020

Several statistics point to high demand among industry for more workers and experts and to a significant labour and skills shortages in the field of engineering. The Cedefop Skills OVATE shows that engineers, technicians and metal and machinery workers account for a high proportion of job vacancies in Europe (see Figure 2-30). Similarly, an analysis of the top skills/labour shortage occupations in the European Economic Area (EEA), performed on the basis of national PES data in 2019, reveals that many relevant occupations such as metal workers, electrical engineers, civil engineers, electronics engineering technicians, electrical engineering technicians, and electrical mechanics are among the top bottleneck professions (see Table 2-25).

**Figure 2-30: Share of all online job vacancies in %, EU-27, 2018/2019**



Note: Data refer to EU-27 (exc. UK). Data are based on online job vacancies gathered from a defined list of online sources, including private job portals, public employment service portals, recruitment agencies, online newspapers, employers' portals etc. Data were gathered between 1 July 2018 and 31 December 2019.

Source: Cedefop Skills-OVATE, 2020



**Table 2-25: Top skills/labour shortage occupations in the EEA, 2019**

| Occupation                                               | Total number of national PES reporting skills/labour shortage |
|----------------------------------------------------------|---------------------------------------------------------------|
| Heavy truck and lorry drivers                            | 15                                                            |
| Systems analysts                                         | 14                                                            |
| Welders and flame cutters                                | 14                                                            |
| Agriculture and industrial machinery repairers           | 13                                                            |
| Building and related electricians                        | 12                                                            |
| Carpenters and joiners                                   | 12                                                            |
| Plumbers and pipe fitters                                | 12                                                            |
| Cooks                                                    | 11                                                            |
| Concrete placers, concrete finishers                     | 10                                                            |
| <b>Metal workers, machine tool setting and operators</b> | <b>10</b>                                                     |
| Motor vehicle mechanics and repairers                    | 10                                                            |
| Nursing professionals                                    | 10                                                            |
| Bricklayers and related trades                           | 9                                                             |
| Bus and tram drivers                                     | 9                                                             |
| <b>Electrical engineers</b>                              | <b>9</b>                                                      |
| Generalist medical practitioners                         | 9                                                             |
| Structural metal preparers and erectors                  | 9                                                             |
| Butchers, fishmongers and related food                   | 8                                                             |
| Chefs                                                    | 8                                                             |
| <b>Civil engineers</b>                                   | <b>8</b>                                                      |
| Software and applications developers                     | 8                                                             |
| Software developers                                      | 8                                                             |
| Accountants                                              | 7                                                             |
| Advertising and marketing professionals                  | 7                                                             |
| Air conditioning and refrigeration mechanics             | 7                                                             |
| <b>Electrical engineering technicians</b>                | <b>7</b>                                                      |
| <b>Electrical mechanics and fitters</b>                  | <b>7</b>                                                      |
| <b>Electronics engineering technicians</b>               | <b>7</b>                                                      |
| Industrial and production engineers                      | 7                                                             |
| Plasterers                                               | 7                                                             |
| Shop sales assistants                                    | 7                                                             |
| Waiters                                                  | 7                                                             |
| Web and multimedia developers                            | 7                                                             |

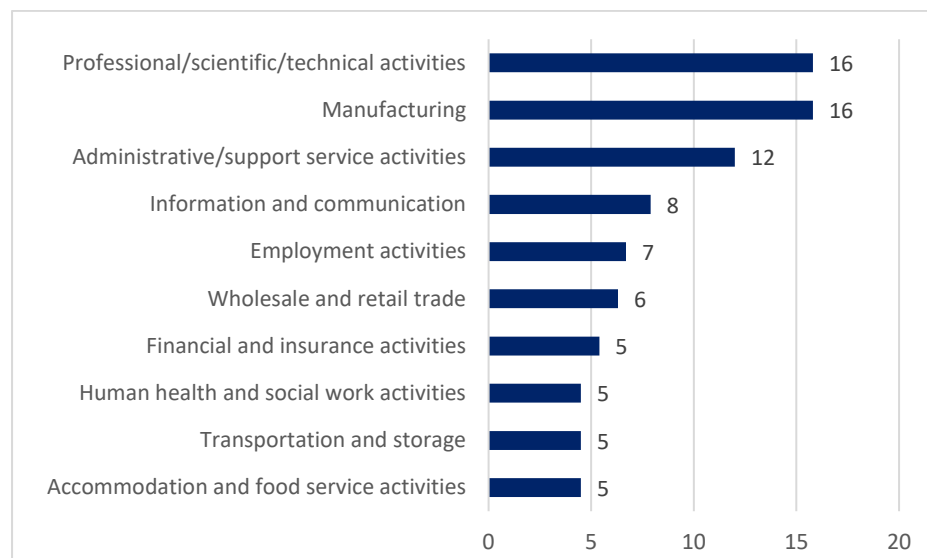
*Note: Total number of PES reporting: 26*

Source: European Commission, Analysis of shortage and surplus occupations based on national and Eurostat Labour Force Survey data; Shortages and surpluses 2019

Looking at labour demand and job vacancies from a sector perspective rather than an occupation perspective reveals a similar pattern. Scientific and technical activities and manufacturing account for the highest shares of vacancies and have the highest demand

for labour (see Figure 2-31). In a situation where the supply of skilled workers is scarce, SMEs are usually most impeded, as they need to compete with bigger corporations that are well-known, use professional employer branding and offer comprehensive social benefits to potential employees (European Commission, 2020).

**Figure 2-31: Share of all online job vacancies by NACE in %, EU-27, 2018/2019**



Note: Data refer to EU-27 (excl. UK). Data are based on online job vacancies gathered from a defined list of online sources, including private job portals, public employment service portals, recruitment agencies, online newspapers, employers' portals etc. Data were gathered between 1 July 2018 and 31 December 2019.

Source: Cedefop Skills-OVATE, 2020

A main cause for current skills shortages is often attributed to **insufficient supply of new graduates in engineering-related occupations** at all qualification levels. Reasons include low interest of young people in enrolling in STEM studies and high dropouts due to intellectual requirements.

In order to attract more young people to education and training in STEM fields, effective vocational information and orientation at early stages and especially breaking up gender stereotypes in this field to attract more girls to STEM studies are required.

While there is a wide range of literature discussing the type of skills needed for the implementation of advanced manufacturing and industry 4.0 processes/technologies, a 2017 study by the Australian Digital Skills Project Reference Group concludes that there is little research available on specific digital skills in manufacturing industries. This study uses the example of the aerospace sector following the reasoning of another study done by Lappas and Kourousis (2016), in which the latter cite the applicability of "The Assessment and Teaching of 21st Century Skills Project (2016)" and its ten priority skill areas as being particularly relevant:

- Ways of Thinking:
  - Creativity and innovation
  - Critical thinking, problem solving, and decision making
  - Learning to learn, metacognition
- Ways of Working:
  - Communication
  - Collaboration (teamwork)

- Tools for Working:
  - Information literacy
  - Information and Communication Technologies (ICT) literacy
- Living in the World:
  - Citizenship — local and global
  - Life and career
  - Personal and social responsibility — including cultural awareness and competence

The Interim Report on the 'Curriculum Guidelines for Key Enabling Technologies and Advanced Manufacturing Technologies' (European Commission, 2019, p 37) expects the following skills to be gaining importance for advanced manufacturing:

- Knowledge/data management skills
- IT security and data protection
- Methodologies for real-time decision making
- Computer programming and coding abilities
- Communication skills
- Teamwork skills
- Self-management
- Mind-set of continuous improvement

Lappas and Kourousis argue that the lack of specific technical skills in their list of priority skills is due to there being a major and rapid shift occurring in the way people work. This is confirmed by European Commission (2019, p 38), who underline that non-technical skills are becoming at least as important as technical skills for professionals involved in advanced manufacturing.

According to Hartmann and Bovenschulte (2013), skills are linked to a) specific technologies and b) sector-specific application of these technologies. The authors also conclude that 'to [their] best knowledge, a systematic technology/sector analysis, with respect to skills needs, has not yet been undertaken'. The same seems to hold true for other sectors as well. For instance, in its recently published study on 'Supporting digitalisation of the construction sector and SMEs. Including Building Information Modelling' (European Commission, 2019f), the authors do not focus on specifying the skills needed for the digitalisation of the construction sector apart from mentioning a lack of data scientists and experts with expertise in (big) data handling and analysis, which is true for most sectors undergoing a transformation driven by digitalisation. Taking another lesson from the construction sector, the 2017 European Construction Sector Observatory (European Commission 2017), also concluded that some skills will likely remain functionally relatively unchanged compared to the current needs. New production technologies etc. rather require professionals working in these trades to adopt a more efficient, strategic and collaborative method of working, as opposed to developing completely new technical skills.

At any rate, new skills requirements need to be included in all types of curricula and levels of the **education system** since a strong competitive strength of Europe is its widely used system of vocational training. New ways of teaching are needed going beyond traditional 'silos' and addressing the ability to link previously unconnected fields, a breadth of disciplines as well as the ability to apply theoretical knowledge to real industry problems (European Commission, 2019). This is especially important for SMEs, and dual forms of

VET (such as in Germany and Austria) can support aligning skills and competencies with needs and requirements of companies. Beyond adapting the (initial) education systems, more regular reskilling (lifelong learning) is needed.

An analysis based on the QS World University Rankings (<https://www.topuniversities.com>) focussing on subject area 'Engineering – Mechanical, Aeronautical and Manufacturing' revealed that among the world's top 10 universities in that field only three are located in Europe (UK), while six come from the US and one from Japan (European Commission, 2019, p. 49). When looking at the top 20 universities, the share of Europe remains the same (30%), but the share of East Asia increases from 10% to 35%.

According to the *JRC's RIO reports*, **major competing world regions** face very different situations with a view to the availability of highly educated engineering experts. The United States remains particularly attractive to international students and is still 'the destination of choice for the largest number of internationally mobile students worldwide.' A substantial portion of US S&E doctoral degrees are conferred to international students (mainly from Asian countries such as China and India) with temporary visas and those are particularly concentrated in engineering, computer sciences, and economics. A majority of the S&E doctorate recipients with temporary visas – more than 60% – remain in the United States for subsequent employment, meaning a significant gain in intellectual capital to the US industry. However, there are indications that the US education system is losing market share and the US immigration system is an increasing strain on the recruitment of foreign intellectual capital.

India is facing alternating phases of brain drain and brain gains in terms of graduate engineers and scientists; a phenomenon also known as 'brain circulation'. Various schemes have been established to increase return migration of Indian professionals, but a need is seen for more incentives to scientists and engineers to mitigate the problem of professional flight.

China is characterised by a very high share of engineering degrees among all new university degrees (significantly higher than in the US or European countries). While engineering accounts for approx. one third of degrees in China, the shares in the United States and the EU are around one fifth to one quarter. Absolute numbers of science and engineering graduates have been growing significantly over the past years. Similar to India, China is running major national schemes attracting national leading scientists and engineers to return from abroad. Indeed, the gap between students and talents going abroad and returnees has been shrinking. While both EU countries and the US are attractive for Chinese students, the number going to the US is approx. 50% higher than the number going to the EU.

In Brazil, a key challenge in the skills domain is that university education and research is very theoretical and a high share of graduates is being absorbed by the academic and public sector rather than working in the private sector, which consequently suffers from a scarcity of engineers. The industrial sector is generally affected by stark skills shortages due to low shares of students opting for technical subjects, low qualification levels across all segments of the labour force and generally low geographic mobility.

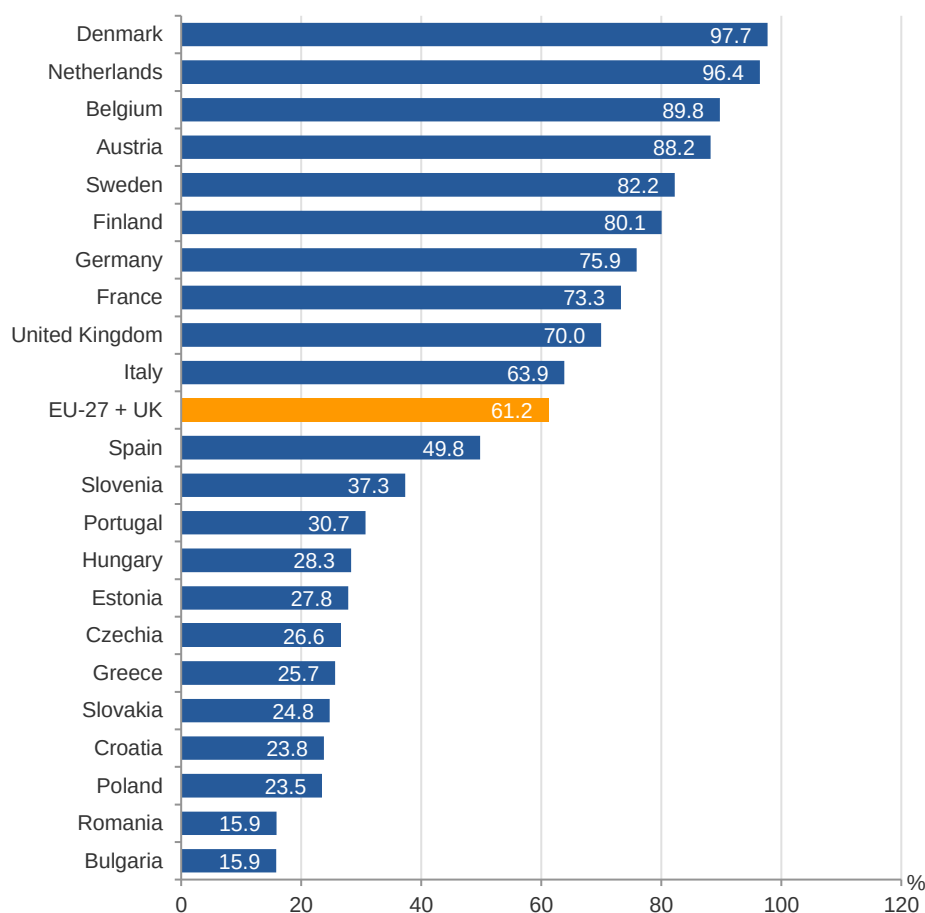
### **2.2.6 Performance, price competitiveness**

The following graphs describe the difference in the price competitiveness of the EU-27 countries + UK by using key indicators such as productivity, unit labour costs and gross operating rate.

Productivity – measured as value added per persons employed – in the engineering industries in the EU-27 + UK is highest in the Denmark, Netherlands, Belgium and Austria. In the other northern and western European countries, such as Sweden, Finland and

Germany, productivity is also higher than the EU average (incl. UK) of € 61,200. In contrast, most Southern economies and the CEE-countries show a productivity in the engineering industries below average.

**Figure 2-32: Productivity in € 1,000<sup>1</sup> in the engineering industries in the EU-27 + UK by countries<sup>2</sup>, 2017<sup>3</sup>**



<sup>1</sup> Productivity: Value added/persons employed (in nominal terms)

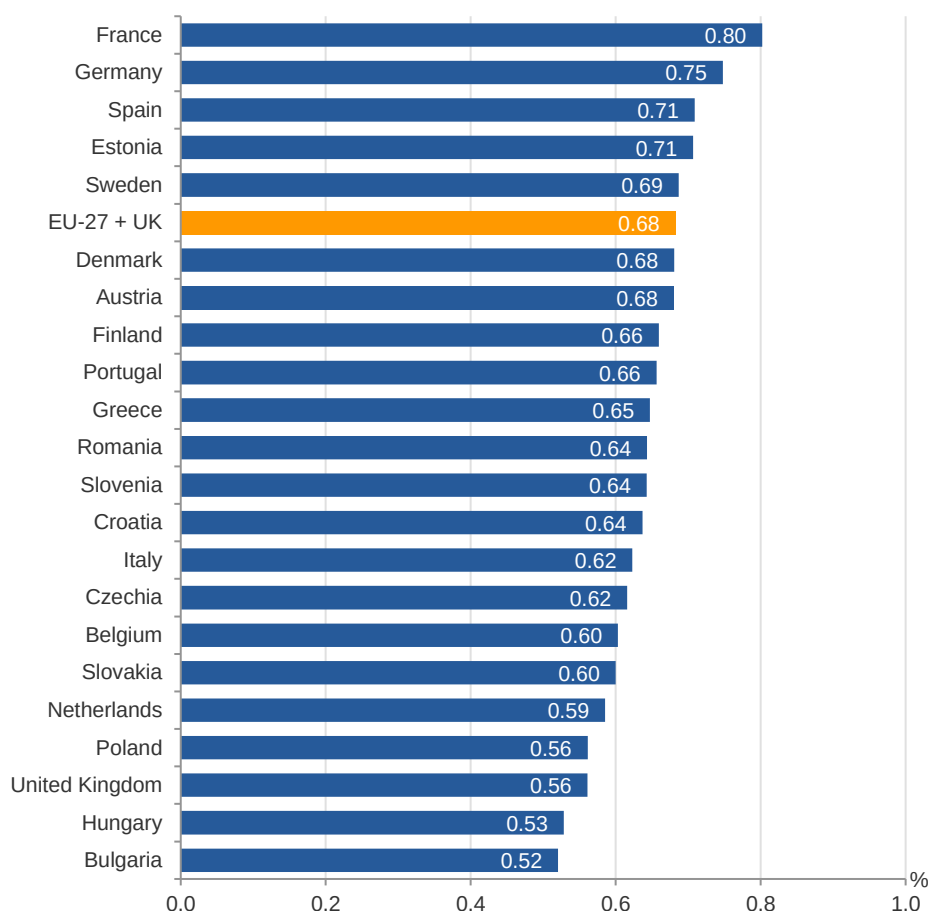
<sup>2</sup> For Ireland, Cyprus, Latvia, Lithuania, Luxembourg, Malta data is not available for all sectors of the engineering industries.

<sup>3</sup> latest year available

Source: Eurostat, Structural Business Statistics; own calculations; Status: August 2020

Unit labour costs in the engineering industries in the EU-27 + UK account 2017 for € 0.68 (per € 1 value added). Bulgaria and Hungary have unit labour costs of less than € 0.55, while in France, Germany, Spain and Estonia they are higher than € 0.70.

**Figure 2-33: Unit labour costs<sup>1</sup> in the engineering industries in the EU-27 + UK by countries<sup>2</sup>, 2017<sup>3</sup>**



<sup>1</sup> Unit labour costs: Total labour costs in € per € 1 value added (Nominal total labour costs (=personnel costs)/value added) (all in nominal terms)

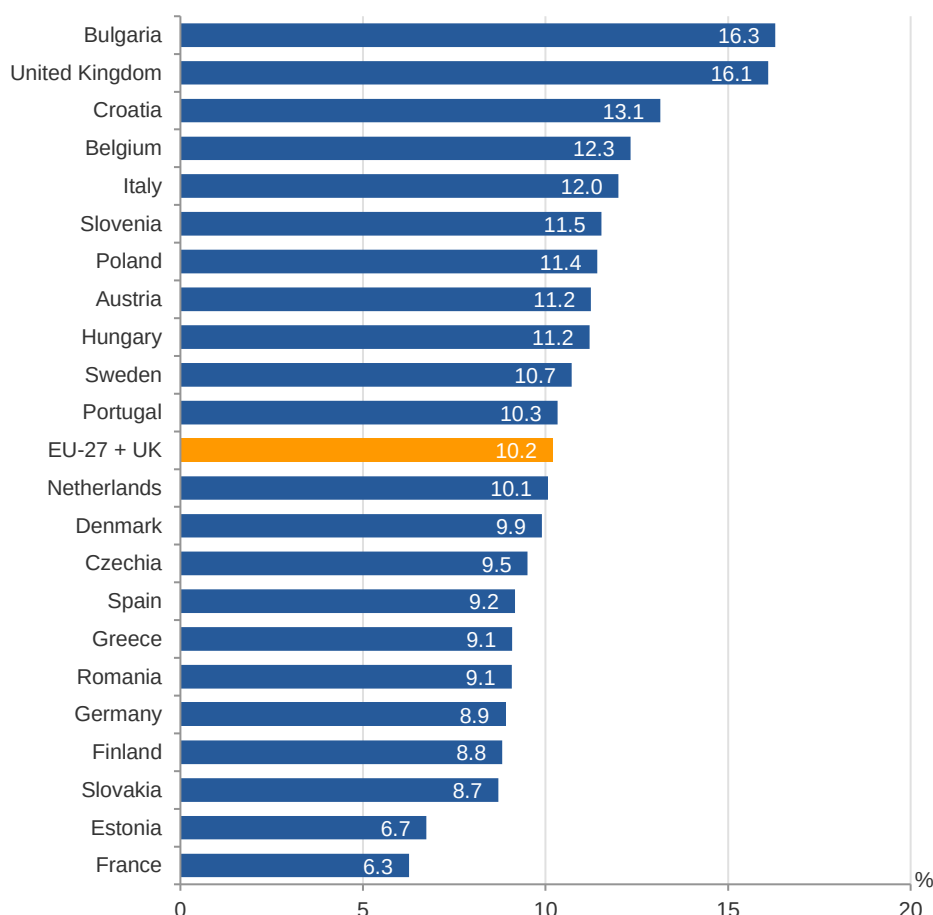
<sup>2</sup> For Ireland, Cyprus, Latvia, Lithuania, Luxembourg, Malta data is not available for all sectors of the engineering industries.

<sup>3</sup> latest year available

Source: Eurostat, Structural Business Statistics; own calculations; Status: August 2020

In 2017, the gross operating rate, which is an indicator for profitability, accounts for 10.2% in the engineering industries in the EU-27 + UK. A high rate can be found especially in Bulgaria and the United Kingdom. These are countries with low unit labour costs. In contrast France and Estonia, countries with high unit labour costs, show the lowest gross operating rate.

**Figure 2-34: Gross operating rate<sup>1</sup> in the engineering industries in the EU-27 + UK by countries<sup>2</sup>, 2017<sup>3</sup>**



<sup>1</sup> Gross operating rate: (Value added - total labour costs (=personnel costs))/turnover) (all in nominal terms)

<sup>2</sup> excluding NACE 32.5 (Manufacture of medical and dental instruments and supplies) as data from the National accounts are not published for every NACE code according to the definition

<sup>3</sup> For Ireland, Cyprus, Latvia, Lithuania, Luxembourg, Malta data is not available for all sectors of the engineering industries.

<sup>4</sup> latest year available

Source: Eurostat, Structural Business Statistics; own calculations; Status: August 2020

In the EU-27 + UK, the unit labour costs and the gross operating rate are higher in the engineering industries than in the total manufacturing sector, whereas productivity is higher in manufacturing. Since 2008, the productivity in the total manufacturing sector (+28.4%) increased to a greater extent than in the engineering industries (+17.8%). This can be traced back to the period 2013-2017, where the average annual change rate in productivity in the engineering industries was much lower, whereas in the period 2008-2013, productivity growth in the engineering industries and in the manufacturing sector was nearly equal.

On the other hand, throughout the whole time period 2008 and 2017, unit labour costs in the engineering industries decreased less than in the manufacturing sector. Between 2008 and 2013, the unit labour costs in the engineering industries increased to a greater extent than in manufacturing, and between 2013 and 2017 they decreased to a lesser extent.

The gross operation rate increased in the engineering industries from 9.3% (arithmetic average for the period 2008-2013) by 0.4%-points to 9.7% (arithmetic average for the

period 2013-2017). In total, in the manufacturing sector, the growth rate was higher (+1.1% points).

**Table 2-26: Key indicators for the price competitiveness in the manufacturing sector and the engineering industries in the EU-27 + UK, 2008-2017**

|                                         | 2017                    | 2008-2017   | 2008-2013                  | 2013-2017 |
|-----------------------------------------|-------------------------|-------------|----------------------------|-----------|
|                                         | Absolute data           | Change in % | Average annual change in % |           |
| Productivity <sup>1</sup> in € 1,000    |                         |             |                            |           |
| Engineering industries                  | 61.2                    | 17.8        | 1.3                        | 2.5       |
| Manufacturing total                     | 65.0                    | 28.4        | 1.4                        | 4.6       |
| Unit labour costs <sup>2</sup> in € / € |                         |             |                            |           |
| Engineering industries                  | 0.68                    | -0.5        | 0.7                        | -1.0      |
| Manufacturing total                     | 0.60                    | -6.3        | 0.4                        | -2.1      |
|                                         | Arithmetic average in % |             |                            |           |
| Gross operating rate <sup>3</sup> in %  |                         |             |                            |           |
| Engineering industries                  | 10.2                    | 9.5         | 9.3                        | 9.7       |
| Manufacturing total                     | 10.1                    | 8.8         | 8.2                        | 9.3       |

<sup>1</sup> Value added /persons employed (in nominal terms)

<sup>2</sup> Total labour costs in € per € 1 value added (Nominal total labour costs (=personnel costs)/value added) (all in nominal terms)

<sup>3</sup> (Value added - total labour costs (=personnel costs))/turnover) (all in nominal terms)

Source: Eurostat, Structural Business Statistics; own calculations; Status: August 2020

The following graphs compare the price competitiveness of the engineering industries in the EU (incl. UK) with important major competing countries, such as US, Japan, South Korea, Brazil, Russia, India, China etc. by using key indicators such as productivity, unit labour costs and gross operating rate. The data were retrieved from the UNIDO INDSTAT 2 Database, which is the only source where data for all countries are available. However, comparison between countries is limited, as the data are based on different enterprise surveys in the respective countries, using, for instance, different definitions of enterprises. Moreover, every country uses slightly different definitions of the economic sectors in scope.<sup>63</sup> However, the data provide an insight into rough dimensions and the development over time.

In the Republic of Korea, the US, Japan and Israel, **productivity in the engineering industries** – measured as value added per employee – is higher than in the EU. In contrast, China, Brazil, Thailand, Russia and India have a productivity that is much lower than that of the European Union.

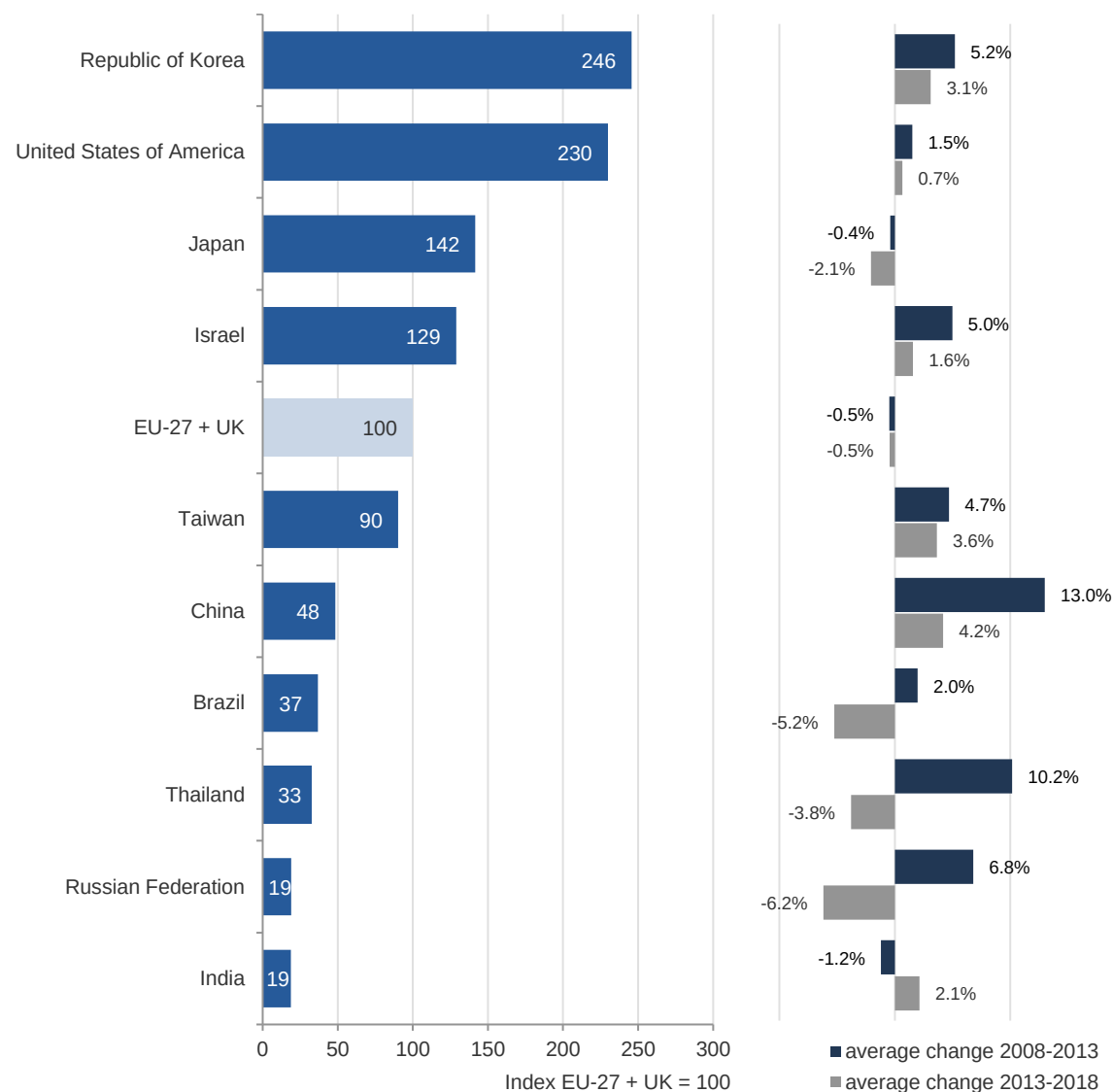
The average annual change rate demonstrates the different development in the periods 2008 to 2013 and 2013 to 2018. While in the Republic of Korea, the US, Israel, Taiwan and China, productivity in the engineering industries increased in both periods, Japan and

<sup>63</sup> For example, in the US, the North American Industry Classification System (NAICS) is used, in Japan the Japan Standard Industrial Classification (JSIC), and so on. While this is not an issue when analysing the data, as all information in the database is standardised, it should be noted that every country adopts the ISIC according to the structure of their economy, and all enterprise surveys use this country specific adoption of the ISIC. Furthermore and most importantly, the INDSTAT 2 Database uses the ISIC 3 classification, which is only partially comparable to the ISIC 4 / NACE 2. Also, the INDSTAT 2 database offers only a limited range of variables (e.g. information on wages and salaries, but not compensation of employees). Therefore, the results presented here are not suited for a direct comparison with results based on data from other databases that use ISIC 4 or NACE 2.



the EU (incl. UK) showed a slight decline. Almost all of these countries performed better in the period 2008 to 2013 than between 2013 and 2018. In Brazil, Thailand and Russia, productivity grew between 2008 and 2013 and decreased in the period 2013 to 2018. The trend was reversed in India.

**Figure 2-35: Productivity<sup>1</sup> in the engineering industries<sup>2</sup> in the EU-27 + UK<sup>3</sup> and in important major competing countries, 2018<sup>4</sup> (Index: EU-27 + UK=100) and average change 2008 – 2018**



<sup>1</sup> Productivity: Value added in current prices/employees

<sup>2</sup> Definition according to ISIC Rev. 3; the codes are similar to the definition according to NACE Rev. 2 used for the EU data in the other chapters, except for NACE Rev. 2 33 (Installation, repair and maintenance of mechanical, electrical and electronic engineering equipment) where there are big differences.

<sup>3</sup> Excluding Ireland, Luxembourg and Malta, as data for these countries are not available for all sectors of the engineering industries. The different development of the EU compared to data from Eurostat is due to a slightly different definition for the engineering industries as well as for productivity. For the sake of comparability, INDSTAT 2 data were used for both the EU and the major competing countries.

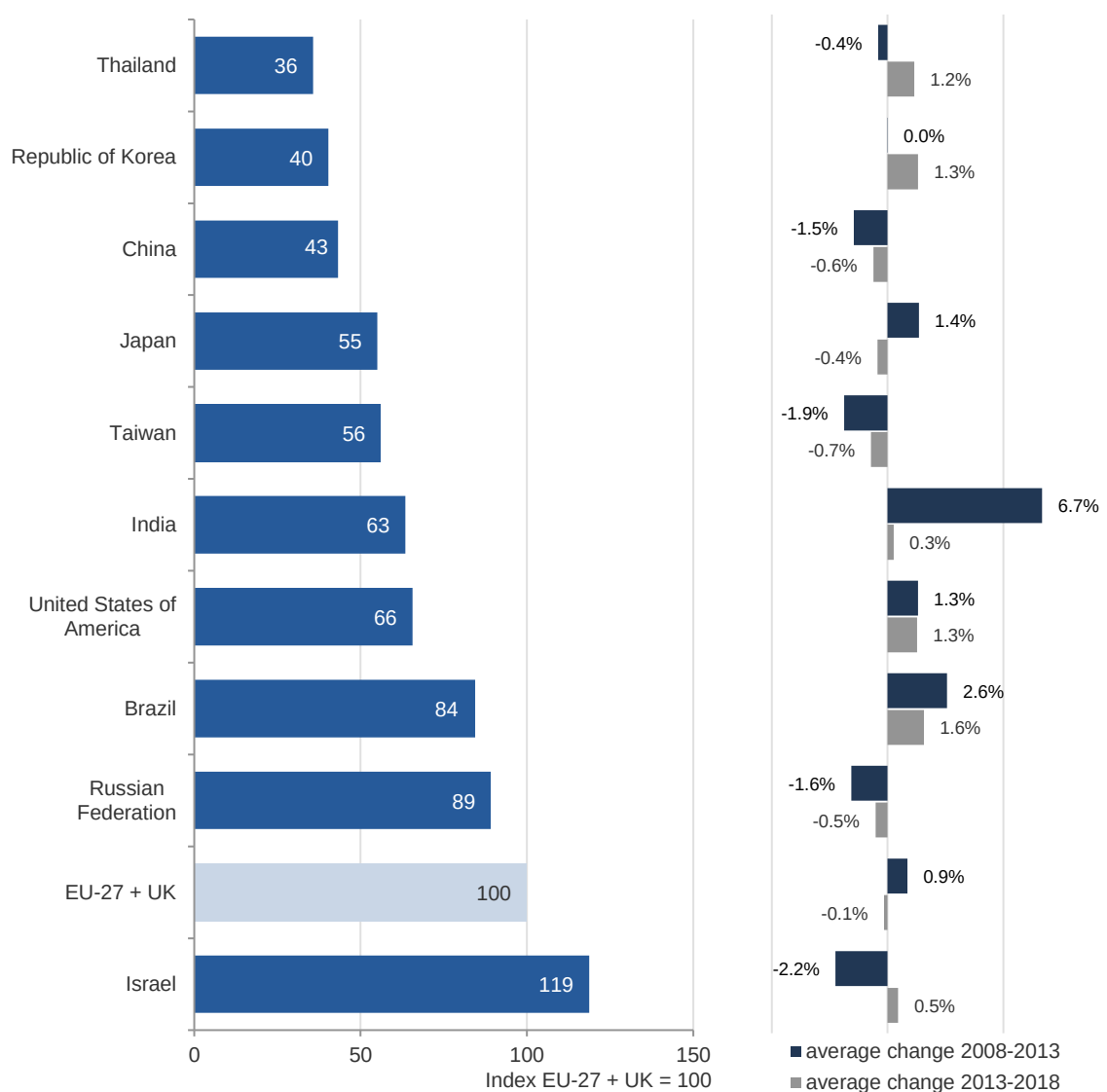
<sup>4</sup> latest year available; for Taiwan, data is available only for 2017

Source: UNIDO INDSTAT 2 Database; own calculations; Status: August 2020

The **unit labour costs in the engineering industries** are lowest in the Asian countries Thailand, Republic of Korea, China, Japan, Taiwan and India. Only in Israel, the unit labour costs are higher than the EU average (incl. UK).

The average annual percentage change rate for the periods 2008 to 2013 and 2013 to 2018 indicates the different development in the major competing countries. Unit labour costs grew particularly high in India between 2008 and 2013. In this country, as well as in the USA and Brazil, there was an increase in both time periods. In China, Taiwan and Russia, on the other hand, unit labour costs declined since 2008. In Japan, there was a slight decline between 2013 and 2018 after an increase between 2008 and 2013 – this has been also the case for the EU-27 + UK.

**Figure 2-36: Unit labour costs<sup>1</sup> in the engineering industries<sup>2</sup> in the EU-27 + UK<sup>3</sup> and in important major competing countries, 2018<sup>4</sup> (Index: EU-27 + UK=100) and average change 2008 – 2018**



<sup>1</sup> Unit labour costs: wages and salaries/value added in current prices

<sup>2</sup> Definition according to ISIC Rev. 3; the codes are similar to the definition according to NACE Rev. 2 used for the EU data in the other chapters, except for NACE Rev. 2 33 (Installation, repair and maintenance of mechanical, electrical and electronic engineering equipment) where there are big differences.

<sup>3</sup> Excluding Ireland, Luxembourg and Malta, as data for these countries is not available for all sectors of the engineering industries. The different development of the EU compared to data from Eurostat used before is due to a slightly different definition for the engineering industries as well as for unit labour costs. For the sake of comparability, INDSTAT 2 data were used for both the EU and the major competing countries.

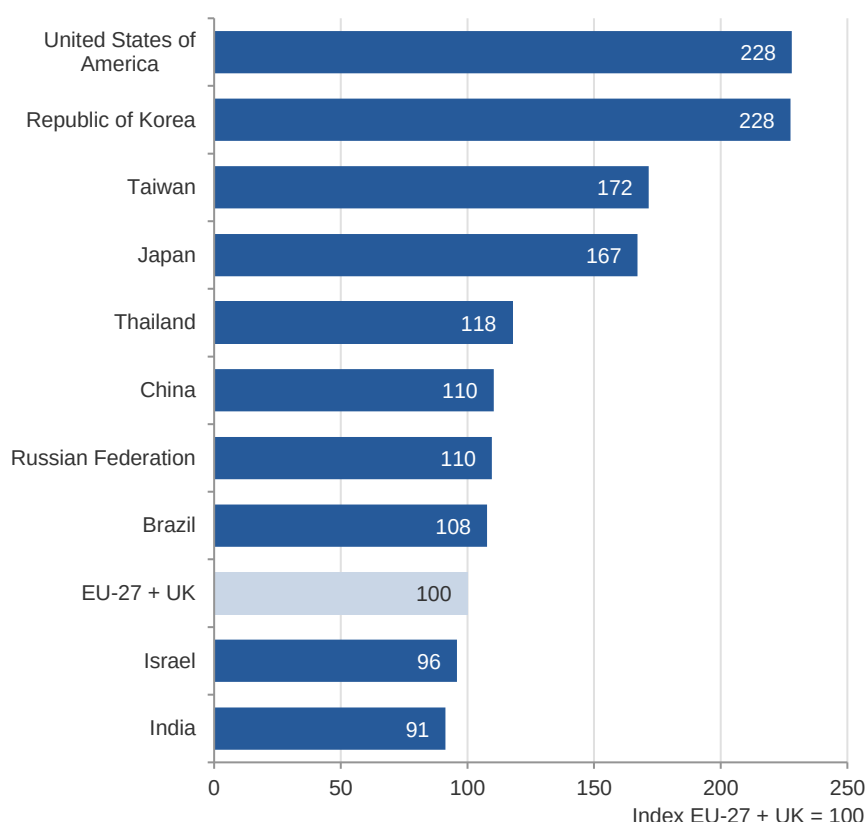
<sup>4</sup> latest year available; for Taiwan, data is available only for 2017

Source: UNIDO INDSTAT 2 Database; own calculations; Status: August 2020

The **gross operating rate (GOR)**, which is an indicator for profitability, is especially high in the US and the Republic of Korea, the two countries with the highest productivity. In India and Israel, the GOR is lower than in the EU-27 + UK. While in Israel this is due to the high unit labour costs, in India, this can be referred to the particularly low productivity.

Regarding the arithmetic averages for the period 2008-2013 and 2013-2018, the gross operating rate increased in Taiwan by more than 4%-points and in Russia by around 2%-points. In Brazil and India, it declined by approx. 2%-points. The difference was approx. 1% point and less in all other countries.

**Figure 2-37: Gross operating rate<sup>1</sup> in the engineering industries<sup>2</sup> in the EU-27 + UK<sup>3</sup> and in important major competing countries, 2018<sup>4</sup> (Index: EU-27 + UK=100)**



<sup>1</sup> Gross operating rate: (Value added – wages and salaries)/ output (all in current prices)

<sup>2</sup> Definition according to ISIC Rev. 3; the codes are similar to the definition according to NACE Rev. 2 used for the EU data in the other chapters, except for NACE Rev. 2 33 (Installation, repair and maintenance of mechanical, electrical and electronic engineering equipment) where there are big differences.

<sup>3</sup> Excluding Ireland, Luxembourg and Malta, as data for these countries is not available for all sectors of the engineering industries. The different development of the EU compared to data from Eurostat used before is due to a slightly different definition for the engineering industries as well as for unit labour costs. For the sake of comparability, INDSTAT 2 data were used for both the EU and the major competing countries.

<sup>4</sup> latest year available; for Taiwan, data is available only for 2017

Source: UNIDO INDSTAT 2 Database; own calculations; Status: August 2020

As compared to most of the other competing countries, the EU-27 + UK performs lower in terms of unit labour costs and GOR. However, as stated above, a detailed comparison between countries is limited due to data sources used (national surveys that use different definitions, different target groups, and different methods of data collection). Nevertheless, the data show that the EU (incl. UK) seem to be on the upper level of labour costs and on the lower level of the GOR, which pose major challenges when it comes to competitiveness and profitability.

## 2.2.7 Investment

Investment is indispensable to promote technological progress and increase productivity, therefore being an important driver of long-term growth and competitiveness. In 2017, the whole engineering sector was investing about € 66,400 Mio in tangible goods. Most gross investments (35%) were taken by the sector manufacturing of fabricated metal products, which also exhibits the highest annual gain in investments (5.3% annually within the past five years). The manufacturing of machinery and equipment also exhibits high sums of investments in goods (30%). Growth investments of the sector manufacture of computer, electronic and optical products were declining in real terms over the last decade.

**Table 2-27: Gross and net investments in tangible goods by sectors of engineering industries**

|                                                           | 2017<br>(value in Mio<br>EUR) | Average<br>annual change<br>08-13 in % | Average<br>annual change<br>13-17 in % |
|-----------------------------------------------------------|-------------------------------|----------------------------------------|----------------------------------------|
| <b>Gross investments in tangible goods</b>                |                               |                                        |                                        |
| Fabricated metal products, except machinery and equipment | 23,322                        | -5.2                                   | 5.3                                    |
| Computer, electronic and optical products                 | 8,550                         | -0.6                                   | -2.2                                   |
| Electrical equipment                                      | 10,000                        | -2.2                                   | 3.7                                    |
| Machinery and equipment n.e.c.                            | 19,601                        | -5.6                                   | 2.6                                    |
| Repair and installation of machinery and equipment        | 4,930                         | -0.2                                   | 4.7                                    |
| <b>Engineering industry</b>                               | <b>66,403</b>                 | <b>-4.0</b>                            | <b>3.1</b>                             |
| <b>Net investments in tangible goods</b>                  |                               |                                        |                                        |
| Fabricated metal products, except machinery and equipment | 20,200                        | -5.1                                   | 6.3                                    |
| Computer, electronic and optical products                 | 7,000                         | 0.4                                    | -1.5                                   |
| Electrical equipment                                      | 7,400                         | -2.0                                   | -0.1                                   |
| Machinery and equipment n.e.c.                            | 15,400                        | -10.1                                  | 7.4                                    |
| Repair and installation of machinery and equipment        | 1,900                         | 0.1                                    | -12.4                                  |
| <b>Engineering industry</b>                               | <b>51,900</b>                 | <b>-5.1</b>                            | <b>3.4</b>                             |

Note: annual changes in 2015 prices.

Source: Eurostat, Structural Business Statistics Database, Status: August 2020

Table 2-28 displays for the EU (incl. UK) the amount invested per each person employed in thousand Euros. On EU level, investments per employee range between € 8,000 (Manufacture of computer, electronic and optical products) and € 3,900 (Repair and installation of machinery and equipment), and are lower than those of the overall manufacturing (€ 8,900). However, there is wide variation also within countries: For example, investments in manufacturing of computer and electronic products in Austria are almost double as high as for the EU average value, whereas Croatia holds the lowest value (€ 2,300).

**Table 2-28: Investment per person employed by EU countries (incl. UK) and engineering sectors, 2017**

|                      | Investments in thousand Euro (2017) |            |            |            |            |            |            |
|----------------------|-------------------------------------|------------|------------|------------|------------|------------|------------|
|                      | C                                   | C25        | C26        | C27        | C28        | C32.5      | C33        |
| Belgium              | 19.4                                | 11.5       | 9.2        | 8.7        | 8.7        | 8.7        | 5.4        |
| Bulgaria             | 3.9                                 | 3.0        | 4.9        | 5.3        | 3.1        | :          | 1.6        |
| Czech Republic       | 6.6                                 | 5.5        | 7.4        | 6.4        | 5.0        | 3.1        | 3.5        |
| Denmark <sup>1</sup> | 12.1                                | 7.1        | 7.4        | 7.6        | 10.0       | 5.8        | 3.4        |
| Germany              | 8.9                                 | 5.9        | 9.3        | 6.4        | 6.7        | 4.5        | 2.7        |
| Estonia              | 5.4                                 | 4.1        | 6.8        | 3.5        | 5.3        | 4.1        | 3.8        |
| Ireland              | 5.0                                 | 1.2        | :          | 0.6        | :          | :          | :          |
| Greece               | 4.9                                 | 3.2        | 9.4        | 4.1        | 1.9        | 0.7        | 1.3        |
| Spain                | 9.6                                 | 6.0        | 5.2        | 9.3        | 5.9        | 5.8        | 3.2        |
| France               | 11.4                                | 8.6        | 8.2        | 9.1        | 8.6        | 8.7        | 7.9        |
| Croatia              | 4.0                                 | 2.3        | 2.3        | 3.2        | 3.7        | 0.9        | 1.0        |
| Italy                | 8.2                                 | 7.5        | 7.9        | 7.1        | 6.3        | 6.1        | 2.6        |
| Cyprus               | 4.8                                 | 1.9        | :          | :          | 4.9        | 1.8        | 6.5        |
| Latvia               | 4.4                                 | 4.0        | :          | 3.4        | 4.6        | 3.6        | 6.4        |
| Lithuania            | 4.6                                 | 5.2        | 3.3        | 3.2        | 3.8        | :          | 2.5        |
| Luxembourg           | 12.2                                | 5.7        | :          | 8.9        | 8.4        | 2.0        | 9.0        |
| Hungary              | 8.6                                 | 5.1        | 10.9       | 5.3        | 5.3        | 8.1        | 2.6        |
| Malta                | :                                   | 3.6        | :          | 3.0        | :          | :          | 3.2        |
| Netherlands          | 12.5                                | 7.3        | 8.8        | 8.4        | 7.0        | 3.7        | 9.6        |
| Austria              | 11.4                                | 10.3       | 15.4       | 7.9        | 6.8        | 3.8        | 3.7        |
| Poland               | 5.9                                 | 4.0        | 3.8        | 5.9        | 4.4        | 3.5        | 2.3        |
| Portugal             | 7.7                                 | 6.6        | 13.4       | 6.4        | 7.5        | 3.1        | 3.2        |
| Romania              | 5.8                                 | 4.4        | 5.5        | 6.5        | 5.9        | 1.7        | 1.4        |
| Slovenia             | 8.1                                 | 7.1        | 5.1        | 8.3        | 7.5        | 2.9        | 2.6        |
| Slovakia             | 8.3                                 | 4.0        | 8.2        | 6.5        | 6.3        | 4.7        | 2.4        |
| Finland              | 14.3                                | 7.4        | 9.8        | 4.8        | 4.7        | 3.7        | 2.7        |
| Sweden               | 13.4                                | 6.3        | 6.7        | 5.5        | 5.9        | 6.4        | 3.0        |
| United Kingdom       | 9.6                                 | 6.5        | 5.6        | 4.9        | 5.6        | 8.1        | 5.3        |
| <b>EU-27 + UK</b>    | <b>8.9</b>                          | <b>6.2</b> | <b>8.0</b> | <b>6.7</b> | <b>6.4</b> | <b>5.3</b> | <b>3.9</b> |

<sup>1</sup> 2016 values: not available

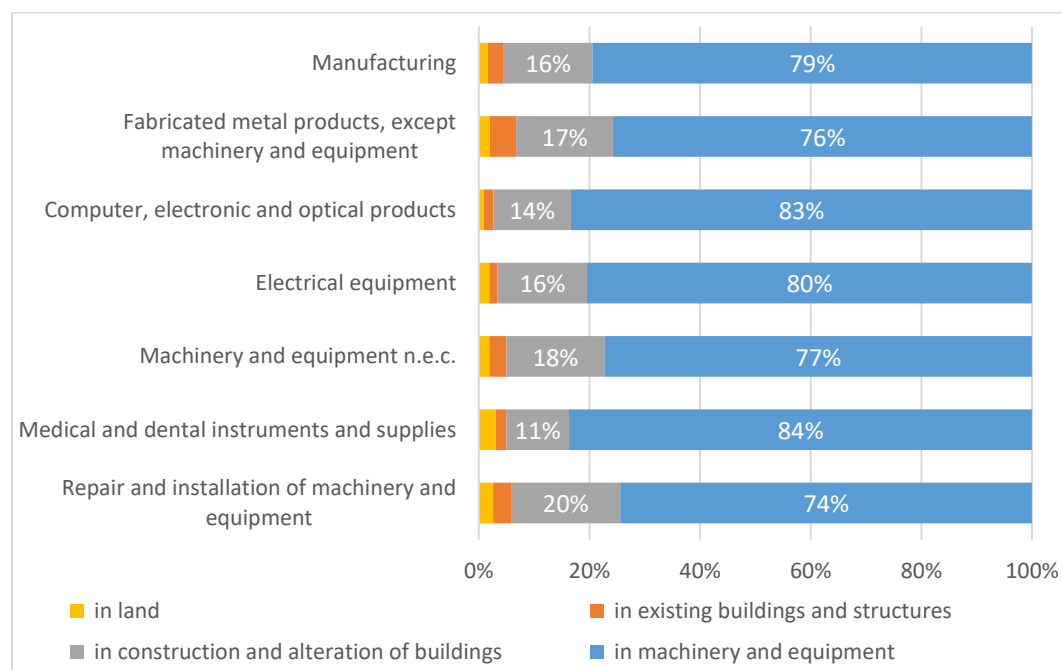
C: Manufacturing, C25: Fabricated metal products, C26: Computer, electronic and optical products, C27: Electrical equipment, C28: Machinery and equipment, C32.5: Medical and dental instruments, C33: Repair and installation of machinery and equipment

Source: Eurostat, Structural Business Statistics Database, Status: August 2020

The following figure illustrates that the vast majority (around 80%) of all gross investments flow into machinery and equipment. This pattern holds for all engineering sectors, the share being lowest (74%) for repair and installation. Gross investments in land are 2%, those in existing buildings and structures 3% across all engineering sectors.

Investments in construction and alteration of buildings vary between 11% (manufacture of medical and dental instruments) and 20% (Repair and installation of machinery and equipment).

**Figure 2-38: Gross investments flows by engineering sectors, 2017**



Source: Eurostat, Structural Business Statistics Database, Status: August 2020

## 2.2.8 Foreign Direct Investment and Mergers & Acquisitions (M&A)

### 2.2.8.1 Foreign Direct Investment (FDI)

Foreign direct investment (FDI) is a category of cross-border investment in which an investor resident in one economy establishes a lasting interest in and a significant degree of influence over an enterprise resident in another economy. Such an interest is formally deemed to exist when a direct investor owns 10% or more of the voting power on the board of directors (for an incorporated enterprise) or the equivalent (for an unincorporated enterprise).<sup>64</sup>

FDI is a key element in international economic integration because it creates stable and long-lasting links between economies. FDI is an important channel for the transfer of technology between countries, promotes international trade through the access to foreign markets, and can be an important vehicle for economic development. By contributing to economic growth, job creation and integration in global value chains, foreign investment tends to benefit host countries as well as home countries.<sup>65</sup> In general, high inward FDI indicates a high location competitiveness, especially when it comes to greenfield investments. However, there are also potential drawbacks of FDI, e.g. the repatriation of profits, effects on competition in national markets, or an increasing dependence on internationally operating enterprises that comes with a perceived loss of political sovereignty of host country authorities.

<sup>64</sup> Definition of FDI as used, for instance, at Eurostat and OECD.

<sup>65</sup> [https://www.oecd-ilibrary.org/finance-and-investment/foreign-direct-investment-fdi/indicator-group/english\\_9a523b18-en](https://www.oecd-ilibrary.org/finance-and-investment/foreign-direct-investment-fdi/indicator-group/english_9a523b18-en); <https://ec.europa.eu/trade/policy/accessing-markets/investment/>, queried June 2020

Since 2009, the EU handles foreign direct investment policies on behalf of the EU Member States. In 2012, the EU adopted a regulation creating a set of rules for bilateral investment agreements between individual EU members and non-EU countries, to make sure that they are consistent with EU law and with the EU's investment policy. The Regulation sets the conditions for applying the more than 1,400 bilateral investment agreements currently in force, as well as the conditions for EU members to modify existing agreements and negotiate or conclude new ones.<sup>66</sup>

The annual IBM reports on Global Location Trends (e.g. 2013-2019) survey trends in corporate location selection, i.e. where companies are locating and expanding their businesses and creating jobs around the world. The analysis shows that the international economic landscape is being fundamentally changed by so called key transformative drivers of a new global economy that lead to a transformation of corporate activity and economic globalisation and therefore influencing investment considerations (IBM Institute for Business Value, 2019):<sup>67</sup>

- **Changing trade regimes and trade uncertainty:** This refers in particular to adaptations of trade between the US and other major economic areas like China and the EU that result in trade-inhibiting measures such as increased tariffs and concomitant retaliations. The reconfiguration of trading relationships pursued by the US, along with the associated emphasis on national economic interests, may also have contributed to a marked change in investment activity by US companies. Furthermore, there have been challenges in concluding trade agreements between the EU and some other countries, such as the US. Changing trade regimes have an impact on the capability of companies to leverage global supply chains.
- **Digital disruption:** Digital disruption is changing how and where value creation takes place. As companies respond to opportunities brought by digital technologies and automation, the job-intensity and the average size of investment projects decreases gradually year-on-year. Consequently, the average number of jobs created per investment project globally in 2018 was approximately 84, as compared to 104 in 2014. Moreover, the majority of the reduction in investment is in production and shared service centres, where the adoption of new technologies and automation has been particularly pronounced.
- **Brexit:** The uncertainty around Brexit and the new relations of the UK with the EU-27 has had significant implications for investment patterns in Europe and the UK in particular. Inward investment to the UK declined substantially in 2018, notably measured by the number of jobs created (-29%), but also in terms of the number of projects (-17%). The reduced investment was particularly pronounced in some sectors and economic activities, such as manufacturing, R&D, and international headquarters.

In light of these drivers, a transformation of corporate activity and economic globalisation can be observed. These impacts are changing the patterns of global corporate investment activity as well as companies' decisions to establish and expand operations across different locations. As a result of these changes, it has been observed that global foreign direct investment continues to decline.

According to the following figure, 2018 saw a decline in overall international investment activity to 1.06 million, with the number of overall jobs created falling by 9%. According to IBM Business Value (2019), the overall reduction in the number of jobs created is partly explained by the structural shift in investment activity. As companies respond to opportunities brought by digital technologies and automation, a gradual reduction in the average size of investment projects can be observed. The reduced investment is also a result of uncertainty surrounding potential trade tensions as well as regional or local disruptive events, such as Brexit. However, it is also important to emphasize that the

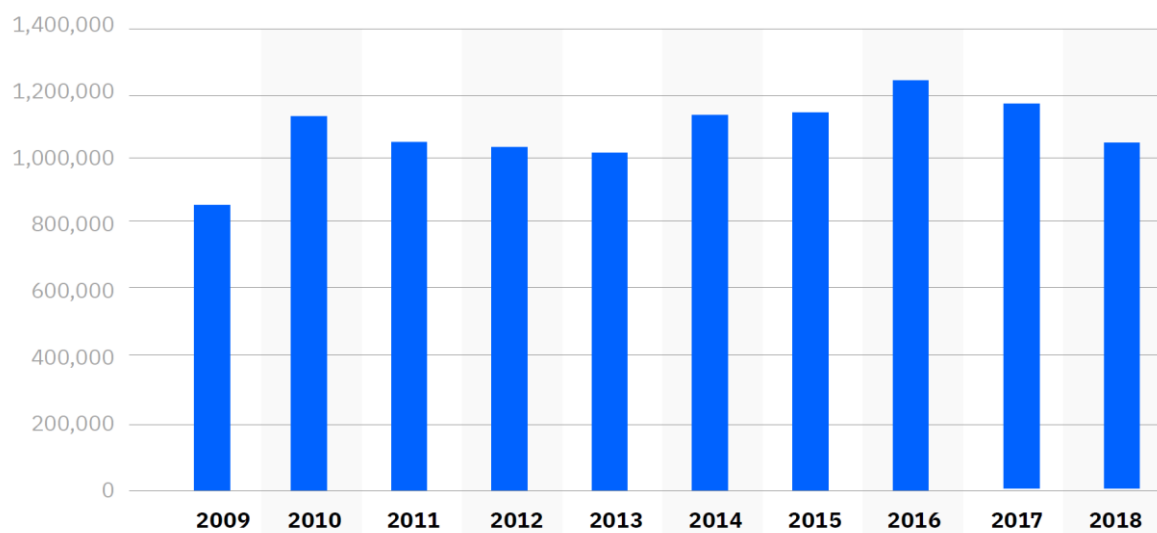
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<sup>66</sup> Ibid.

<sup>67</sup> The impact of Covid-19 on investment decisions is analysed at the end of this chapter.

investment declines in the last couple of years have followed a period of growth, with a peak in international investment activity in 2016. The lower levels of investment in 2018 may therefore also be partly due to saturation. Many companies have made major investments in previous years and have established the capacity they need for their immediate growth plans.

**Figure 2-39: New foreign investment activity in number of jobs worldwide, 2009-2018**



Source: IBM Institute for Business Value (2019): Global Location Trends 2019, p. 1

The transport equipment sector, which is dominated by the automotive industry, has experienced a significant decline in overall investment and job creation and is second behind hospitality and tourism in 2018 after ranking 1<sup>st</sup> every year since the start of the Global Location Trends series in 2003.

The lower level of international investment reflects a wider transformation of the sector, as customers and companies are moving toward new and more environmentally sustainable mobility options, such as electric vehicles. As part of this transformation, companies are reassessing their future business models and operations and are taking a step back to consider their options before adding major new capacity to their operating footprints.

The ICT sector ranks 3<sup>rd</sup> in job creation in 2018, while being the leading source of global investment when measured by the number of projects, highlighting the prominent role of digital technologies in the global economy.

**Table 2-29: Top-ranking sectors by job creation, worldwide, 2013-2018**

| Rank 2018 | Rank 2013 | Sectors                    | Estimated jobs created |
|-----------|-----------|----------------------------|------------------------|
| 1         | 2         | Hospitality and tourism    | 165,000                |
| 2         | 1         | <b>Transport equipment</b> | <b>145,000</b>         |
| 3         | 7         | <b>ICT</b>                 | <b>90,000</b>          |
| 4         | 5         | Business services          | 70,000                 |



| Rank 2018 | Rank 2013 | Sectors                                   | Estimated jobs created |
|-----------|-----------|-------------------------------------------|------------------------|
| 5         | 3         | Chemicals                                 | 60,000                 |
| 6         |           | Textile and clothing                      | 55,000                 |
| 7         | 8         | Wholesale and retail                      | 55,000                 |
| <b>8</b>  | <b>10</b> | <b>Electrical equipment</b>               | <b>50,000</b>          |
| <b>9</b>  | <b>4</b>  | <b>Electronics</b>                        | <b>49,000</b>          |
| 10        | 6         | Food and beverage                         | 49,000                 |
| -         | <b>9</b>  | <b>Industrial machinery and equipment</b> | <b>-</b>               |

Note: " - " not listed among the top-ranking sectors or destination countries in 2018

Source: IBM Institute for Business Value (2019): Global Location Trends 2019 (p. 3 ff) and 2014 (p. 3 and 9)

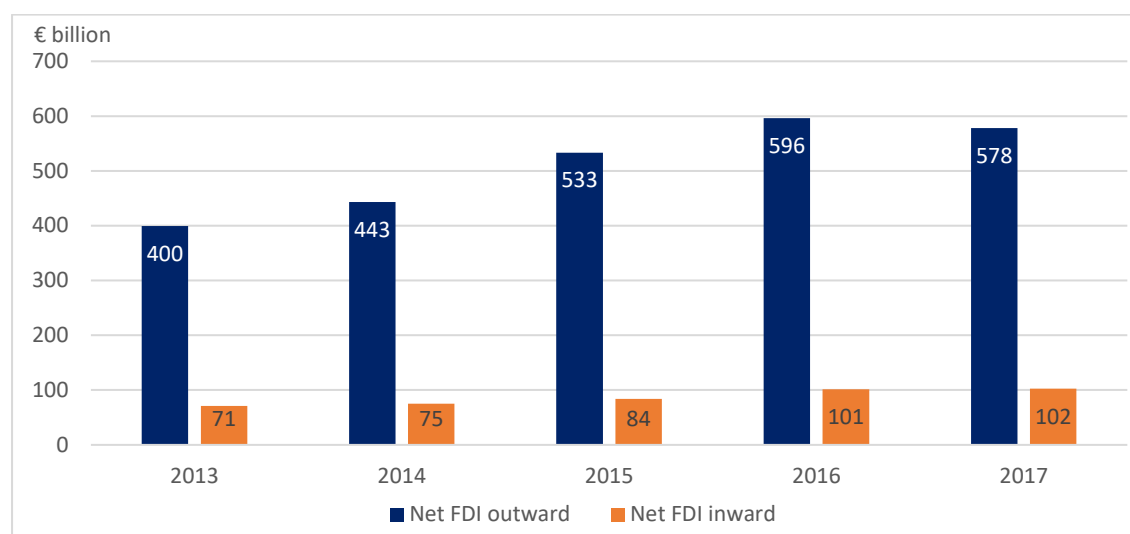
The EU (incl. UK) is the world's main provider and the top global destination of foreign investment. According to the IBM Global Location Trends Monitor (2019), Europe saw an overall decrease of 9% in job creation from foreign investment in 2018. As regards the number of jobs created caused by inward investment, the UK saw dramatic declines but managed to remain number one in Europe. However, as regards the number of projects received, Germany is the top destination country in Europe. Further important countries in Europe for inward direct investment are France and Poland, creating a leading group of four countries considerably ahead of the rest of Europe. Other European countries that experienced considerable growth both in jobs and in the number of projects include Belgium, Ireland, and Serbia, which all recorded the highest levels of inward investment in the last 10 years.

In total, according to Eurostat, the EU as an investor (incl. UK) holds € 7,820 billion **net outward FDI stock**<sup>68</sup> in Non-EU countries at the end of 2018. 31% of the outward FDI stock goes to manufacturing. The share of engineering industries is approximately 7.5% of all outward FDI stock, with computer, electronic and optical products holding 4.1%, machinery and equipment holding 2.1%, and metals and fabricated metal products holding 1.3%.

In return, the **net inward FDI stock** in the EU (incl. UK) held by third country investors amounts to € 6,760 billion at the end of 2018. The share that goes into manufacturing is 13%, which is less than half of the share of manufacturing in the outward FDI stock. Also, the share of investments going into the engineering industries is smaller (1.5%), with 0.9% going into machinery and equipment, and 0.3% each going to computer, electronic and optical products as well as metals and fabricated metal products. Throughout the 2013-2017 period, the net outward FDI stock has been approx. 6 times higher than the net inward FDI stock.

<sup>68</sup> According to Eurostat, FDI positions provide information on the total stock of investment (abroad and in the reporting economy) for a given reference date which is generally the end of the year. FDI positions data are useful for structural analysis of investment in the host economy, or investment in the investing (home) country, especially to establish the relative FDI importance/presence of an economy in another one.

**Figure 2-40: Development of net outward and net inward FDI stock in engineering industries<sup>1</sup>, EU (incl. UK) to/from Extra-EU, 2013-2017<sup>2</sup>**



Note:

Net outward FDI: value of total Direct investment abroad (DIA); EU (incl. UK) to Extra-EU countries

Net inward FDI: value of total Direct investment in the reporting economy (DIRE); Extra-EU countries to EU (incl. UK)

<sup>1</sup> Engineering industries: NACE Rev.2 C24\_25, C26, C28 (no data available: C27, C32.5 and C33)

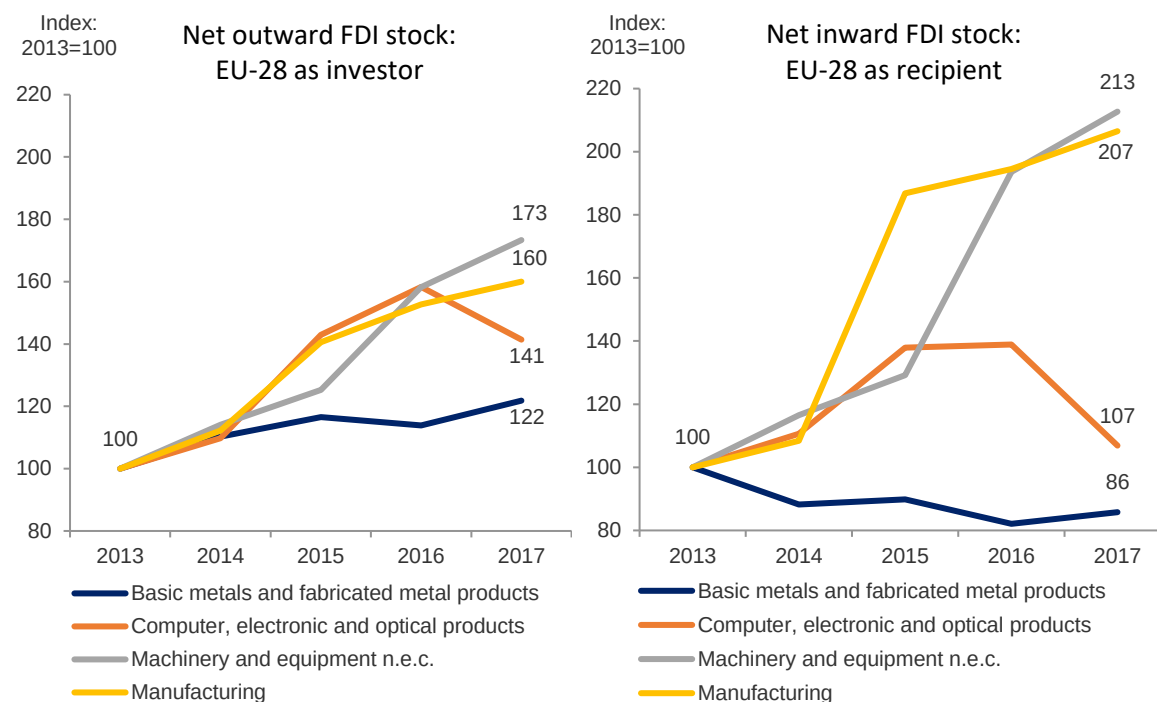
<sup>2</sup> For FDI stock by sectors, the latest year available is 2017

Source: Eurostat, European Union direct investments (BPM6), [bop\_fdi6\_pos], Status: August 2020

The following figure shows the development of net outward and inward FDI stocks of single engineering sectors from 2013 onwards. As regards the net outward FDI stock of the EU as an investor (incl. UK), the development of manufacturing increased by 60% from 2013 (data from 2008 to 2012 are not available for BPM6). Machinery and equipment showed the highest increase in outward FDI stock, with 73% above the value of 2013. The outward FDI stock in the field of computer, electronic and optical products developed very positive until 2016, with a decrease in 2017 – however, the value of FDI stock was still 41% above 2013. The outward FDI stock in basic metals and fabricated metal products developed moderately, with a value of +22% in 2017 as compared to 2013.

The inward FDI stock development is more dynamic than the outward FDI stock development. A considerable increase has arisen in the field of machinery and equipment between 2013 and 2017 (+113%). The investment stock in the field of computer, electronic and optical products increased until 2015, stagnated in 2016, and showed a decline in 2017, while the inward investments in basic metals and fabricated metal products declined between 2013 and 2017.

**Figure 2-41: Development of net outward and net inward FDI stock in engineering industries<sup>1</sup>, EU (incl. UK) to/from Extra-EU, 2013-2017<sup>2</sup>**



Note:

Net outward FDI: value of total Direct investment abroad (DIA); EU (incl. UK) to Extra-EU countries

Net inward FDI: value of total Direct investment in the reporting economy (DIRE); Extra-EU countries to EU (incl. UK)

<sup>2</sup> For FDI stock by sectors, the latest year available is 2017

Source: Eurostat, European Union direct investments (BPM6), [bop\_fdi6\_pos], Status: August 2020

Outward FDI (EU as an investor, incl. the UK) in the field of engineering does not evenly distribute over the target economies –the highest net outward FDI stock is located in the US (value: € 187 billion), followed by Switzerland (€ 94 billion) and China except Hong Kong (€ 32 billion). FDI in these three countries is concentrated in the manufacture of computer, electronic and optical products. Other countries with a strong focus on computer, electronic and optical products are South Korea and Hong Kong.

Brazil ranks fourth in the list of target economies for outward FDI (€ 27 billion). FDI is mainly focused on basic metals and fabricated metal products. This is also the case for investments to Canada (in total € 10 billion in engineering industries) and Japan (in total € 8 billion).

Approximately € 12 billion of net outward FDI stock is located in India and € 10 billion in Russia. Here, most of the investments are in machinery and equipment. Further important countries for machinery and equipment investments are Switzerland, China, South Korea and Hong Kong.

**Table 2-30: Top target economies for net outward FDI stock from the EU(incl. UK) and top source economies for net inward FDI stock to EU(incl. UK) in the engineering industries<sup>1</sup>, 2017<sup>2</sup>**

| Rank | Net outward FDI stock: Top target economies | Value 2017 in € million | Rank | Net inward FDI stock: Top source economies | Value 2017 in € million |
|------|---------------------------------------------|-------------------------|------|--------------------------------------------|-------------------------|
| 1    | United States                               | 187,458                 | 1    | United States                              | 23,878                  |
| 2    | Switzerland                                 | 94,157                  | 2    | Switzerland                                | 18,884                  |
| 3    | China except Hong Kong                      | 31,815                  | 3    | Japan                                      | 13,561                  |
| 4    | Brazil                                      | 26,789                  | 4    | Hong Kong                                  | 6,245                   |
| 5    | India                                       | 11,605                  | 5    | Brazil                                     | 4,134                   |
| 6    | Russia                                      | 10,316                  | 6    | South Korea                                | 2,256                   |
| 7    | Canada                                      | 9,984                   | 7    | Canada                                     | 2,174                   |
| 8    | Japan                                       | 7,794                   | 8    | China except Hong Kong                     | 783                     |
| 9    | South Korea                                 | 4,504                   | 9    | India                                      | 14                      |
| 10   | Hong Kong                                   | 2,974                   | 10   | Russia                                     | -149                    |
|      | <b>To Extra-EU total</b>                    | <b>578,389</b>          |      | <b>From Extra-EU total</b>                 | <b>102,376</b>          |

Note:

Net outward FDI: value of total Direct investment abroad (DIA); EU (incl. UK) to Extra-EU countries

Net inward FDI: value of total Direct investment in the reporting economy (DIRE); Extra-EU countries to EU (incl. UK)

<sup>1</sup> Engineering industries: NACE Rev.2 C24\_25, C26, C28 (no data available: C27, C32.5 and C33)

<sup>2</sup> Latest data available

Source: Eurostat, European Union direct investments (BPM6), [bop\_fdi6\_pos], Status: August 2020

As regards the net inward FDI stock, again the US is the biggest investor in the EU (incl. the UK) with approx. €24 billion, going in particular into the computer, electronic and optical products sector. Other important source economies for this sector are Hong Kong, China and South Korea.

Switzerland ranks second with € 19 billion investments in the EU, investing mostly in machinery in equipment, which in common with Japan, ranks third with € 14 billion. Another important source economy for inward FDI in this sector is Canada.

Brazil invests in total approximately. € 4 billion in the EU engineering industries, above all in metals and fabricated metal products. This sector also receives investments from India and Russia.

The following table shows the world's top non-financial multinational enterprises (MNEs) ranked by their foreign assets, in the engineering industries. Out of the 100 Top MNEs with considerable foreign assets (see column "Rank"), 17 are in the field of engineering industries. Some of the big European companies are listed, such as Siemens (Germany) in the field of industrial/commercial machinery, as well as Robert Bosch GmbH and Schneider Electric in the field of electrical engineering. The companies Medtronic plc (instruments and related products), ArcelorMittal (metals and metal products) and Johnson Controls Intern. PLC (electric equipment) have relocated their headquarters to Europe (mainly due to tax reasons), but are originally from the US (Medtronic plc, Johnson

Controls Intern. PLC) and from India (ArcelorMittal). The European companies have in common a Transnationality Index (TNI) of at least 66%.

**Table 2-31: World's top non-financial MNEs in engineering industries, ranked by foreign assets, 2018**

| Rank <sup>1</sup> | Corporation                                       | Home economy                      | Industry <sup>2</sup>                    | Foreign assets in \$ million | TNI <sup>3</sup> in % |
|-------------------|---------------------------------------------------|-----------------------------------|------------------------------------------|------------------------------|-----------------------|
| 4                 | Softbank                                          | Japan                             | Telecommunications                       | 240,305                      | 66                    |
| 12                | Apple Computer Inc                                | US                                | Computer Equipment                       | 153,545                      | 49                    |
| 16                | General Electric Co                               | US                                | Industrial / Commercial Machinery        | 134,637                      | 57                    |
| <b>17</b>         | <b>Siemens AG</b>                                 | <b>Germany</b>                    | <b>Industrial / Commercial Machinery</b> | <b>133,891</b>               | <b>66</b>             |
| 27                | Microsoft Corporation                             | US                                | Computer and Data Processing             | 114,648                      | 45                    |
| 31                | Hon Hai Precision Industries                      | Taiwan                            | Electronic components                    | 106,644                      | 93                    |
| 36                | Medtronic plc                                     | USA (headquarter in Ireland)      | Instruments and related products         | 88,435                       | 98                    |
| 39                | Samsung Electronics Co., Ltd.                     | South Korea                       | Communications equipment                 | 84,717                       | 53                    |
| 44                | ArcelorMittal                                     | India (headquarter in Luxembourg) | Metals and metal products                | 77,897                       | 83                    |
| 54                | International Business Machines Corporation (IBM) | US                                | Computer and Data Processing             | 68,772                       | 55                    |
| 68                | Intel Corporation                                 | US                                | Electronic components                    | 56,080                       | 58                    |
| <b>70</b>         | <b>Robert Bosch GmbH</b>                          | <b>Germany</b>                    | <b>Electrical engineering</b>            | <b>55,161</b>                | <b>68</b>             |
| 88                | Johnson Controls Intern. PLC                      | USA (headquarter in Ireland)      | Electric equipment                       | 45,302                       | 81                    |
| 89                | Sony Corporation                                  | Japan                             | Consumer electronics                     | 45,051                       | 50                    |
| <b>90</b>         | <b>Schneider Electric</b>                         | <b>France</b>                     | <b>Electrical engineering</b>            | <b>44,894</b>                | <b>92</b>             |
| 92                | Oracle Corporation                                | US                                | Computer and Data Processing             | 44,576                       | 50                    |
| 98                | China Minmetals Corp (CMC)                        | China                             | Metals and metal products                | 42,790                       | 21                    |

<sup>1</sup> rank among the world's top 100 MNEs according to foreign assets

<sup>2</sup> Industry classification for companies follows the United States Standard Industrial Classification as used by the United States Securities and Exchange Commission (SEC).

<sup>3</sup> TNI, the Transnationality Index, is calculated as the average of the following three ratios: foreign assets to total assets, foreign sales to total sales and foreign employment to total employment.

Source: UNCTAD. World Investment Report, Annex table 19. The world's top 100 non-financial MNEs, ranked by foreign assets, 2018, modified by DECISION

In 2020, global FDI are severely impacted by the Covid-19 pandemic that has hit the globe since the end of 2019 and that has altered fundamentally the global economy. According to the most recent Unctad Investment Trends Monitor (3a and 3b, 2020), the automotive MNEs in the Top 100 appear to be most affected by the Covid-19 impact, with all 12 signalling negative implications (8 out of 12 due to production or supply chain disruptions). Nine out of 13 MNEs in the electronic components and equipment sectors have done the

same. Most of the extractive industry and basic materials and chemicals MNEs, as well as the consumer goods firms in the top 100, have issued warnings about negative demand shocks. To date (end of March 2020), concrete profit warnings have been issued by 23 of the Top 100 MNEs as a direct result of the Covid-19 outbreak. Most concern the consumer-facing firms, indicating that the demand shock, for now, is expected to have more direct effects on earnings than production or supply chain disruptions.

The majority of the top 5,000 (by revenues) have had earnings revisions since 1 February 2020 (until 5 March); expected earnings were revised downwards especially in the energy, basic materials and consumer cyclical sectors; the automotive and the travel and tourism industries have been among the worst hit. Companies in these sectors and industries are normally important investors.

**Table 2-32: Earnings revisions and capital expenditures of the top 5,000, March 2020**

| Sector / industry             | Number of companies with earnings revisions | Average earnings revision in % | Share of capital expenditures in % |
|-------------------------------|---------------------------------------------|--------------------------------|------------------------------------|
| Basic materials               | 389                                         | -13                            | 8                                  |
| Consumer Cyclicals            | 671                                         | -16                            | 16                                 |
| Airlines                      | 45                                          | -42                            | 2                                  |
| Hotels, restaurants & leisure | 111                                         | -21                            | 2                                  |
| Consumer Non-Cyclicals        | 351                                         | -4                             | 6                                  |
| Energy                        | 243                                         | -13                            | 20                                 |
| Healthcare                    | 195                                         | 0                              | 3                                  |
| Industrials                   | 739                                         | -9                             | 14                                 |
| Automobiles & Auto Parts      | 142                                         | -44                            | 9                                  |
| Technology                    | 358                                         | -3                             | 11                                 |
| Telecommunication Services    | 105                                         | 1                              | 11                                 |
| Utilities                     | 175                                         | -5                             | 10                                 |
| Total                         | 3,226                                       | -9                             | 100                                |

Note: Top 5,000 public companies that had at least one revision of earnings forecast for the fiscal year 2020 since 1 February 2020. A few outliers (5 in total) were excluded as extreme revisions of earnings that were driven by idiosyncratic factors not related to Covid-19.

Source: UNCTAD, based on data from Refinitiv SA, 2020

### **2.2.8.2 Mergers & acquisitions (M&A)**

There are two kinds of FDI: the creation of productive assets by foreigners, or the purchase of existing assets by foreigners, e.g. through acquisitions, mergers or takeovers).<sup>69</sup> The following chapter deals with mergers & acquisitions and tries to break down relevant M&As for the engineering industries.

Any proposed merger must be notified to the European Commission for examination, if the annual turnover of the combined businesses exceeds specified thresholds in terms of global and European sales.<sup>70</sup> Below these thresholds, the national competition authorities in the EU Member States may review the merger. These rules apply to all mergers no matter where in the world the merging companies have their registered office, headquarters, activities or production facilities. This is so because even mergers between

<sup>69</sup> Definition used at Eurostat

<sup>70</sup> [https://ec.europa.eu/competition/mergers/overview\\_en.html](https://ec.europa.eu/competition/mergers/overview_en.html), queried 06 June 2020

companies based outside the European Union may affect markets in the EU if the companies do business in the EU. The European Commission may also examine mergers, which are referred to it from the national competition authorities of the EU Member States.

There are also some critical views on the merger control of the European Commission, mainly citing that prohibited mergers may result in European companies not big enough to be able to compete on the global market and that this lack of size may become a competitiveness issue at some point.

According to the mergers database from the European Commission<sup>71</sup>, between 2008 and 2020, approx. 560 mergers in the field of engineering industries have been notified to and decided by the European Commission. Of these, the majority has been compatible with the EC Merger Regulation, 45 have been permitted with conditions and obligations, and 11 have been withdrawn.

Most mergers in the engineering industries that were notified to the European Commission were in the field of machinery and equipment (150), followed by computer, electronic and optical products (122), electrical equipment (102), metal products (80), repair and installation of machinery and equipment (66) and medical devices (41).

The Institute for Mergers, Acquisitions and Alliances (IMAA) research provides data on M&A worldwide. The data reach from 1985 to 2020, indicating that the most important acquirer industries are in particular financials, banks, oil and gas.<sup>72</sup> These three industries constitute approx. one third of all 10,000 M&A registered. The first engineering industry enters the list on rank 7, i.e. metals & mining (in total 350 cases since 1985), followed by ranks 16 to 18 automobiles & components (150), computers & peripherals (143) and cable (140). Semiconductors (113) and software (109) rank 22<sup>nd</sup> and 23<sup>rd</sup>, while machinery ranks 30<sup>th</sup> (85) and electronics ranks 37<sup>th</sup> (62).

Among the top 10 acquirer countries, 5 out of ten are European countries, i.e. UK, France, Germany, Italy, Spain and Netherlands, while the other countries are the US, China, Canada, Japan and Australia, with the US ranking 1<sup>st</sup> with seven times more acquisitions (in total 4,700) than the second ranked UK (in total 775) throughout the time period since 1985.

Among the worldwide top deals since 2008, only very few M&A can be attributed to the (wider) engineering industries. For example, in 2009, Vehicle Acq Holdings LLC acquired the multinational motor vehicle and vehicle parts company General Motors-Cert Assets for a value of € 39 billion, continuing the activities of the American multinational corporation under the name of General Motors Company LLC (or New GMC). In the field of computer technology, in 2015, Dell Inc, a US based hard- and software technology company acquired competitor EMC Corp for a value of € 51 billion.

Among the top deals in Europe since 2008, one big merger refers to the medical technology company Medtronic Inc (USA, but headquarters relocated to Ireland) acquiring the company Covidien PLC (Ireland) in the field of medical devices for a value of € 31.56 billion in 2014.

There have been other crucial developments in Europe, for instance in the field of **semiconductors**: The Dutch manufacturer NXP Semiconductors spin off from Philips in 2006 and then merged with the US manufacturer Freescale Semiconductor Inc. in 2015. In 2016, Qualcomm, a US manufacturer of telecommunications equipment and

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<sup>71</sup> [https://ec.europa.eu/competition/elojade/isef/index.cfm?fuseaction=dsp\\_merger\\_ongoing](https://ec.europa.eu/competition/elojade/isef/index.cfm?fuseaction=dsp_merger_ongoing), queried 26 May 2020, available data include only company name and NACE code, but not country information

<sup>72</sup> <https://imaa-institute.org/>, queried 26 May; overview data are available only on an aggregated level from 1985 to 2020.



semiconductors, announced the plan to buy NXP Semiconductors. China did not approve the acquisition, which was ultimately cancelled in 2018. Other examples include the acquisition of the British microprocessor design company ARM<sup>73</sup> by the Japanese telecommunications conglomerate Softbank in 2016, or the acquisition of the US power semiconductor company International Rectifier Corporation (IRC) by the German semiconductor manufacturer Infineon Technologies in 2015. Infineon also bought the US semiconductor design and manufacturing company Cypress Semiconductor Corporation in April 2020.

Also further relevant deals in the field of **other electronics** are related to Philips (Netherlands). In 2016, the lighting division (one of the largest in the world) spun off into an independent company called Philips Lighting N.V., which was renamed Signify N.V. in 2018. In 2016, Lumileds, a business unit of Philips Lighting focussing on the development, manufacture and distribution of LEDs, light bulbs, and related products for automotive lighting, general lighting, and specialty lighting, was sold to the investment group Apollo Global Management (with Philips retaining a 19.9% share). An initial plan to sell Lumileds to a China-led private equity consortium was blocked by the Committee on Foreign Investment in the United States (CFIUS), which decided that the deal represented a national security risk.<sup>74</sup> Already in 2011, Philips outsourced their television activities that were merged into a joint venture with TPV (a Chinese Hong Kong company), who took over the activity in 2014, becoming one of the leading global TV companies.

In the field of **electrical engineering**, the following crucial deals / plans have to be mentioned: In 2015, the French electrical engineering company Alstom agreed to sell its power and grid divisions to the US company General Electric (GE) through establishment of joint ventures, which were then fully acquired by General Electric in 2018. In 2017, Alstom Rail and Siemens Mobility (Germany) proposed a merger to compete with the China Railway Rolling Stock Corporation (CRRC) on the world rail transport market. In February 2019, the European Commission prohibited this merger. In February 2020, Alstom signed a Letter of Agreement to purchase the entire rail transportation division of the Canadian manufacturer Bombardier. In July 2020, the European Commission officially approved the sale of Bombardier Transportation to Alstom and is officially expected to close in the first half of 2021.<sup>75</sup>

In the field of **robotics**, in 2016, the Chinese company Midea (consumer appliances) acquired KUKA, a German manufacturer of industrial robots and solutions for factory automation, which ranks among the top key players in the global industrial robotics market (e.g. Fanuc, Yaskawa Electric, ABB, Kawasaki Heavy Industries, Nachi-Fujikoshi). Germany had tried to fend off in vain the takeover of KUKA by the Chinese company in order to prevent future-oriented technology from migrating from Germany to China and to keep value creation and research in Europe. End of 2016, US authorities CFIUS (Committee on Foreign Investment in the United States) and DDTTC (Directorate of Defense Trade Controls) approved the sale of KUKA to Midea. The KUKA board of directors had concluded an investor agreement with Midea according to which the company is guaranteed extensive independence until 2023. According to the contract, the company's brands are to be secured as well as the data of customers and suppliers, in order to counteract fears that Midea could extract patents, data and other know-how from KUKA and use them itself after the takeover.

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<sup>73</sup> ARM microprocessors are used in mobile phones throughout the world.

<sup>74</sup> <https://optics.org/news/8/7/11>, August 2020

<sup>75</sup> [https://ec.europa.eu/commission/presscorner/detail/en/ip\\_20\\_1437](https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1437), August 2020



## **2.2.9 Financial performance of the EU engineering industries and access to finance**

### **2.2.9.1 Financial performance of the EU engineering industries**

Important international indicators related to the capital resources and the profits of enterprises include the equity ratio and the EBT margin. These indicators have been chosen because they are available on an international level. Launched in 1985 by the General Directorate Economic and Financial Affairs (DG ECFIN) of the European Commission, the Bank for the Accounts of Companies Harmonized (BACH) provides comparable information on the financial structures and performances of European companies. Although data is not available for all EU Member States, it is available for countries that are most important for the engineering industries such as Germany, Italy, France, Spain, Austria, Poland and Czech Republic – these countries generate approx. 70% of the value added and employment in the EU engineering industries.

#### *Equity and equity ratio*

This key figure indicates the proportion of a company with equity capital.

$$\text{Equity ratio} = \frac{\text{Total equity}}{\text{Total assets}} * 100$$

Equity fulfils important tasks within a company and has a financing function (financing of long-term assets), a risk function (covering losses), a liability function (towards creditors) and provides the basis for the distribution of profits. The higher the equity component, the more creditworthy is the company. It will also become more competitive because it is more flexible on the market. From a business perspective, the equity ratio should be at least 30%. Higher values strengthen the company's security against crises. However, the leverage effect must also be taken into account. When considering the different countries mentioned above, it should be noted that the local accounting legislation differs with regard to the valuation or the approach of the asset/liability items, as well as the timing of the profit realisation, which make direct comparisons between countries difficult.<sup>76</sup> Nevertheless, the equity ratios provide important insights on the financial situation of enterprises and especially with regard to the development over time and differences between sectors. In the following, the equity ratios for the big engineering sectors fabricated metal products (C 25) and machinery and equipment (C 28) are shown.<sup>77</sup>

Although the equity ratios are on a different level across the countries (due to differences in the local accounting laws, see Annex 2: "Financial Performance" for a detailed explanation), the average equity ratios – all above 30% - have increased over the period 2008-2017 (latest year available) as a whole. Only in France and Spain were there slight decreases in the period after 2013. The changes were more pronounced in the period 2008-2013 due to the recovery from the economic and financial crisis of 2008-2010.

A similar picture can be observed, in the machinery and equipment sector: here, in some countries, the equity ratios are higher in machinery than in the field of metal products and in manufacturing in general, especially in Italy, Spain, Poland and the Czech Republic. However, German and Austrian companies have higher equity ratios in the metal product sector than in the machinery sector and the total manufacturing sector.

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<sup>76</sup> An explanation of the different approaches is provided in the Annex 2 ("Financial Performance").

<sup>77</sup> Data for the other engineering sectors and manufacturing are enclosed in the Annex 2 ("Financial Performance").

**Table 2-33: Average equity ratio of companies in fabricated metal products, 2008-2017, in %**

|                | Fabricated metal products (C 25) |       |       |                              |                              |
|----------------|----------------------------------|-------|-------|------------------------------|------------------------------|
|                | 2008                             | 2013  | 2017  | Change 2008/2013 in %-points | Change 2013/2017 in %-points |
| Germany        | 33.98                            | 40.14 | 41.07 | 6.16                         | 0.93                         |
| Italy          | 30.60                            | 33.86 | 34.38 | 3.26                         | 0.52                         |
| France         | 36.20                            | 40.40 | 38.45 | 4.20                         | -1.95                        |
| Spain          | 40.85                            | 46.20 | 46.00 | 5.35                         | -0.20                        |
| Austria        | 36.01                            | 40.96 | 44.85 | 4.95                         | 3.89                         |
| Poland         | 44.79                            | 50.65 | 51.29 | 5.86                         | 0.64                         |
| Czech Republic | 44.30                            | 48.80 | 56.30 | 4.50                         | 7.50                         |

Source: Bank for the Accounts of Companies Harmonized (BACH), May 2020

**Table 2-34: Average equity ratio of companies in machinery and equipment, 2008-2017, in %**

|                | Machinery and equipment (C 28) |       |       |                              |                              |
|----------------|--------------------------------|-------|-------|------------------------------|------------------------------|
|                | 2008                           | 2013  | 2017  | Change 2008/2013 in %-points | Change 2013/2017 in %-points |
| Germany        | 28.75                          | 34.70 | 33.11 | 5.95                         | -1.59                        |
| Italy          | 28.28                          | 32.17 | 39.92 | 3.89                         | 7.75                         |
| France         | 37.97                          | 40.94 | 40.83 | 2.97                         | -0.11                        |
| Spain          | 44.47                          | 47.73 | 51.76 | 3.26                         | 4.03                         |
| Austria        | 29.37                          | 33.86 | 32.33 | 4.49                         | -1.53                        |
| Poland         | 43.75                          | 53.79 | 56.51 | 10.04                        | 2.72                         |
| Czech Republic | 41.40                          | 50.00 | 56.90 | 8.60                         | 6.90                         |

Source: Bank for the Accounts of Companies Harmonized (BACH), May 2020

#### *EBT – Earnings before taxes and EBT margin*

The key figure EBT represents the ratio of earnings before taxes in net turnover. Net turnover includes sales of goods and services net of returns, deductions and rebates. Sales are net of VAT and excise taxes.

$$EBT \text{ margin: } \frac{\text{Earnings before taxes}}{\text{Net turnover}} * 100$$

The higher this indicator, the better the earning power of the company or the sector. The EBT definition is important and useful for the comparison of the profitability of a company with its international competition, especially for companies operating worldwide. The EBT is a key figure from business management and describes the profit that is made in a company before the deduction of income taxes. In addition, the EBT is independent of special tax effects and therefore free of tax reductions through losses carried forward or additional tax payments. In this way, the pre-tax profit is more suitable for comparing different financial years.

Increases in the average EBT of companies in the metal products sector can be particularly observed in the time period 2013-2017 (except a slight decrease in Poland), while the increases in the machinery sector are only moderate (slight decreases in France, Austria and Poland). Especially companies in Poland and the Czech Republic have a positive development of the EBT margin in the field of machinery and equipment throughout the whole time period. In general, EBT margins in machinery and equipment appear to be higher than in the total manufacturing sector (except in France, Austria and the Czech Republic).

**Table 2-35: Average EBT margin of companies in fabricated metal products, 2008-2017, in %**

|                | Fabricated metal products (C 25) |      |      |                              |                              |
|----------------|----------------------------------|------|------|------------------------------|------------------------------|
|                | 2008                             | 2013 | 2017 | Change 2008/2013 in %-points | Change 2013/2017 in %-points |
| Germany        | 5.16                             | 3.97 | 4.68 | -1.19                        | 0.71                         |
| Italy          | 3.82                             | 2.95 | 5.90 | -0.87                        | 2.95                         |
| France         | 4.73                             | 4.47 | 5.08 | -0.26                        | 0.61                         |
| Spain          | 3.75                             | 2.51 | 5.23 | -1.24                        | 2.72                         |
| Austria        | 6.77                             | 6.01 | 8.29 | -0.76                        | 2.28                         |
| Poland         | 5.90                             | 6.58 | 5.86 | 0.68                         | -0.72                        |
| Czech Republic | 4.70                             | 6.10 | 7.30 | 1.40                         | 1.20                         |

Source: Bank for the Accounts of Companies Harmonized (BACH), May 2020

**Table 2-36: Average EBT margin of companies in machinery and equipment, 2008-2017, in %**

|         | Machinery and equipment (C 28) |      |      |                              |                              |
|---------|--------------------------------|------|------|------------------------------|------------------------------|
|         | 2008                           | 2013 | 2017 | Change 2008/2013 in %-points | Change 2013/2017 in %-points |
| Germany | 6.75                           | 5.40 | 5.56 | -1.35                        | 0.16                         |
| Italy   | 4.92                           | 4.55 | 6.19 | -0.37                        | 1.64                         |
| France  | 6.26                           | 5.06 | 4.53 | -1.20                        | -0.53                        |
| Spain   | 7.38                           | 7.70 | 8.31 | 0.32                         | 0.61                         |
| Austria | 9.08                           | 7.76 | 7.27 | -1.32                        | -0.49                        |

|                | Machinery and equipment (C 28) |      |      |                              |                              |
|----------------|--------------------------------|------|------|------------------------------|------------------------------|
|                | 2008                           | 2013 | 2017 | Change 2008/2013 in %-points | Change 2013/2017 in %-points |
| Poland         | 3.19                           | 8.44 | 7.11 | 5.25                         | -1.33                        |
| Czech Republic | 4.30                           | 5.30 | 5.90 | 1.00                         | 0.60                         |

Source: Bank for the Accounts of Companies Harmonized (BACH), May 2020

### 2.2.9.2 Access to finance

The previous chapter presented evidence that the financial performance of the EU engineering industries had been generally stable before the Covid-19 pandemic affected Europe from February 2020 onwards. However, access to finance is particularly important for SMEs, which is the reason why it is one of the main priorities<sup>78</sup> of the Small Business Act (SBA) – the overarching EU policy framework for SMEs. In general, policy measures targeted at SMEs also benefit SMEs in the engineering sector, although the prevalence of large-scale enterprises is higher in the engineering industries than in the total manufacturing sector (see also chapter 2.1.1 on the sectoral structure of engineering industries).

According to the latest SME Performance Review (2018-2019), since 2011, approx. 735 policy measures have been implemented in the EU that specifically deal with the improvement of the access to finance of SMEs, accounting for 20% of all 3,750 policy measures specifically directed towards SMEs. Most of the measures consist of public financing programmes for SMEs. All EU Member States have funding dedicated to starting up a business, as well as for supporting innovation, proof of concept and commercialisation. EU-based funds for SMEs are relatively easily accessible in most EU Member States. In addition, business angel funds and venture capital funds are established in most EU Member States, as well as funds for alternative equity and debt financing. More than half of the EU Member States have a one stop shop supporting SMEs in accessing funds or an expert group offering inspiration and guidance on alternative finance.

However, according to the SME envoy finance final report 2019, there are still financing gaps that differ widely across EU Member States. Although SMEs' access to bank finance largely recovered after the financial crisis of 2008/2009, market failures and structural challenges remain, including information asymmetries, high transaction costs in servicing SMEs, and lack of financial skills/ knowledge among small business owners.

In the majority of EU countries, access to **bank finance** show less constraints in general, however major gaps still exist especially for start-ups and smaller companies who lack proper collateral. The report asserts that SME financing through bank loans is particularly well available in Germany, Austria, Denmark, Portugal, France and Belgium. Bank finance continues to be a central problem for SMEs in Greece, Croatia and Slovakia due to the lack of equity and collateral. In Finland, finance gaps for SMEs exist especially when starting-up, scaling-up or internationalising their businesses, as well as in succession processes or other changes in business.

In the field of **alternative finance**, in most EU Member States, financing gaps exist mainly for early-stage and in funding innovative business models. Access to finance for start-ups and innovation projects can be more difficult, as their risk profile and capital structure require different financing approaches compared to funding for traditional SMEs. Venture

<sup>78</sup> Besides "promoting entrepreneurship", "less regulatory burden", "access to markets and "internationalisation"

capital seems to be maturing in many countries; crowdfunding is still in a developmental phase, albeit growing rapidly. Other more traditional financing tools such as factoring and leasing are widely used in many countries. In many countries, including Germany, the availability of Venture capital/business angels is limited if compared with international benchmarks, such as the US or Israel. In Estonia and Denmark, venture capital is doing very well but a large part is invested abroad. Alternatives such as bond issuances, access to debt funds and IPOs (initial public offerings) are less a relevant option for SMEs in most of EU Member States.

Challenges still exist for SMEs accessing different sources of finance. Banks are constrained by low global interest rates, and by European interest-rate policy, regulatory burdens and, in some countries, the size of Non-Performing Loans (e.g. Greece and Italy). Alternative sources of finance also present challenges: the small size of EU venture capital funds is a hurdle for institutional investors, while crowdfunding markets face regulatory issues, such as fragmentation between national regimes.

The latest Survey on the Access to Finance of Enterprises (SAFE) in the Euro area by the European Central Bank was carried out between October 2019 and March 2020.<sup>79</sup> The full implications of the Covid-19 pandemic are only partially incorporated into the responses. During the survey period, the financial situation of Euro area SMEs remained consistent with expectations of a rapid deterioration in the economic environment, despite generally accommodative financing conditions.

The survey results show that a growing number of SMEs considered the macroeconomic outlook to be an impediment to their access to external finance. The weakness of their own outlook in terms of sales and profits was starting to weigh on the availability of external funds, leading to a deterioration of the access to external finance despite net declines in bank interest rates and the increased willingness of banks to provide credit. This perceived deterioration differs significantly across countries: Italy, Slovakia, Greece and Spain reported a turnover/profit development resulting in a negative net percentage<sup>80</sup>, while in Austria, Belgium, Ireland, Netherlands and, to a lesser extent also in France and Germany, reported – on balance – a (still) positive development.

Access to finance remains the least important business obstacle behind the availability of skilled labour, difficulty in finding customers, production costs, as well as legislation and competition. An exception is Greek SMEs that continue to be highly affected by the lack of access to finance. Except in Greece, the demand for external finance, e.g. loans and credit lines, increased sharply in Spain, France, Portugal and Italy. In general, SMEs expect a sharp deterioration in access to bank loans, credit lines and bank overdrafts as well as a sharp decline in the availability of trade credit.

The SAFE does not include many industry-specific results but provides some information for broad economic sectors<sup>81</sup>: for instance, the decline in SMEs' expectations regarding the access to bank loans seems to affect the industry sector less than other sectors. In net terms<sup>82</sup>, firms in the construction sector (-12%) and the services sector (-13%) appear to be somewhat more pessimistic about the change in conditions than those in the trade sector (-9%) and the industry sector (-7%), possibly reflecting the more severe impact of the lockdown measures in these sectors. Within countries, Italian SMEs reported larger declines in expectations across all sectors compared with the euro area averages, notably in the construction and services sectors (-16%, both), as well as the industry sector (-11%) and the trade sector (-10%). For Spanish SMEs the deterioration was sharper in the

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<sup>79</sup> [https://www.ecb.europa.eu/stats/ecb\\_surveys/safe/html/index.en.html](https://www.ecb.europa.eu/stats/ecb_surveys/safe/html/index.en.html)

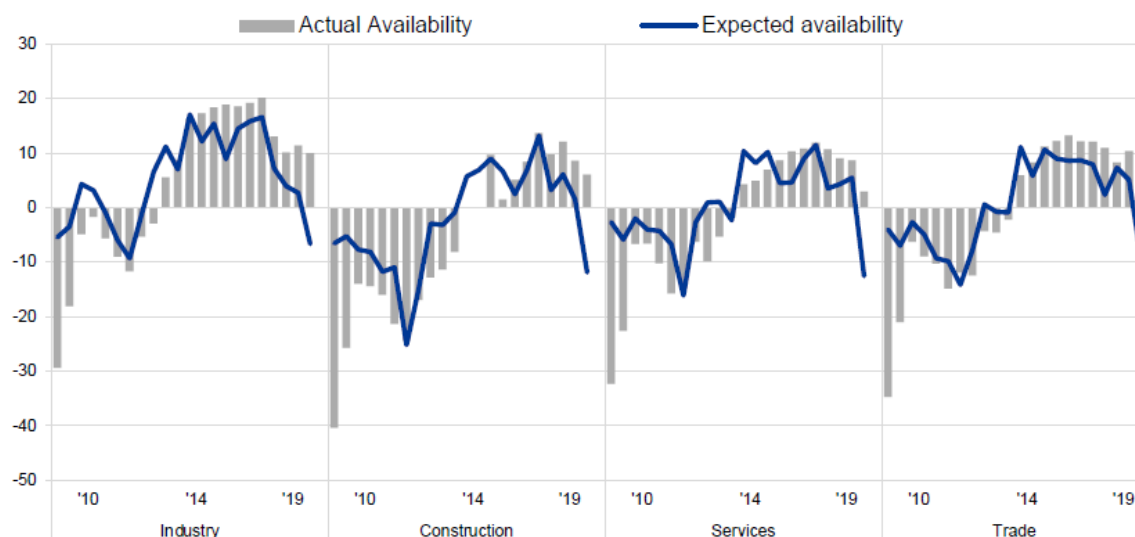
<sup>80</sup> The net percentage - or balance - is the difference between the percentage of enterprises reporting an increase for a given factor and the percentage reporting a decrease.

<sup>81</sup> Industry, construction, services and trade

<sup>82</sup> See footnote 63

construction (-17%), services (-14%) and trade (-11%) sectors, while in France, SMEs in the trade sector were more pessimistic than their euro area counterparts (-12%).

**Figure 2-42: Change in the actual and expected availability of bank loans for SMEs across sectors over the preceding six months and over the next six months**



Q9. For each of the following types of financing, would you say that their availability has improved, remained unchanged or deteriorated for your enterprise over the past six months?

Q23. Looking ahead, for each of the following types of financing available to your enterprise, please indicate whether you think their availability will improve, deteriorate or remain unchanged over the next six months.

Note: Net percentage of respondents; the net percentage is the difference between the percentage of enterprises reporting an increase for a given factor and the percentage reporting a decrease.

Source: Survey on the Access to Finance of Enterprises (SAFE), 2020, p.20

In the context of the COVID-19 pandemic which has affected Europe since January 2020 (supply chain dislocations in GVCs in Asia) and February 2020 (the pandemic spreading across Europe), EU Member States, national promotional and commercial banks have been putting together measures for adversely affected SMEs. They focus on facilitating financing, in particular working capital, and flexibility on repayments of existing loans. At EU level, financial support for SMEs through the COSME programme has been mobilised: In particular, the existing "Loan Guarantee Facility" (LGF) under the programme has been boosted with additional resources from the European Fund for Strategic Investments to enable banks to offer bridge financing for SMEs. This includes long-term working capital loans (of 12 months or more), as well as credit holidays allowing for delayed repayments of existing loans.<sup>83</sup>

A particular challenge for engineering SMEs in a COVID-19 context has been liquidity, as some national furlough schemes have been slow to pay out employment subsidies, and there have been cancellation orders. The impacts of COVID-19 are explored in greater detail in Section 5.

<sup>83</sup> [https://ec.europa.eu/growth/access-to-finance\\_en](https://ec.europa.eu/growth/access-to-finance_en), queried 10 June 2020

## **2.3 ASSESSMENT OF THE COMPETITIVE POSITION AND PERFORMANCE OF THE EU ENGINEERING INDUSTRY**

### ***2.3.1 Strengths, weaknesses, opportunities and threats relating to the EU engineering industries***

Based on the results of the data analysis and the **stakeholder consultation** (interview programme, surveys etc.), the specific strengths, challenges/weaknesses, opportunities and threats of/for the EU engineering industries have been analysed. In the following sub-sections, both the intra-industry view (strengths and weaknesses of the engineering industries) as well as an external view (opportunities and threats for the engineering industries) are presented. Strengths and weaknesses represent the current situation of the EU engineering industries, whilst opportunities and threats are forward-looking.

#### ***2.3.1.1 Strengths of the EU engineering industries***

##### **Successful branches in the global value chain**

- The EU has a strong industrial base, with a strong B2B orientation;
- In mechanical engineering, the EU has particular strengths in the machinery and equipment sector, i.e. manufacturing of high-end products, machines and devices;
- Furthermore, the EU's mechanical engineering industry is globally competitive, and has competitive advantages in many niche markets, with strong exports;
- The EU also has strengths in materials supply, plant operations engineering and mechatronics;
- The presence of SME is especially strong in the medical and dental instruments sector, in the field of metal products and, in niche markets;
- The automotive industry, in which Europe has particular strength, is an important sales market for the engineering industries;
- Considering logistics technologies, the EU materials handling industry is a global leader on supply chain solutions;
- The EU is also strong in equipment safety and reliability (including cybersecurity) and the production of high-quality products;
- Satisfactory financial performance of companies and good access to international markets are additional strengths of the EU engineering industries.

##### **Specialisation and diversity**

- Production of high-end products and highly specialised machines, focus on high-value manufacturing with high quality requirements for materials and products;
- Knowledge-intensive production processes;
- Strong focus on design, development of design tools and functionality;
- Reshoring of production processes back to the EU could be facilitated by digitalisation, but there is a need to be realistic about the scale and scope of reshoring (limited to specialist production, prototyping and new product development using additive manufacturing);
- Production shifts within the EU, from long-established EU Member States to new Member States, e.g. Poland is the biggest producer of household appliances in Europe, increasing the diversity of the EU engineering industries;
- Switch to regional procurement/ production in connection with the COVID-19-crisis and new supply chains; and

- Diversity and heterogeneity of manufacturing and engineering industries.

#### **Highly-skilled workforce**

- Availability of industry-specific know-how and skills;
- Highly-skilled, well-educated and relatively mobile workforce facilitating innovation and the production of complex products and innovative solutions;
- Quality of training: good dual training system, apprenticeship training for young specialists with practical working experience, continuous further training and competence development, and cooperation between companies, schools, colleges and universities;
- Quality of digital skills;
- Working conditions and high social standards; and
- Loyalty of employees.

#### **Research and development, infrastructure and machinery**

- The share of EU R&D expenditure in machinery is higher than in Japan, China, United States and South Korea;
- Strong existing engineering infrastructure (research labs, universities) and research cooperation; and
- European Technology Platforms enabling the exchange of research actors between universities and industry as well as academic breakthroughs.

#### **Stable regulatory framework**

- The regulatory framework is regarded as relatively stable, at least in respect of core applicable industrial product legislation, although there are concerns regarding the administrative burdens of environmental legislation;
- In many areas, the EU regulatory framework requires world-leading workplace health and safety, product safety and consumer protection, with a number of third countries basing their regulatory approaches on that of the EU (e.g. for REACH and RoHS-type legislation).
- Compliance with the legal framework in Europe allows many manufacturers to achieve broad regulatory compliance in other jurisdictions or at least to place their products on local markets in some third countries (for instance, when CE marking is accepted as a compliance mark even outside the EU).

### **2.3.1.2 Weaknesses of the EU engineering industries (challenges)**

#### **Global value chains**

- Dependency on the US and Asia for raw materials, components and IT-equipment; transport from Asia is expensive and disturbed;
- In comparison, Europe only has strengths in a few key strategic industries (e.g. the telecommunications business, once a European core technology, is now outside Europe);
- Europe has reacted relatively late to innovations in the mobility sector (e.g. the automotive industry);
- Focus on niche equipment results in a lack of big players in Europe as the European engineering industry is often not able to cover the whole value chain;



- European industries built on intellectual property; competitive advantage depends largely on intellectual property rights; and
- Europe is less competitive in terms of costs (e.g. high location-related costs, (ancillary) labour costs, tax systems etc.) and costs related to environmental legislation.

### **Regulatory framework**

- Different legislation in different Member States (e.g. in the field of AI and machine learning in advanced production processes);
- Strict framework conditions as compared to other parts of the world e.g. in the field of chemicals (REACH), hazardous substances in electrical and electronic equipment and vehicles (RoHS), labour market legislation;
- Water, waste, energy legislation – measures (e.g. in the field of CO<sub>2</sub> emissions) might negatively affect competitiveness; high costs of treatment, costs of energy may rise;
- Regulatory burdens that particularly affect SMEs and start-ups / young enterprises, whilst bigger market participants are able to manage compliance obligations in-house, and/ or may shift some compliance activities further down the value chain;
- Strict interpretation of the General Data Protection Regulation (GDPR) that increases bureaucracy and risks holding back progress towards digitalisation through national and EU initiatives;
- Market surveillance and enforcement are perceived by economic operators as not being implemented in the same way across all European countries due to very differing levels of human and financial resources invested. Market surveillance is generally seen as being weak in Europe, with too many non-compliant products remaining on the European market due to insufficiently proactive surveillance and enforcement;
- Product liability laws are an obstacle to European companies when other countries like China do not comply with them; and
- Regulatory framework at EU level on mergers and acquisitions in Europe: the European Commission may halt some proposed mergers of companies/divisions under some circumstances. This could arguably limit the formation of larger companies able to compete in global markets.

### **Research and Development / Market entrance**

- R&D intensity and business expenditure on R&D in the EU engineering industries is lower than in South Korea, Japan, United States and – more recently – also China;
- The share of patent applications at EPO with EU origin has decreased over the last 10 years; also, the share of PCT patent publications in engineering industries with EU origin has decreased considerably; the total number of patent applications/publications increased only slightly (as compared to other parts of the world);
- In Europe, most developments are still in the B2B market, whilst the US is very dominant in innovations in the B2C market; trend of B2C firms penetrating B2B market;
- Turning data into data-driven business knowledge represents a major opportunity, but Europe lags behind international competitors, especially in Asia, in translating big data into commercial value;
- European manufacturers entering the European market usually do so with good-quality, regulatory compliant products, whilst non-EU manufacturers sometimes enter the European market with non-compliant or low-quality products, which undermines the level playing field; and

- Europe is struggling to translate all its R&D efforts into industrialisation.

### **Specific aspects of digitalisation**

- Digitalisation: whilst European industry generally and the EU engineering industries in particular is embracing digitalisation, the EU lags behind Asia and the USA. Digitalisation leaders also include companies in Singapore and Korea;
- The digitalisation process comes with an enormous number of risks and investments. In the US, there is a greater readiness to take risks and SMEs are more willing to invest capital in digitalisation;
- There is heterogeneity of industry 4.0 readiness across different EU Member States;
- Speed of digitalisation: SMEs, traditional or family businesses need more time while sectors dominated by big companies (e.g. automotive) can make the digital transition more quickly because they have easier access to capital to make the necessary capital investments in advanced manufacturing facilities, smart factories and in the development of digitalised, inter-connected production hubs.
- Data protection: With the implementation of the IoT in particular, cybersecurity has become a big issue; connected machines, are more vulnerable to security concerns. There is a need to strengthen access to, and the management and protection of, industrial data;
- Digitalisation needs to master the entire electronic value chain including the design and assembly of electronic boards and supporting the development of electronics in the new uses (IoT, etc.). These parts of the value chain suffer from a lack of visibility from public bodies compared to component manufacturers and equipment manufacturers;
- Digitalisation leads to an increase in competition in the middle of the value chain (with a negative impact on margins). In fact, economic operators from digital industry and enterprises in the electric and electronic industries are becoming competitors for applications involving both digital and electronic skills and processes;
- Digital skills and digital upskilling (as compared to the US and China);
- Use of big data analytics (as compared to the US and China); and
- The implementation of the industrial IoT, and the integration and use of AI and machine learning in production processes - Firms tend to be much less efficient when they do not use AI, because manual decision-making takes much longer. Whilst some engineering firms in Europe have embraced robotics and AI, many have not yet done so, putting them at a competitive disadvantage especially compared with Asian engineering firms.

### **Enterprise size (SMEs)**

- Europe has a greater percentage of micro and small engineering firms and lacks firms with sufficient critical mass to compete globally, with the exception of a few market leaders. In total, 99% are small and medium-sized enterprises (SMEs). Only 1% are enterprises with 250 or more persons employed;
- The diffusion of digitalisation / Industry 4.0 to SMEs is difficult: the challenge, especially for SMEs, is to provide appropriate in-house know-how in order to keep up with the high speed of product development;
- Enterprise size is an important factor underlying the pace of digitalisation. The digital transition has been driven by large companies, because this requires major capital investment, including on upgrading the skills of the workforce.
- Whilst Industry 4.0 technologies have become more ubiquitous, the champions remain

very large, often multi-national companies. Large European engineering companies can create their own digital platforms, whereas SMEs may be able to do so increasingly in future, as some costs have decreased over time (e.g. automation software in smart factories). However, given the capital investment needed in new Industry 4.0 production facilities, many SMEs will have to instead rely on shared access to digital platforms. There are execution risks associated with this, which could potentially be detrimental, as SMEs could end up locked-in to the wrong platforms or technologies.

- Large companies are more able to benefit from foreign growth opportunities than SMEs. Keeping track of technological developments and their societal implications (including for the workforce) in fast-changing areas, is a challenge for SMEs.

### **Access to finance**

- The EU engineering industries face investment barriers and limited access to finance, especially SMEs. The situation has been exacerbated by COVID-19, which has meant some firms face liquidity problems, and a lack of access to capital;
- Access to new forms of innovative financing is also a challenge facing the engineering industries.

### **2.3.1.3 Opportunities for the EU engineering industries**

#### **Regulatory framework**

- The EU has helped manufacturers to push the transition toward LEDs (light-emitting diodes). The transition toward LEDs has been pushed by binding legislation globally. The EU, encouraged by major European producers, has reacted rapidly, adopting legislation on eco-design requirements for lighting which have accelerated the adoption by consumers of LEDs.
- The Machinery Directive (MD) is still fit for purpose, one of first new approach Directives. Technology-neutral, flexibility. Even if machines integrate AI, manufacturers can still take into account any hazards in the existing MD. Whether interaction between machines and machines or machines and workers.
- The launch of a European Strategy for data in February 2020: a single market for data should help to ensure Europe's global competitiveness and data sovereignty. There are opportunities for engineering firms in the analysis of big data in smart factories located in different countries. However, whilst such data is portable within the EU, agreements still need to be reached with other jurisdictions in third countries, given the globalised nature of production and GVCs.
- Strengthening the resilience of European Supply Chains through coherent EU policies and by encouraging industry to diversify supply chains and to consider reshoring, such that they are not overly-dependent on third countries for crucial components and parts necessary for the manufacturing of final products. This has become much more important following the COVID-19 pandemic.

#### **Collaboration**

- Maintenance of positive economic relations between the EU engineering sectors and vertical industries that use intermediate engineering inputs in final production in Europe. The automotive and metal industries work together very closely. Strong networking relationships, have various advantages in terms of strengthening intra-European value chains;
- For smaller players, there is a need for increased collaboration in order to remain competitive (e.g. joint ventures). Co-operation with other firms provides an opportunity for small companies to learn from larger economic operators (especially in

the area of digitalisation);

- Co-operation in the context of digitalisation: Collaboration in the value added chain with partners for digital solutions and computer scientists are important to create new business models;
- Regional co-operation: Working with local stakeholders to ensure that knowledge is retained and fully exploited at a regional level. This implies catalysing the full potential of smart specialisation strategies, as many regions have prioritised specific niche areas within engineering; and
- Co-operation is helpful in dealing with managing complexity and the speed of change (and for accessing new market, developing new business areas, coping with changes to existing, as well as the adoption of new legislation etc.).

### **Specific markets**

- Transport and logistic technologies, medical industry, industry automation, household appliances, energy (Smart grids, energy generation and storage, power electronics), automotive / e-mobility;
- Transport infrastructure projects due to the Corona-crisis on rail, road etc. will give a boost to the industry;
- Market for semi-conductors will grow because of digitalisation, IoT and AI;
- Automotive / E-Mobility:
  - Europe is catching up on electric vehicle technologies. Strong changes in the automotive industry (automated driving, connected cars etc.). Autonomous vehicles as future opportunity;
  - Autonomous driving and smart mobility – however, the developments in the US seem to go much faster;
  - Focus on European strengths in the fields of sensors, communication, artificial intelligence and power electronics in the context of autonomous driving;
  - Move towards a ban of combustion engines, which has significant consequences for the sector; and
  - Germany is an important player in the automotive / e-mobility sector. Important challenge to maintain the European dominance.

### **Circular Economy**

- Relevant topics for the industry are e.g. energy labelling, eco-design, circular economy, recycling of materials, resource and energy efficiency, decarbonisation and reduction of CO<sub>2</sub>-emissions (e.g. green steel) etc.;
- The ambition to achieve zero emissions towards 2050 drives the need for a change in the energy landscape;
- Power electronics concerns the efficient use of energy. With further developments in this area, it is possible to reach the goal of building up an economy with (power) electronics (almost) without resource consumption;
- Circular economy is identified as an opportunity to re-shore activities in the EU territory and to distinguish European players from their competitors;
- Combination of digitalisation/industry 4.0 with environmental and sustainability aspects. 3D printing – can reduce environmental waste. Sensors can optimise logistics or the energy usage etc.; and

- Semiconductors – people require more energy-efficient products. Urgent need for more semiconductors to achieve carbon neutrality.

### **Digitalisation – productivity and efficiency gains**

- Progress in digitalisation varies widely across the EU; Scandinavian countries, Germany and the UK are quite advanced in applying digital technologies;
- Digitalisation of the supply chain (Industry 4.0);
- Real-time analytics, greater flexibility in the production process and customisation capabilities;
- Robotics, Smart Production, Automation, Artificial Intelligence – Productivity and efficiency gains through higher throughput rate, predictive maintenance, smaller error rates, Big data and data processing;
- Reshoring driven by robotics and automation – less workforce needed;
- Artificial intelligence with highest performance at lowest energy consumption will be a big opportunity for a European comeback;
- New technology around 3D-printing (parts), more parts are made locally, closer to the customer; and
- Industry 4.0 allows getting closer to the markets and allows reacting to real-time changes in the market.

### **New business models / Service orientation**

- Digitalisation allows customisation of products and services (e.g. customised and unique machines, total solutions and service activities for customers, software-driven solutions);
- Shift of business models towards services: end users appreciate access to high-end technologies and manufacturing services;
- Value added not only on product, but on data generated by the product;
- New players from other sectors (automotive, energy, IT, cloud and / or software) - can be new competitors but also partners (open platform, R&D, co-development); and
- Adaptation speed to changing requirements, flexibility (e.g. in the field of mechatronics with a switch to medical technology due to the Corona-crisis); focus on new products as a business opportunity.

### **Research and Development / Innovation**

- R&D support and innovation is the key to support the competitiveness of the European high-price industry;
- (Digital) innovation and creativity; also customer-driven;
- Open innovation: Level of open innovation has been growing. Large companies have really opened up to open innovation; and
- Factories of the future – not about producing specific technologies but integrating the latest developments.

#### **2.3.1.4 Threats for the EU engineering industries**

##### **Global competition in different branches**

- Dependence on electric components, IT, IA (information architecture), Embedded Software, Big Data/Data Center on competitor countries (such as China and South Korea);
- Conditions for international acquisitions and trade; protectionism and competition law: both the US ("America first") and China pursue aggressive economic policies that favour their own companies over others (e.g. introduction of additional tariffs on steel and aluminium by the US);
- Apart from the ICT sector, the competition increased especially in the manufacturing of electronic equipment, medical devices, mechanical engineering and automotive;
- Dominant position of US in services and software;
- Dominant position of China at the level of components production and most of systems production; semi-conductors are the biggest priority for China;
- Automotive industry: new legislation (bonus / penalty) on pollution emissions; a lot of uncertainty regarding the development of electric cars; US and Chinese car producers are more advanced than the European car producers in electric cars - could take profit of these restrictive measures in Europe to become the leaders in the electric car market
- Aircraft manufacturing is an area of growing competition;
- Humanoid robots: the current major players in the hardware and software sector are mostly non-European companies;
- Lack of high-end processing capacity in Europe: China, Japan, India and Russia are beginning to develop their own processing capacity to prevent a potential shortage.

##### **Complexity**

- Speed of change and managing complexity are the big challenges;
- Organisations are in flux with so many big issues, there are so many complexities: new technologies and changes in the work. Priorities change very fast;
- Managing complexity is the biggest problem in integrating many new technologies in the production process and in the workforce;
- Dealing with a new software complexity: Computers have reached an unprecedented level of performance. With gigantic computer solutions come serious challenges for software programming.

##### **Shortages of skilled workers**

- Demographic change will lead to a huge gap of staff at all levels;
- International shortage of highly-skilled engineers;
- Changing needs of competences due to digitalisation;
- Shortages of digital workers and experts in IT, AI and cybersecurity;
- Loose alignment of vocational training / dual education system and industry.

##### **Impact of Covid-19**

- Economic uncertainty due to the coronavirus-crisis;
- Impact on supply chains, also due to the suspension of the Schengen area, e.g. drop

in sales and reduced orders, delayed production;

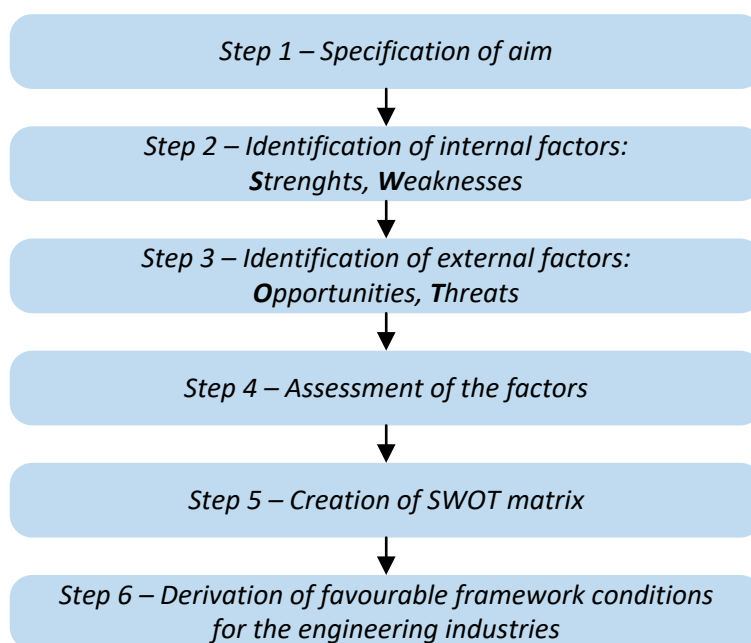
- Due to the decline in incoming orders, the after-effects of the crisis in the mechanical and plant engineering sector are likely to be delayed;
- Sharp decline in demand in steel construction combined with uncertainty on the markets;
- Companies with structural challenges even before the coronavirus-crisis are especially affected by the crisis.

### **2.3.2 SWOT analysis of the competitiveness of the EU Smart Specialisation regions in the field of engineering**

The following chapter provides the results of a SWOT analysis at regional level assessing the competitiveness of EU smart specialisation regions in the field of engineering industries.<sup>84</sup> The analysis summarises their key strengths, weaknesses, opportunities and threats and develops favourable framework conditions for their further development. The assessment also shows the extent to which (and how) the development and implementation of Smart Specialisation Strategies has been making a difference in terms of contributing to improving the competitiveness of the engineering industries.

The SWOT analysis of the EU Smart Specialisation regions was carried out based on the following six steps:

**Figure 2-43: Steps of a SWOT analysis of the EU Smart Specialisation regions in engineering industry**



Source: Austrian Institute for SME Research

The detailed approach to the methodology for the SWOT analysis is summarised in Annex 8.

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<sup>84</sup> The SWOT analysis was implemented in March/April 2020 and does therefore not reflect the full impact of the COVID-19 pandemic.



## Survey results

The following subchapter includes the survey results and the **SWOT analysis** as well as preliminary conclusions and necessary framework conditions for the European regions focusing on engineering industries.

Prior to the rating of the SWOT factors the regional representatives were asked to assess the **overall competitiveness of the engineering industry sectors** within their region. When compared to other EU regions four out of ten regions consider the competitiveness of their engineering industries as (rather) strong. When compared to countries outside the EU, one third of the respondents assess their engineering industries' competitiveness as (rather) strong. Regions that have **made digitalisation / digital transformation** an explicit policy objective of their Smart Specialisation Strategy tend to rate their competitiveness higher than those regions without a digitalisation objective. The competitiveness also varies according to where the region is located. **Western** and especially **Northern regions** evaluate their competitiveness more often as (very) strong than regions in **CEE and Southern regions**<sup>85</sup>.

Most regions that have implemented a **Regional Smart Specialisation Strategy** focussing on engineering industries consider that there is a **positive impact** of the strategy on **the competitiveness** of their regional engineering industry. One third of respondents observed a (rather) strong impact; about 45 % see a medium impact and about on fifth considers the contribution to be (rather) weak.

The implementation of the Regional Smart Specialisation Strategy contributed to the competitiveness of the engineering industries in different ways: E.g. by improving the cooperation between key actors such as universities, public bodies and companies as well as the establishments of clusters and more effective cluster collaboration. This in turn increased innovation cooperation and increased R&D spending in companies. In addition, regional innovation platforms have been strengthened. The regional funding also helped the development of research infrastructures and innovation support for companies, start-ups and spin-offs. Furthermore, knowledge exchange and sharing of best practices in cooperation with other regions were helpful to improve the competitiveness.

On the other hand, the regions where the implementation of the Regional Smart Specialisation Strategy had a (rather) weak contribution on the engineering industries' competitiveness this was e.g. because of a too broad approach of the Smart Specialisation Strategy or a lack of awareness of funding possibilities as well as funding procedures being perceived as too bureaucratic by companies.

To perform the SWOT analysis, at first the **internal factors** of the regional engineering industries were analysed and identified according to their assessment as **strength** (favourable condition), **weakness** (unfavourable condition), **neutral factor** (neither favourable nor unfavourable condition) or **ambiguous factor** (representing a favourable condition for some but an unfavourable condition for other regions).

The **major strengths** of the EU regions specialised in engineering industries relate to their **business structure** (especially the "degree of specialisation" and "degree of diversification" of the engineering industry), their **access to international markets** as well as factors related to **human resources** ("working conditions", "availability of industry specific know-how and skills", "quality and availability of digital skills"). For some of these factors the assessment changes depending on the region. The "access to international markets" as well as the "access to international supply markets incl. access to raw

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<sup>85</sup> „Northern regions" include survey respondents in the following countries: Denmark, Finland, Sweden; "Western regions": France, Austria, Netherlands; "Central and Eastern European (CEE) regions": Poland, Romania, Lithuania; "Southern regions": Greece, Italy, Malta, Portugal, Spain



materials” are considered major strengths mainly by Northern and Western regions, whereas CEE and Southern regions assess it as neutral factor or less pronounced weakness.<sup>86</sup> Similarly, “working conditions” represent a major strength for Northern and Western regions whereas they are a neutral factor for CEE and a weakness for Southern regions. Furthermore, the “quality and availability of digital skills” is a more pronounced strength in Northern regions as compared to the rest of the regions. “Cooperation and networks” (e.g. regional industry clusters, platforms, sector initiatives) represent an **ambiguous factor**: they are a major strength for Northern and Western regions but a major weakness for CEE and Southern regions.

**Weaknesses** of the engineering industries in the European regions include the lacking “access to new forms of financing”, the missing “focus on high tech products”, high “production costs” as well as a lacking “capacity to transfer innovations into marketable products and services”.

The assessment of the **access to finance** for the regional engineering industries therefore varies: “access to traditional forms of finance” and “public funding instruments / subsidies” are considered as **strengths** whereas “access to new forms of financing” (such as venture capital, business angels or crowdfunding) represents a **major weakness**. Again some differences among regions become evident: “Access to traditional forms of financing” represents a more pronounced strength for Northern and Western regions while the factor is assessed less favourably in CEE (less pronounced weakness) and Southern (neutral factor) regions. Similarly, Northern regions assess the “access to new forms of financing” better (as neutral factor) than Western and Southern (less pronounced weakness) or CEE (more pronounced weakness) regions.

Factors related to **innovation and digitalisation** are not found among the major strengths. While the factors “product innovation” as well as “access to R&D support and subsidies” represent less pronounced strengths, “access to research infrastructure”, “(pace of) adoption of new digital technologies”, “R&D capabilities and intensity” as well as “service innovation” only range among the neutral factors. The “focus on high tech products” and the “capacity to transfer innovations into marketable products and services” are assessed as **(major) weaknesses**. CEE regions lack behind in the area of innovation: The level of “product innovation”, the “access to research infrastructure”, the “(pace of) adoption of new digital technologies”, “R&D capabilities and intensity”, the level of “service innovation” all represent weaknesses for CEE regions whereas Northern, Western and Southern regions assess them as strengths or neutral factors.

“Production costs” on the other hand refer to a strength for CEE regions whereas they represent a neutral factor for Northern and a weakness for Western and Southern regions.

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<sup>86</sup> However, the COVID-19 crisis has revealed that global supply chains can be disrupted fast and deeply.

**Figure 2-44: SWOT Analysis: Internal factors – Strengths and weaknesses**

| Strengths                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                   | Weaknesses                                                                                                                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Degree of specialisation</li> <li>• Degree of diversification</li> <li>• Access to international markets</li> <li>• Working conditions</li> <li>• Availability of industry-specific know-how and skills</li> <li>• Quality and availability of digital skills</li> <li>• Access to traditional forms of financing</li> <li>• Access to international supply markets incl. access to raw materials</li> <li>• Access to public funding instruments / subsidies</li> <li>• Product innovation</li> <li>• Access to R&amp;D support and subsidies</li> <li>• Sustainable newcomers / start-ups</li> </ul> |  | <ul style="list-style-type: none"> <li>• Access to new forms of financing</li> <li>• Focus on high tech products</li> <li>• Production costs</li> <li>• Capacity to transfer innovations into marketable products and services</li> </ul> |
| Neutral / Ambiguous factors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                   |                                                                                                                                                                                                                                           |
| <ul style="list-style-type: none"> <li>• Access to research infrastructure</li> <li>• (Pace of) adoption of new digital technologies</li> <li>• Financial viability of enterprise</li> <li>• R&amp;D capabilities and intensity</li> <li>• Service innovation</li> <li>• Cooperation and networks</li> </ul>                                                                                                                                                                                                                                                                                                                                    |                                                                                   |                                                                                                                                                                                                                                           |

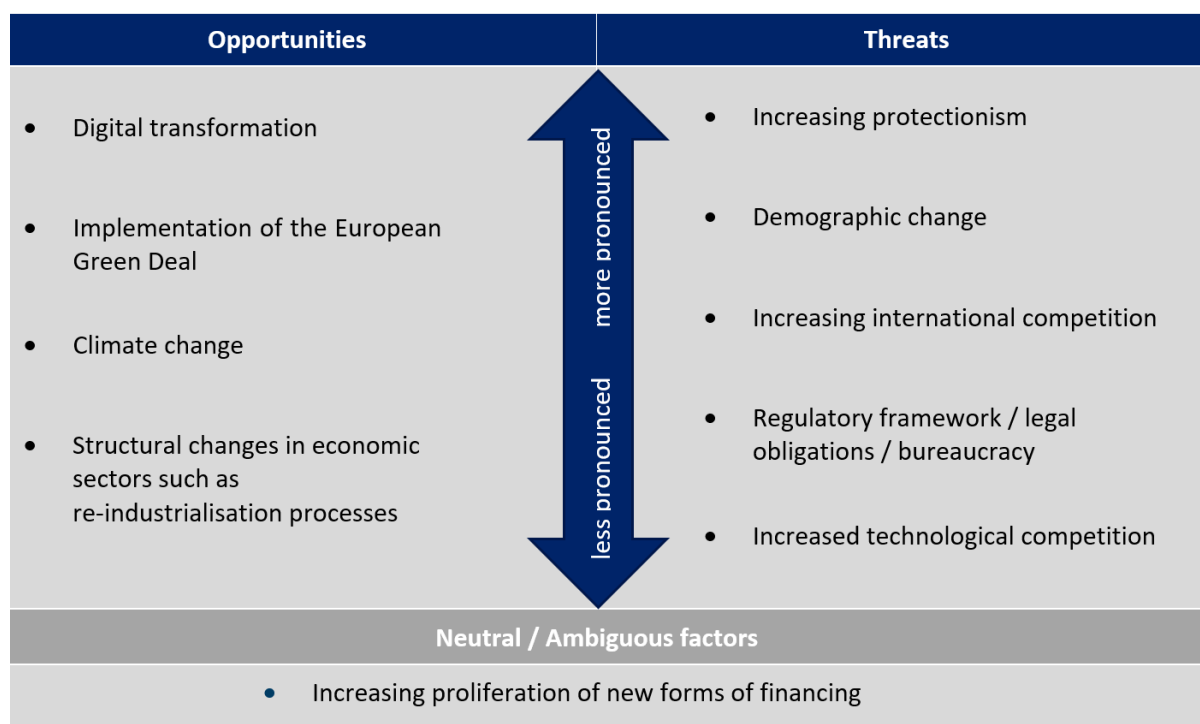
Note: The SWOT analysis was implemented in March/April 2020 and does therefore not reflect the full impact of the COVID-19 pandemic. The COVID-19 crisis led to a disruption of global value chains which affected both the access to international markets and the access to international supply markets.

Source: Austrian Institute for SME research

As regards **external factors** that impact on the future development of the engineering industries in the EU regions, the **major opportunities** for the engineering industries lie in the area of “digital transformation” and “climate change” as well as the “implementation of the European Green Deal”. The **major threats** for the sector refer to “increasing protectionism”, “demographic change” and “increasing international competition”.

The assessment of the external factors similarly varies depending on the region. “Digital transformation” represents a major opportunity mainly for Northern, Western and Southern regions, whereas CEE regions assess it as neutral factor. The same is true for the “implementation of the European Green Deal”. “Climate change” is equally seen as an opportunity by all regions. When it comes to threats, “regulatory framework, legal obligations and bureaucracy” represent a more pronounced threat for CEE regions than for Western and Southern (less pronounced threat) or Northern (neutral factor) regions. “Increasing international competition” is considered a major threat mainly by CEE and Southern regions, while Northern and Western regions consider it a neutral factor. “Demographic change” on the other hand is a greater threat for Northern and Western regions than for CEE and Southern region (less pronounced threat).

**Figure 2-45: SWOT Analysis: External Factors – Opportunities and threats**



Source: Austrian Institute for SME research

Through the analysis of the interrelation between strengths, weaknesses, opportunities and threats, **necessary framework conditions** for the favourable development of Smart Specialisation regions in the field of engineering were derived and a number of preliminary conclusions were drawn from the analysis of the abovementioned factors.

From the policy perspective, addressing successfully all relevant topics requires a **multilevel approach**, e.g. collaboration on the regional, national and EU-level. For some topics, a regional approach or a country-focused approach may be more suitable to address specific regional or national issues/goals. For other topics (e.g. climate change) an approach on EU-level seems more likely to succeed. However, all measures undertaken should be implemented in order to complement each other.

Overall, the SWOT analysis shows that European regions focusing on engineering industries can count on many strength and competitive advantages. **Human resources and skills** represent major **strengths** of the EU regions focusing on engineering industries. To enable businesses in the engineering industries to use the full potential of the drivers and **opportunities** in the area of **digitalisation** and **climate change** continuing future-oriented skills development will be crucial to provide companies with a performant work force. This includes investment in high quality research and education systems at all levels including strengthening (vocational) training of engineers in the ICT/high tech/environmental technology area. In addition, continuous education and “re-skilling” of labour to adapt to digital transformation processes is important. The necessity to invest in excellent education systems becomes even more crucial when considering the major **threats** of **increased international** and **technological competition**. The focus on entrepreneurship training and education can further help to raise the level of sustainable newcomers and start-ups and lift the potential for innovation.

Against the background of the major **threat** of **demographic change** especially for Northern, Western as well as more rural and remote regions, it will become crucial to implement strategies to secure and attract skilled labour as well as reverse brain drain. This can be done e.g. by international recruitment campaigns and legislation that makes

it easier to recruit talents from abroad, increasing the attractiveness of professions in the engineering industry sectors for young people, increasing the quota of female specialists, etc. In addition, the cutting of income tax levels (especially against the background of **high productions costs** in Western and Southern regions and areas with high salary levels) can be considered a way to improve competitiveness.

The analysis of the SWOT factors showed that EU regions specialised in engineering industries have some strengths in the area of **innovation and digitalisation** but also some neutral factors and weaknesses with need for improvement (e.g. when it comes to the missing focus on high tech products or the lacking capacity to transfer innovations into marketable products). When considering the **threats of increased international and increased technological competition** the need to enhance the innovation capacity of the regional engineering industries becomes even more evident. This includes e.g. the increased digitalisation on all levels of the industries (incl. SMEs) and an increased support for the uptake of new (digital) technologies, the provision of digital infrastructure and digitalisation support (especially in CEE and Southern regions), maintained and increased R&D spending or public procurement strategies focusing on fostering innovation.

In CEE and Southern regions **cooperation and networks** (between engineering industries, companies of different sizes, corporates and start-ups, businesses and universities / research institutes but also international cooperation) should be fostered. In addition, innovative ecosystems and favourable environments for start-ups should be created in order to enhance innovativeness. Furthermore, the access to research infrastructures incl. the opportunities to transfer and test technologies should be improved especially in CEE and Southern regions.

Another area to be addressed is the **financing of innovations** – while traditional forms of financing count among the strengths of the regional engineering industries, new forms of financing such as venture capital financing / financing for growth stages that could enhance the level of innovation as well as create more competitive key enterprises on the global level are currently lacking. Also, the access to European funds (especially for CEE and Southern regions) supporting innovation could be enhanced.

While **access to international markets** (incl. supply markets and access to raw materials) is considered a strength for Northern and Western regions, these factors are assessed less favourably by CEE and Southern regions and could be further **threatened** by the tendency to **increased protectionism** as well as the current corona crisis with interrupted value chains. The continuing support for internationalisation incl. the participation in international networks and projects therefore plays an important role.

Another area to be addressed for favourable framework conditions is the **regulatory framework and bureaucracy, which** currently represents a **threat** for the competitiveness of the regional engineering industries. This includes especially a favourable tax system and reduction of red tape. To take advantage of the **opportunity** of **climate change** this could also include an equal playing field concerning legislation on climate change and environmental protection measures.

### **2.3.3 Summary of the competitiveness assessment**

The main global competitors of the EU's engineering industries are China, the U.S., South Korea and Japan. China's and South Korea's engineering industries outperformed the EU's engineering industries in terms of value added growth in the period 2013-2018, while in the U.S. and Japan, the development of the sector was more similar to the EU. So, overall, there was a moderate weakening of the EU's competitive position over the period vis-à-vis some of its main competitors.

Looking at international trade, the EU's competitiveness is still quite high for machinery and equipment and for medical instruments. There, EU engineering companies are particularly competitive in specialised niche markets in the B2B and high-end areas.

However, for computer and electronic products, the EU's position is (still) relatively weak (especially compared to China, the U.S., and South Korea). Global non-EU IT players are entering traditional engineering markets.

The following table summarises the factors currently determining the competitiveness of the EU's engineering industries.

**Table 2-37: Overview of factors of competitiveness of the EU's engineering industries**

| Factor                         | Strength or weakness relative to competitors | Comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------------------|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Labour costs                   | Weakness                                     | Labour costs are comparatively high in EU engineering compared to China                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Availability of skilled labour | Strength                                     | <p>Existing workforce in engineering is very well educated and have outstanding technical knowledge in the EU, which supports the EU's strength in application-oriented innovation; effective dual training systems and renowned technical universities in relevant MS</p> <p>However, skills/labour shortages in engineering due to demographic developments and occupational choice pose a threat in the EU; U.S. is more attractive to international students; in China, higher shares of students opt for engineering and China is able to increasingly retain students in the country</p> |
| Product quality                | Strength                                     | High safety standards, product reliability                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| R&D and innovation             | Weakness                                     | <p>Business R&amp;D expenditures are lower in the EU than in China, the U.S., Japan and Korea, especially in relation to computer and electronic products;</p> <p>Share of EU patents in engineering is decreasing in comparison to Asian competitor countries;</p> <p>Weakness in transition from R&amp;D to market (commercialisation), including appropriate forms of funding / risk finance</p> <p>Relative backlog in some strategic fields of research and innovation, e.g. mobility</p> <p>Still strong patenting position in mechanical engineering</p>                                |
|                                | Strength                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

| Factor                              | Strength or weakness relative to competitors | Comment                                                                                                                                                                                                                                                                          |
|-------------------------------------|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                     |                                              | Good performance in application-oriented product innovation<br><br>Good research infrastructures                                                                                                                                                                                 |
| Digitalisation level and investment | Weakness                                     | Investments in and use of AI and big data are lower in EU than in Asia and U.S.                                                                                                                                                                                                  |
| Economies of scale, efficiency      | Weakness                                     | High prevalence of SMEs in EU engineering, where e.g. operating on international markets, getting market power, digitalising, keeping up with technology developments is more challenging for smaller enterprises<br><br>Dissimilarity and cost burden of legislation high in EU |
| Access to raw materials             | (Weakness)                                   | High import reliance; entailing significant transport costs<br><br>However, the negative impact on performance and competitiveness is currently moderate, but it might turn into a threat or potential future challenge                                                          |

### **3. REGULATORY ANALYSIS OF EU LEGISLATION AFFECTING THE EU'S ELECTRONIC, ELECTRICAL AND MECHANICAL ENGINEERING INDUSTRIES**

#### **3.1 OBJECTIVES AND SCOPE**

The purpose of this section is to provide an assessment of the EU and international regulatory frameworks applicable to the EU engineering industries, and to analyse the impacts of legislation on the different branches of engineering. This section contains:

- (1) A **mapping of core existing EU legislation applicable to the EU engineering industries** and a review of how the regulatory framework has evolved in the past decade;
- (2) A **comparative assessment of the current baseline situation in the EU with international legislation** applicable;
- (3) Consideration of the extent to which there is **national divergence in the transposition, implementation and enforcement of EU legislation**, specifically:
  - a. Incorrect national transposition has also been considered, as evidenced by notifications issued and any infringement proceedings, launched by the Commission against particular Member States.
  - b. Any evidence of gold-plating issues (going beyond the minimum requirements in EU legislation at national level);
- (4) An **assessment as to how the EU regulatory framework might evolve in future**, which considers the ongoing fitness for purpose of the body of applicable product legislation. Specifically, this considers:
  - a. The impact of new technologies linked to digitalisation and Industry 4.0, especially Artificial Intelligence, machine learning, robotisation and automisation, and developments in the industrial internet of things (IIoT); and
  - b. The implications of new EU policy developments, such as the European Green Deal, and potential regulatory developments in the environmental and sustainability fields.
- (5) Consideration of the **interplay between EU legislation, industrial competitiveness and innovation** (including reflections on the cumulative effects and interactions between different applicable EU legislation and the associated compliance costs); and
- (6) Consideration as to how the **prevailing regulatory framework influenced the market behaviours of individual firms**, and of **specific sub-sectors** across the three main branches of the EU engineering industries (electrical, mechanical and electronic).

The extent to which **similarities and differences between EU legislation and legislation applicable in other jurisdictions** could be identified has also been assessed, and the impact that this has had on industrial competitiveness in the European engineering industries. More specifically, the analysis has assessed the **degree of global regulatory divergence and alignment** between the body of applicable European legislation for the engineering industries, and the corresponding legislation applicable in international comparator countries across different jurisdictions.

The **impact of the extension of responsibilities to economic operators in Global Value Chains ("GVC")** has also been considered, including through the alignment of EU product legislation with the common requirements in the **New Legislative Framework (NLF)**. The implications have been considered for actors such as importers and distributors of finished industrial products<sup>87</sup>, components manufacturers, Original Equipment Manufacturers (OEM) in the value chain.

The following strategic issues have also been assessed:

- **The level of ambition of the EU regulatory framework in comparison to other regulatory jurisdictions in major third-country competitors;**
- The extent to which the EU regulatory framework applicable to the engineering industries **promotes (and/ or conversely hinders) industrial competitiveness and innovation;**
- **The issue as to how far EU legislation have had a positive effect in terms of influencing the development of applicable legislation for the engineering industries in third countries.**

The **scope of the legal mapping** covers the main applicable legislation to the EU engineering industries. This includes: **industrial product legislation; environmental legislation; horizontal legislation; occupational health and safety laws; data protection and privacy laws** and their implications for product design; **cybersecurity-related** as well as **labour market legislation**.

### **Scope of the regulatory mapping**

Regarding the **country scope** of the mapping and analysis of the applicable legislation to the EU engineering industries, this focused on the EU-27. The situation internationally in major third-country competitor countries within study scope, such as the **US, Japan, South Korea** and the **BRICs (Brazil, Russia, India and China)** was also mapped.

An explanation of the methodology adopted is provided in Annex 8. In brief, the analysis draws on extensive desk research, complemented by feedback from stakeholder consultations (e.g. **interviews, online surveys and webinars**).

#### **3.1.1 Analytical framework**

The analytical framework for the study drew on the Tender Specifications for inspiration. This influenced the development of the research tools to carry out interviews and online surveys. In particular, the following strategic issues were integrated into an overall analytical framework:

- **Mapping which legislation was applicable and examining EU current regulatory compliance requirements. This was done for manufacturers and other economic operators, so as to include a global value chains ("GVC") dimension.**
- Considering the degree of **regulatory alignment (and/ or divergence) between the body of European legislation applicable to the European engineering industries and corresponding legislation applicable in international comparator countries across different jurisdictions.** Regulatory similarities and differences were analysed.
- Considering **the impact of EU legislation on the European engineering industries in terms of industrial competitiveness and innovation and on SMEs;**

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<sup>87</sup> Some EU regulatory requirements are also applicable to them, given recent regulatory developments to strengthen traceability requirements.



- Considering the **impacts on market behaviours of EU legislation among engineering firms;**

As noted above, the following strategic study issues were also considered. The types of issues investigated as part of the analysis are now explained.

#### **Strategic study issues**

- **Level of ambition of the EU regulatory framework compared with other regulatory jurisdictions globally.** The degree to which EU legislation focuses on the minimum necessary legislation to achieve objectives relating to product safety and to the internal market, as opposed to more ambitious policy objectives, such as driving innovation and competitiveness (e.g. through investment in exploring the scope for alternative chemical substances as substitutes under the REACH Regulation and encouraging industry to adopt improved technologies to foster energy efficiency through the Ecodesign Directive and requirements to use best available technologies benchmarks as the basis for setting the minimum regulatory requirements. The regulatory approach outlined in the White Paper on AI was considered regarding the level of ambition. The extent to which new proposed EU legislation, such as the new EU climate law, is ambitious and how this is perceived by engineering industry stakeholders has been considered.
- **How far EU legislation has had a demonstration effect in influencing the development of legislation in non-EU countries.** Although some industry stakeholders may perceive compliance with EU legislation as being burdensome, the reality is a complex picture, as some industry participants view the legal framework as having provided stability and working well overall. Teasing out the complexity of the relationship between legislation and competitiveness required a review as to how influential EU legislation has been in terms of influencing the development of legislation in other jurisdictions. For example, about 50 countries globally have adopted REACH and RoHS -type regulatory regimes outside the EU.<sup>88</sup> It was therefore considered interesting to explore how far the fact that the EU was globally-leading as a first mover in regulating these areas to the same extent impacted on the competitiveness of the European engineering industries, in comparison with competitor countries. Or is the picture more complex and nuanced, i.e. the role of legislation as both a driver and inhibitor of innovation and competitiveness?
- **The degree to which EU and wider legislation influence sectoral and firm-level performance from a causality perspective.** This will include a consideration of the cumulative effects and interactions between different applicable EU legislation and the related administrative costs. It will also be necessary to review economic theories regarding the interplay between legislation and performance.

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<sup>88</sup> REACH and RoHS legislation was first adopted in the EU, but has subsequently been either adopted, or is being considered in modified form by up to 40 different jurisdictions globally. AmCham EU, Our position: Response to the stakeholder consultation on the draft RoHS substance methodology manual, December 2018. Last accessed on 23.11.2019 at: [https://rohs.exemptions.oeko.info/fileadmin/user\\_upload/RoHS\\_Pack\\_15/2nd\\_Consultation/Contribution\\_AmCham\\_EU\\_response\\_RoHS15\\_substance\\_methodology\\_2018.pdf](https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_15/2nd_Consultation/Contribution_AmCham_EU_response_RoHS15_substance_methodology_2018.pdf)

## 3.2 KEY FINDINGS – MAPPING OF LEGISLATION APPLICABLE TO THE EUROPEAN ENGINEERING INDUSTRIES

### 3.2.1 Key findings – mapping existing EU legislation on European engineering industries

The findings from the presentation of the mapping of EU legislation applicable to the European engineering industries are now presented.

A **wide range of EU legislation was found to be applicable** to both European and international firms in the engineering industries placing products on the European market. **Core pieces of legislation applicable to the European engineering industries include industrial product legislation**, such as the Machinery Directive (MD), Low Voltage Directive (LVD), Electromagnetic Compatibility Directive (EMCD), and Radio Equipment Directive (RED). Further core applicable legislation at EU level includes environmental legislation, notably the WEEE Directive (2012/19/EU) and the RoHS Directive (2011/65/EU), which have implications for manufacturers of electrical equipment and household appliances. Additionally, a number of other different types of legislation applicable such as: horizontal, occupational health and safety, and labour market legislation.

It should be noted that in some cases, existing legislative is under review, and revised regulatory proposals have either already been made or are expected in 2020 or 2021. These have been mentioned in the mapping of existing legislation as they involve direct follow-up. A more detailed assessment of forward-looking legislation is provided in the scenario analysis to 2030.

In the following table, a summary of the applicable key EU legislation is provided below:

**Table 3-1: Summary of key applicable EU legislation**

| EU legislation                                                       | Simple overview of core objectives (e.g. in essential requirements, other objectives)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Industrial product legislation (core)</b>                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Machinery Directive (MD)<br/>2006/42/EC</b>                       | <ul style="list-style-type: none"> <li>• Essential requirements: Directive promotes free movement of machinery within the single market, and guarantees a high level of protection for EU workers and citizens.</li> <li>• A public consultation and impact assessment (IA) were launched in 2019-2020 on possible revisions to the MD to reflect technological developments such as AI.</li> </ul>                                                                                                                                                                                                                                               |
| <b>Low Voltage Directive (LVD)<br/>2014/35/EU</b>                    | <ul style="list-style-type: none"> <li>• Ensures that health and safety requirements are the same across Europe for products placed on the market.</li> <li>• Essential requirements (Art. 3): Electrical equipment may be made available on the European market if, having been constructed in accordance with good engineering practice in safety matters, it does not endanger the health and safety of persons and domestic animals, or property, when properly installed and maintained and used in applications for which it was made.</li> </ul>                                                                                           |
| <b>Electromagnetic Compatibility Directive (EMCD)<br/>2014/30/EU</b> | <ul style="list-style-type: none"> <li>• Main objectives are to regulate the electromagnetic compatibility of apparatus (electrical equipment and appliances) and fixed installations and to prevent disturbance).</li> <li>• Apparatus needs to comply with EMC requirements when it is placed on the market and/or taken into service.</li> <li>• The application of good engineering practice is required for fixed installations, with the possibility that competent authorities of EU countries may impose measures in instances of non-compliance.</li> <li>• Interesting feature of EMCD is that it is not a safety Directive.</li> </ul> |

| EU legislation                                                               | Simple overview of core objectives (e.g. in essential requirements, other objectives)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Radio Equipment Directive (RED)</b><br><b>2014/53/EU</b>                  | <ul style="list-style-type: none"> <li>• Essential requirements (Art. 3) are set for safety and health, electromagnetic compatibility, and the efficient use of radio spectrum.</li> <li>• A series of delegated acts could potentially be activated in future which would extend the essential requirements. Examples are: Art. (3)(3)(e) data protection and privacy and (3)(3)(f) protection from fraud.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Industrial product legislation (wider legislation)</b>                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Explosive atmospheres equipment (ATEX) Directive</b><br><b>2014/34/EU</b> | <ul style="list-style-type: none"> <li>• Directive covers equipment and protective systems intended for use in potentially explosive atmospheres. Defines the essential health and safety requirements and conformity assessment procedures, to be applied before products are placed on the EU market.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Gas Appliances Regulation (GAR)</b><br><b>2016/426/EU</b>                 | <ul style="list-style-type: none"> <li>• Objectives are to provide access to the EU market for appliances and fittings in so far as the gas safety of these products is concerned. The GAR deals also with the energy efficiency of the products covered where no more specific EU Eco-design legislation applies.</li> <li>• Essential requirements - appliance or a fitting must meet when it is placed on the EU market. It does not indicate how these requirements must be met, thus leaving flexibility to manufacturers as regards technical solutions to be adopted.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Lifts Directive</b><br><b>2014/33/EU</b>                                  | <ul style="list-style-type: none"> <li>• Ensures the free circulation (trade) of lifts in the EU market by harmonising the essential requirements that lifts and their safety components must comply with. The Directive entered into force on 20 April 2016 and repealed its predecessor (Directive 95/16/EC).</li> <li>• The Directive establishes a conformity assessment procedure for manufacturers of lifts and components and rules for the national authorities in charge of supervising their market access.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Outdoor Equipment Noise Emissions Directive</b><br><b>2000/14/EC</b>      | <ul style="list-style-type: none"> <li>• Aims to improve the control of noise emissions by 57 types of equipment used outdoors e.g. used on construction sites and in parks and gardens. It establishes noise limits for 22 of those types and requires a specific noise marking for all equipment types</li> <li>• Harmonises noise emission standards, conformity assessment procedures, noise level marking, and establishes rules to gather data on noise emissions.</li> <li>• Almost all of the 57 types of equipment are also within the scope of the MD 2006/42/EC and both directives address issues arising from noise emissions. However, the MD focuses on the occupational safety of the operator (amongst other things) and the OND on the control of the noise emissions by this equipment in the environment.</li> </ul>                                                                                                                                                                    |
| <b>Personal Protective Equipment (PPE) Regulation</b><br><b>EU/2016/425</b>  | <ul style="list-style-type: none"> <li>• Covers the design and manufacture of Personal Protective Equipment (PPE), which is to be made available on the market, in order to ensure protection of the health and safety of users and establish rules on the free movement of PPE in the Union. The PPE Regulation lays down the rules aimed to ensure that PPE, which is being made available on the EU internal market provides to the users of such PPE the highest level of protection against one or more risks to those persons' health or safety.</li> <li>• As legislation based on the 'new approach' aligned to the NLF, the PPE Regulation requires manufacturers or their authorised representative in the EU to comply with the essential requirements listed in Annex II thereof but it does not prescribe any specific mandatory technical solutions.</li> </ul> <p>The PPE Regulation became applicable as from 21 April 2018, replacing and replacing the previous Directive 89/686/EEC.</p> |

| EU legislation                                                                                                                                   | Simple overview of core objectives (e.g. in essential requirements, other objectives)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Pressure equipment (PED) Directive 2014/68/EU</b>                                                                                             | <ul style="list-style-type: none"> <li>• Applies to the design, manufacture and conformity assessment of stationary pressure equipment with a maximum allowable pressure greater than 0,5 bar.</li> <li>• Applies from 19 July 2016.</li> <li>• The Pressure Equipment Directive aims to guarantee free movement of the products in its scope while ensuring a high level of safety.</li> <li>• The implementation of the Directive is supported by a set of PED Guidelines and guidance documents.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Simple Pressure Vessels Directive (SPVD) 2014/29/EU</b>                                                                                       | <ul style="list-style-type: none"> <li>• Applies to the design, manufacture and conformity assessment of simple pressure vessels.</li> <li>• Entered into force on 20 April 2016.</li> <li>• The Simple Pressure Vessel Directive aims to guarantee free movement of the products in its scope while ensuring a high level of safety.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Ecodesign Directive - 2009/125/EC.</b>                                                                                                        | <ul style="list-style-type: none"> <li>• The Ecodesign Directive provides consistent EU-wide rules for improving the environmental performance of products, such as household appliances, information and communication technologies or engineering. The directive sets out minimum mandatory requirements for the energy efficiency of these products. This helps prevent creation of barriers to trade, improve product quality and environmental protection.</li> <li>• The Ecodesign Directive and the energy labelling regulation also establishes a <a href="#">consultation forum</a> (X03609) to consult stakeholders on the implementation of the directive and regulation. Members include representatives from EU countries, candidate and EFTA countries, industry and civil society.</li> </ul>                                                                                                                                |
| <b>Energy-labelling of products Regulation 2017/1369</b>                                                                                         | <ul style="list-style-type: none"> <li>• This legislation works in combination with the Ecodesign Directive (2009/125/EC) to form the legal framework for ecodesign. Within this framework, the energy labelling Regulation details mandatory labelling requirements for energy-related products before they can be placed on the market.</li> <li>• Through this labelling, the Regulation requires provision of standard product information regarding energy efficiency, as well as energy consumption and other resources used by the product.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Cableways Regulation EU/2016/424</b>                                                                                                          | <ul style="list-style-type: none"> <li>• Regulation (EU) 2016/424 of the European Parliament and of the Council of 9 March 2016 on cableway installations became applicable as of 21 April 2018, replacing Directive 2000/9/EC.</li> <li>• This Regulation has been aligned with the NLF. This aligned the conformity assessment procedures available for subsystems with those already used for safety components.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Medical Device Regulation (Council Regulation 2017/745)</b>                                                                                   | <ul style="list-style-type: none"> <li>• Covers medical devices and equipment. Electronic components must meet data protection and privacy requirements.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Regulation (EU) 2019/1020 of the European Parliament and of the Council of 20 June 2019 on market surveillance and compliance of products</b> | <ul style="list-style-type: none"> <li>• Whilst this Regulation doesn't apply directly to economic operators, it will affect them as it concerns surveillance and enforcement.</li> <li>• The new Regulation provides an updated legal framework on market surveillance and enforcement, which is often regarded as the weak spot in the efficacy of the EU regulatory framework by European manufacturers, as there is 1) divergence in the level of human and financial resources devoted to surveillance and enforcement across different Member States and 2) there remain</li> <li>• The previous legal framework from Regulation (EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products was regarded as needing to be updated to strengthen surveillance and to address the challenges</li> </ul> |

| EU legislation                                                                                                                                                                               | Simple overview of core objectives (e.g. in essential requirements, other objectives)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                              | faced by MSAs in monitoring sales through online platforms and e-commerce channels.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Horizontal legislation</b>                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>REACH Regulation (EC) No 1907/2006</b>                                                                                                                                                    | <ul style="list-style-type: none"> <li>• REACH provides a legal framework for the Registration, Evaluation, Authorisation and restriction of Chemicals.</li> <li>• It has four main objectives: to ensure (1) a high level of protection of human health and the environment, including (2) the promotion of alternative methods for assessment of hazards of substances, as well as the (3) free circulation of substances on the internal market while (4) enhancing competitiveness and innovation.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Environmental legislation</b>                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>RoHS Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment. Legislative amendment RoHS 2 Directive (EU) 2017/2102</b> | <ul style="list-style-type: none"> <li>• Since its adoption in 2002, the RoHS Directive has been through several recasts.</li> <li>• First version of RoHS Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment was replaced by Directive 2011/65/EU (known as the RoHS 2 Directive. This was updated in Directive (EU) 2017/2102 of 15 November 2017.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>WEEE Directive 2012/19/EU (disposal of electronic equipment waste)</b>                                                                                                                    | <ul style="list-style-type: none"> <li>• The first WEEE Directive (Directive 2002/96/EC) entered into force in February 2003. The Directive provided for the creation of collection schemes where consumers return their WEEE free of charge. These schemes aim to increase the recycling of WEEE and/or re-use.</li> <li>• The new WEEE Directive 2012/19/EU entered into force on 13 August 2012 and became effective on 14 February 2014.</li> <li>• Whilst the 2012 Directive remains in place, there have subsequently been further developments designed to support the Directive's implementation. For example, the "WEEE package" was adopted in 2017, including Commission implementing Regulation 2017/699 establishing a: <ul style="list-style-type: none"> <li>- Common methodology for the calculation of the weight of electrical and electronic equipment (EEE) placed on the national market in each MS.</li> <li>- Common methodology for the calculation of the quantity of waste electrical and electronic equipment (WEEE) generated by weight in each MS.</li> </ul> </li> <li>• The EC then adopted Implementing Regulation (EU) 2019/290 establishing the format for registration and reporting of producers of electrical and electronic equipment to the register.</li> </ul> |
| <b>Waste Packaging Directive Council Directive 94/62/EC on Packaging and Packaging Waste and industry</b>                                                                                    | <ul style="list-style-type: none"> <li>• Member States were required to put in place systems guaranteeing the return of used packaging and/or packaging waste</li> <li>• Life-cycle assessments have to be completed to justify a clear hierarchy between reusable, recyclable and recoverable packaging.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Waste Framework Directive</b>                                                                                                                                                             | <ul style="list-style-type: none"> <li>• Community strategy for waste management was set out in Council resolution of 7 May 1990 on waste policy and Council Directive 75/442/EEC of 15 July 1975 on waste.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Energy legislation</b>                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

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|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• <b>Energy Taxation Directive</b></li> <li>• <b>Effort Sharing Regulation</b></li> <li>• <b>Energy Efficiency Directive</b></li> <li>• <b>Renewable Energy Directive</b></li> </ul> | <ul style="list-style-type: none"> <li>• The Commission plans to review all relevant EU laws and regulations to align them with the proposed new European Climate Law.<sup>89</sup> By June 2021, the Commission will review or propose the revision of all relevant EU policy instruments to deliver the additional emissions reductions by 2030.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Industrial emissions and climate change mitigation</b>                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Industrial Emissions Directive (IED) Directive 2010/75/EU</b>                                                                                                                                                            | <ul style="list-style-type: none"> <li>• The EC will likely present a proposal to revise the Directive by the end of 2021 after collecting experts and stakeholders' opinions via an online survey<sup>90</sup>. The EC will also conduct an impact assessment to look at all economic, social and environmental impacts.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>European Union's Emissions Trading System (EU ETS)<sup>91</sup></b>                                                                                                                                                      | <ul style="list-style-type: none"> <li>• To achieve the EU's overall greenhouse gas emissions reduction target for 2030, the sectors covered by the EU Emissions Trading System (EU ETS) must reduce their emissions by 43% compared to 2005 levels.</li> <li>• The revised EU ETS Directive, which will apply for the period 2021-2030, will enable this through a mix of interlinked measures (expected 2021).</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Batteries</b>                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Directive 2006/66/EC</b>                                                                                                                                                                                                 | <ul style="list-style-type: none"> <li>• Legislation on batteries in support of the Strategic Action Plan on Batteries and the circular economy is expected to be adopted by October 2020.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Data protection and privacy legislation</b>                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>The General Data Protection Regulation (GDPR) 2016/679</b>                                                                                                                                                               | <ul style="list-style-type: none"> <li>• The GDPR provides a comprehensive legal framework to ensure personal data protection and privacy, but does not cover non-personal data.</li> <li>• The GDPR has implications for manufacturers (data controllers) and for any service providers and data analytics companies they work with in the value chain (data processors).</li> <li>• Among the key articles in the Directive applicable to economic operators prior to placing products on the European market are Art. 25 data protection by design and by default and Art. 24 (putting in place technical and organisational measures).</li> <li>• Once products are on the market, other Articles within GDPR are applicable e.g. the data controller (and/ or data processor gathering data on behalf of the controller) needs to inform users about the intention to collect and / or process personal data.</li> <li>• GDPR has implications for manufacturers collecting big data from their users, who need to ensure that data collected respects privacy requirements.</li> </ul> |
| <b>e-Privacy Directive (Directive 2002/58/EC)</b>                                                                                                                                                                           | <ul style="list-style-type: none"> <li>• The Directive concerns the processing of personal data and the protection of privacy in the transmission of data through electronic communications after products have been placed on the market.</li> <li>• However, the legislation still needs to be aligned with the GDPR (see entry below)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Proposal for an e-Privacy Regulation (COM/2017/010 final)</b>                                                                                                                                                            | <ul style="list-style-type: none"> <li>• A regulatory proposal has been made for a new Regulation to replace the e-PD and align it with the GDPR. This has taken a considerable period of consultation to move forward on and the Regulation has not yet been adopted.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

<sup>89</sup> [https://ec.europa.eu/clima/policies/eu-climate-action/law\\_en](https://ec.europa.eu/clima/policies/eu-climate-action/law_en)

<sup>90</sup> <https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12306-EU-rules-on-industrial-emissions-revision>

<sup>91</sup> The aim of the EU Emissions Trading System (EU ETS) is to help EU Member States achieve their commitments to limit or reduce greenhouse gas emissions in a cost-effective way. Allowing participating companies to buy or sell emission allowances means that emission cuts can be achieved at least cost.



|                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                       | <ul style="list-style-type: none"> <li>• Purpose of updating the Directive is that electronic communications have significantly evolved due to the development of the internet and there is a need to increase privacy for individuals and legal entities.</li> <li>• The regulatory proposal suggests extending key definitions and legal concepts in the GDPR to the e-PR. Examples of definitions provided for in the GDPR that could be used in the e-PR are: data protection and privacy, data subjects, the concept of informed consent, and aligning approaches to financial sanctions across the GDPR and e-PR (maximum fine of €20 million or 4% of annual global turnover).</li> </ul>                                                                                                                       |
| <b>Labour market legislation</b>                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Working Time Directive</b><br>(2003/88/EC)                                                                                                                                         | <ul style="list-style-type: none"> <li>• Lays down the minimum safety and health requirements for the organisation of working time.</li> <li>• Sets minimum periods of daily rest, weekly rest and annual leave, breaks and maximum weekly working time.</li> <li>• Aims to protect workers from negative health effects due to shift and night work, as well as certain patterns of work.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Part-Time and Fixed-Time Workers Directive EU Directive</b><br>(97/81/EC), which was extended to the UK by another Directive (98/23/EC).                                           | <ul style="list-style-type: none"> <li>• A Framework Agreement between Europe's employers and trade unions sets out to eliminate unjustified discrimination against part-time workers and improve the quality of part-time work. It aims to facilitate the development of part-time work on a voluntary basis and contribute to the flexible organisation of working time in a way that takes account of employers' and workers' needs. Framework agreements are agreed at a sectoral level by the social partners.</li> <li>• The Framework Agreement requires that part-time workers' employment conditions may not be less favourable than those of comparable full-time workers, unless there are objective reasons for different treatment.</li> </ul>                                                            |
| <b>Posting of Workers Directive</b><br><br><b>DIRECTIVE (EU) 2018/957 amending Directive 96/71/EC concerning the posting of workers in the framework of the provision of services</b> | <ul style="list-style-type: none"> <li>• 1996 Directive addressed the challenge of balancing the rights of workers and companies. To avoid the risk of posted workers being misused or exploited, Directive 96/71/EC clarified the legislation on posted workers' working conditions.</li> <li>• EU MS have to ensure that companies give posted workers the minimum standard of employment conditions in the host country in terms of, for example, working hours, pay, annual leave, health and safety, protective measures and equal opportunities.</li> <li>• A revision of the rules on the posting of workers was adopted on 28 June 2018, DIRECTIVE (EU) 2018/957.</li> </ul>                                                                                                                                   |
| <b>Occupational health and safety legislation</b>                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Framework Decision on Occupational Health and Safety (Directive 1989/391/EEC - OSH "Framework Directive")</b>                                                                      | <ul style="list-style-type: none"> <li>• Directive 1989/391/EEC is often referred to as the "framework directive" and the 'basic law' on occupational safety and health in the EU. It established the instrument of risk assessment in European OSH legislation.</li> <li>• Employers can decide on improvement measures that best meet the risk profile of the company. The Framework Directive can thus be considered a milestone for workplace prevention measures</li> <li>• Occupational safety and health risk assessment methodologies may need to be revised for some branches of the engineering sector in instances where they are using AI and machine learning in production processes to ensure that any risks linked to machines taking decisions rather than humans are adequately assessed.</li> </ul> |

The overview of currently-applicable legislation in the table above was the starting point for exploring the impact of EU legislation on the EU engineering industries.

A few observations can be made regarding the **characteristics of the applicable product and environmental legislation**:

- Product legislation are based on Art. 114 (ex Article 95 TEC) of the Treaty for European Union (TFEU), as they concern harmonisation measures for the functioning of the internal market. Art. 114 provides scope for measures concerning health, safety, environmental protection and consumer protection.
- As the legal base is Art. 114, product legislation utilise the maximum harmonisation legal base.
- Whereas some environmental and horizontal legislation, such as the RoHS Directive and REACH Regulation also use Art. 114 as the legal basis (as this also covers environmental protection), there are also pieces of environmental legislation, such as the WEEE Directive, that refer instead to Art. 192.<sup>92</sup>
- A key difference between legislation based on Art. 114 and Art. 191/ 192 etc. (the latter being part of the environmental title of the Treaty) is that a *maximum harmonisation approach* is common under the former, whereas a *minimum harmonisation approach* is more common under the latter. This matters as gold-plating is an issue for minimum harmonisation approaches, as Member States can stipulate national requirements that go beyond the minimum requirements in EU legislation.
- A further trend observed – at least for product legislation – is that there has been a gradual shift towards the increased use of directly-applicable regulations over directives. Examples are the Gas Appliances Regulation, Personal Protective Equipment (PPE) Regulation and the Medical Device Regulation. This has helped to reduce regulatory divergence due to divergent national transposition by Member States. Regulations have also been encouraged as a more reliable legal mechanism in terms of achieving objectives relating to harmonisation in the Better Regulation guidelines.
- Notwithstanding, it is notable that the core applicable EU legislation to the engineering industries, e.g. the MD, the EMCD, LVD and the RED are all Directives. However, this is arguably not that much of a problem as legislation adopted under Art. 114 adopts the maximum harmonisation approach. Besides, the trend is to convert the Directives into Regulations as expected in the MD revision.
- Due to the NLF, there is significant commonality between the requirements stemming from the EU's industrial product legislation, although there is clearly complexity provided by the specific technical harmonised standards that are a voluntary means to comply with the legislative requirements. On the other hand, the environmental legislation relevant to the engineering industries within scope contain significant and vastly differing requirements. These extensive environmental requirements are reportedly some of the most burdensome obligations stemming from EU legislation. Thus, their impact is explored in greater detail through case studies in the following section.
- The legal underpinning for data protection and privacy legislation is Art. 16 TFEU (protection of personal data).

The following table provides an overview of the **specific obligations for economic operators** for the main pieces of applicable legislation (e.g. industrial product, environmental and horizontal legislation). The legal basis is given for the TFEU unless otherwise stated.

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<sup>92</sup> Art. 192 TFEU allows measures to be taken in order to achieve the objectives referred to in Article 191 (Union policy on the environment).



**Table 3-2: Industrial product legislation – administrative requirements for economic operators**

| Legislation                                                 | Directive or Regulation? | Aligned with the NLF? (e.g. common approach to market surveillance and enforcement, traceability requirements) | Declaration of conformity (DoC) | Technical file to support DoC | Testing against (voluntary) technical standards to meet essential requirements | CE marking | Consumer Safety within essential requirement? | Legal basis (TFEU) |
|-------------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------------------------------|---------------------------------|-------------------------------|--------------------------------------------------------------------------------|------------|-----------------------------------------------|--------------------|
| <b>Industrial product legislation (core)</b>                |                          |                                                                                                                |                                 |                               |                                                                                |            |                                               |                    |
| Machinery Directive (MD) 2006/42/EC                         | Directive                | N                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 95 (TEC)      |
| Low Voltage Directive (LVD) 2014/35/EU                      | Directive                | Y                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 114           |
| Electromagnetic Compatibility Directive (EMCD) 2014/30/EU   | Directive                | Y                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | N                                             | Art. 114           |
| Radio Equipment Directive (RED) 2014/53/EU                  | Directive                | Y                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 114           |
| <b>Industrial product legislation (wider legislation)</b>   |                          |                                                                                                                |                                 |                               |                                                                                |            |                                               |                    |
| Explosive atmospheres equipment (ATEX) Directive 2014/34/EU | Directive                | Y                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 114           |
| Gas Appliances Regulation (GAR) 2016/426/EU                 | Regulation               | Y                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 114           |
| Lifts Directive 2014/33/EU                                  | Directive                | Y                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 114           |
| Outdoor Equipment Noise Emissions Directive 2000/14/EC      | Directive                | N                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 114           |
| Personal Protective Equipment (PPE) Regulation EU/2016/425  | Regulation               | Y                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 114           |
| Pressure equipment (PED) Directive 2014/68/EU               | Directive                | Y                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 114           |

| Legislation                                             | Directive or Regulation? | Aligned with the NLF? (e.g. common approach to market surveillance and enforcement, traceability requirements) | Declaration of conformity (DoC) | Technical file to support DoC | Testing against (voluntary) technical standards to meet essential requirements | CE marking | Consumer Safety within essential requirement? | Legal basis (TFEU) |
|---------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------------------------------|---------------------------------|-------------------------------|--------------------------------------------------------------------------------|------------|-----------------------------------------------|--------------------|
| Simple Pressure Vessels Directive (SPVD) 2014/29/EU     | Directive                | Y                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 114           |
| Ecodesign Directive 2009/125/EC                         | Directive                | N                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 95 (TEC)      |
| Energy-labelling of products Regulation 2017/1369       | Regulation               | NA                                                                                                             | Y                               | Y                             | Y                                                                              | Y          | N                                             | Art. 194           |
| Cableways Regulation EU/2016/424                        | Regulation               | Y                                                                                                              | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 114           |
| Medical Device Regulation (Council Regulation 2017/745) | Regulation               |                                                                                                                | Y                               | Y                             | Y                                                                              | Y          | Y                                             | Art. 114           |
| General Product Safety Directive, 2001/95/EC            | Directive                | N                                                                                                              | N                               | N                             | N                                                                              | N          | Y                                             | Art. 95 (TEC)      |

**Table 3-3: Environmental and horizontal EU legislation applicable to economic operators – administrative requirements**

| Legislation                                                                                                                                    | Directive or Regulation? | Aligned with NLF? | Rules for economic operators (manufacturers, importers, distributors, authorised representatives)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | CE marking | Declaration of conformity (DoC) | Technical file to support DoC | Legal basis (TFEU) |
|------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------------------|-------------------------------|--------------------|
| REACH Regulation (EC) No 1907/2006                                                                                                             | Regulation               | N                 | <ul style="list-style-type: none"> <li>• Yes, specific obligations for each individual substance manufactured, imported or used depending on tonnage of chemicals produced.</li> <li>• Preparation of a registration dossier (registration and reporting requirements for producers and where appointed, by authorised representatives).</li> <li>• Make an assessment of the hazards and potential risks presented by the substance.</li> <li>• Enquiries for new uses of phase in substances and non-phase in substances</li> <li>• Authorisation if substance in Annex XIV of the Regulation</li> <li>• Compliance with restriction requirements if substance in Annex XVII</li> <li>• Provision of necessary information to customers (downstream users and distributors) using SDS if substance is dangerous or in the candidate list.</li> <li>• Preparation of safety data sheets by manufacturer of chemicals for other economic operators in value chain.</li> <li>• Post-notification requirements</li> </ul> | Y          | Y                               | Y                             | Art. 114           |
| <b>Environmental protection legislation</b>                                                                                                    |                          |                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |            |                                 |                               |                    |
| RoHS Directive 2011/65/EU of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment. | Directive                | Y                 | <ul style="list-style-type: none"> <li>• Economic operators must identify who supplied them and who they supplied for 10 years following the placing on the market of the EEE. Economic operators must take specific steps if they know (or suspect) that a product is non-compliant. This includes: notifying the Market Surveillance Authority (MSA)</li> <li>• Manufacturers must manufacture EEE within these limits and evaluate their production</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Y          | Y                               | Y                             | Art. 114           |

| Legislation                                                                                                                            | Directive or Regulation?                | Aligned with NLF? | Rules for economic operators (manufacturers, importers, distributors, authorised representatives)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | CE marking | Declaration of conformity (DoC) | Technical file to support DoC | Legal basis (TFEU) |
|----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------------------------|-------------------------------|--------------------|
| Legislative amendment RoHS 2 Directive (EU) 2017/2102                                                                                  |                                         |                   | <p>controls with reference to the measures detailed in the Directive.</p> <ul style="list-style-type: none"> <li>• A Declaration of Conformity must be completed, supported by technical documentation to show compliance.</li> <li>• Individual products must have a type, batch or serial number and show the manufacturer's name or mark, and address and display the CE mark</li> </ul>                                                                                                                                                                                                                                                                                                                                                                          |            |                                 |                               |                    |
| WEEE Directive (Directive 2012/19/EU) (disposal of electronic equipment waste)                                                         | Directive                               | N                 | <ul style="list-style-type: none"> <li>• Registration and reporting requirements for producers and or, where appointed, by authorised representatives - set out in Annex X.</li> <li>• Regular declaration of electronic equipment placed on the Market.</li> <li>• Provision of information to end-users.</li> <li>• National implementing regulations to support the Directive, requiring reporting of tonnage of electrical equipment waste placed on national market annually by producers</li> <li>• Make information available to recyclers.</li> <li>• Organisation of pick-up of waste electrical and electronic equipment and recycling.</li> <li>• Financing of take-back and recycling.</li> <li>• Reporting take-back and recycling outcomes.</li> </ul> | Y          | Y                               | Y                             | Art. 192           |
| Implementing Regulation (EU) 2019/290 establishing the format for registration and reporting of producers of electrical and electronic | Regulation (supporting above Directive) |                   | <ul style="list-style-type: none"> <li>• Format for registration and reporting of producers of electrical and electronic equipment to the register.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |            |                                 |                               |                    |

| Legislation                              | Directive or Regulation? | Aligned with NLF? | Rules for economic operators (manufacturers, importers, distributors, authorised representatives) | CE marking | Declaration of conformity (DoC) | Technical file to support DoC | Legal basis (TFEU) |
|------------------------------------------|--------------------------|-------------------|---------------------------------------------------------------------------------------------------|------------|---------------------------------|-------------------------------|--------------------|
| equipment to the register.               |                          |                   |                                                                                                   |            |                                 |                               |                    |
| Future possible legislation - carbon tax | NA                       | NA                | NA                                                                                                | NA         | NA                              | NA                            | Art. TBC           |

**Table 3-4: Mapping of data protection and privacy legislation (requirements for manufacturers and other economic operators)**

| Legislation                                | Directive or Regulation? | Rules for data controllers and processors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Legal basis (TFEU)                                                       |
|--------------------------------------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| GDPR Regulation (EU) 2016/679              | Regulation               | <ul style="list-style-type: none"> <li>• Applicable to economic operators (manufacturers, service providers, third-parties working with manufacturers on data collection and processing if they are designated as a data controller/ data processor.</li> <li>• Some Articles are especially relevant, e.g. Art. 25 GDPR (data protection by design and by default) and Art. 24 (responsibility of the data controller) to put in place appropriate technical and organisational measures to ensure data protection and privacy.</li> <li>• GDPR means that engineering firms have to focus on documenting business processes in the design, engineering and manufacturing phases to comply with the above articles. Therefore, significant implications for EU engineering industries, especially those with integrated value chains (e.g. often manufacturers are also service providers and therefore may fulfil both data controller and data processor functions.</li> <li>• As the GDPR is a regulation, not a directive, it is directly binding and applicable, but does provide flexibility for certain aspects of the regulation to be adjusted by individual member states.</li> <li>• Looking ahead, GDPR rules also establish key legal concepts and principles relating to data protection and privacy at EU level. These may be incorporated into some EU industrial product legislation in the next decade.</li> <li>• One of the impact assessments of the RED (2019-20) focuses on the issues of data protection and privacy (Art. 3(3)(e) and the issue as to whether the GDPR is sufficient in an IoT context without further guidance on how legal compliance should be achieved in an IoT environment. Taking an example, obtaining informed consent without a suitable user interface is difficult in a consumer IoT environment. Further investigation is needed as to how such issues affect industrial IoT.</li> </ul> | <ul style="list-style-type: none"> <li>• Art. 16</li> </ul>              |
| e-Privacy Directive (Directive 2002/58/EC) | Directive                | <ul style="list-style-type: none"> <li>• Directive concerns the processing of personal data and the protection of privacy in the transmission of data through electronic communications after products have been placed on the market. However, legislation needs to be aligned with the GDPR (see entry below).</li> <li>• As fines of up to 4% of global turnover and 20 million EUR are possible, there are further implications for industry.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>• Art. 95 TEC</li> </ul>          |
| e-Privacy Regulation                       | Regulation               | <ul style="list-style-type: none"> <li>• The Regulation is a proposal to update the e-PD to regulate electronic communications to increase privacy for individuals and entities.</li> <li>• The e-PR needs to be aligned with the GDPR, e.g. regarding definitions, reflecting key legal concepts in the GDPR relating to data protection and privacy, such as informed consent, and a common approach to sanctions across the GDPR and e-PD.</li> <li>• Adoption of the e-PR as currently written would lead to even data stored on the device falling subject to privacy rules, not only data transmitted from the device. Therefore, this would have implications for industry.</li> <li>• As fines of up to 4% of global turnover and 20 million EUR are possible, there are further implications for industry.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <ul style="list-style-type: none"> <li>• Art. 16 and Art. 114</li> </ul> |

### **3.2.2 Key findings – mapping of existing EU legislation on the EU engineering industries.**

The findings from the baseline mapping in respect of existing applicable EU legislation are that:

The regulatory framework applicable to the European engineering industries (and international firms selling into the EU's single market) encompasses **different types of legislation**. This includes core industrial product legislation applicable to the EU engineering sectors (e.g. for electrical equipment, industrial machinery and electronic components). It also extends to a broader set of requirements which includes horizontal, environmental, occupational health and safety and labour market legislation. A challenge for manufacturers and other economic operators in complying with the Directive is that **different legislation has different objectives**.

The core applicable legislation includes the Machinery Directive (MD), the Low Voltage Directive (LVD), the Electro Magnetic Compatibility Directive (EMCD), and the Radio Equipment Directive (RED). Such legislation is based on Art. 114 of the TFEU, and is focused first and foremost on ensuring product safety and harmonisation within the internal market. Other legislation, particularly environmental, has a different set of objectives, depending whether the legislation falls under Art. 114 of the TFEU, which includes environmental protection or under Art. 191/ Art. 192 TFEU, in which case the primary objective will relate to EU environmental objectives. A concern raised by some stakeholders from an industry perspective (especially associations) is that considerations relating to industrial competitiveness and innovation, whilst mentioned in impact assessments for proposed new legislation, are secondary objectives. The impacts on the engineering industries are perceived as something of an afterthought by some stakeholders, and therefore, the imperative of full consideration of the impacts on industry before going ahead with new legislation was stressed by some industry associations, to avoid overly-burdensome new environmental legislation in future, unless it has been fully assessed for its impacts on manufacturers and SMEs.

The main Directives applicable to the European engineering sectors were found to have **remained stable for a prolonged period of two to three decades as regards the essential requirements, which were** developed under the New Approach. These Directives have therefore provided regulatory certainty for economic operators. The original versions of the Directives date back to the late 1980s (e.g. the MD and the EMCD), the 1970s (LVD) and the late 1990s (the RED, formerly the R&TTE Directive). Although these Directives have been through either one or two iterations since they were originally adopted, as they have been recast approximately once every decade, the essential requirements themselves have not changed. **Stability in the core legal framework was welcomed by industry**, as it has helped to ensure regulatory certainty at least regarding industrial product legislation for engineering producers.

Although there are common requirements for economic operators (e.g. placing goods on market, information obligations such as preparation of technical file, DoC and CE marking), there remain some differences between the core applicable legislation in terms of the conformity assessment procedures that economic operators follow. By definition, the harmonised standards also vary between Directives, as the standards relate to different types of legal requirements, e.g. pertaining to low voltage, the safety of machinery, electromagnetic compatibility (EMC) to check disturbance, etc. the EMCD is unusual compared with the other applicable legislation as it does not cover product safety, only electromagnetic disturbance.

Nonetheless, there are broad similarities as regards conformity assessment procedures in that economic operators can commonly either pursue a self-declaration of conformity assessment or must follow a third-party conformity assessment.

Nonetheless, recasts were made to the core applicable Directives, such as the EMCD, the LVD and the RED in 2014, due to their **alignment with the New Legislative Framework (NLF)**, a process which is not yet fully complete as the Machinery Directive, the central piece of legislation for the mechanical engineering sector has not yet been aligned with the NLF (though it has been subject to both an evaluation and impact assessment in 2017 and in 2019-20 and is expected to be aligned in the near future).

Despite the past decade being characterised by stability overall in the core applicable legislation, there have been **incremental changes at EU level to strengthen the coherence and consistency of EU legislation at a horizontal and vertical level**. At the horizontal level, for example, the NLF has led to a number of changes that whilst not altering the essential requirements in any way have implications for economic operators in the EU engineering sectors. A summary assessment of the main implications of the gradual alignment of EU legislation (since 2008), with the NLF<sup>93</sup> is now provided:

- Common requirements for placing goods on market;
- Common approach to market surveillance;
- Standard template of “manufacturer”, “importer” and “distributor” obligations set out in the NLF. Requirements extended to other economic operators in value chain”;
- New information obligations: Long process from 2008 (e.g. LVD, EMCD, RED only since April 2016). Most legislation today already adapted to NLF with exceptions e.g. Machinery Directive, GPSD;
- Corrective action requirements of non-compliant products; and
- An obligation to notify the regulator if a product is non-compliant and presents a risk

It should be noted that whilst the NLF was adopted in 2008, and was therefore also relevant in the earlier 2012-13 competitiveness studies on the mechanical engineering and electrical engineering and components sectors, its full impact has taken considerable time to be manifested, as many of the core pieces of applicable legislation to these sectors were adopted in 2014, but only came into force in 2016.

The impacts of the NLF could be worthy of a study in their own right, but a summary of some of the implications for product legislation affecting the EU engineering industries are that:

- The **legal texts themselves have grown in length**, due to common text on administrative requirements across different EU industrial product legislation having been integrated through an alignment process. However, from an engineering firm perspective, as the essential requirements have remained unchanged, this was not viewed as being problematic.
- There has been a **shift towards a value chain approach in the EU regulatory framework** by bringing wider economic operators (e.g. distributors importers, authorised representatives) within the scope of EU legislation. This recognises that compliance is a shared responsibility rather than solely the responsibility of manufacturers. There are still some uncertainties about whether the responsibilities of all economic operators (EO) in the value chain are sufficiently clear and if these EO also take their responsibilities seriously enough (e.g. e-commerce platforms/ EMCD).
- Strengthened focus on improving traceability for market surveillance and enforcement.

As regards **further changes in the EU legal framework for product legislation**, electrical and electronic equipment that contains radio device functionality and internet connectivity is since the 2014 Directive only subject to the EMC requirements in the RED,

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<sup>93</sup> The two seminal supporting documents relevant to the NLF’s implementation setting out common requirements across industrial product legislation are (1) Regulation (EC) No 765/2008 on accreditation and market surveillance and (2) Decision No 768/2008/EC on establishing a common framework for the marketing of products.



rather than those in the EMCD. An *Evaluation of the Machinery Directive*<sup>94</sup> undertaken for the European Commission in 2017 pointed out that 50% of products are smart and connected, therefore, this means that many more manufacturers now follow the RED rather than the EMCD. An interviewee representing a certification company noted that the changes made to the RED in the 2014 recast Directive have only focused on elements that economic operators had been implementing incorrectly under the previous iteration of the Directive.”.

Whilst the core legislation is characterised by a long period of stability, technological developments, such as Industry 4.0 (including the use of advanced manufacturing processes, automation, robotics, and the industrial IoT) mean that the legal framework has already evolved.

For example, in an Industry 4.0 context, there are complex value chains not only during the production process, but also, post-product placement. In particular, in their capacity as data controllers, manufacturers working with service providers downstream in the value chain involved in collecting big data for commercial reasons (e.g. data processors) are subject to the **GDPR**, which came into force in May 2018.

Moreover, the implications of the wider adoption of digital technologies and digitalised production processes due to Industry 4.0 has raised strategic questions for EU regulators as to whether the existing body of legislation is fit for purpose, or should be modified and updated. Accordingly, a number of regulatory reviews have taken place in 2019 and 2020 through impact assessments undertaken on behalf of the European Commission. Examples are:

| Directive                             | Study                                                                                 | Year      | Description of key issues relating to possible revisions to existing EU legislation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Implications for engineering industry                                                                                                                                                                                                                                                                                                                                         |
|---------------------------------------|---------------------------------------------------------------------------------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Machinery Directive 2006/42/EC</b> | Impact assessment study of the possible revision of Directive 2006/42/EC on Machinery | 2019-2020 | <ul style="list-style-type: none"> <li>The MD has not yet been aligned with the NLF and will need to be updated.</li> <li>Moreover, some stakeholders suggested that the MD may need to be adapted so that it accommodates recent technological developments, especially growing use of AI and machine learning in advanced production processes.</li> <li>Additional safeguards may be required when producing industrial machinery so as to ensure continued high levels of occupational health and safety (e.g. the question of human-robot interactions, degree of autonomous decision-making by machines).</li> <li>However, many industry associations expressed the view in position papers<sup>95</sup> that the New Approach can accommodate technologies, through a</li> </ul> | <ul style="list-style-type: none"> <li>Depends if the MD is simply aligned with the NLF (modest impacts) or the Directive is changed to explicitly introduce new essential requirements pertaining to AI and machine learning (potentially much more significant impacts).</li> <li>Impacts can't be determined until regulatory proposal published by Commission.</li> </ul> |

<sup>94</sup> European Commission's DG GROW, Evaluation study of Directive 2006/42/EC on Machinery, 2017, Technopolis Group. <https://op.europa.eu/en/publication-detail/-/publication/2b213537-25a8-11e8-ac73-01aa75ed71a1/language-en/format-PDF/source-68663524>

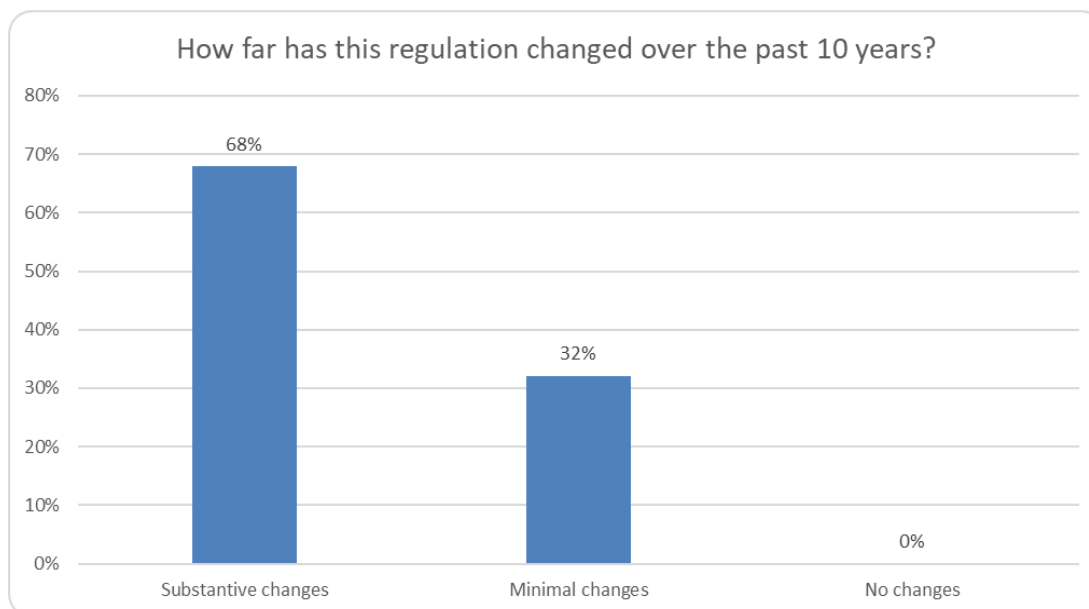
<sup>95</sup> Example – Orgalim's 2019 position paper on the IA of the MD - <https://www.orgalim.eu/position-papers/orgalim-comments-upcoming-impact-assessment-machinery-directive>

| Directive                                         | Study                                                                                                                                                        | Year      | Description of key issues relating to possible revisions to existing EU legislation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Implications for engineering industry                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                   |                                                                                                                                                              |           | <p>technology-neutral approach, and continuing reliance on harmonised standards to reflect state of the art technological developments and to address any new risks identified.</p> <ul style="list-style-type: none"> <li>In the webinar on the impacts of EU legislation, there was also support from several major national engineering associations for continuing reliance on the New Approach, through the setting of simple essential requirements, technology-neutral legal texts and technical harmonisation processes addressing any risks.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                       |
| <b>Radio Equipment Directive 2014/53/EU (RED)</b> | Study to support an Impact assessment of the Radio Equipment Directive Article 3(3)(e) and Article 3(3)(f) in respect of internet-connected radio equipment. | 2019-2020 | <ul style="list-style-type: none"> <li>The IA study explored how far existing EU legislation – especially the GDPR and e-Privacy Directive and proposed e-Privacy Regulation – were fit for purpose to address data protection and privacy issues in internet-connected radio equipment.</li> <li>Also considered how effective voluntary certification approaches are likely to be under the Cybersecurity Act 2019.</li> <li>The Commission has started preparatory work with the ESOs on the Delegated Acts that could be activated under the RED (Directive 2014/53/EU), namely Article 3(3)(e) and Article 3(3)(f),</li> <li>These could lead to invoking additional essential requirements to strengthen product security of internet-connected radio equipment.</li> <li>Possible introduction of concept of minimum baseline security requirements.</li> <li>The possible activation of the DAs could ensure safeguards to enhance data protection and privacy and to strengthen protection from fraud in consumer IoT devices. This would have design and cost implications for producers, such as the need to integrate security</li> </ul> | <ul style="list-style-type: none"> <li>Manufacturers already need to integrate data protection by design and default into product design due to GDPR (Art. 25).</li> <li>If the DAs were to be activated, manufacturers may have to change their behaviours e.g. procuring secure chips and components, investing more in product security</li> </ul> |

| Directive | Study | Year | Description of key issues relating to possible revisions to existing EU legislation                                                                                                                                 | Implications for engineering industry |
|-----------|-------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
|           |       |      | <p>by design principles from the outset of the design process.</p> <ul style="list-style-type: none"> <li>Industry was divided in this study regarding whether the Commission should activate these DAs.</li> </ul> |                                       |

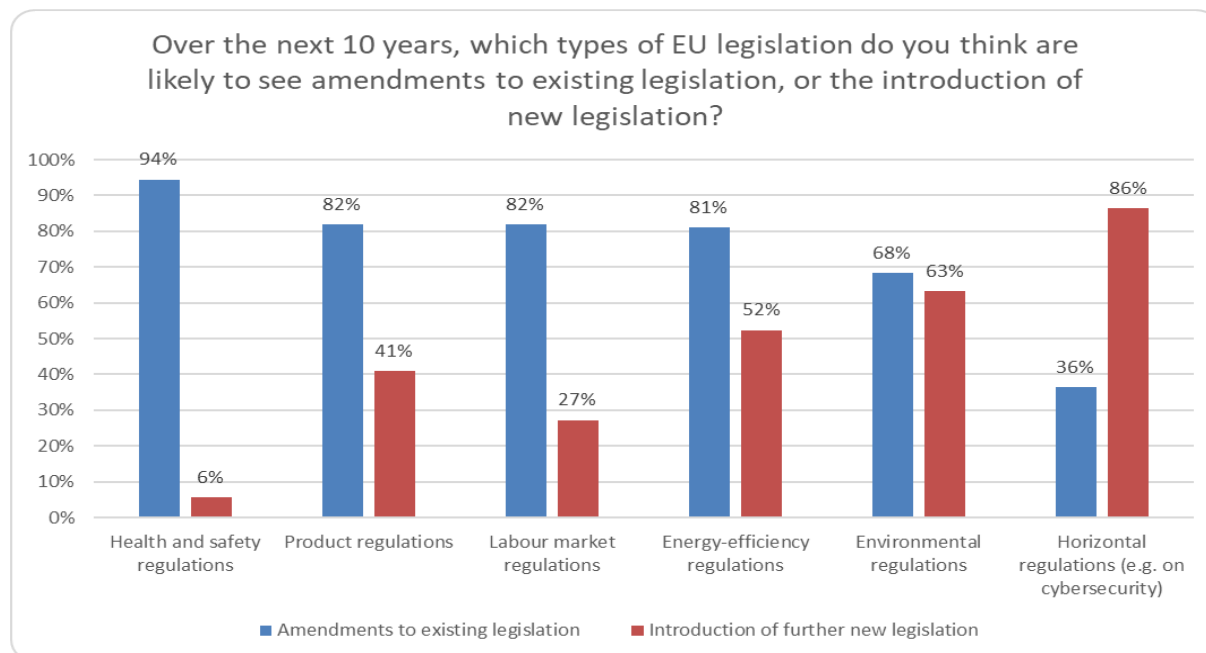
Regarding the issue as to how far overall the EU legal framework has changed, through the Survey of testing and certification bodies (incl. notified bodies) and MSAs, it was interesting that more than two-thirds of NBs thought that legislation had changed significantly, whereas around one-third said that there had been minimal changes.

**Figure 3-1 – How far has this regulation changed over the past 10 years?**



Source: CSES' Survey of testing and certification bodies (incl. notified bodies) and MSAs

**Figure 3-2 - Over the next 10 years, which types of EU legislation do you think are likely to see amendments to existing legislation, or the introduction of new legislation?**



Source: CSES' survey of testing and certification bodies (incl. notified bodies) and MSAs

A Market Surveillance Authority from Lithuania noted that a challenge identified for MSAs and testing bodies is that only limited adaptations have been made to reflect increasingly important areas of product testing by laboratories and testing for market surveillance purposes that are being driven by digitalisation.

**Consultation feedback e.g. through interviews and the webinar on the impact of legislation suggested that industry associations and manufacturers they represent are strongly in favour of maintaining the status quo as regards the core applicable legislation.** They do not want to see changes either to the essential requirements, or to the rest of the legal text to accommodate new technologies, on the basis that the New Approach is already centred on a technology-neutral approach.

**Notwithstanding, there was support among some industry stakeholders for a horizontal piece of law regulating cybersecurity, possibly through legislation over the medium-term to cover all industrial products.** This would have implications for the EU engineering industries, such as the need to design products that go beyond existing legal requirements under the GDPR (data protection by design and default) to a more holistic approach focused on broader security by design and default considerations. Whereas steps would need to be taken to integrate more encrypted technologies into product design (from chips and other electronic components, through to the design of hardware and software) and in ensuring that authentication requirements are built into product design more systematically, arguably such considerations are already implicit in the GDPR (e.g. Art. 25 data protection by design and default, and Art. 24, ensuring that appropriate technical and organisational measures are put in place to protect personal data). Therefore, to some extent, regulatory costs and burdens here would be expected to show high business as usual costs.

However, a horizontal piece of law on cybersecurity may extend beyond data protection and privacy alone. Some consumer associations interviewed as part of the recent RED IA study stated that they viewed there as being a growing interconnectedness between

product safety and security, which even if not yet reflected in the Treaty, will have implications for manufacturers in future. Whilst some engineering industry stakeholders interviewed (e.g. electrical equipment and domestic appliances) and EU umbrella organisations representing different branches of engineering were against the activation of the two delegated acts in the RED, they were more supportive of a horizontal law on cybersecurity of all industrial products in future, as this could help to avoid different regulatory requirements for internet-connected radio equipment products compared with non-smart products (which may have largely the same product features, except one product being wired and the other wireless).

**Cybersecurity is an area where some stakeholders interviewed representing the electronic component and semi-conductor manufacturers express the view that Europe has a relative competitive advantage, which could be built upon.** Europe's competitive advantages are in specific areas such as secure payment devices (smart cards) or ID systems and biometrics, where European companies such as IDEMIA or Gemalto (acquired by Thales in 2019) have secured world leading positions. The European banking system contributed to enabling this by introducing EMV chip cards at the turn of the 21st century, when the American banking system stuck to the old magnetic strip cards introduced in the 1970s. This is similar to the way in which the same European companies gained their leadership in SIM cards for mobile phones thanks to the European GSM standard introduced in 1991, when the Americans kept to their earlier AMPS (1983), D-AMPS, and later CDMA standards. The European GSM was pioneered in Finland, enabling Nokia to become world leader in mobile phone supply.

These advanced European standards have helped the European semiconductor suppliers Infineon and STMicroelectronics to acquire strong positions in these market segments with cybersecure chips, showing the very efficient relationship between unified standards, regional company interrelations and market and production growth. Competitiveness is here determined by overall market performance of companies throughout the segments of the value chain.

Europe also retains competitive strengths in producing encrypted and more cybersecure chips in fast-growth industries such as the use of semi-conductors in the automotive sector (electric vehicles) and in specialised industrial IoT applications.

There are a number of other different types of EU legislation applicable to the engineering industries. Among those identified by interviewees to date as being most burdensome are: the REACH Regulation (Regulation (EC) No 1907/2006), Directive 2011/65/EU (the RoHS Directive) on the restriction of the use of certain hazardous substances in electrical and electronic equipment (EEE) and the WEEE Directive regarding the disposal and recycling of electrical and electronic waste. In addition, following a 2013 Top 10 consultation, the European Commission reported that, when specifically considering SMEs, the REACH Regulation is in fact the most burdensome. Specifically, the Commission concluded that, although REACH functions well and delivers on all objectives, REACH places a disproportionate burden on SMEs, including in relation to the extent of the administrative costs.<sup>96</sup>

As demonstrated in the case studies on the WEEE Directive and RoHS Directive respectively, whilst the legal framework has remained broadly stable, there have nevertheless been several iterations of the Directive through various recasts. Moreover, even where legislation remains stable, a participant in the webinar pointed to there being additional cost burdens and regulatory uncertainty for industry due to detailed

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<sup>96</sup> Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Smart regulation – Responding to the needs of small and medium - sized enterprises /\* COM/2013/0122 final. <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52013DC0122>

implementation requirements for environmental Directives gradually evolving, not always in predictable ways.

Familiarising with legislation as it has been amended implies some administrative costs. Additionally, new requirements have been introduced for producers and other economic operators through additional implementing regulations that have been introduced, such as the need to provide national data feeding into an EU database to measure the quantity in tonnage of electronic and electrical products put on the market. Such measures may help to strengthen manufacturers' compliance with the legislation, but additional reporting requirements also impose additional costs.

In addition, a key challenge for producers raised specifically in relation to the RoHS Directive relates to the need to find alternative substances to those that are restricted by the Directive. In particular, the current exemption system is considered to be inefficient. As such, this inefficiency increases the economic burden on economic operators alongside the costs incurred by producers to identify adequate substitutes.

Considering the impact of the EU legislative framework on SMEs specifically, it is found that they often face higher regulatory compliance costs relative to turnover than larger producers from vertical legislation. SMEs commonly produce in lower volume and are therefore less likely to offset costs against high production volume. Furthermore, these compliance costs tend to be relatively high and cumulative across multiple legislation. When examining the impact of horizontal legislation on SMEs, it has been found that negative impacts can arise in areas such as access to finance and employment law. It should be noted that a detailed provisional analysis of EU legislation to accommodate innovation and new technologies, such as AI, machined learning, advanced manufacturing processes, such as robotics and advanced automation are described later in this section, where we analyse developments in the EU policy and regulatory framework alongside that of international competitor countries.

One of the further issues for investigation through the research is the question of the extent to which the transposition process into national legislation has resulted in erroneous or incorrect transposition into national legislation (for example due to translation issues, misunderstandings about the original intended meaning of legislation).

Some feedback was received regarding gold-plating. However, it was difficult to identify more than a few relevant examples, with prominent issues only found in relation to environmental legislation.

Some stakeholders pointed out that gold-plating was less a problem in respect of the transposition of industrial product legislation, but was seen as being particularly prevalent in the domains of workplace safety and the environment.

Furthermore, some literature has identified environmental protection legislation, such as the REACH Regulation, that where gold-plating has occurred, citing Denmark, France, Germany, the Netherlands and Sweden as Member States commonly stipulating additional requirements.

Whilst some industry stakeholders advocate a lighter regulatory regime for SMEs, there are no specific differences in the applicable legislation to the EU engineering industries between SMEs and large firms, as this could risk undermining the Single Market, by not having a level regulatory playing field. However, legislation affects firms differently depending on their size. Moreover, for certain environmental and horizontal Directives, the requirements may only kick in for larger producers.

The first example was that for the first 10 years of its implementation, the REACH Regulation was implemented on a phased basis (with requirements coming in from 2008,

2013 and 2018, starting with big tonnage producers (mainly large firms) and then progressively bringing small tonnage producers within the Directive's scope. The only piece of EU legislation where professional engineers are concerned is the Construction Products Regulation where differentiated requirements were introduced for micro firms.

The same is true of the WEEE Directive, which also has differentiation depending on the size of producer. The registration requirements are different, as follows:

- If manufacturers (or other economic operators) place less than 5 tonnes of EEE on the European market in a compliance year, they can register directly with their environmental regulator as a small producer; and
- If manufacturers (or other economic operators) place more than 5 tonnes of EEE on the market, they must join a producer compliance scheme (PCS). The PCS takes on their obligations to finance the collection, treatment, recovery and environmentally sound disposal of household WEEE collected.

There are however further EU laws applicable to only very large firms, such as the Non-Financial Reporting Directive.

### **3.2.3 Key findings – mapping legislation in major competitor countries**

In this section, an assessment of the legislation applicable to firms in the European engineering industries in third countries within study scope is provided. This assessment covers the **US, China, India, Japan, South Korea and Russia**. Building on the above mapping of EU legislation applicable to the engineering industries, this section primarily provides an overview of core industrial product legislation and environmental legislation relevant to the engineering industries. Other types of legislation, including safety and health legislation are also covered. Within the descriptions of relevant legislation, this section provides insight into the requirements for economic operators and the level of alignment of third-country rules with EU legislation.

#### **3.2.3.1 Brazil**

Brazil has inherent challenges related to competitiveness, in particular the complexity of its regulatory system, the burdensome corporate tax regime and a lack of technical engineering skills. For instance, Brazil's federative system illustrates the complexity of its regulatory system, as it gives the 5,570 federated units, which span the 27 Brazilian states, autonomy on a range of issues.<sup>97</sup> The World Bank Group rates Brazil poorly in terms of the time and cost associated with the logistical process of exporting and importing goods; the country is ranked 106<sup>th</sup> globally in the 2019 Doing Business report.<sup>98</sup>

Furthermore, key sectors of relevance with regard to the engineering industries are considered to be subject to high foreign competition. A competitiveness profile, developed by the FGV Projetos, concluded this in relation to a range of sectors, including: electronic and communication products; medical equipment; computers and office machines; machines and equipment; and the automotive sector.<sup>99</sup>

#### **Industrial product legislation**

Brazil seems to have a longstanding legal framework of industrial product legislation, for example covering standardisation and certification regimes related to electronic and electrical equipment, comprising the following texts:

- **Law No. 5,966 / 1973** and **Law No. 9.933 / 1999** provide for the establishment and remits of Brazil's standards regime, the National Council of Metrology,

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<sup>97</sup> World Economic Forum, Brazil Competitiveness and Inclusive Growth Lab Report, 2018.

<sup>98</sup> World Bank Group, Doing Business 2019, Training for Reform: Brazil.

<sup>99</sup> FGV Projetos and Financial Times, Brazil Competitiveness Profile, May 2015.



Standardization and Industrial Quality (Conmetro) and its Executive Secretariat (i.e. its operational arm), the National Institute of Metrology, Standardization and Industrial Quality (Inmetro).<sup>100</sup> Inmetro is a federal agency linked to the Special Secretariat of Productivity, Employment and Competitiveness at the Ministry of Economy. Within its remit, Inmetro can prepare and issue technical regulations in areas determined by Conmetro with the broad objectives of strengthening national companies and increasing productivity through services to improve product quality and product safety.

- As such, Inmetro holds responsibility for coordinating Brazil's conformity assessment programs in relation to a wide range of industrial products. The Brazilian Conformity Assessment System (SBAC) utilises three types of mechanism to ensure conformity:
  - **Certification** by third parties accredited by Inmetro. There are seven certification models implemented by Inmetro, which cover, for example: a single assessment (Model 1a), where one or more product samples are assessed; or a batch test (Model 1b), where a batch of products is tested and certified.<sup>101</sup> Examples of products that require certification are plugs and socket adapters, steel bars and wires for reinforcement and automotive components.<sup>102</sup>
  - **Supplier's Declaration** comprises a written declaration from the economic operator that a product conforms to a specific standard or requirement. Inmetro stipulates that the information to be declared must follow ABNT NBR ISO/IEC 17050 Conformity Assessment standards.<sup>103</sup> Examples of products subject to a supplier declaration are centrifugal pumps and pumps, air conditioners and televisions.<sup>104</sup>
  - **Inspection** is defined by Inmetro as "conformity Assessment by observation and judgement, accompanied, as appropriate, by measurements, tests or use of gauges".<sup>105</sup> Inspection in Brazil is often used to evaluate services. It is the primary conformity mechanism, for example, for issues related to vehicle safety.<sup>106</sup>
- In May 2019, to support the objectives outlined above, Inmetro initiated the implementation of a **New Regulatory Model** (Novo Modelo Regulatório) for product regulation, to be implemented fully by December 2021. The new model and the associated implementation roadmap detail more specific regulatory objectives, including: promoting safety; the protection of human, plant and animal life; the protection of the environment; and the prevention of misleading trade practices. Furthermore, it aims to deliver impact across four major dimensions:<sup>107</sup>
  - **Regulatory Quality:** This dimension aims to ensure the application of good regulatory practices, including regulatory inventory management, measurement of administrative burden and regulatory impact analysis.
  - **Normative Environment:** This dimension focuses on the implementation of general rules and essential requirements such that they do not inhibit industry by being, for example, overly detailed or poorly scoped.

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<sup>100</sup> <http://www4.inmetro.gov.br/aceso-a-informacao/institucional>

<sup>101</sup> <http://www.inmetro.gov.br/qualidade/certificacao.asp>

<sup>102</sup> <http://www.inmetro.gov.br/qualidade/rtepac/compulsorios.asp>

<sup>103</sup> <http://www.inmetro.gov.br/qualidade/declaFornecedor.asp>

<sup>104</sup> <http://www.inmetro.gov.br/qualidade/rtepac/compulsorios.asp>

<sup>105</sup> <http://www.inmetro.gov.br/qualidade/inspecao.asp>

<sup>106</sup> <http://www.inmetro.gov.br/qualidade/inspecao.asp>

<sup>107</sup> <http://www4.inmetro.gov.br/novo-modelo-regulatorio>



- **Monitoring and Control:** This dimension aims to increase the effectiveness of Brazil's market surveillance structure.
  - **Management and Governance:** This dimension focuses on ensuring the leadership, strategy and control mechanisms will facilitate the effective evaluation, direction and monitoring of the new regulatory model.
- In addition to Inmetro's work, 25 additional government agencies are active in relation to conformity assessment procedures, across a range of sectors.<sup>108</sup> A prominent example is **ANATEL**, the National Telecommunications Agency, which is responsible for the certification of telecommunications products, including, for example, electromagnetic compatibility (handled via the EMC Directive in the EU).
  - Since 2000, **Resolution 242 (and its update through Resolution 323)** has stipulated the general requirements for the certification of telecommunications products are established, including the procedures for certification and homologation of such products. These resolutions are supported by IGs (*Instrumento de Gestão*), which provide detail on approval processes and providers, and *Ofícios Circulares*, which aim to clarify the rules relating to the certification processes. Considering the requirements, these resolutions stipulate the requirements for approval / certification or declarations of conformity, as well as the accreditation of third-party laboratories. Certification and testing must be performed by ANATEL-authorised organisations. As such, certification can only be provided by Designated Certification Bodies (*Organismo de Certificação Designado* – OCD) and testing can only be conducted at laboratories accredited by an OCD or a foreign member of the International Laboratories Accreditation Cooperation, or by Inmetro itself. Furthermore, an authorised local representative is required and ANATEL has strict product labelling requirements.<sup>109</sup>
  - This regulatory regime delineated three categories of products: the first category covers terminal equipment, which require retesting and re-evaluation every year; the second category covers radio frequency equipment not included in the first category, which require retesting and re-evaluation every two years; and the third category, which covers any telecommunications products not included in the first two categories.
  - Currently, however, this legal framework is being revoked and replaced by **Resolution No. 715** of October 23, 2019, which will come into force in April 2020. Among its main changes, this new resolution: removes the homologation fee; revises the conformity assessment model to increase its flexibility and remove the strict categories; and aims to enhance market surveillance practices through the publication of a specific operational procedure for market surveillance by ANATEL, under which the certificate holder will be responsible for the market surveillance costs.<sup>110</sup>
  - Specifically considering the example of **electromagnetic compatibility**, this issue is regulated by Resolution 442. These requirements are based on the international CISPR 22 and CISPR 24 standards and are similar to the EU's requirements, as detailed in the EMC Directive.<sup>111</sup>

Beyond the implementation of legislation concerning the safety and quality of industrial products, Brazil implements **national health and safety legislation** through the Consolidation of Labor Laws 1943 and Decree Law 5452. Within this law, 36 *Norma Regulamentadoras* (NRs) stipulate specific regulatory standards for ensuring workplace

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<sup>108</sup> <https://www.standardsportal.org/Brazil/resources/Brazilian-Government-Entities.aspx>

<sup>109</sup> <https://www.anatel.gov.br/legislacao/resolucoes/2000/129-resolucao-242>

<sup>110</sup> ANATEL presentation, New conformity assessment framework for telecommunications products in Brazil, 2019, accessed on 28.01.2020 at: [https://www.wto.org/english/tratop\\_e/tbt\\_e/04\\_c\\_4c\\_brazil.pdf](https://www.wto.org/english/tratop_e/tbt_e/04_c_4c_brazil.pdf)

<sup>111</sup> <https://incompliancemag.com/article/compliance-in-brazil-russia-india-and-china-for-information-technology-equipment/>

safety. NR-12 relates specifically to machinery safety and places requirements on machinery or equipment designers and manufacturers.<sup>112</sup>

Furthermore, on a more contextual note, as part of the EU-Mercosur negotiations for a comprehensive Association Agreement, the two parties reached a political agreement for a trade agreement in June 2019. This trade agreement will, in particular, boost the EU's industrial sectors by reducing historically prohibitive tariffs, for example on cars, car parts and machinery.<sup>113</sup>

### Environmental legislation

In addition to the new national approach to legislating industrial products highlighted above, the Brazilian government, in May 2019, published a draft proposal for legislation on the Restriction of Hazardous Substances (RoHS) in relation to electronic and electrical equipment.<sup>114</sup> It will reportedly align Brazil with the European RoHS legal framework by covering the same substances, including, for example, lead, cadmium and mercury.<sup>115</sup>

Other prominent areas of environmental legislation that place obligations on economic operators in Europe include legislation in relation to **chemical safety** and **electronic waste**. Considering the former issue, Brazil does not currently have an overarching law similar to the EU's REACH Regulation or focused on new chemical substance notification requirements for industrial chemicals. However, it does have specific laws on the use of chemicals in a range of products, including pharmaceutical products, pesticides, cosmetics and explosives.

Regarding an overarching law on industrial chemicals, there have been notable developments in recent years. In October 2018, a draft law was published by the Ministry of the Environment and the National Chemicals Safety Commission (*Comitê Nacional Sobre Segurança Química* – CONASQ) for the 'Inventory, Evaluation and Control of Chemical Substances'. Among other elements, this draft law aims to establish a national inventory of chemical substances and implement processes for the evaluation and control of new and existing chemical substances.<sup>116</sup> However, in April 2019, it was reported that the preliminary bill was shelved and, as such, the regulatory regime will remain in its current form for the foreseeable future.<sup>117</sup>

The situation concerning handling electronic waste in Brazil is more complex, as Brazil is known as a trans-boundary destination of Waste Electrical and Electronic Equipment (WEEE).<sup>118</sup> With this in mind, the 2010 National Law on Solid Waste, an overarching waste law, stipulates that importation of WEEE is illegal. Furthermore, this policy requires that manufacturers, as well as importers, distributors and retailers, design and deploy take-back schemes for WEEE and that economic operators dispose of the waste appropriately in accordance with relevant standards for WEEE recycling. In line with both RoHS and REACH-type regulatory activities in Brazil, recent years saw the publication of draft legislation on the Management and Disposal of Electronic Waste (WEEE, Draft Law 2940/2015). However, no progress appears to have been made on the implementation of this draft law.

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<sup>112</sup> <http://www.braziliannr.com/brazilian-regulatory-standards/nr12-machinery-and-work-equipment-safety/>

<sup>113</sup> [https://ec.europa.eu/commission/presscorner/detail/en/ip\\_19\\_3396](https://ec.europa.eu/commission/presscorner/detail/en/ip_19_3396)

<sup>114</sup> <https://www.ecomundo.eu/en/blog/rohs-brazil-2019>

<sup>115</sup> <https://www.ecomundo.eu/en/blog/rohs-brazil-2019>

<sup>116</sup> [https://www.chemicalsafetypro.com/Topics/Brazil/chemical\\_regulations\\_in\\_Brazil\\_and\\_developments.html](https://www.chemicalsafetypro.com/Topics/Brazil/chemical_regulations_in_Brazil_and_developments.html)

<sup>117</sup> <https://chemicalwatch.com/76218/brazil-shelves-chemicals-bill-until-further-notice>

<sup>118</sup> Superti C, Receita apreende 353 toneladas de lixo eletrônico vindos dos Estados Unidos no porto de Navegantes, 2013.

### 3.2.3.2 China

China has historically been strong in the mass production of consumer and industrial products. Currently, the country is changing its focus, in particular in mechanical engineering, from one of mass production to higher end products. However, from an external perspective, market access requirements in China are often a barrier for foreign companies, with key challenges including the complexity and lack of transparency of Chinese legislation, regulation and industrial standards.

#### Industrial product legislation

China places key importance on its standardisation regime, particularly in relation to mechanical engineering, as demonstrated through the relevant legal texts:

- **Standardisation Law:** Originally passed by the Chinese State Council in 1989, this law focuses on enhancing the quality of products and services, ensuring the safety of people and property and strengthening standardisation.<sup>119</sup> The State Administration of Standardisation (SAC) is responsible for standardisation in China. In concert, the SAC and the law provide the basis for Chinese industry standards – level two of the five level standards system (as of the amended law, enacted on 1<sup>st</sup> January 2018<sup>120</sup>). Under this system, the responsibility for each industry is spread across a wide range of government bodies / organisations. For instance, the standards related to the automobile industry are the responsibility of the China Machinery Industry Federation (CMIF), whereas those related to electronics are the responsibility of the Ministry of Information Industry (MIIT).
- Notably, it is reported by the VDMA that only a “very small percentage of the ‘Industry Standards’ are based on international reference standards”<sup>121</sup>. For the most part, the prevailing standards are drafted by institutes, universities or large national enterprises. Furthermore, considering the specific issue of machinery safety, it is noted that there is currently no comparable set of rules to those implemented in the EU through the Machinery Directive.
- **Laws implementing the Chinese certification and accreditation system:** Prominently, these laws include the: i) **Product Quality Law** (2000),<sup>122</sup> which aims to improve product quality and strengthen supervision and control; ii) **Import and Export Commodity Law** (2002),<sup>123</sup> which aims to strengthen the inspection of imports and exports; and iii) **Regulations on Compulsory Certification** (2001/2009),<sup>124</sup> which establish the CCC (China Compulsory Certificate) mark. The CCC mark is the compulsory safety mark in China for many manufactured products.

#### Environmental legislation

In terms of environmental legislation that impacts economic operators in the engineering industries, China has measures covering key areas, including those covered in the EU by the WEEE and RoHS Directives and the REACH Regulation.

Considering **WEEE**, for example, China is the largest producer of electronic waste, according to the Global e-waste monitoring report published in 2017 by the International

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<sup>119</sup> [https://share.ansi.org/Shared%20Documents/News%20and%20Publications/Links%20Within%20Stories/China%20Standardization%20Law\\_English%20translation\\_SESEC\\_5.17.2017.pdf](https://share.ansi.org/Shared%20Documents/News%20and%20Publications/Links%20Within%20Stories/China%20Standardization%20Law_English%20translation_SESEC_5.17.2017.pdf)

<sup>120</sup> <https://www.qma.trade/single-post/2017/12/04/New-revised-Law-on-Standardization-of-China-will-come-in-force-on-January-1st-2018>

<sup>121</sup> VDMA, Study on “Standardization for Mechanical Engineering in China”, 2013. [https://normung.vdma.org/documents/22594015/26164157/VDMA%20study%20on%20Standardization%20in%20China\\_1524815290488.pdf/16b6fa68-72b1-067e-244d-a8d536c448d2](https://normung.vdma.org/documents/22594015/26164157/VDMA%20study%20on%20Standardization%20in%20China_1524815290488.pdf/16b6fa68-72b1-067e-244d-a8d536c448d2)

<sup>122</sup> <http://english.mofcom.gov.cn/article/policyrelease/Businessregulations/201303/20130300046024.shtml>

<sup>123</sup> <http://english.mofcom.gov.cn/article/policyrelease/Businessregulations/201303/20130300045852.shtml>

<sup>124</sup> <http://www.ccc-mark.com/>

Telecommunication Union (ITU) and the United Nations University (UNU), with China reportedly producing 7.2 million metric tons per year.<sup>125</sup> As per the Regulations for the Administration of the Recovery and Disposal of Waste Electric and Electronic Products (Order No.551, 2009), WEEE recycling (often referred to as WEEP – Waste Electric and Electronic Products) is based on a system of “multichannel recovery and centralised treatment” (Article 5). Originally, this law applied to five products: televisions, microcomputers, washing machines, refrigerators, and air conditioners.<sup>126</sup> In 2015, however, nine additional products, including for example fax copiers and printers, were added to the Catalogue of Waste Electrical and Electronic Products, maintained by the National Development and Reform Commission (NDRC), in collaboration with the Ministry of Environmental Protection (MEP) and the Ministry of Industry and Information Technology (MIIT).<sup>127</sup> Among other elements, the regulation established a special fund to support the costs of recycling, to which manufacturers and other economic operators must contribute, thereby instilling the concept of producer responsibility in Chinese law.<sup>128</sup>

However, informal recycling practices remain prevalent across China and offer strong competition to the formal electric and electronic waste recycling plants established by China’s legal framework.<sup>129</sup>

With regard to the **restriction of hazardous substances** in electrical and electronic products (i.e. RoHS-type legislation), China implemented the Administrative Measure on the Control of Pollution Caused by Electronic Information Products (ACPEIP), which took effect on 1 March 2007 and was updated by the Administrative Measures for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products (January 2016). Originally, this legislation only targeted electronic information products but since has been expanded to cover electric and electronic equipment more broadly.

The Chinese MIIT maintains the catalogue of products that are subject to restrictions, which include the original six substances restricted under the EU RoHS framework. For these substances, the Chinese regulatory regime requires product marking indicating either compliance with the regulation or the Environment Friendly Use Period (EFUP) of the product, alongside a hazardous substances table, as stipulated in the regulation ‘Marking for the control of Pollution Caused by Electronic Information Products’.<sup>130</sup> Unlike in the EU, there are no exemptions, for example for large commercial applications and large-scale fixed installations. Furthermore, there are nuances in the way the EU and Chinese approaches impose substance concentrations, with the EU imposing concentrations per product or component, whereas China restricts substance concentrations for each homogeneous material within a product (as published in GB/T 26572-2011, Requirements for concentration limits for certain restricted substances in electronic and electrical products).

Considering the **regulation of chemical substances**, the main law is Order No.7, the Provisions on Environmental Administration of New Chemical Substances (2010), referred to as ‘China REACH’. In a similar manner to the EU’s REACH Regulation, the Chinese approach currently places the burden of proof on the manufacturer or importer of substances. Furthermore, the legislation established an Inventory of Existing Chemical Substances Produced or Imported in China (IECSC) and is overseen by the Chemical Registration Centre (CRC) of the MEP. Under Order No.7, there are three types of

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<sup>125</sup> Baldé, C.P., Forti V., Gray, V., Kuehr, R., Stegmann, P.: The Global E-waste Monitor – 2017, United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn / Geneva / Vienna.

<sup>126</sup> <http://www.loc.gov/law/foreign-news/article/china-regulations-on-electronic-waste/>

<sup>127</sup> Li et al., “Control-Alt-Delete’: Rebooting Solutions for the E-Waste Problem, 2015.

<sup>128</sup> <http://www.loc.gov/law/foreign-news/article/china-regulations-on-electronic-waste/>

<sup>129</sup> OECD Case Study, How Does the Chinese E-Waste Disposal Fund Scheme Work, <https://www.oecd.org/environment/waste/China%20case%20study%20final.pdf>

<sup>130</sup> <https://www.rohsguide.com/china-rohs.htm>

notifications potentially required for listed substances: i) typical notification; ii) simplified notification; and iii) scientific research record. The most prominent type is the typical notification for substances to be manufactured or imported, which follows similar tonnage bands as the EU's REACH Regulation, requires toxicology and ecotoxicological data and may require some tests to be conducted in Chinese-certified laboratories.<sup>131</sup> Although there are clearly similarities between Order No.7 and EU REACH, there are also a number of notable differences. For example, data sharing under the Chinese approach is not required as it is in the EU.<sup>132</sup>

In 2019, however, the Chinese Ministry of Ecology and Environment (MEE) notified the World Trade Organization (WTO) of new draft legislation; namely its "Environmental Risk Assessment and Control Regulation for Chemical Substances (Notification Draft)" and "Measures on the Environmental Management of New Chemical Substances (Notification Draft)".<sup>133</sup> Although the former draft legislation remains under development, the final version of the latter was published by the Chinese government in April 2020 as MEE Order 12 on 'Measures for the Environmental Management Registration of New Chemical Substances'. This law will replace MEP Order 7 and will enter into force on 1 January 2021. In this law, even though it deals only with new chemical substances, similarities remain with EU REACH. For instance, foreign companies must appoint a local agent to submit new chemical notifications, similar to the role of 'only representative' under EU REACH.

Considering the draft legislation on "Environmental Risk Assessment and Control Regulation for Chemical Substances" (Erac), however, if implemented, this law will reportedly cause significant changes to the management of chemical substances in China, with manufacturers and other economic operators impacted.<sup>134</sup> According to compliance commentators, Erac will affect all companies that handle chemicals and will "require pre-market approval of new substances and risk evaluation of certain existing ones"<sup>135</sup>. As such, it has been likened to the US TSCA.<sup>136</sup>

### 3.2.3.3 India

India is a net importer (including from the EU) of a wide range of industrial products and, in particular, capital goods, including heavy electrical equipment, process plant equipment, earthmoving and mining machinery, textile machinery, printing machinery, food processing machinery, machine tools, metallurgical machinery and plastic machinery. For instance, in 2016, India's imports in capital goods from Europe and Central Asia were worth nearly double their exports to the same region.<sup>137</sup> However, engineering is currently considered an area of strategic importance to the Indian economy, particularly due to its intense integration with other industry segments, the low manufacturing costs that are possible and the large domestic demand in comparison to many of its competitor nations.<sup>138</sup>

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<sup>131</sup> European Commission, Impacts of REACH and corresponding legislation governing the conditions for marketing and use of chemicals in different countries/regions on international competitiveness of EU industry, October 2016.

<sup>132</sup> Lepisto, C, REACH's consequences, An overview of how REACH is spreading globally, Presentation at Chemical Watch Expo 2017 by Underwriters Laboratories Inc., UL-SCS/WERCS, <http://www.cw-presentations.com/8.2-christine-lepisto.pdf>

<sup>133</sup> <https://www.natlawreview.com/article/china-notifies-wto-two-draft-chemical-regulations>

<sup>134</sup> <https://www.natlawreview.com/article/china-notifies-wto-two-draft-chemical-regulations>

<sup>135</sup> <http://en.tireworld.com.cn/Industry/2020518/7310.html>

<sup>136</sup> <https://www.natlawreview.com/article/china-notifies-wto-two-draft-chemical-regulations>

<sup>137</sup>

<https://wits.worldbank.org/CountryProfile/en/Country/IND/Year/2016/TradeFlow/EXPIMP/Partner/All/Product/U NCTAD-SoP4>

<sup>138</sup> India Brand Equity Foundation (IBEF), Indian Engineering and Capital Goods Industry Report, July 2019.



At this stage in the research, given the challenges of accessing relevant literature, the focus in relation to the Indian legislative regime is machine safety and standards and environmental legislation.

### **Industrial product legislation**

In relation to machine safety and industrial product standards, there are three relevant governmental pillars: i) the Ministry of Labour and Employment; ii) the Bureau of Indian Standards; and iii) the Ministry of Heavy Industries and Public Enterprises.<sup>139</sup> Here, the relevant roles and legislation under each pillar are documented:

Under the **labour and employment pillar**, the key focus is understandably labour welfare and machinery safety. India has two key pieces of legislation addressing this issue; namely, the Factory Act of 1948 (and its 1987 amendment) and the Dangerous Machines (Regulations) Act of 1983.

- The Factory Act deals with occupational safety and health, stipulating, in particular, that:
  - Employers must ensure full mitigation of risks posed by machinery within the workplace (Sections 21 to 30);
  - Designers, manufacturers and importers of articles used in factories need to adequately test and provide information to workers to ensure the article does not pose health and safety risks; and
  - Employers and users of machinery and equipment are required to conduct systematic and periodic maintenance to ensure compliance with industry standards.
  - The Dangerous Machines (Regulations) Act covers similar ground to the Factory Act with regard to the design and manufacture of machinery, placing a duty on the designers and manufacturers of machinery to: i) ensure compliance with industry standards and provide clear legible safety indicators on machinery; and ii) test and provide information on the machinery. In addition, employers are also required, under the Dangerous Machines (Regulations) Act, to ensure the machinery they purchase complies with the relevant industry standards.

Although provisions on machine safety are in place, a report on the issue by the Mechanical Engineering Industry Association (VDMA) found a number of limitations.<sup>140</sup> In particular, the report highlights that there is a lack of universal enforcement of such provisions and that rules lack uniformity across states. Furthermore, this report notes that the Dangerous Machines (Regulation) Act only covers a limited range of machines.

The **Bureau of Indian Standards (BIS)** was established by the Bureau of Indian Standards Act of 1986 to ensure the "harmonious development of standardisation, conformity assessment, and quality assurance of goods, articles, processes, systems and services"<sup>141</sup>. As implied, the BIS is responsible for setting and promoting standards for products and systems, the organisation and management of testing laboratories, creating consumer awareness and maintaining close liaison with international standard bodies. Considering the last point, the Sectional Committee of the BIS specifically examines the adoption of ISO/IEC standards wherever possible. Furthermore, the BIS engages across a range of sectors, including mechanical engineering and electronics and information technology.

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<sup>139</sup> VDMA, Making safe machines a standard in India, December 2018.

<sup>140</sup> VDMA, Making safe machines a standard in India, December 2018.

<sup>141</sup> <https://bis.gov.in/>

The third pillar deals with **heavy industries** and is governed by the Department of Heavy Industries. This Department holds responsibility for developing and promoting the engineering industry and improving competitiveness. A key recent action under this third pillar builds on the earlier observation on capital goods – in 2016, India developed a National Capital Goods Policy with explicit focuses on promoting exports of capital goods, increasing domestic production, technology improvement, mandatory standardisation of machines and other equipment through the adoption of ISO standards, reducing the import of sub-standard machines and, finally, development of the necessary workforce skills. In addition, the National Capital Goods Policy defines the minimum acceptable safety, environment and performance requirements for machinery.<sup>142</sup>

### Environmental legislation

This sub-section presents an overview of India's approach to environmental legislation that is relevant to the engineering industries; namely, legislation on electronic waste, restriction of hazardous substances in electrical and electronic products and chemical substances.

In India, the legislative regime deals with **electronic waste** and **hazardous substances in electrical and electronic products** together. Originally, they were stipulated in the Electronic Waste (Management and Handling) Rules 2011, which placed the responsibility on producers to finance the collection, treatment, recovery and environmentally sound disposal of e-waste. This legislation was amended in 2016 by the E-Waste (Management) Rules, which introduced the concept of 'Extended Producer Responsibility', thus making manufacturers and other economic operators liable for the proper disposal of WEEE.<sup>143</sup> The 2016 Rules have since been amended by notification G.S.R.261 (E), 2018, which amended the collection targets and aims to improve the efficiency of e-waste management.

Currently, the legislation places responsibilities on manufacturers and producers, as well as collection centres, dealers, recyclers, consumers and others. Considering the manufacturers, key responsibilities include: the collection and correct recycling/disposal of e-waste generated during the manufacturing process; applying for an authorisation; and maintaining records of e-waste generated. Producers of electrical and electronic equipment, in turn, are required, primarily, to implement the Extended Producers Responsibility framework.

Chapter V of the 2016 Rules detail measures to reduce the use of hazardous substances. In particular, this chapter is aligned to the EU's RoHS Directive, for example in the substances included, such as lead, mercury and cadmium.

However, even with this legislative framework in place, the techniques used in recycling of WEEE are often primitive, without the appropriate facilities to safeguard environmental and human health.<sup>144</sup> As such, large amounts of informal recycling; more specifically, it has previously been reported that only 3% of the WEEE produced is collected by institutions authorised to recycle WEEE.<sup>145</sup>

Moving beyond environmental legislation applicable to electrical and electronic equipment, another key area of EU legislation that impacts the engineering industries is with regard

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<sup>142</sup> <https://dhi.nic.in/writereaddata/Content/NationalCapitalGoodsPolicy2016.pdf>

<sup>143</sup> Chaudhary, N, Electronic Waste in India: A Study of Penal Issues, 2018, ILI Law Review Vol. II, Winter Issue 2018, <http://ili.ac.in/pdf/env.pdf>

<sup>144</sup> Ghosh, S.K. et al., Waste electrical and electronic equipment management and Basel Convention compliance in Brazil, Russia, India, China and South Africa (BRICS) nations, Review Article, Waste Management & Research 2016, Vol 34(8) 693-707.

<sup>145</sup> Ghosh, S.K. et al., Waste electrical and electronic equipment management and Basel Convention compliance in Brazil, Russia, India, China and South Africa (BRICS) nations, Review Article, Waste Management & Research 2016, Vol 34(8) 693-707.

to **chemical safety** (in the EU, through the REACH Regulation). India attempted to develop comprehensive legislation in this regard in 2011, publishing a draft law called the Hazardous Substances (Classification, Packaging and Labelling) Rules. However, the draft law was never adopted. As such, India has no REACH-like legislation for chemicals and, thus, no national chemical inventory exists and no chemical registration requirements exist. In its place, India published a National Action Plan in December 2019 which reportedly covers these two elements.<sup>146</sup>

Furthermore, although no overarching legislation exists, India does have two existing sets of rules on chemicals, which regulate: i) the manufacture, storage and import of hazardous chemicals across three schedules of chemicals (the Manufacture, Storage and Import of Hazardous Chemical (Amendment) Rules, 1989, amended in 1994 and 2000); and ii) the production, import and use of ozone depleting substances (the Ozone Depleting Substance Rules, 2000).<sup>147</sup>

### 3.2.3.4 Japan

Japan has a strong history in manufacturing, with cities developed as hubs for different types of manufacturing. For instance, the city of Yokohama in the Kanagawa Prefecture has significant expertise in the electrical, machinery and automotive industries.<sup>148</sup> However, Japan's competitiveness is being challenged, in particular due to its ageing and shrinking workforce.

Although its competitiveness is being challenged, Japan has an extensive and stable legislative framework in place to deal with topics related to the industries of mechanical, electronic and electrical engineering. Furthermore, the Japanese government is taking measures to address its competitiveness challenges, including increasing cooperation between industry and academia and prioritising research and development activities through its Science and Technology plan. Furthermore, February 2019 saw the EU-Japan Economic Partnership Agreement (EPA) enter into force, which, in particular, ensures high standards of labour, safety, environmental and consumer protection.<sup>149</sup> This sub-section details the Japanese legislative approach to industrial products and the environment, as it impacts the engineering industries.

### Industrial product legislation

As highlighted above, Japan has a stable legislative framework, comprising of the following key legislation:

- **Industrial Competitiveness Enhancement Act:**<sup>150</sup> Enacted in 2013, this Act aims to implement the Japan Revitalisation Strategy of June 14, 2013, which aims to enhance the industrial competitiveness of Japanese businesses. To do this, the government highlights three challenges it is aiming to address; namely, over-regulation, under-investment and delay in consolidation. More specifically, the Act allows preferential regulatory flexibility to enterprises through a System of Special Arrangements for Corporate Field Tests. Furthermore, it aims to facilitate the renovation of industries.
- **Industrial Standardisation Act:**<sup>151</sup> This Act aims to promote industrial

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<sup>146</sup> <https://chemicalwatch.com/72436/india-draft-chemical-plan-possible-early-2019#overlay-strip>

<sup>147</sup> [https://www.chemsafetypro.com/Topics/India/Overview\\_of\\_Chemical\\_Regulations\\_in\\_India.html](https://www.chemsafetypro.com/Topics/India/Overview_of_Chemical_Regulations_in_India.html)

<sup>148</sup> Japan National Tourism Organisation, Japan: Competitiveness in Academia and Industry – Introduction to twelve excellent cities, 2013.

<sup>149</sup> [https://europa.eu/rapid/press-release\\_IP-19-785\\_en.htm](https://europa.eu/rapid/press-release_IP-19-785_en.htm)

<sup>150</sup> [https://www.meti.go.jp/english/publications/pdf/journal2014\\_05a.pdf](https://www.meti.go.jp/english/publications/pdf/journal2014_05a.pdf)

<sup>151</sup>

<http://www.japaneselawtranslation.go.jp/law/detail/?re=01&dn=1&x=0&y=0&co=1&ia=03&yo=%E5%B7%A5%E6%A5%AD%E6%A8%99%E6%BA%96%E5%8C%96%E6%B3%95&gn=&sy=&ht=&no=&bu=&ta=&ky=&p&age=1>



standardisation through the development and dissemination of industrial standards with the aim of improving the quality of industrial products and increasing productivity. In particular, this Act establishes the Japanese Industrial Standards Committee (JISC), which sits under the Ministry of Economy, Trade and Industry, as well as the procedure for the establishment of a Japanese Industrial Standard and for compliance of industrial products with the JIS mark scheme.

- **Product safety legislation:** including: i) the **Electrical Appliances and Materials Safety Act**, which aims to prevent hazards and disturbances caused by electrical appliances and materials by regulating the manufacture, sale and import of such products;<sup>152</sup> and ii) the **Consumer Product Safety Act**, which aims to regulate the manufacture and sale of specified products (i.e. those products likely to cause harm, as specified), to promote proper maintenance of such products and to monitor product incidents.<sup>153</sup>
- **Radio Law (JRF):**<sup>154</sup> Established in 1950, this law aimed to ensure fair and efficient use of the radio spectrum. Within Article 38-2-2, the law defines Specified Radio Equipment (SRE), which includes Wi-Fi, Bluetooth, LTE etc. Furthermore, the Radio Law stipulates that most SRE must be tested for compliance and obtain third-party certification by a Registered Certification Body (RCB), as designated by the Ministry of Internal Affairs and Communications (MIC). There are two types of certification: SRE Type Certification and SRE Batch Certification, which are relevant to mass-produced equipment and small batches of equipment, respectively. The test methods and technical standards are stipulated in the Ordinance Regulating Radio Equipment, as well as accompanying notifications from the MIC.
- **Ministerial Ordinances** stipulating the requirements for: i) certification of manufacturers, processors, retailers of products, or exporters of products; ii) certification of electromagnetic record developers, importers, retailers and exporters of electromagnetic records by electromagnetic mediums; iii) regulating radio equipment; and iv) certification of conformity to technical standards, etc. of Specified Radio Equipment; and v) Certification of service providers.
- **Industrial Safety and Health Law:** This law aims to work in conjunction with the Japanese Labour Standards Act (No. 49, 1947) to ensure the safety and health of workers in the workplace, including in relation to industrial accidents, and to clarify responsibility for safety and health management. In particular, Chapter V of this law specifically regulates machines and harmful substances.<sup>155</sup>

Furthermore, in order to guide those wishing to import consumer and industrial products into Japan, the Japan External Trade Organisation (JETRO) has produced the following handbooks:

- Consumer products import regulations, 2009<sup>156</sup>
- Industrial products import regulations, 2010<sup>157</sup>

## Environmental legislation

Japan has a longstanding legal framework related to key issues of relevance to the engineering industries. In particular, this sub-section considers the legislative regimes

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<sup>152</sup> <https://www.meti.go.jp/english/policy/economy/consumer/pse/index.html>

<sup>153</sup> <http://www.japaneselawtranslation.go.jp/law/detail/?ft=2&re=01&dn=1&yo=%E6%B6%88%E8%B2%BB%E7%94%9F%E6%B4%BB%E7%94%A8%E8%A3%BD%E5%93%81%E5%AE%89%E5%85%A8%E6%B3%95&ia=03&x=42&y=11&ky=&page=1>

<sup>154</sup> [https://www.jqa.jp/english/safety/file/guide\\_radio.pdf](https://www.jqa.jp/english/safety/file/guide_radio.pdf)

<sup>155</sup> [https://www.jniosh.johas.go.jp/icpro/jicosh-old/english/law/IndustrialSafetyHealth\\_Law/index.htm](https://www.jniosh.johas.go.jp/icpro/jicosh-old/english/law/IndustrialSafetyHealth_Law/index.htm)

<sup>156</sup> [https://www.jetro.go.jp/ext\\_images/en/reports/regulations/pdf/industry2009e.pdf](https://www.jetro.go.jp/ext_images/en/reports/regulations/pdf/industry2009e.pdf)

<sup>157</sup> [https://www.jetro.go.jp/ext\\_images/en/reports/regulations/pdf/cons2010ep.pdf](https://www.jetro.go.jp/ext_images/en/reports/regulations/pdf/cons2010ep.pdf)

related to electronic waste, the restriction of hazardous substances in electrical and electronic products and chemical substances.

Considering **WEEE and RoHS issues**, the overarching legal framework for both is provided by the Japanese Recycling Law (the Law for Promotion of Effective Utilisation of Resources, 2000). This law aims to establish a material-cycle economic system based on three key principles: i) reducing waste generation; ii) enhancing recycling measures; and iii) implementing measures to encourage the reuse of parts recovered from used products. In terms of responsibilities, economic operators are obliged to fulfil these principles by reducing the generation of used goods and by-products in the manufacturing process; increase utilisation of recyclable resources and reusable parts; and promoting the re-utilisation of used goods.<sup>158</sup>

From a **RoHS perspective**, this overarching framework functions in collaboration with the JIS C 0950 standard, which details marking requirements for the presence of specific chemical substances for electrical and electronic equipment. Compliance with this standard and, thus, the RoHS legislation, is demonstrated by the J-MOSS marking, for which guidelines are issued by JEITA (Japan Electronics and Information Technology Industries Association), JEMA (Japan Electrical Manufacturers Association) and JRAIA (Japan Refrigeration and Air Conditioning Industry Association). The green J-MOSS mark indicates a product that is RoHS compliant for all materials, whereas the orange mark is for products that contain substances above the limits detailed in the legislation. Through this framework, Japan restricts the same six substances in the same concentration limits as were included in the original EU RoHS Directive.<sup>159</sup>

Concerning the second of these issues, namely **electronic waste**, the overarching legal framework is complemented by the Law for Recycling of Specified Kinds of Home Appliances, 1998. This legislation covers a range of appliances, including air conditioners, Cathode-Ray Tube (CRT) and Liquid Crystal Display (LCD)/plasma TVs, refrigerators and freezers and washing/drying machines. This law places various responsibilities on the manufacturers, retailers, consumers and municipalities. Regarding manufacturers of these appliances, responsibilities include take back systems, recycling collected used appliances and publishing the costs of recycling the appliances.<sup>160</sup>

Considering the management of **chemical substances**, Japan passed its fourth amendment of the Japan Chemical Substances Control Law (CSCL) in 2017, which was implemented in phases from April 2018 to January 2019. This law aims to manage risks related to industrial chemicals both manufactured in Japan and imported into Japan. The CSCL is overseen by the Ministry of Health, Labor and Welfare (MHLW), Ministry of Environment (MOE) and Ministry of Economy, Trade and Industry (METI).

More specifically, the CSCL categorises existing chemical substances as well as new chemical substances. The Japanese chemical inventory is known as the Japanese Existing and New Chemical Substances (ENCS). Existing chemical substances, under the purview of the CSCL, are categorised into five classes:<sup>161</sup>

- **Class I Specified Chemical Substances** are persistent, highly bio-accumulative and chronically toxic. These substances are strictly prohibited, except for special uses, and are subject to recalling measures and labelling obligations;
- **Monitoring Chemical Substances** are also considered to be persistent, highly bio-accumulative and chronically toxic. The substances are subject to reporting

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<sup>158</sup> <https://www.env.go.jp/en/laws/recycle/06.pdf>

<sup>159</sup> <https://www.rohsguide.com/japan-rohs.htm>

<sup>160</sup> Sugimoto, S, E-waste Management and Recycling Mechanism in Japan, JICA Expert Presentation.

<sup>161</sup> <https://www.reach24h.com/en-us/practices/japan-korea-taiwan/japan-cscl.html>

requirements and inspection of hazard properties;

- **Class II Specified Chemical Substances** pose health and environmental risks and are subject to reporting requirements and compliance with official technical guidelines and labelling obligations;
- **Priority Assessment Chemical Substances** are subject to reporting requirements and information sharing with downstream users; and
- **General Chemical Substances** are also subject to reporting requirements.

New substances are notified on the basis of whether they are considered low or high hazard risks. Low hazard risk substances are added to the inventory five years after their notification, whereas high hazard risk substances are directly assigned to one of the classes indicated above within 6-12 months.<sup>162</sup>

It is reported that the Japanese approach to the control of chemical substances resembles the EU's REACH Regulation. This includes placing the burden of proof on the manufacturer or importer, the application of specific conditions to the most hazardous substances (much like for SVHCs in EU REACH) and similar post-notification obligations, for example including providing tonnage updates and communication to downstream users.<sup>163</sup>

### 3.2.3.5 *Russia*

Given the presence of EU and US sanctions, in particular, importing to and exporting from Russia is difficult. This is reflected by the position of Russia in the World Bank Groups Doing Business 2019 report, where the country places 99<sup>th</sup> in the world for the time and cost associated with the logistical process of exporting and importing goods.<sup>164</sup> This subsection presents information on the industrial product and environmental legislation relevant to the mechanical, electronic and electrical engineering industries.

#### **Industrial product legislation**

Russia has a unique system of standardisation in relation to industrial products. Although certain areas are subject to international standards, most areas rely on product testing as the key element of the product approval process. The Federal Agency for Technical Regulations and Metrology<sup>165</sup> (Rosstandart) is responsible for the development of technical standards and RosAccreditation, established via Presidential Decree No. 86 on January 24, 2011 "On the Unified National System of Accreditation", is responsible for: controlling all legal entities accredited as testing labs; issuing certificates to organisations; and, ultimately, the Unified National System of Accreditation.<sup>166</sup>

Furthermore, Russia does not recognise internationally recognised product certificates (such as the EU's CE mark) and, as a result, additional product tests are often necessary in Russia.

However, efforts have been made in recent times to ensure greater alignment between Eurasian countries – through the Eurasian Economic Union – and between Russia and the EU – through, for example, the dialogue on industrial and enterprise policy and the

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<sup>162</sup> <https://www.reach24h.com/en-us/practices/japan-korea-taiwan/japan-cscl.html>

<sup>163</sup> European Commission, Impacts of REACH and corresponding legislation governing the conditions for marketing and use of chemicals in different countries/regions on international competitiveness of EU industry, October 2016.

<sup>164</sup> World Bank Group, Doing Business 2019, Training for Reform: Russia.

<sup>165</sup> <https://www.gost.ru/portal/eng/home>

<sup>166</sup> <https://www.export.gov/article?id=Russia-Trade-Standards>

dialogue on industrial products (standardisation, technical regulations and conformity assessment procedures).<sup>167</sup>

In addition to the systems in place for standardisation and certification of industrial products, Russia has longstanding occupational safety and health legislation. In particular, the Labour Code of the Russian Federation of 30 December 2001, in which §215 details the provisions in relation to the risks related to machinery and tools, as well as the related duties on designers, manufacturers, importers, suppliers and buyers in relation to machinery; and §254 details requirements related to the maintenance of machinery and other equipment.<sup>168</sup>

In December 2014, the Russian government passed Federal Law No. 488-FZ, which aims to deliver new incentives and mechanisms to support industrial production in the country, prioritise regional development and favour Russian-based manufacturers. It aims to achieve this through the implementation of various subsidies, tax incentives and other state funding programmes, such as special investment contracts.<sup>169</sup>

### Environmental legislation

In relation to environmental legislation that are relevant to the engineering industries, Russia has legislation on a range of key issues, including electronic waste and chemical products. Furthermore, in relation to **restrictions on hazardous substances in electrical and electronic equipment**, Russia, as part of the Eurasian Economic Union (EAEU) has recently approved a Technical Regulation of the Customs Union 'On restriction of the use of hazardous substances in products of electrical engineering and radio electronics' (TR CU 037/2016). This Technical Regulation came into force in March 2018 and the EAEU states have until March 2020 to comply.<sup>170</sup>

These rules contain mandatory safety requirements for six named hazardous substances across a range of electrical and electronic devices, for example including electrical household appliances and telecommunication equipment. Furthermore, such products can only be placed on the market if they are in compliance with this and other key legislation (e.g. on electromagnetic compatibility). In relation to this legislation, the conformity assessment is on the basis of an EAC Declaration of Conformity, which must be registered in the EAEU's uniform register by an accredited notified body.<sup>171</sup>

In this respect, this Technical Regulation aligns the Eurasian Economic Union, including Russia, with the EU's RoHS Directive.<sup>172</sup>

Concerning other areas of environmental legislation, Russia also has a relatively new legal framework in relation to **management of chemicals**. Although discussions were initiated at the level of the EAEU, disagreements between member states led to Russia adopting its own version of REACH-like legislation through the Technical Regulation on Safety of Chemical Products of 7 October 2016 (Decree No.1019). This Technical Regulation is due to take effect on 1 July 2021. However, soon after, in March 2017, the EAEU did agree its own approach, adopting Technical Regulation on Safety of Chemical Products No 41 (TR 041/2017). It is anticipated that, following the agreement of the 'Eurasia REACH', the

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<sup>167</sup> Co-operation with Russia, European Commission, Joint Co-Chairs Report: Dialogue on Industrial and Enterprise Policy EU-Russia and Dialogue on Industrial Products (Standardisation, Technical Regulations and Conformity Assessment Procedures) EU-Russia, 12 March 2013.

<sup>168</sup> [https://www.ilo.org/dyn/legosh/en/f?p=14100:1100:0::NO::P1100\\_ISO\\_CODE3,P1100\\_YEAR:RUS,2013](https://www.ilo.org/dyn/legosh/en/f?p=14100:1100:0::NO::P1100_ISO_CODE3,P1100_YEAR:RUS,2013)

<sup>169</sup> <https://www.lexology.com/library/detail.aspx?q=2b314695-6eb6-4377-a41e-967b2c828793>

<sup>170</sup> <https://schmidt-export.com/tr-eaeu-0372016-on-restriction-of-use-of-certain-hazardous-substances>

<sup>171</sup> <https://schmidt-export.com/eac-declaration-conformity-technical-regulations-eurasian-economic-union>

<sup>172</sup> <https://schmidt-export.com/tr-eaeu-0372016-on-restriction-of-use-of-certain-hazardous-substances>

Russian version will not be maintained.<sup>173</sup> As such, this description deals primarily with the EAEU's approach to REACH-type legislation.

The 'Eurasia REACH' framework aims to ensure safe use of chemical substances by implementing certain requirements for market access, covering a broad range of chemicals. More specifically, the legislation requires companies, manufacturing or importing substances, as well as mixtures, to register all tonnages at the Competent Authorities. The new Regulation comprises existing provisions, for example relating to the classification of chemicals and precautionary labelling, while introducing new requirements, such as identification procedures, conformity assessments, notification procedures and obligatory classification of chemicals.<sup>174</sup>

Considering **electronic waste** (WEEE), Russia does not currently have consolidated legislation specifically dealing with the management of WEEE. However, there are a range of obligations places on economic operators by various statutory instruments. These prominently include **Federal law #89-FZ1998 'On waste of production and consumption', 1998**. As a whole, this law aims to ensure that manufacturers and importers provide for the recycling and disposal of waste, including waste generated by product use and used products.<sup>175</sup> Although this legislation is not specific to WEEE, it does cover a range of relevant product groups. As per Government Order 1886-p, which provides a list of products that are subject to recycling after consumer use, the WEEE products covered include computers and peripheral equipment, household electrical equipment and electrical lighting equipment. Furthermore, a 2014 amendment introduced the concept of 'extended producer responsibility' (EPR) and places take back and recycling obligations on producers and importers.<sup>176</sup>

In addition to the above Federal Law and Government Order, Resolution No. 2491/2015 stipulates mandatory annual recycling targets for listed products and Resolution No. 1342/2015 requires that economic operators subject to obligations under the above law report on compliance annually to the Federal Service for Supervision of Natural Resources (Rosprirodnadzor).<sup>177</sup>

### 3.2.3.6 South Korea

South Korea has a sophisticated manufacturing market, in particular in relation to semiconductors, as it is the home of Samsung Electronics and SK Hynix, reported by Gartner to be the first and third largest semiconductor vendors, respectively, in both 2017 and 2018.<sup>178</sup> Furthermore, the domestic industry is largely dominated by conglomerates known as 'Chaebols', of which the Samsung family group is one of the biggest.

However, although its strong competitive position, in particular in relation to semiconductors and electrical components, is clear, South Korea has been the subject of Japanese sanctions since July 2019, which could impact its competitiveness in the affected industries. More specifically, Japan has implemented tighter controls on the export of three chemicals (fluorinated polyimide, resists and hydrogen fluoride) to South Korea. In turn, this action will slow the export process significantly and impact South Korean companies. To illustrate the potential impact, Reuters reported that one chipmaker exports more than 70% of its resists and hydrogen fluoride from Japan.<sup>179</sup> Along with the situation between

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<sup>173</sup> <https://www.toxplanet.com/an-overview-of-eurasia-reach.html>

<sup>174</sup> <https://www.enhesa.com/blog/russia-technical-regulation-safety-chemical-products-adopted>

<sup>175</sup> [https://www.wto.org/english/thewto\\_e/acc\\_e/rus\\_e/WTACCRUS58\\_LEG\\_355.pdf](https://www.wto.org/english/thewto_e/acc_e/rus_e/WTACCRUS58_LEG_355.pdf)

<sup>176</sup> <https://www.pravsky.com/russia-weee-management-legal-framework>

<sup>177</sup> <http://blog.complianceandrisk.com/commentary-analysis-old/the-mystery-of-russian-weee>

<sup>178</sup> <https://www.gartner.com/en/newsroom/press-releases/2019-04-10-gartner-says-worldwide-semiconductor-revenue-grew-12->

<sup>179</sup> <https://www.reuters.com/article/us-southkorea-japan-laborers/japan-to-tighten-tech-material-exports-to-south-korea-in-wartime-labor-row-idUSKCN1TW144>



the US and China, this activity represents another factor that could influence the global value chain, in particular in relation to semiconductors and electrical components.

Within this political context, the legal situation in South Korea seems to be well-established and stable, with a wide range of legislation in place to tackle industrial product safety and occupational safety and health, as well as standardisation, certification and conformity assessments for equipment, as well as environmental legislation.

### Industrial product legislation

As highlighted above, South Korea has a rather stable legislative framework in relation to industrial product legislation, which, in particular, includes:

- **Industrial Standardisation Act:**<sup>180</sup> Aims to improve the quality of mining and industrial products and services involving industrial activities, as well as the efficiency of production and manufacture of technology by developing industrial standards. To this objective, the Act details the procedures and governance for standard adoption, the designation of accreditation institutions and the procedures for the accreditation of both products and services, market surveillance powers and the remit of the Korean Standards Association (KSA), which has the power to grant the KS mark (Korean Industrial Standards). The KSA publishes standards in both mechanical and electrical and electronic engineering, but the KS mark is, in most cases, a voluntary measure. Furthermore, the Act requires that the government devise a policy to promote cooperation in standardisation with the ISO.
  - In addition to the regulatory structure developed through the Industrial Standardisation Act, **standards for industrial products are developed by the Korean Agency for Technology and Standards**. The Agency establishes reliability assessment and certification guidelines and conducts market surveillance on products marked with its KC mark (Korean Certification), penalising those that do not meet the requirements. Certification systems of interest that introduced the KC mark include the Energy Use Rationalisation Act, which relates in particular to the certification of high-efficiency energy machinery, equipment or materials.<sup>181</sup>
- **Product Safety Acts**, including the Framework Act on Product Safety, the Special Act for Child Product Safety Controls, the Quality Management and Industrial Product Safety Control Act and the Electrical Appliances Safety Control Act.
- **Radio Waves Act:**<sup>182</sup> Covering a similar scope to the EU Radio Equipment Directive, the South Korean Radio Waves Act details a certification system for broadcasting and communications equipment. The Act details three types of certification which relate to different types of equipment and the Act provides exemptions for equipment that has undergone conformity assessment through international mutual recognition arrangements. Interestingly, equipment manufactured domestically for export to overseas markets is also exempt.
- **Occupational Safety and Health Act:**<sup>183</sup> As is the case for the other occupational safety and health legislation examined in this section, this Act aims to maintain and promote the safety and health of workers and clarify where the responsibility lies. In particular, the Act stipulates regulations for safety and health management (Chapter III), details management system requirements (Chapter II), establishes the duty of the government, employers and workers (under Chapter I) and provides for specific measures for preventing harm and hazard (Chapter IV), including safety certification

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<sup>180</sup> [http://english.kca.go.kr/download/eng/laws/Industrial\\_Standardization\\_Act.pdf](http://english.kca.go.kr/download/eng/laws/Industrial_Standardization_Act.pdf)

<sup>181</sup> [https://www.standardsportal.org/usa\\_kr/e/conformity\\_assessment/ca\\_marks\\_used\\_in\\_korea.aspx](https://www.standardsportal.org/usa_kr/e/conformity_assessment/ca_marks_used_in_korea.aspx)

<sup>182</sup> <https://rra.go.kr/en/cas/intro.do>

<sup>183</sup> <http://www.moleg.go.kr/english/korLawEng?pstSeq=57986&searchKeyword=safety+and+health&searchCondition=AllButCsfCd&rctPstCnt=3>

for machines, instruments and equipment (Article 34).

Furthermore, in 2009, the South Korean government adopted the Special Act on the support of science and engineering manpower for strengthening national science and technology competitiveness. The purpose of this Act being “to contribute to the improvement of national competitiveness and the development of the national economy through promoting the use of science and engineering manpower and improving labour conditions by fostering superior science and engineering manpower.”<sup>184</sup> Under this Special Act, the government is to develop a Master Plan for every 5-year period as well as an annual implementation plan.

### Environmental legislation

In addition to this extensive and stable suite of legislation on industrial products, South Korea has a range of environmental legislation that place obligations on economic operators. In particular, this sub-section reviews legislation on waste electrical and electronic equipment, hazardous substances in electrical and electronic equipment and management of chemical substances.

In South Korea, **WEEE and RoHS-type issues** are dealt with in the same legislation. More specifically, the Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles came into effect in Korea in January 2008.<sup>185</sup> Regarding RoHS elements (dealt with in Title 2), this legislation restricts hazardous substances in electronic and electrical products, as well as vehicles. Concerning electronic and electrical products, the Act applies to a range of products, including mobile devices and TVs, and restricts the six substances with the same limits as the original EU RoHS Directive. At present, the four phthalates restricted by the updated RoHS Directive are not covered by this South Korean legislation.<sup>186</sup>

Within the legislation, producers and importers of covered electronic and electrical equipment are required to self-declare compliance against the concentration limits of the hazardous substances restricted. This declaration is done through notification of certain product information via the Eco-Assurance System (ECOAS) for electric, electronic equipment and vehicles<sup>187</sup>. Unlike in certain other countries, South Korea does not require certification and has no labelling requirements.<sup>188</sup>

Concerning **e-waste**, the same Act stipulates requirements for the recycling of waste electrical and electronic equipment in Chapter 1 of Title 3. Within this chapter, the legislation stipulates the recycling requirements for manufacturers and importers of electrical and electronic equipment. More specifically, it stipulates that such economic operators must follow the Recycling Methods and Standards by Product Categories, published via Ordinances of the Ministry of Environment, when recycling waste. It further states the process for the annual publication of mandatory recycling amounts and recycling rates, the requirements for producers or importers to submit a recycling requirement implementation plan and the process for applying recycling charges and the proper use of

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<sup>184</sup> <http://www.moleq.go.kr/english/korLawEng?pstSeq=52159&rctPstCnt=3&brdSeq=33>

<sup>185</sup> Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles, English Translation by Eco-Frontier, 2007, [http://www.env.go.jp/en/recycle/asian\\_net/Country\\_Information/Law\\_N\\_Regulation/Korea/Korea\\_RoHS\\_ELV\\_April\\_2007\\_EcoFrontier.pdf](http://www.env.go.jp/en/recycle/asian_net/Country_Information/Law_N_Regulation/Korea/Korea_RoHS_ELV_April_2007_EcoFrontier.pdf)

<sup>186</sup> [https://www.chemsafetypro.com/Topics/Korea/Korea\\_RoHS\\_WEEE.html](https://www.chemsafetypro.com/Topics/Korea/Korea_RoHS_WEEE.html)

<sup>187</sup> [https://www.apec-vc.or.kr/Default.asp?p\\_name=database&sort=program&sort2=EP1&gotopage=1&query=view&unique\\_num=1406](https://www.apec-vc.or.kr/Default.asp?p_name=database&sort=program&sort2=EP1&gotopage=1&query=view&unique_num=1406)

<sup>188</sup> [https://www.chemsafetypro.com/Topics/Korea/Korea\\_RoHS\\_WEEE.html](https://www.chemsafetypro.com/Topics/Korea/Korea_RoHS_WEEE.html)

such charges, including for example to support the recycling of waste and fund research and development for efficient recycling and reduction of waste.<sup>189</sup>

In addition to WEEE and RoHS-type legislation, South Korea adopted has implemented the **Act on the Registration and Evaluation of Chemicals** in 2013. This legislation came into force in January 2015 and aims to protect public health and the environment through: registration of chemical substances; screening of hazardous chemical substances; hazard and risk assessment of products that contain hazardous and chemical substances; and sharing of information on such substances.<sup>190</sup>

The approach is often referred to as 'Korea REACH' or 'K-REACH', as it is reportedly modelled directly on the EU's REACH Regulation. Moreover, a study conducted for the European Commission noted that "indications are that Korea intends to take strong inspiration from the implementation of EU REACH"<sup>191</sup>. Most prominently, Korea REACH reflects the EU's approach in that it places the burden of proof on the manufacturer or importer. Furthermore, with regard to tonnage band deadlines and the requirement of joint submission, Korea REACH also follows the EU approach.<sup>192</sup>

Within the Korea REACH approach, existing chemical substances are listed in the Korea Existing Chemicals Inventory (KECI) and the Korea Toxic Chemicals Control Act (TCCA) covers toxic chemicals, new chemicals, observational chemicals and banned/restricted chemicals. This reflects the treatment of SVHCs under the EU's REACH Regulation. The Ministry of Environment (MoE) holds responsibility for the evaluation and registration of substances. Manufacturers and importers are required to report uses and quantities of the chemical substances to the MoE on an annual basis, and have post-notification obligations, such as the provision of information to downstream users.<sup>193</sup>

### **3.2.3.7 The US**

This sub-section provides an overview of applicable legislation in the US. There are number of key differences as to how the US regulates the mechanical and electrical engineering industries, including components. In summary:

- In the US, occupational safety and health legislation drives the regulatory approach, rather than vertical sectoral legislation. In other words, the safety of machinery and equipment is assessed based on the industrial location where it will be used.
- In the US, there is mandatory third-party conformity assessment and certification by Nationally Recognized Testing Laboratories (NRTLs), who are authorised under OSHA's Nationally Recognized Testing Laboratory Program NRTLs to test and issue certification on products before they can legally be sold;
- This can be contrasted with the regulatory situation in the EU, where a Self-Declaration of Conformity issued by the manufacturer themselves is permitted for the majority of industrial products under most EU industrial product legislation, unless the product is

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<sup>189</sup> Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles, English Translation by Eco-Frontier, 2007,

[http://www.env.go.jp/en/recycle/asian\\_net/Country\\_Information/Law\\_N\\_Regulation/Korea/Korea\\_RoHS\\_ELV\\_April\\_2007\\_EcoFrontier.pdf](http://www.env.go.jp/en/recycle/asian_net/Country_Information/Law_N_Regulation/Korea/Korea_RoHS_ELV_April_2007_EcoFrontier.pdf)

<sup>190</sup> <http://www.cirs-reach.com/news-and-articles/revised-korea-reach---the-act-on-the-registration-and-evaluation-of-chemicals.html>

<sup>191</sup> European Commission, Impacts of REACH and corresponding legislation governing the conditions for marketing and use of chemicals in different countries/regions on international competitiveness of EU industry, October 2016, p.10.

<sup>192</sup> European Commission, Impacts of REACH and corresponding legislation governing the conditions for marketing and use of chemicals in different countries/regions on international competitiveness of EU industry, October 2016.

<sup>193</sup> European Commission, Impacts of REACH and corresponding legislation governing the conditions for marketing and use of chemicals in different countries/regions on international competitiveness of EU industry, October 2016.



high risk and mandatory use of a third-party and / or of an EC-type examination by a notified body is required.

- There is no equivalent concept of placing a product on the market in the US in the same legal sense as on the Europeans single market. However, goods need to be tested and obtain the necessary certifications;
- The European regulatory system relies on an extensive system of market surveillance post product-placement, which is not the case in the US, as the focus is on checking the safety of goods before they can be sold;

Occupational safety and health legislation cover the safety of machinery in the workplace.

### **Occupational Safety and Health – Focus on Machinery, including Electrical Products and Components and Electronic Components in Machinery**

Occupational safety and health legislation in the US operates at three levels:

- (i) **Federal level** – firms must follow the OSHA requirements (set by the national Occupational Safety and Health Administration in the US, OSHA) relating to machinery safety. These concern the safety of the users of industrial machinery and are mandatory for employers. Although it is non-mandatory for manufacturers, in practice, these requirements are often followed to be able to sell products to the US market. Some product legislation is mandatory, and must be met by manufacturers, e.g. in relation to electrical components with a strong/dominant market position of Underwriters Laboratories (UL) – a standards-writing body – that develops standards for electrical products and components which are mandatory, although other NRTLs can be used to actually check the products.
- (ii) **State level** – about half of individual US states have been delegated responsibility by OSHA for setting mandatory occupational health and safety requirements for employers to protect machinery users. Moreover, Underwriters Laboratories (UL) – a standards-writing body – has developed standards for electrical products and components that are mandatory for products.
- (iii) **Local level** – depending on the nature of the employer, local level standards and certification may apply, such as those set-out by public bodies or trade associations.

At the **federal level**, the **1970 Occupational Safety and Health Act (OSH Act)** requires employers to provide safe and healthy working conditions for workers, including for users of machinery in the workplace. US federal legislation under the OSH Act take the form of OSHA standards<sup>194</sup>, the OSHA requirements. These relate to occupational safety and health and to the protection of workers when using machinery.

The Occupational Safety and Health Administration (OSHA) was set up to oversee the implementation of occupational health and safety requirements in the use of machinery. Unlike the Machinery Directive 2006/42/EC, in the US, there are no requirements specifically relating to the safety of machinery products from a mechanical safety point of view. The OSH Act places responsibility for ensuring safety in the use of machinery on the employer, rather than the manufacturer. Part 1910 of the 29th Code of Federal Regulations (CFR)<sup>195</sup> provides for mandatory standards for employers in order to ensure a safe industrial environment. Subpart O of Part 1910 sets out standards for the use of machinery and machine guarding by workers, and is divided into Part 1910.211 to Part 1910.219, as summarised in the following table:

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<sup>194</sup> The OSHA standards are in fact regulatory requirements and should not be confused with voluntary technical standards.

<sup>195</sup> <https://www.osha.gov/laws-regs/regulations/standardnumber/1910>

**Table 3-5: List of applicable standards under the Code of Federal Regulations**

| Standard | Title                                                    |
|----------|----------------------------------------------------------|
| 1910.211 | Definition                                               |
| 1910.212 | General requirements for all machines                    |
| 1910.213 | Woodworking machinery requirements                       |
| 1910.214 | Cooperage machinery                                      |
| 1910.215 | Abrasive wheel machinery                                 |
| 1910.216 | Mills and calendars in the rubber and plastic industries |
| 1910.217 | Mechanical power presses                                 |
| 1910.218 | Forging machines                                         |
| 1910.219 | Mechanical power-transmission apparatus                  |

The general requirements set out in CFR 1910.212 apply to all categories of industrial machines and machinery. The main points in Part 1910.212 are provided below:

**Paragraph (a)(1)**

One or more methods of machine guarding shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips, and sparks. Examples of guarding methods are barrier guards, two-hand tripping devices, electronic safety devices, etc.

**Paragraph (a)(3)(ii)**

The point of operation of machines whose operation exposes an employee to injury shall be guarded. The guarding device shall be in conformity with any appropriate standards, therefore, or, in the absence of applicable specific standards, shall be so designed and constructed as to prevent the operator from having any part of his body in the danger zone during the operating cycle.

The following sections describe the relevance of federal regulatory requirements to: i) industrial machinery products; and ii) electrical products and components, and electrical components in machinery.

Considering **industrial machinery products**, the research into federal legislation in the U.S. has shown so far that:

- There are no federal requirements relating to the mechanical safety of industrial machinery. OSHA requirements – implemented through OSHA standards – only relate to occupational health and safety in relation to the use of machinery in the workplace.
- Since the employer (rather than the manufacturer) is ultimately legally responsible for workers' safety and for ensuring that machinery meets OSHA requirements, these requirements are not "mandatory" for manufacturers themselves, but rather for employers. This differs from the approach being adopted under the NLF, whereby the manufacturer assumes responsibility for CE marking to confirm that the relevant conformity assessment procedures have been followed.
- However, in practice, in order to sell products into the US market, most manufacturers will provide machinery safety equipment (such as guards) pre-installed and undertake conformity assessment testing to ensure compliance with the OSHA requirements.

- The US does not have an equivalent concept to “placing machinery products on the market” that corresponds to Decision 768/2008 in the New Legislative Framework (NLF), which provides for a common regulatory framework for placing harmonised industrial products on the internal market.
- Most manufacturers of industrial and other types of machinery choose to provide safety guarding pre-installed in the US, but a machine can legally be sold without any safeguarding, since the employer of the product user is legally responsible for making the machine safe for workers and must add the necessary safeguarding.

As there are no mechanical safety requirements for industrial machinery, employers can interpret the requirements according to their specific circumstances. For example, new machinery purchased that will be integrated into an existing assembly-line may not need to be sold with protective guarding. The employer may ensure compliance with the OSHA requirements through alternative means. Consequently, in relation to safety requirements for industrial machinery, European manufacturers are subject to contractual arrangements with clients (and not mandatory requirements).

Some purchasers of machinery try to pass on some responsibilities for meeting federal OSHA requirements to the manufacturers or distributors/ resellers of the machinery (since employers rather than manufacturers are ultimately legally responsible for the safety of machinery users). Alternatively, the customer purchasing machinery equipment may require European manufacturers to provide machinery that meets the OSHA requirements at the point that the machinery is provided to the client. For instance, guarding requirements for machinery may be required when the machinery is installed through contractual obligations.

In the electrical machinery field, manufacturers must comply with US standards and codes in order to obtain product certificates issued in the US by National Recognized Testing Laboratories (NRTLs)<sup>196</sup>. The machine for export can be assessed by NRTL inspectors at the manufacturer’s factory, along with the provision of the appropriate documents and markings. In addition, machines are inspected at the site of an AHJ (Authority Having Jurisdiction – see the section below on electrical engineering standards) and either approved for operation or rejected. AHJs also examine installation of equipment on industrial or construction sites. If there are any issues raised during on-site inspections or objections that prevent an approval of a piece of machinery as safe for use in the workplace, then the necessary changes that need to be made are normally only allowed to be carried out by appropriately qualified US professionals.

Examples of technical standards used in the U.S. for electrical machinery are:

- NFPA 79 (Electrical Standard for Industrial Machinery)
- NFPA 70 (National Electrical Code)
- UL 508A (Industrial Control Panels)
- UL 2011 (Factory Automation Equipment)
- UL 1740 (Robots and Robotic Equipment)

Concerning **electrical products and components and electronic components**, the research into federal legislation in the U.S. has shown so far that:

- OSHA requirements (implemented through OSHA standards – see 1910.212, which also covers electrical equipment/materials) only relate to occupational health and safety in the use of electrical equipment in the workplace.

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<sup>196</sup> <https://www.osha.gov/dts/otpc/nrtl/>

- There is a general requirement for electrical equipment and electronic components to be approved by NRTLs before they are placed on the market. The research suggests that 37 different types of products require NRTL approval, of which electrical equipment is the biggest category.
- Electrical equipment products used in the workplace must be approved (i.e. tested and certified) by an NRTL to ensure that they can be safely used in the workplace before these are installed in workplaces (there being no direct equivalent to the concept in the European legislative framework of placing on the market).
- The testing procedure is typically on the basis of standards developed by the leading testing body in the U.S, United Laboratories (UL)<sup>197</sup>. At least until the early 2010s, UL had the exclusive rights to carry out testing of electronic components prior to these being placed on the market.
- There is no federal legislation setting out technical safety requirements relating to electrical equipment and electronic components. Rather, individual NRTLs have been allowed to define the technical standards and parameters against which products should be tested – the only federal rule is that the products must be NRTL-approved<sup>198</sup>.
- The lack of clear guidance in the US has created legal ambiguity and uncertainty for manufacturers, particularly for component manufacturers, since complete electrical equipment must be tested, but it is unclear against which standards components used in the complete product will be tested.
- Lastly, OSHA's electrical standards are based on the National Fire Protection Association's standard NFPA 70. These do not appear to be mandatory at federal level but are often adopted by states, cities and municipalities.

As noted above, OSHA requires NRTL approval for 37 different types of products. Electrical equipment is the largest of these product categories and encompasses products such as a printer, copier, desktop computer, telephone, employee alarm, electric heater, air conditioner, electric generator, exit component, fire extinguisher, electrical conduit, conductor and electric motor. In accordance with OSHA Safety Standards, NRTL approval requirements only apply where electrical products are used in workplaces. However, it should be stressed that federal requirements relate to occupational health and safety, with the detailed standards against which safety requirements are tested in order to obtain the certificate left to the discretion of NRTLs. The only federal requirement is that the product must be NRTL-approved (which means tested and certified). The detailed technical specifications are not defined and there is no specific federal legislation regarding the equipment's safety (only workers using the equipment).

In relation to electrical components integrated into industrial machinery or electrical equipment, there are mandatory third-party testing and certification requirements in the US. However, OSHA requirements relate only to the need for NRTL approval without setting any substantive technical requirements. Consequently, NRTLs have developed their own product-specific testing and certification requirements based on their own interpretation of the law. The absence of federal rules setting out the technical specifications for the requirements for electrical equipment, but particularly for component manufacturers creates a degree of legal uncertainty for manufacturers. Whereas electrical equipment is mentioned as one of the 37 product groups covered by the OSHA requirements, there is no specific mention of electrical components, yet components used in complete products are nevertheless subject to mandatory NRTL approval testing and certification requirements.

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<sup>197</sup> <https://www.ul.com/>

<sup>198</sup> NRTLs work with product manufacturers to test and certify (i.e. approve) products. In approving a product for a manufacturer, the NRTL issues a certification document and allows the manufacturer to apply the NRTL's registered certification mark or symbol on all units of the product manufactured.

An explanation about the role of NRTLs and how they should use product safety test standards to check products is provided in the box below:

An NRTL must use appropriate product safety test standards in certifying products for workplace safety. These test standards contain technical requirements that products must meet for workplace safety. OSHA does not develop these test standards. However, OSHA defines what it means by "appropriate test standard" in its regulation (29 CFR 1910.7). Organizations such as the American National Standards Institute (ANSI) and the American Society for Testing and Materials (ASTM) publish many appropriate product safety test standards. A product safety test standard for which an NRTL is recognized is different than, but must be consistent with, OSHA standards, with which employers must comply pursuant to the Occupational Safety and Health Act of 1970 (29 USC 651 et seq).

Source: [https://www.osha.gov/dts/otpc/nrtl/nrtl\\_faq.html](https://www.osha.gov/dts/otpc/nrtl/nrtl_faq.html)

Third-party testing and certification of the final product is de facto mandatory before products can be sold on the US market. The development of specific requirements for certification and testing in the US has been driven by two main factors: first, the absence of clear federal legislation setting out technical specifications to which manufacturers must adhere; and secondly a concern on the part of NRTLs that testing and certification processes need to be sufficiently rigorous to minimise the risk of product liability issues. As part of mandatory NRTL approval, NRTLs have introduced stringent safety requirements through testing and certification in order to compensate for the absence of detailed federal legislation.

All NRTLs have the same legal standing and are viewed as being technically equivalent, if their accreditation scope covers the same US national standard as another NRTL's accreditation. Although European components manufacturers may not be directly subject to specific mandatory requirements relating to worker safety, they are indirectly "regulated" through certification requirements relating to the complete electrical equipment and other electrical products, as well as for electrical components. Safety components, such as control devices, circuit boards, cables, etc. are often supplied by separate component manufacturers and are then integrated into the complete product. Manufacturers of electrical components need to obtain product certification recognised by the product testing and certification organisation/company that will carry out certification of the complete product. Otherwise, the components would not be marketable in the USA.

In summary, the federal OSHA requirements are implemented through OSHA standards. These are based on ANSI standards which whilst primarily voluntary become mandatory when they are incorporated by reference into OSHA standards. The OSHA standards underpin the implementation of the OSHA requirements, which are federal level regulations whose legal basis is derived from the 1970 OSH Act.

The US system can be described as a system in which third-party conformity assessment of electrical products and components and electrical components in machinery before they can be legally sold is mandatory, and where the technical standards developed by the American National Standards Institute (ANSI) or by NRTLs must be met before certification can be obtained. This includes ongoing audit requirements to maintain the rights to hold the certification. In the case of final electrical products, (including components), the research found that only ANSI / UL standards can be used, whereas for other types of products, NRTLs can test and certify according to their own standards/ testing protocols.

In addition, there are non-mandatory OSHA electrical standards, which may be legally required at the state, city or municipality level. OSHA standards are based on the National Fire Protection Association's standard NFPA 70E, Electrical Safety Requirements for Employee Workplaces, and the NFPA 70 Committee derived Part I of their document from the 1978 edition of the National Electrical Code (NEC). According to OSHA, "the National

Electrical Code (NEC), or NFPA 70, is a regionally adoptable standard for the safe installation of electrical wiring and equipment in the United States. The NEC, while having no legally binding legislation as written, is often adopted by US states, municipalities and cities in an effort to standardize their approaches to ensuring safe electrical practices within their respective jurisdiction<sup>199</sup>. Although the NEC is not mandatory at federal level, it is often mandated by State or local law in most territories of the US. The NEC for instance requires ANSI / UL product safety labels on lighting fixtures. The NEC code for installing any lighting fixture states upfront that "the fixture must be UL listed".

### Electrical and electronic products and components

In the US, **radio frequency devices** are regulated under Parts 15 and 18 of Title 47 of the Code of Federal Regulations (CFR). Part 15 deals with incidental radiators (subpart A), unintentional radiators (subparts B and G) and intentional radiators (subparts C-F and H) of radio frequency energy. Definitions of these terms can be found in Section 15.3 of the legislation. Here, the requirements for each type of radiator are described.

- **Incidental radiators** (e.g. mechanical light switches, etc.) are not required to obtain equipment authorisation but are regulated under the general operating conditions of Section 15.5, which prominently stipulate that operation of such radiators must not cause harmful interference and, if harmful interference is caused and upon notification from the FCC, the user must cease operation of the radiator.
- **Unintentional radiators** (e.g. PCs, printers etc.) cover the majority of electronic-electrical products. Such radiators must receive authorisation prior to placement on the market by certification or alternatively, in most cases, through a Supplier's Declaration of Conformity (SDoC). See descriptions of these authorisations below.
- **Intentional radiators** (e.g. Wi-Fi transmitters, Bluetooth radio devices) require certification or SDoC authorisation, as per subpart C, §15.201. In addition, Sections C-F and H stipulate technical requirements for a range of different specific systems, for example vehicular radar systems (subpart F, §15.515).

Beyond the regulation of these radiators, Part 18 details specific requirements for electronic-electrical products that provide radio frequency energy for non-telecommunications applications. Such applications include industrial, scientific and medical equipment (e.g. fluorescent lighting, microwave ovens etc.) The majority of such devices are required to obtain authorisation via certification or, in some cases, SDoC.

Furthermore, considering electromagnetic compatibility specifically, a range of equipment types are considered to be exempt from FCC rules, including: medical equipment (due to its coverage by FDA standards), industrial process control equipment (as per Section 15.103(b)) and devices used exclusively as industrial, commercial, or medical test equipment (Section 15.103(c)).

#### Equipment authorisation – 47 CFR part 2, subpart J<sup>200</sup>

**Supplier's Declaration of Conformity (SDoC):** Equipment is required to be tested, but not necessarily by an FCC-recognised testing laboratory. However, non-FCC recognised laboratories that are used are subject to certain requirements related to recording measurements (Section 2.938) and measurement facilities (Section 2.948). Following testing, the manufacturer or other responsible party is subject to additional

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<sup>199</sup> <https://www.osha.gov/dts/otpc/nrtl/NRTLarticle.html>

<sup>200</sup> FCC Webpage, Equipment Authorisation Approval Guide, accessed on 28.01.2020 at: <https://www.fcc.gov/engineering-technology/laboratory-division/general/equipment-authorization>



approval requirements such as maintaining relevant documentation and preparing compliance information statements.

**Certification:** Equipment is required to be tested by an FCC-accredited testing laboratory. Subsequently, the manufacturer or other responsible party is subject to additional requirements to formalise the product certification with a Telecommunication Certification Body (TCB).

## Environmental legislation

In addition to the industrial product and safety and health legislation described above, the US places certain responsibilities on economic operators through environmental legislation. As in the EU, the key legislation in this regard focuses on chemical safety and the use of hazardous substances.

In the US, such topics are covered by the **Toxic Substances Control Act (TSCA)**, updated in 2016 by the Frank R. Lautenberg Chemical Safety for the 21st Century Act (less formally known as the TSCA Modernisation Act). The TSCA stipulates rules relating to the production, importation, use, and disposal of specific chemicals, including asbestos, polychlorinated biphenyls (PCBs), radon and lead-based paint. Many of the key chemicals included in the TSCA are aligned to the chemicals included under the EU's RoHS Directive and REACH Regulation. However, there are some differences between the two regulatory regimes that are important to note. For example, the TSCA requires the US Environmental Protection Authority (EPA) to prove that a chemical poses a risk to the environment or human health before regulating, while REACH requires that the companies prove that the chemicals they are using do not pose such risks or, alternatively, that they are able to implement sufficient measures to ensure safe use. with the authorities as opposed to economic operators, as is the case in the EU.<sup>201</sup> Furthermore, significant differences exist with regard to the number of chemicals that are considered as hazardous. Under REACH, for instance, around 70 unique substances are restricted as of August 2020, whereas more than 12,000 chemicals are subject to EPA regulatory flags under the TSCA.

As detailed above, another significant piece of environmental legislation in place in the EU is the WEEE Directive, which regulates electronic waste. However, **the US has not enacted WEEE-type legislation at the federal level**, even though it places as the second largest producer of electronic waste globally (6.3 million metric tons per year, as of 2016), behind only China. Although it has no federal legislation on the management of electronic waste, many states have enacted some type of relevant legislation: 25 states, as well as DC and Puerto Rico have adopted a form of consumer take-back law; and 17 states and New York City have bans on landfills.<sup>202</sup> An example of such a state-enacted law is the California Electronic Waste Recycling Act of 2003 (EWRA), which established a funding system for the collection and recycling of certain electronic waste. In contrast to the WEEE Directive, which places responsibility on the producer, the EWRA charges a fee to the consumer.<sup>203</sup>

Furthermore, in place of legislation, certain measures have been implemented at the federal level to: i) prevent electronic waste; and ii) tackle the negative effects of electronic

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<sup>201</sup> US Government Accountability Office, Report to Congressional Requesters, Chemical Regulation: Comparison of US and Recently Enacted European Union Approaches to Protect Against Risks of Toxic Chemicals, August 2007. Accessed at: <https://www.gao.gov/assets/270/265550.pdf>

<sup>202</sup> Baldé, C.P., Forti V., Gray, V., Kuehr, R., Stegmann, P.: The Global E-waste Monitor – 2017, United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn / Geneva / Vienna.

<sup>203</sup> California Government CalRecycle webpage, Electronic Waste Recycling Act of 2003, accessed on 28.01.2020 at: <https://www.calrecycle.ca.gov/electronics/act2003>



waste disposal and treatment. These measures include the Resource Conservation and Recovery Act (RCRA) and the Electronic Product Environmental Assessment Tool (EPEAT), against which more environmentally-friendly electronic products can be registered.<sup>204</sup>

### **3.2.3.8 Key findings – review of international legislation**

Regarding the findings from the mapping of **international legislation**, the main findings are as follows.

- **In almost all third countries examined, legislation applicable to the engineering industries broadly follows similar strategies and implements structures similar to that established by EU legislation.** For the most part, the countries examined have a well-established regulatory model for industrial products based on legislation detailing requirements for the standardisation and certification of certain industrial products. For instance, Brazil's Law No. 9.933 / 1999 establishes the objectives and mandate of Inmetro, the country's National Institute of Metrology, Standardization and Industrial Quality. Inmetro, alongside ANATEL (National Telecommunications Agency) and other governmental bodies, implements the Brazilian legal framework in relation to topics such as electromagnetic compatibility and processes such as conformity assessment. An exception to the general similarity of approaches is the issue of machinery safety in the US, where the focus of such legislation is the safety of users of industrial machinery and, thus, obligations are placed on employers, through the Occupational Safety and Health Act. As such, there is not mandatory duty on manufacturers. On this note, however, all the other third countries examined also have occupational safety and health legislation in place that considers the use of machinery. In other third countries examined, machinery safety requirements are placed on the designer/manufacturer or other economic operator or dealt with in separate legislation (for example, in India through the Factory Act 1948 and the Dangerous Machines (Regulations) Act 1983).
- **Varying approaches exist in relation to the alignment of national standards with international standards.** All the third countries examined have national standards bodies that hold responsibility for the development and maintenance of standards on the manufacture of industrial products, including mechanical, electrical and electronic equipment and products. For instance, the Russian government established Rosstandart (the Federal Agency for Technical Regulations and Metrology) to oversee the development of technical standards and OSHA (Occupational Safety and Health Administration) in the US. However, the extent to which the third countries examined have aligned their national standards with international (e.g. ISO/IEC) or European (EN) standards varies significantly. India, for instance, states that its Bureau of Indian Standards maintains close liaison with international standards bodies and specifically examines the adoption of ISO/IEC standards where possible and relevant. On the other hand, in Russia, there has historically been limited alignment with international or regional standards. With this said, Russia has been increasing its cooperation in this respect, in particular through the work of the Eurasian Economic Union and its dialogues with the EU on industrial products.
- **The engineering industries are considered to be important priorities in each third-country examined**, albeit for varying reasons. As a result, most are taking extensive steps, including the adoption of relevant legislation to ensure their engineering industries and industrial productivity is supported and enhanced in coming years. For instance, in 2009, the South Korean government adopted the Special act on the support of science and engineering manpower for strengthening national science and technology competitiveness. Since its adoption, South Korea develops a Master Plan every five years and annual implementation plans to ensure progress against this

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<sup>204</sup> Baldé, C.P., Forti V., Gray, V., Kuehr, R., Stegmann, P. : The Global E-waste Monitor – 2017, United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn / Geneva / Vienna.

objective. Moreover, in Russia, December 2014 saw the adoption of Federal Law No. 488-FZ which aims to deliver new incentives and mechanisms to support industrial production in the country through the provision of subsidies, tax incentives and other state funding, such as special investment contracts. In addition, India, through its 2016 National Capital Goods Policy, is aiming, in particular, to promote exports of capital goods, increase domestic production, improve the adoption of technology and the mandatory standardisation of machines and other equipment through the further adoption of ISO standards.

- **As detailed further in section 3.4, in relation to the accommodation of new technologies in the legislation of the third countries examined, it has been found that there is limited engagement with this topic.** Non-binding product standards and guidelines – rather than binding legislation – are currently the most common way of engaging, in particular, with AI and other emerging technologies in third countries. For instance, Japan’s Ministry of Economy, Trade and Industry (METI) has a long history of publishing non-binding industrial policy and safety guidelines on robotics. Furthermore, in relation to the relationship between liability and new technologies, it is found that specific provisions are, for the most part, not in place. One exception is in relation to autonomous vehicles in the US, where more advanced case law exists on the liability of humans in the manufacture and use of such vehicles. In addition, where concrete legislation does exist in relation to new technologies, it often takes the form of sector specific legislation rather than horizontal. An example is the South Korean Motor Vehicle Management Act, which was amended in 2016 to add a legal base for autonomous vehicle testing.

#### **Future development of International legislation**

- **There is a noticeable move towards the adoption of environmental legislation relevant to the engineering industries in the third countries examined.** In a number of countries, certain EU-type environmental legislation (such as the Directives on WEEE and RoHS and the REACH Regulation) does not have corresponding regulatory approaches or the regulatory approaches are in draft form or only recently adopted. Examples of this are mostly found in the BRICs countries (Brazil, Russia, India and China). In May 2019, for instance, Brazil published a draft proposal for legislation on the Restriction of Hazardous Substances (RoHS) in relation to electronic and electrical equipment. This legislation will align the Brazilian legal framework with the European RoHS framework, covering the same substances. Brazil has also recently published specific draft laws on the Management and Disposal of Electronic Waste (Draft Law 2940/2015) and the Inventory, Evaluation and Control of Chemical Substances (October 2018). However, both these laws have not progressed. In addition, India does not currently have overarching REACH-like legislation for the management and control of chemical substances. Draft rules on Hazardous Substances (Classification, Packaging and Labelling) were published in 2011 but made no progress through Indian legislators.
- In those third-country competitors considered to be more industrially developed (e.g. Japan, South Korea), the approach to environmental legislation, covering WEEE, RoHS and REACH issues, tends to be more established. However, the approaches differ. For instance, on REACH-type issues, both Japan and South Korea, on the one hand, are found to have implemented similar frameworks to the EU’s REACH Regulation, with the respective legislation often referred to as J-REACH and KOREA REACH. On the other hand, the US has implemented a different approach, through its Toxic Substances Control Act (TSCA). A key difference is that the US system places the burden of proof on the authorities (namely, the Environmental Protection Authority – EPA) rather than the manufacturer or importer, as is the case in the EU, as well as Japan and South Korea. Furthermore, China is in the process of updating its approach to the management of chemical substances and appears to be developing a mixed approach that combines elements similar to the US TSCA and other elements similar to EU REACH.

- In fact, on a more systematic level, the US approach to environmental legislation in the areas relevant to the engineering industries is different to that of the EU and its other global competitors. An example of this is the fact that no federal legislation related to recycling and disposal of waste electrical and electronic equipment currently exists in the US.
- As indicated above, **there are efforts being made in certain third countries to increase the alignment of their national standards with international standards.** For instance, as highlighted above, Russia are cooperating on this topic through the Eurasian Economic Union and India, in its 2016 National Capital Goods Policy, stated, as a key objective, the need to align Indian standards with ISO/IEC standards.

### **3.3 IMPACT OF APPLICABLE LEGISLATION ON THE EUROPEAN ENGINEERING INDUSTRIES**

The impact of legislation on the European engineering industries was then assessed. In particular, the following key study issues were investigated:

- The extent to which the EU regulatory framework applicable in the past decade has impacted on the **industrial competitiveness of the European engineering industries and on innovation;**
- The impact of the EU regulatory framework on the **market behaviours of European and international producers**, and economic operators integrated in Global Value Chains (GVCs); (e.g. the links with the competitiveness and digitalisation parts of the study); and
- The **drivers of the costs of regulatory compliance with EU legislation** <sup>205</sup>, and any changes over time experienced by economic operators in the EU engineering industries.

#### ***3.3.1 The relationship between EU legislation, industrial competitiveness and innovation***

The study explored the inter-relationship between EU legislation, industrial competitiveness and innovation. Evidence was identified of a complex interplay, as regulation can serve as **both a driver and inhibitor of competitiveness and innovation**, sometimes for the same piece of EU law. Examples are therefore provided in this sub-section to illustrate that EU legislation can have both positive and negative impacts on the EU engineering industries.

Some industry associations interviewed noted that they viewed impact assessments and evaluations of EU environmental legislation as having over-estimated the benefits from a competitiveness and innovation perspective, and also that the costs could sometimes be greater than those forecast ex-ante. This is perhaps not surprising in that if the primary drivers of going ahead with EU environmental legislation are driven by environmental policy and sustainability-related objectives, competitiveness and innovation were seen as being secondary considerations.

Feedback from the stakeholder consultations on the impacts of EU legislation is now considered.

There were found to be **cumulative effects** (including costs) of having an increasing body of applicable legislation within the EU legislative framework overall applicable to the EU

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<sup>205</sup> It should be noted that the focus was on reviewing secondary documentation sources, such as evaluations and impact assessments, and on gathering qualitative feedback, rather than on a detailed analysis of costs and benefits due to the multiplicity of legislation under review.

engineering industries. This includes industrial product legislation, but also horizontal and environmental legislation, such as through the REACH Regulation, RoHS Directive and WEEE Directive, and waste legislation, such as the European Waste Directive.

The fact that, in most cases, this legislation has been subject to multiple iterations, i.e. Directives get revised, updated and recast, but also aligned through the New Legislative Framework (NLF). This, in turn, means that producers are required to ensure familiarity for a lot of regulatory developments. This creates the need for on-going updating on developments and regulatory uncertainty. There is a tendency to 'gild the lily' by adding additional information requirements (e.g. the SCIP database where an impact assessment was not carried out).

The other important development is that there are now **greater responsibilities throughout the value chain** in terms of the extension of the applicability of the legislation to other types of economic operators. This has resulted, for instance, from the strengthening of legislation to improve traceability, and the introduction of associated databases.

Overall, industry associations stressed the importance of maintaining the overall stability of the regulatory framework, particularly in respect of industrial product safety legislation. On this point, Orgalim, the representative body for Europe's technology industries, stressed the need for stability in an interview conducted for this study; more specifically, in relation to the Machinery Directive, they noted that it does not need to be amended and, in fact, changing the standards could harm competitiveness. This was also alluded to by the VDMA in relation to the recent alignment of legislation through the NLF. In particular, they noted that the safety requirements remained unchanged, which was welcome for producers that need a stable legal framework.

Furthermore, industry stakeholders interviewed for this study have stressed the need to promote and undertake international standardisation, as discrepancies between different geographies result in significant challenges and burden for economic operators in the engineering industries.

It has also been noted by interviewed stakeholders, including, for example, the European Semiconductor Industry Association (ESIA), that European legislation on environmental and energy efficiency topics is more stringent than those implemented (or not implemented) by their international competitors (see section 3.3.2 for further detail on international legislative trends in this regard). In concert with significant subsidies, in particular, provided to the semiconductor industries in China and the US, it was argued that this puts European producers at a significant disadvantage.

Third-country competitors were found to experience lower regulatory burdens compared with their European counterparts (as evidenced by the survey of manufacturers and survey of industry associations). However, many larger manufacturers outside Europe also sell into Europe so also have to comply with EU legislative requirements.

European engineering firms could be disadvantaged by the overall burden of having to comply with EU legislative requirements, especially horizontal and environmental legislation, such as the REACH Regulation and the WEEE Directive. In relation to REACH, the mechanism by which this occurs relates in particular to the use of substances identified as substances of very high concern (SVHC), as included in the candidate list and listed in Annex XIV of the REACH Regulation. As it is the use of these substances that requires authorisation, it only applies to EU firms. This places a greater burden on EU firms, as their international counterparts are able to utilise such substances and enter the EU market without requiring authorisation, in particular when the SVHC is not present in the final product (and thereby does not confer any risk to consumers). There is a counter-mechanism designed to create a level playing field if the SVHC is present in the final product, as the Commission can issue a restriction on the placing on the market of the product, which also applies to imports.

Here, it is also important to mention the cumulative effects of EU legislation, and of producers needing to keep pace not only with changes in the core applicable legislation, but also any implementing regulations that are introduced to complement the legislation. An example in this regard was the WEEE Directive, where additional rules have been introduced relating to the need for economic operators to declare the weight of electronic and electrical products being put on the European market. This forms part of the WEEE product lifecycle disposal and recycling requirements.

A further point is that legislation is harder to comply with for SMEs than larger enterprises, given their difficulties in obtaining finance, lack of senior management/ owner time, shortage of and difficulties in the recruitment of specialist staff (including costs), less experience and limited internal know on how to manage change processes, lack of market knowledge, bureaucratic hurdles, less resources and capabilities for the economic exploitation of intellectual property rights, and a smaller network of partners or lack access to relevant actors with specialist knowledge (e.g. regulations, R&D, standards). This has further implications because SMEs are not evenly distributed throughout the EU-27 as a share of their population of enterprises – those with a relatively higher share of small and micro enterprises will be at a disadvantage to those with more medium-sized and less small and micro enterprises. For example, Italy has some 3.6 million microenterprises, compared to Germany's 2 million, even though the German economy is some 90% larger than that of Italy in terms of GDP. This has implications for the competitiveness of the enterprises in different Member States.

Legislation, such as the REACH Regulation, RoHS Directive, WEEE Directive and Ecodesign Directive were perceived as costly to implement by the EU engineering industries. For instance, compliance with the REACH Regulation requires investment in testing, R&D to identify, research and gradually substitute existing substances with safe chemicals. Yet whilst REACH is costly, it has driven adoption of safe chemicals, and this has sometimes been incorporated into the value proposition of firms, that their goods are REACH-compliant.

The fact that electrical products are compliant with the RoHS Directive often features prominently on product packaging. Sometimes, labelling is used to indicate compliance as part of a manufacturers' marketing/ branding, as at least some firms perceive compliance with EU law as being seen by consumers as a sign of quality. However, a further finding is that less well-known brands may tend to put compliance with EU legislation very prominently on their product packaging. Nevertheless, even many big brands and well-known manufacturers mention RoHS (and sometimes also REACH) compliance) on their products.

A further finding is that legislation can sometimes contribute to industrial competitiveness in areas where the EU is a first or second regulatory mover globally, in instances when other jurisdictions then subsequently adopt similar legal frameworks and / or harmonised technical standards. Good examples in this regard include the RoHS Directive as RoHS-type regulatory regimes have been adopted into third-country legislation in circa 40-50 jurisdictions globally. For example, the following countries have implemented their own version of RoHS - China, Japan, Taiwan, Korea, Norway, India, Ukraine, UAE, Turkey, Singapore and Vietnam. In Brazil, the legislation is under development, and a RoHS type law has also been proposed in Malaysia.<sup>206</sup> In addition, REACH-types regulatory regimes have been adopted in many major EU competitor countries.<sup>207</sup> This shows that even if there are different legal traditions, regulators globally share many of the same objectives when it comes to product and environmental legislation.

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<sup>206</sup> Source - <https://www.rohsguide.com/rohs-future.htm> and wider research

<sup>207</sup> Examples were provided in the mapping of international legislation. For example, China, South Korea, Japan and Russia have all introduced REACH-type legal regimes. See for instance <http://www.cirs-reach.com/chinareach.html>

Some stakeholders interviewed from industry associations suggested that if Europe becomes a 'first global regulatory mover' in an area such as product security, this may help to promote industrial competitiveness medium-term, as Europe has some competitive strengths in cyber-security, in terms of technologies / solutions and regarding how far products are viewed as being trusted and reliable.

A further advantage of being among the first to regulate in new areas is that there is a chance that European law and technical standards become the global *de facto* standards that firms comply with, as their preference is to comply with those standards likely to best enable them to meet differing legal and standards requirements globally subsequently. As even outside Europe, some larger customers further downstream require their suppliers to comply with EU legislation, this is arguably one way in which EU legislation affecting the engineering sector contributes to industrial competitiveness in Europe.

However, the estimated level of cost savings when EU legislation has been emulated elsewhere e.g. REACH and RoHS type legal regimes remains unclear, as often legal regimes share many similarities, but the requirements and standards aren't identical, therefore engineering firms will still face at least some additional compliance costs from third-country legislation even where these are similar to the EU legislation.

It should be stressed that the benefits of complying with EU product and environmental legislation in terms of being able to comply with legislation in some third countries only applies in a few specific cases, such as RoHS, and to some extent REACH. However, this could potentially apply to cybersecurity in future.

Nevertheless, many industry associations – both in position papers and the interviews – stressed that they would prefer to avoid either the adaptation of existing, or the introduction of new legislation to accommodate new technologies, such as AI and machine learning. Instead, their preference would be for Europe to maintain its longstanding commitment to the New Approach, with simple essential requirements set out in technology-neutral industrial product legislation. Many engineering industry associations continue to favour new technologies being regulated through the development of state-of-the-art standards based on longstanding and stable core applicable legislation, such as the Machinery Directive, the EMC Directive and the Radio Equipment Directive.

In parallel, industry stakeholders also strongly supported the common approach introduced through the New Legislative Framework. In other words, many stakeholders viewed continuity and stability as being preferable to introducing further legislation in new areas. This was also stressed during the webinar on the impact of legislation on the engineering industries.

Large firms (including multinationals) are perceived as benefiting from compliance with EU legislation more than SMEs (irrespective as to whether they are European or non-European firms). The reason for this is that even outside the EU, compliance with EU legislation is commonly required, and therefore once a firm has invested in ensuring compliance with EU product and environmental legislation, some of the costs incurred reap benefits subsequently as they can then show compliance in some global jurisdictions where compliance with EU product laws and standards is considered equivalent to any national product laws.

The analysis of available documentation through desk research has shown that different types of EU legislation may have a particularly significant impact on firms in the European engineering industries.

For example, the REACH Regulation No. 1907/2006 was mentioned as an example of legislation that has a considerable impact on the European engineering industry overall, and on specific branches in particular. It was seen as both a driver and inhibitor of competitiveness and innovation.

REACH came into force on 1st June 2007, with the following four main objectives: to ensure (1) a high level of protection of human health and the environment, including (2) the promotion of alternative methods for assessment of hazards of substances, as well as the (3) free circulation of substances on the internal market while (4) enhancing competitiveness and innovation. REACH aims to achieve this by introducing a system for the Registration, Evaluation, Authorisation and restriction of chemicals. It was expected that whilst there would be costs for industry of implementing the REACH Regulation, and registering and testing products, it would also have positive benefits, for example from promoting investment by chemical manufacturers and by producers in different sectors in R&D&I to develop substitutes for substances of very high concern (in terms of health or environmental impacts) included in the candidate list and listed in Annex XIV of the REACH Regulation. This was meant to strengthen the European chemicals industry's competitiveness and to foster competitiveness in other sectors.

Previous evaluations and studies on the impact of the REACH Regulation<sup>208</sup> have shown that there is a complex inter-play between REACH's role in competitiveness and innovation across different branches of industry, including the engineering sectors since it can be both a driver and an inhibitor. Based on the research produced to date, it is not possible to come to an unqualified conclusion either way – whether the Regulation has driven innovation or not. However, in the meantime, industry has incurred the costs of regulation, which include direct financial costs, compliance costs (substantive and administrative), and long-term structural costs (such as those related to changes in the number and size profile of enterprises in the relevant sector/ sub-sector, firm entry and exit, employment, market consolidation, etc.).<sup>209</sup>

The following box presents a detailed insight into the REACH Regulation and its impact on competitiveness and innovation.

### Box 3-1: Case study – the REACH Regulation

**Purpose of case study:** The aim of the case study to illustrate how the REACH Regulation has affected the competitiveness of EU Engineering industry, both in serving as a driver and inhibitor of innovation.

**REACH Regulation:** As detailed above, the aims of REACH are to ensure a high level of protection of human health and the environment, as well as the free movement of substances (on their own, in preparations and in articles), while enhancing competitiveness and innovation. The Regulation should also promote the development of alternative methods for the assessment of hazards of substances.

The main principle underlying the legislation is that the burden of proof that substances are safe lies on the manufacturer of the substance. Such manufacturers must register the substance, after which the registration dossier will be evaluated. If the substance meets the criteria of a substance of very high concern (SVHC) it is placed on the 'candidate list' where it can be recommended by the European Chemicals Agency for inclusion in REACH Annex XIV and where the continued use of the substance requires an authorisation.

The main driver underlying REACH is the identification and making available of substance data in the Registration Dossiers and the use thereof to reduce risks to the environment and human health. Data are communicated down the value chain through Safety Data Sheets (SDS) for each substance, including exposure scenarios.

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<sup>208</sup> See for example Monitoring the Impacts of REACH on Innovation, Competitiveness and SMEs, CSES for DG GROW, 2014

<sup>209</sup> *International Standard Cost Manual* by the SCM Network, and the Commission's *Impact Assessment Guidelines*.



According to REACH definitions, enterprises in the engineering industry are categorised as Downstream Users (DUs), Producers of Articles (PAs) and Importers of Articles (IAs). As such, they are not responsible for manufacture of chemicals and development of dossiers and SDSs, but rather use data supplied to them to inform their decisions with regard to risk assessment and exposure scenarios.

The competitiveness of the engineering industries, in their roles as DUs, PAs and IAs, has been affected in two main ways by REACH: their **role in the data and communication chain** between manufacturers and final users of articles that contain chemical substances; and, the **effect on use of substances**.

**Data and communication:** For engineering industry stakeholders such as Orgalim<sup>210</sup>, the provision by data by the manufacturers/ suppliers was initially seen in a positive light as it would help the DUs, PAs and IAs to manage their environmental and health risks effectively. However, the following matters have tended to counteract this:

- There are still **issues with the quality and reliability of data** in the SDSs which opens up industry users of the SDSs to liability regarding workers and the environment and related legal consequences, as well as potential loss of reputation.<sup>211</sup> Engineering companies therefore have to incur administrative burdens and costs to ensure that SDSs are correct. Costs derive from both chemical substance research and having to engage additionally with the supply chain and stakeholders. In 2016 the European Chemicals Agency (ECHA) found that some 64% of registration dossiers had not been updated with new information that has become available since 2008, and those that have been, were mostly updated only after a letter from ECHA.<sup>212</sup> The implication is that registration is *not a one-off cost but a recurring cost* and despite it being a legal obligation to update, not all relevant new information where it exists is being incorporated into SDSs and exposure scenarios and reaching users of chemicals which may put the users and consumers at risk.<sup>213</sup>
- It has also become clear that the **costs of implementing REACH with DUs, PAs and IAs had been significantly underestimated** at the time of the impact study which preceded the implementation of REACH. A good example of how this is the case is in the **Interpretation of REACH Art 33 by the ECJ** (C-1066/14 of 10 September 2015)<sup>214</sup> which Article 33 applies to individual articles within a complex article or assembly, rather than the overall article – that is, the thousands of components that make up an aeroplane, a motor car or a computer, so that each item has to be individually tested to determine the presence or otherwise of substances on the Candidate List. This is a significant cost. Orgalim points out that this is generally the case in the electrical/ electronic engineering industry which produces highly complex articles consisting of thousands of components, often in small batch sizes, and which works with very long and multi-tiered, global supply chains.<sup>215</sup><sup>216</sup>
- A further driver of **increasing requests for data** in terms of the requirements of

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<sup>210</sup> Orgalim represents Europe's technology industries – innovative companies spanning the mechanical engineering, electrical engineering and electronics, and metal technology branches.

<sup>211</sup> ACEA, ASD and Orgalim; Joint industry statement on Safety Data Sheets quality, Brussels, 15th December 2015

<sup>212</sup> <https://newsletter.echa.europa.eu/home/-/newsletter/entry/too-many-companies-are-not-updating-their-reach-and-clp-data>

<sup>213</sup> Amec Foster Wheeler, Peter Fisk Associates (2017); A study to gather insights on the barriers, costs and benefits, for updating REACH Registration and CLP notification dossiers, ECHA

<sup>214</sup> According to Article 33 any supplier of an article containing a substance of very high concern above 0,1 % weight by weight (w/w) has to make information available allowing safe use thereof, and if a consumer asks for such information it should be provided free of charge.

<sup>215</sup> [www.orgalim.eu/sites/default/files/historic/CARACAL\\_Consultation\\_SiA\\_Guidance\\_Final\\_Orgalime\\_Comment\\_s\\_13%20Apr%202017.pdf](http://www.orgalim.eu/sites/default/files/historic/CARACAL_Consultation_SiA_Guidance_Final_Orgalime_Comment_s_13%20Apr%202017.pdf)

<sup>216</sup> Orgalim Information Note on Article 33 of Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH): communication obligations on substances in articles

Art 33 is the insufficient quality of SDSs as set out above.

- Article 33 requests can be very administratively burdensome and have costly consequences if they trigger 'unnecessary' substitution costs. If consumers (or other supply chain participants) think that an article appearing on the Candidate List automatically means it is harmful when in fact it involves no *risk* to consumers or other users, consumer pressure may still lead to 'unnecessary' substitution costs.
- According to Orgalim, it has emerged that **ECHA Guidance 18** relating to Exposure scenario building and environmental release estimation for the waste life stage has not been fully implemented so there is not data for users or importers to use in this respect. Developing this data will be costly.
- A further data requirement placed on the industry is with regard to the need to supply information on the presence of SVHCs in articles and products in a **new ECHA Database** (the SCIP database) established under the Waste Framework Directive (WFD). This is considered a new onerous administrative burden for which an impact assessment that balances costs with benefits has not been carried out. There is some scepticism in the industry as to whether additional costs are proportionate and if it will lead to changes in treatment processes at the end of life of an article<sup>217</sup>. There is also a concern about making Confidential Business Information available in such a database and lack of protection of IP which can also contribute to a loss of competitiveness.

**Use of substances:** Another impact on industry competitiveness has been through the effect on the ability to use various substances in products. Some examples identified in the course of various evaluations are listed below.

- The requirement for '**Authorisation**' of some coatings of metal products that provide protection against corrosion means that costs to ensure that, aluminium or iron/ steel used in construction (e.g. buildings, bridges) will be increased or they will not have the durability and longevity they had before REACH. Some such coating activities may also move offshore to locations where those chemicals are still available without the challenges and costs of authorisation and then imported into the EU. It might also affect the location of, for example, aircraft maintenance facilities.
- In some instances, SVHCs have been substituted for products with lower performance characteristics, as in the case for example of printing and coatings.
- Some of the chemicals used in **Key Enabling Technologies** e.g. photonics/ electro-optics, and semiconductors are challenging from a REACH perspective (they are SVHCs) and trying to find substitutes with equivalent levels of performance. Authorisation is a costly procedure and products produced in non-REACH jurisdictions could be more advantageous to acquire.
- The challenges faced by producers of complex articles are of course acute if they have to meet the data requirements of **Art 33** or find substitutes.
- All the above challenges tend to be multiplied in the case of **micro, small and medium-sized enterprises** (MSMEs).
- There is as yet little evidence of significant levels of **innovation** substances as a result of REACH, other than substitution for compliance purposes, which many in

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<sup>217</sup> For example, according to the European Recycling Industries' Confederation (EURIC), "the existence of the database will not change the treatment processes of end-of-life articles covered by a sector-specific directive" - including WEEE - which already includes particular "requirements on the removal of components and fluids containing hazardous substances". In addition, EURIC confirms that the database "will not solve the issues linked to the legacy substances in material flows" for recyclers. Source: EURIC (2018); Options to address the interface between chemical, product and waste legislation EuRIC position on the Communication and Commission Staff Working Document

industry do not really regard as innovation.

**Overall positives and negatives with regard to competitiveness and innovation:**

On the positive side there has been substantial improvement in the chemical knowledge base with concomitant improvements in risk management (subject to the provisos mentioned above). REACH has also encouraged research to improve competitiveness and moves to a greener more sustainable economy. However, it has proved challenging for industry to develop new substances, or new uses of existing substances, that meet the technical properties required by the REACH Regulation, and new initiatives are continually being launched at national and EU level in the quest for 'safe chemicals'.

The increasing challenges with regard to data requirements and their communication have constituted a burden on industry, as has the need to substitute substances that are subject to authorisation or that are restricted. There has been evidence of offshoring and switching to non-EU suppliers,<sup>218</sup> although data is difficult to collect and it is hard in some instances to attribute causality directly to REACH.

Some imported articles have been able to enjoy an advantage over EU-produced equivalents as they may have not had to incur REACH-related compliance costs. This would be particularly the case in jurisdictions such as the USA and South Korea where registration and compliance costs are lower than in the EU.<sup>219</sup> This could also affect the ability of EU producers to sell in third-country markets.

There is a legacy of regulatory uncertainty that can jeopardise long term investments in Europe.<sup>220</sup> AmCham EU provides several examples of the consequences of such regulatory uncertainty.

There are also concerns about potential increased concentration in the industry as a result of higher fixed costs (resulting from regulatory costs), substance withdrawals, and imports only being available from a reduced number of suppliers (due to regulatory costs). Innovation in the chemical industry is also expensive and tends to favour large multinationals that are in a better position to afford such expenditures than SMEs.<sup>221</sup>

**The findings of the 2017 REACH REFIT Review<sup>222</sup>**

According to the most recent review of the regulation, which has now been in force since 2007, the conclusion is that 'Progress has been made towards the REACH objectives'. However, the Staff Working Document (SWD) states that impact on protection of human health and the environment will take a number of years to become visible, although evidence indicates that the outcomes defined in the intervention logic are being delivered in line with expectations. If the behavioural assumptions underlying the indicators selected are correct, then protection of the environment and health should be occurring. Also, information on substances is being generated and passed to some extent along the supply chain and, assuming that is accurate and being used to better assess and manage chemical risks, the implication would be that REACH is being effective in terms of protecting human health and the environment to some extent. Furthermore, according to the SWD, the development and consideration of alternative methods have greatly improved during the last ten years, although this may have been at the expense of delivering (hazard) information. In fact, alternative methods are not yet available for high-tier endpoints but registrants tended to avoid animal testing.

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<sup>218</sup> See for example: CSES, RPA, Okopol (2015); Monitoring the Impacts of REACH on Innovation, Competitiveness and SMEs, Final Report table 3.10.4, p.151

<sup>219</sup> ECSIP Consortium (2016); Impacts of REACH and corresponding legislation governing the conditions for marketing and use of chemicals in different countries/regions on international competitiveness of EU industry Final Report, DG GROW

<sup>220</sup> AmCham EU (2016); Position Paper. A private sector view on REACH and competitiveness

<sup>221</sup> According to the SWD, p.51, CIEL (2013) notes that the implementation of stricter measures with REACH has enabled significantly increased patenting of alternatives by major chemical manufacturers.

<sup>222</sup> European Commission, Brussels, 5.3.2018 SWD(2018) 58 final PART 1/7 Commission Staff Working Document Commission General Report on the operation of REACH and review of certain elements Conclusions and Actions {COM(2018) 116 final} p.39

Regarding the free circulation of substances on the internal market, the SWD concluded that REACH is delivering towards this objective. **No clear effects are seen on competitiveness and innovation as those depend on other more important factors that influence the market.** However, industry has been bearing the cost of the regulation since it was implemented.

Beyond REACH, there are concerns among the European semi-conductor industry (and the global semi-conductor industry selling products into the European market) regarding the timeframe for identifying suitable substitutes for substances presently used in the manufacturing of semi-conductors.

Where substances are already restricted, subject to authorisation or may be put on the authorisation list in future, companies will need to identify possible substitutes, which may or may not be available. Consequently, major industry global leaders in the manufacturing of semiconductors were concerned as to how limited access to particular chemicals might affect their core business within the European market. In competitor countries, there may not be corresponding legislation equivalent to REACH (even if more jurisdictions internationally are investigating the possibility of introducing a REACH-type regulatory regime). However, it should also be stressed that the picture can be complex, since other jurisdictions globally have in some cases introduced or in others are considering the introduction in future, of a REACH-type regulatory regime for chemicals. The same is true of the RoHS Directive, where many other countries globally have outlawed the use of substances in electronic and electrical equipment mentioned in RoHS. Therefore, the impact on economic operators, both European and non-EU, will need to be further investigated through interviews.

A further example of the complex dynamics involved as regards the intersection between EU legislation and competitiveness is the **Ecodesign Directive**. It is costly for manufacturers to invest in more energy efficient products and to eliminate non-energy efficient products from their product portfolio. However, equally, benchmarking their performance against "*Best Available Technologies*" (BATs) for energy efficiency instils a certain competitive discipline, as consumers are becoming more aware about the energy performance of electrical equipment and household appliances (in large part, due to simple energy labelling in pictogram form on products). As consumers make discretionary spending decisions based on factors such as price, brand, perceived quality but also increasingly energy efficiency, legislation arguably encourages manufacturers to drive continuous improvement processes and to invest in innovation to improve the energy efficiency of their products.

For instance, an MSA from the Netherlands commented that according to the results of their investigations, big enterprises are more likely to comply with the legislation than SMEs. Moreover, if large companies do not comply with the requirements, they often fix non-compliance problems in a short period of time. Whereas SMEs require more help, resources, and time to fix non-compliances.

An industry association representing domestic appliance manufacturers commented that "*energy labelling and eco-design are not a problem from a competitiveness perspective. On the contrary, an impact of these EU regulations is that products in Europe could potentially become more energy efficient than in other regions of the world due to the requirements being stringent*". An international industry association representing manufacturers stated during the webinar that "*It takes a long time to develop Ecodesign implementing regulations, and by the time these into effect, it can be 5 years since the original benchmarking to assess BATs and therefore, what was energy efficient five years ago may no longer be competitive at all*". The need to accelerate the roll-out and implementation of ecodesign requirements at the product level was therefore stressed.

### **3.3.2 Impacts of EU industrial product and environmental legislation on market behaviours of economic operators**

As the preceding remarks have suggested, the impact of legislation on different subsectors of the engineering industry can be varied. The final impacts are often difficult to characterise except in terms of one fixed factor which is the increase in costs and improved health and safety of those working in the industry and using its outputs.

Impacts may also vary at firm level, as legislation may influence a broad set of firm-level decisions, such as recruitment, new product development, new investments in plant and machinery and the decision to either enter new markets or exit existing markets.

A study by CSES<sup>223</sup> looked in some detail at the effects of compliance with EU legislation on SMEs in **the electrical industry from a cumulative point of view**. Overall, that study found that business are aware of cumulative costs and perceive the level as high. However, **much of the legislation has been in force for a long time and many companies have adapted to it and see it as business as usual**. Many vertical Directives are involved and national implementation and related measures increase cumulative costs. Costs imposed by legislation tend to be perceived as high but this is often seen as justified, given the performance requirements of the equipment and the health and safety issues involved. Environmental legislation also has an increasingly prominent role.

REACH, as an instance of environmental legislation, may **impact market behaviours in particular sub-sectors in engineering**. Examples of impacts identified include the case of the printing sector where manufacturers of printing machines have had to substitute printing ink with less effective printing ink (lower level of performance) because the inks they used contained SVHCs; similarly, civil engineering businesses providing bridges have had to reduce the technical specifications of the paints they use to protect their engineering works from the elements as those coatings contain SVHCs. Treatment of metals by chemicals has been one area where an important impact on the engineering industry has been identified. A further side-effect arises from uncertainty regarding the use of certain chemicals in manufacturing if those chemicals are SVHCs, or may become SVHCs in the future, if the substance may become subject to authorisation or restriction. The REACH Regulation and RoHS Directive may require investment in exploring the scope to use substitute chemicals and substances, but it could equally lead to particular products being withdrawn from the market.

With regards to behaviour in terms of handling of chemicals at enterprise level, the 2018 REACH review<sup>224</sup> found that the introduction of extended SDS has led to improvements in communication and more transparency in the supply chain as a result of which about a half of companies have adopted changes in risk management measures. However, in a significant number of cases, the information communicated is too lengthy and technical, or does not provide enough practical information to implement appropriate risk management measures. Some tools have been put in place to support downstream users in this respect which appear to be having a positive effect. But many companies, particularly SMEs, consider extended SDS as burdensome and too technical to be fully understood mainly due to lack of in-house expertise. This has prevented SMEs from using the information on the properties and use of substances in order to manage risks at their workplaces.

A further example of how EU legislation may affect individual firms, and influence market behaviours across different branches of the EU engineering industries relates to possible

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<sup>223</sup> Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (2015); Cost of the Cumulative Effects of Compliance with EU Law for SMEs Final report, pp. 61-66 and Appendix E.4

<sup>224</sup> European Commission, Brussels, 5.3.2018 SWD(2018) 58 final PART 1/7, COMMISSION STAFF WORKING DOCUMENT, Commission General Report on the operation of REACH and review of certain elements Conclusions and Actions {COM(2018) 116 final}, p.28-9

new legislation on AI (see Section 3.4.1). For example, if the EU goes ahead and develops an overarching legal framework on AI, following the February 2020 White Paper on AI, this may accelerate, or conversely delay the adoption of AI by EU engineering firms. At this stage, given that there is no detailed regulatory proposal, it is difficult to anticipate how this will impact firm behaviours. For example, there may be changes in relation to the liability regime, which need clarification, and presently cause regulatory uncertainty for businesses.

Similarly, if industrial product legislation is reviewed and data protection and privacy is more explicitly addressed, then EU engineering firms, especially electrical equipment and device manufacturers, as well as machinery producers, will need to integrate data protection and privacy considerations into product design and manufacturing processes even more closely. Arguably, this is already the case however due to GDPR requirements in force since May 2018. Two further delegated acts within the 2014 RED (Article 3(3)(e) and Article 3(3)(f)) may become new, additional existing essential requirements in future covering data protection and privacy and protection from fraud. The latter has not previously been covered under any EU legislation. Engineering firms would then need to pay greater attention to the relationship between product safety and security. This is likely to impact, *inter alia*, their treatment of these issues in the product design stage (e.g. integration into business processes) and big data collection strategies (both to optimise the production process (likely to be non-personal data) and post-market placement in relation to the treatment of personal data).

### **3.3.3 Impacts on SMEs**

During the study, the impact of different types of legislation on SMEs in the European engineering industries has been investigated. This was considered through a combination of desk research to review earlier evaluations and studies that have considered how EU legislation affects SMEs in these sectors. In addition, interview feedback from SMEs themselves as to how EU legislation affects them, and as to which types of legislation are considered to be more administratively burdensome will be provided and analysed. An analysis is provided below which considers the impacts on SMEs of vertical and horizontal legislation respectively.

#### **3.3.3.1 Impact of core applicable legislation to the engineering industries on SMEs**

As explained in the mapping of EU legislation, there are a few key pieces of product legislation that have a significant impact on the EU engineering industries, such as the Machinery Directive, LVD, RED and EMCD. The extent to which these pieces of legislation have impacted on SMEs is now considered. Key evaluations and impact assessments undertaken recently are cited, as these each involved extensive stakeholder consultations.

In the **2017 Evaluation of the Machinery Directive**,<sup>225</sup> almost half (46%) of all industry respondents to the public and targeted consultations were SMEs. However, the evaluation report pointed out that this is substantially lower than the proportion of enterprises in the 'manufacture of machinery and equipment' sector that are SMEs (98%). For both the EC-type examination and NB approval of full quality assurance, stakeholders pointed out that many SMEs were unlikely to have in place the necessary quality systems, therefore, this may **deter SMEs from using this conformity assessment option**.

The high costs of some conformity assessment methods were identified in the evaluation as being a particular problem for SMEs, especially for those considering manufacturing higher-risk categories of machinery identified in Annex IV of the Directive. However, it was

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<sup>225</sup> European Commission, Evaluation of Directive 2006/42/EC on Machinery, <https://op.europa.eu/en/publication-detail/-/publication/2b213537-25a8-11e8-ac73-01aa75ed71a1/language-en/format-PDF/source-68663524>

pointed out in the evaluation that there are also categories of machinery not presently included that are high-risk. This was viewed as potentially limiting the development of new machinery. An interviewee noted that *"The costs for an EC-type examination or comprehensive quality assurance are too high for SMEs in special-purpose machine construction. This precludes the manufacture of Annex IV machines if there are no harmonised C standards available, even though the residual risk would be acceptable"* (pg. 105).

Whilst **many SMEs are unable to use notified bodies, due to concerns about costs, they do however continue to use third-party testing bodies** to help them check compliance with the essential requirements and harmonised standards, either because they have *"limited in-house resources to undertake the assessment"*, or because *"they valued the credibility offered by independent assessment as a result of a risk-averse approach"* (pg. 97).

The **cost of purchasing European Harmonised Standards** was viewed as being particularly problematic for SMEs, especially when a single standard may make a number of references to other norms. An interviewee highlighted that *"the cost of acquisition is prohibitive... most are €50-€200 each, and you usually need a suite of A and B standards to fully understand a C (product specific) standard."*<sup>226</sup> A further finding (pg. 70) was that it was sometimes *"difficult to find the right standard to apply based on the summaries that were freely available, or to be sure of using the correct and up-to-date standard. Some were also more generally concerned about a lack of awareness and knowledge amongst SMEs"*.

In the **2020 Impact Assessment of the Machinery Directive (MD)**, due for publication imminently, consideration was given to the impact of new technologies (*reference should be made here to the future scenario analysis, addressing AI and machine learning*) on the future revision of the Directive. The majority of SME survey respondents did not have a clear view as to whether the MD needed to be revised to take into account new technological developments, such as **human-robot interaction, addressing the transparency of algorithms and software updates**. This perhaps reflected the complexity of these issues, and uncertainty among SMEs as to how best new technologies should be regulated. However, this can be contrasted with position papers from industry associations, which advocated that all firms would benefit from a retention of the status quo i.e. of setting succinct essential requirements and addressing technological developments and innovation through the development of state-of-the-art standards.

However, SMEs were clearer on the issue as to whether **cybersecurity** should be integrated into the MD. 47.8% of SMEs expressed the view that safety and security requirements should be added to specifically address the question on how cybersecurity requirements should be implemented in the EU. Among those who advocated the inclusion of cybersecurity, 29.6% of SMEs suggested that the best approach would be to integrate such requirements through sectoral legislation (n=115).

Among the findings from the survey of the existing MD were that just over half of SMEs agreed with the need to align the MD with the NLF. As the Directive dates from 2006, and precedes the NLF, it will need to be updated as it has not yet been aligned. 44.3% of SMEs believed that internal checks conducted by manufacturers (the self-declaration of conformity) could lead to safety concerns, but 33.9% of SMEs were of the view that there are no safety concerns associated with conducting such internal checks. This difference of opinion perhaps stems from the fact that many SMEs do not have their own in-house

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<sup>226</sup> Evaluation of Directive 2006/42/EC on Machinery, pg 69, Technopolis Group for European Commission's DG GROW.



testing capabilities and are therefore reliant on a third-party testing and certification laboratory, even if these are currently voluntary.

In the **Interim evaluation of the Low Voltage Directive 2014/35/EU (LVD)** <sup>227</sup> undertaken in 2019, various issues concerned with the impact of the Directive on SMEs were analysed. An online survey was undertaken with electrical equipment manufacturers, including SMEs. A relevant finding was that 69% of SME manufacturers responding to the survey reported that the **LVD improves the safety of products sold in the EU market** (compared with 85% of large manufacturers). The costs of compliance with the LVD were considered to be 'moderate-to-low' by stakeholders consulted, but of a "greater relative importance for SMEs" (pg. 14).

The **timeliness of standardisation procedures** – and the availability of new technical standards – was cited as an issue of concern by stakeholders contributing to the evaluation. However, it was pointed out that paradoxically, this may be beneficial for SMEs. *"SMEs – and/ or their stakeholder representatives – may encounter more difficulties in participating in a faster process, as their involvement is limited by the time and the financial resources available. They would therefore not necessarily be able to cope with a faster standard development process and to participate with the required intensity in the development of standards"* (pg. 58).

A further interesting finding from the evaluation was that many SMEs would *"rather rely on the expertise of a Notified Body in conducting the actual conformity assessment. Notified Bodies are seen as a source of support and guidance for SMEs struggling with the conformity assessment procedure, or in cases of conflicts with Market Surveillance Authorities (MSAs)"*. The supportive role played by NBs was confirmed in the stakeholder survey by manufacturing SMEs, importers and distributors. *"For certain SMEs, it might be difficult to have the required technical expertise to demonstrate compliance, especially when developing innovative products which require a mix of different technical requirements"* (pg. 69).

In an impact assessment study of the RED,<sup>228</sup> there was a focus on the **possible activation of two delegated acts in Article 3(3)(e) and Article 3(3)(f) on data protection and privacy and protection from fraud**. This was one of three studies undertaken in 2019-2020, one of which is also relevant, but ongoing (focusing on software). This involved extensive assessment of the implications of GDPR for producers, including the impact of AI, the industrial IoT and the collection of big data (including personal and non-personal data). Among the findings were that the GDPR is already having a significant impact on firms, but SMEs were generally less aware about the need to incorporate data protection by design and default into their business processes, and had less access to in-house specialist legal expertise on data protection and privacy compared with large manufacturers. Nonetheless, strengthening product security was viewed as an area which might be able to enhance competitiveness in future.

In the ongoing 2020 **Evaluation of the EMCD**, the impact of new technologies and scientific progress is being considered. It is however too early to assess the impacts on SMEs, as the stakeholder consultations have not yet commenced.

Some interview feedback was received from industry associations regarding the impact on SMEs of the core applicable EU legislation for engineering firms. However, this often

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<sup>227</sup> European Commission, 2019 – Interim evaluation of the Low Voltage Directive 2014/35/EU (LVD) - <https://op.europa.eu/en/publication-detail/-/publication/48c2118c-4d4d-11ea-aece-01aa75ed71a1/language-en>

<sup>228</sup> European Commission, 2020, Impact Assessment on Increased Protection of Internet-Connected Radio Equipment and Wearable Radio Equipment, <https://ec.europa.eu/docsroom/documents/40763>

related to generalisations regarding the challenges for SMEs in complying with relevant EU legislation, rather than specific problems.

For instance, an industry association representing domestic appliance manufacturers noted that *"it is generally more difficult for SMEs to follow compliance requirements because they have fewer legal personnel, fewer people generally, including those with an understanding of regulatory compliance, and fewer possibilities of participating directly in EU lobbying activities and stakeholder discussions in Brussels"*. Consequently, the same stakeholder noted that *"smaller companies have fewer possibilities to influence the situation than bigger companies. As a result, SMEs often learn about potential new regulatory requirements at a later stage and have less time to prepare for compliance. At the same time, there are very often several organisations focusing on representing SMEs and many horizontal organisations monitor any new requirements and communicate these to SMEs"*. However, there is an increased volume of information available online about how to comply with legal requirements and what forthcoming regulatory developments are coming. Therefore, SMEs arguably do not face information asymmetries compared with large firms. Rather, they lack the time and resources to review available information. An industry association remarked that it is often the case that SMEs are not that interested during regulatory development processes, but instead show more interest if legislation is imminently about to affect them (e.g. revisions to existing, and adoption of new EU laws).

Lastly, the capacity of firms in the EU engineering industries to adapt to any further EU legislative changes is questionable at least in the next 2 years, according to an open letter from Orgalim sent on behalf of Europe's mechanical and electrical engineering, electronics, ICT and metal technology sectors,<sup>229</sup> to the European Commission President due to the COVID-19 crisis, which means that manufacturers (especially SMEs) are more concerned about survival and about the economic impacts of the pandemic than about possible new EU legislation. In the webinar on the competitiveness of the EU engineering industries and impact of digitalisation, it was confirmed that whilst supply chain dislocation is a concern, falling demand for machinery is a key concern, and therefore, the more stable the regulatory regime during the pandemic and the subsequent recovery period, the better.

### **3.3.3.2 Impact of vertical legislation on SMEs**

SME manufacturers often face higher regulatory compliance costs compared with large producers. The reason for this is they commonly produce in lower volume and are less able to offset costs against high production volume. Moreover, large firms often employ specialist regulatory compliance managers and engineers and are better able to manage the compliance process than their SME counterparts.

A number of previous studies have assessed the impact of EU legislation on SMEs. In addition, there have been assessments funded by the Commission to identify which are perceived to be the most burdensome pieces of EU legislation from an SME perspective.

A study for the Commission's DG GROW on the *Cost of the Cumulative Effects of Compliance with EU Law for SMEs* examined the issue of the cumulative effects of EU legislation in a number of sectors, among which some relevant to the European engineering industries (Electrical Equipment NACE C 27 (excluding C 27.5 and C 27.9)).<sup>230</sup> The study looked at costs in terms of an approach informed by the Standard Cost Model methodology, examining different types of costs, such as familiarisation, adaptation and administrative costs.

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<sup>229</sup>[https://www.ifsa.eu.com/uploads/1/2/0/2/120245019/orgalim\\_letter\\_to\\_ec\\_president\\_covid19\\_impact\\_commission\\_work\\_2020.pdf](https://www.ifsa.eu.com/uploads/1/2/0/2/120245019/orgalim_letter_to_ec_president_covid19_impact_commission_work_2020.pdf)

<sup>230</sup> Centre for Strategy and Evaluation Services (CSES), *Cost of the Cumulative Effects of Compliance with EU Law for SMEs*, 2015, developed for DG GROW, European Commission.

The study found that, given the relatively numerous pieces of vertical legislation that affect the sector, compliance costs tend to be relatively high (compared to other sectors covered by the study – bakeries manufacture and retailing, and computer services). Some case studies related to product development, cross-border working and inspection illustrated the impacts of the costs in question. Further findings of interest were that, given the costs of human capital and capital equipment required to operate in the sector, firms in the sector tended to be larger (than some others) and necessitated a relatively large scale of operations to generate break-even and profitability. Larger firms, as mentioned, usually find it easier to absorb costs of compliance with legislation. Also, there are territorial impacts in that some EU Member States have proportionately larger shares of micro and small firms, suggesting that they might be proportionately more highly impacted than others with relatively larger firms (for example, Italy compared to Germany).

Another initiative by the Commission's DG GROW was carried out on the "*Top 10 most burdensome EU laws*".<sup>231</sup> In a broad consultation initiated by the Commission, around 1000 SMEs and business organisations have now identified the top 10 most burdensome EU laws. The purpose of this consultation was to check where EU legislation might be impeding jobs and growth and to identify areas or issues which would require further examination and action where necessary. Among the findings were that SMEs round REACH chemicals legislation, product safety and labour-market related legislation the most burdensome. Whilst useful in identifying which legislation was seen as problematic, the consultation did not probe in detail the particular problems that SMEs faced in addressing such legislation.

There is also a question of the timeframe since EU legislation was introduced, and the degree of embeddedness, which impacts how burdensome industry stakeholders perceive legislation to be. For example, REACH has often been identified as the most burdensome piece of legislation applicable to industrial products. However, the degree of burden was viewed as being especially heavy during the early period of implementation. Now that there has been a further period of legislative "bedding-down", economic operators have got more used to the requirements, over the three successive phases of REACH's implementation, most recently in 2013 and 2018, when the regulation's applicability was extended to include further categories of chemicals across different tonnages.

A stakeholder taking part in the Webinar on the impact of legislation on the EU engineering industries noted however that even where the legal framework is stable, and the Regulation itself has not changed, the interpretations of the requirements by key stakeholders involved in its implementation, monitoring and enforcement, such as by the ECHA Agency, may evolve, meaning that even when the legislation does not fundamentally change, there remains a degree of regulatory uncertainty from an EO perspective. For instance, one stakeholder pointed out that the process of making an application for the registration of a chemical substance has changed significantly over time, and industry has seen the application requirements as something of a moving target, with changes to the application process being made as ECHA's experience and knowledge has grown.

Recently, the Cross-Industry Initiative (CII), a coalition representing manufacturers and downstream users of chemicals, large companies and SMEs, released a position paper calling for better guidance and an improvement in the effectiveness and consistency of a how risk management option analysis (RMOA) of substance is conducted and to provide a standardised risk assessment framework.<sup>232</sup>

Also relevant are more detailed studies for the Commission's DG GROW, which have specifically focused on REACH. These provide information regarding the Regulation's

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<sup>231</sup> DG GROW, European Commission, Results of the public consultation on the TOP10 most burdensome legislative acts for SMEs, 2011.

<sup>232</sup> CII (2020) POSITION PAPER ON RMOAs Towards a more effective and consistent RMOA process to support the ambitions of the European Green Deal

impact on SMEs. For instance, an evaluation of 2012 relating to the 2010 registration found disproportionately high negative impacts (in terms of compliance costs) as a result of which the Commission reduced the registration costs for SMEs. However, that did not stop some SMEs from closing down, reducing product lines or selling out to larger competitors.<sup>233</sup>

A further study was undertaken for DG GROW on *Monitoring the impacts of the REACH on Innovation, Competitiveness and SMEs* (2014-15).<sup>234</sup> This study found that SMEs faced greater adverse impacts than large enterprises, in particular in relation to compliance costs. The primary reason for this related to the availability of resources to comply with the Regulation. For instance, considering only human resources, small and micro-sized enterprises in particular do not tend to have a specialist Health, Safety and Environmental employee, meaning that either the company owner/manager/research chemist has to deal with REACH compliance (resulting in opportunity costs) or the firm has to outsource compliance (described as costly) or the firm has to employ an additional member of staff, which also entails a costly financial impact. In addition, the study found that SMEs faced further costs, for example in relation to IT, language issues, authorisation, R&D, supply chain communication.

Beyond resource issues, REACH implementation was found to cause a number of SME-specific issues, whilst few benefits were perceived. For example, these issues included technical matters, such as the preparation of Exposure Scenarios, pre-registration issues and inability to access support networks.

### 3.3.3.3 Impacts of horizontal legislation on SMEs

Considering horizontal legislation, there are a number of key areas in which SMEs are impacted, including, for example, access to finance, employment and health and safety.

Regarding the legislation on **access of SMEs to finance**, a study for DG GROW (2013) *Evaluation of Market Policies and Practices in SME rating* in the context of the Capital Requirements Directive (CRD) and now the Capital Requirements Regulation (CRR) found that the smaller a firm, the harder it is for it to obtain bank finance.<sup>235</sup>

**Employment law** also presents a challenge for SMEs, again primarily for those at the smaller end of the scale. For example, they need to comply with legislation regarding giving notice etc. but if employees leave without notice or complying with their obligations, it is often not worth it for a SME to prosecute given the time and costs involved – whereas an employee could more readily do so if the enterprise failed to comply – there is a certain asymmetry.

An interesting finding from the survey with manufacturers undertaken through the present study was that many viewed labour market laws as being burdensome, but there was a lack of understanding as to the delineation in competences between the EU and Member States as regards such laws. Although the EU is responsible for some legislation on working conditions within the context of the employment chapter of the TFEU (e.g. Working Time Directive, Part-Time and Fixed-Time Workers Directives), it is not responsible for large swathes of national employment laws.

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<sup>233</sup> CSES (2012); Interim evaluation of the Functioning of the European Chemical market after the introduction of REACH for DG ENTR

<sup>234</sup> Centre for Strategy and Evaluation Services (CSES), *Monitoring the Impacts of REACH on Innovation, Competitiveness and SMEs*, 2015, developed for DG GROW, European Commission in collaboration with Risk & Policy Analysts (RPA) and Okopol.

<sup>235</sup> The CRD IV package, of which Regulation 575/2013 (CRR) entered into force on 28 June 2013 and the Directive 2013/36 (CRDIV) on 17 July, became applicable as of 1 January 2014.<sup>29</sup>

The impacts of new legislation on SMEs is also meant to be taken into account during the process of developing new and revising exiting EU legislation through the SME Test, which implements the 'think small principle' through:

- A preliminary assessment of businesses likely to be affected
- A consultation with SMEs and SME representative organisations (SMEs, Envoys, EEN)
- The measurement of the impacts on SMEs (cost-benefit analysis)
- The use of mitigating measures, if appropriate
- The impacts on SMEs (intended, unintended) is also considered.

The SME Test was incorporated into the Better Regulation guidelines, which also require an assessment of the impacts on SMEs of EU legislation<sup>236</sup>.

A recent position paper<sup>237</sup> by Business Europe on future EU SME policy notes that among the priorities to strengthen the effectiveness of EU legislation for SMEs are: simplifying administrative procedures needed to operate cross-border; tackling barriers due to poor implementation and a lack of enforcement of Single Market legislation, due to the lack of market surveillance and "gold-plating" practices. The need to strengthen attention to market surveillance and enforcement has been identified as a problem in many studies, that the legal framework and development of harmonised technical standards to meet the essential requirements is working reasonably well, there are many non-compliant products on the European market, although a lack of data on precise levels of non-compliance. A further issue identified has been the lack of timely development of technical standards for some core industrial product legislation (e.g. the RED) applicable to many manufacturers in the engineering industries, and the perceived dominance of standardisation processes led by the European Standardisation Organisations (ESOs) by large firms, which arguably disadvantages SMEs.

As noted at the end of the section mapping EU regulatory requirements for SMEs, legal requirements for micro, small and medium firms are generally not differentiated compared with large firms to avoid distortions within harmonised single market legislation. The impact of this means that as there are a lack of exemptions for say micro and small firms, this means that the overall perception of the level of administrative and substantive compliance burden is quite heavy for SMEs.

### ***3.3.4 Impact of existing environmental legislation on the EU engineering industries***

There are two different theories in the environmental economics literature on the potential impacts on the competitiveness of regulated firms. The first view is based on trade theory and predicts that environmental policies lead to large losses in competitiveness due to the increasing compliance costs. This theory is also known as the pollution haven hypothesis since it argues that the compliance costs would cause a shift of production to other regions and consequently an increase of the emissions in areas with less regulatory stringency.<sup>238</sup>

On the other hand, there is a view that argues that more environmental legislation can have a positive impact on affected firms' competitiveness. This is the theory supported by

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<sup>236</sup> The SME Test - [https://ec.europa.eu/growth/smes/business-friendly-environment/small-business-act/sme-test\\_en](https://ec.europa.eu/growth/smes/business-friendly-environment/small-business-act/sme-test_en)

<sup>237</sup> SETTING AMBITIOUS GOALS FOR FUTURE EU SME POLICY, Position Paper, Business Europe, February 2019 – available [https://www.buinessurope.eu/sites/buseur/files/media/position\\_papers/smes/2019-02-19\\_strengthening\\_the\\_eu\\_sme\\_policy.pdf](https://www.buinessurope.eu/sites/buseur/files/media/position_papers/smes/2019-02-19_strengthening_the_eu_sme_policy.pdf)

<sup>238</sup> Dechezlepretre, A., Sato M., (2017) The Impacts of Environmental Regulations on Competitiveness

the EU and is a theory that is gaining relevance lately.<sup>239</sup> Recent empirical literature shows that environmental policies do not lead to large losses on competitiveness.<sup>240</sup> The evidence is measured quantifying the impacts of environmental legislation on firms' competitiveness on key aspects of competitiveness such as trade, industry location, employment, productivity, and innovation. The conclusions reached in these studies are that not only and the cost burden of environmental legislation has often been found to be very small, but also it has been proven that *"such policies promote cost-cutting efficiency improvements, which in turn reduce or completely offset regulatory costs, and foster innovation in new technologies that may help firms achieve international technological leadership and expand market share."*<sup>241</sup>

Similarly, the study on "Environmental expenditures in EU industries, time series" which measured the business' costs of environmental legislation over the period 1995-2012, reached the conclusion that stricter environmental legislation does not lead to higher environmental expenditures (at the EU level). This is generally assumed to be because sectors become more efficient over time in responding to legislation, and so the costs of existing legislation falling over time.

Nevertheless, when new environmental legislation is implemented, there are large differences between sectors and Member States, especially in the short-term. The available evidence shows that these laws have negative impacts on some sectors and positive productivity impacts for others. For instance, for the energy sector and pollution-intensive sectors, environmental legislation result in larger environmental expenditures. The study "Environmental expenditures in EU industries, time series" calculated the costs and added value for different sectors in all Member States over time (1995-2012) and reached the following conclusions<sup>242</sup>:

- Sectors become more efficient over time in responding to legislation, and so the costs of existing legislation falls over time.
- New environmental legislation leads to peaks in environmental expenditure in the short term.
- There are differences between Member States and sectors. In "newer" Member States environmental expenditures are often above the EU average. A possible explanation is that these countries invested in environmental measures over a relatively short period, in order to comply with EU legislation. Another plausible cause is the scale of enterprises in "newer" member states, which is in many cases smaller than in "older" Member States.

Due to technological progress, relative environmental expenditures have the tendency to decrease over time. Moreover, on-going technological progress can also be illustrated by the increased share of integrated technologies. It seems that relatively high environmental costs have a positive effect on innovative solutions that subsequently decrease those costs.

In the following table, an example as to how different types of legislation affects the EU engineering industries is provided. This focuses on the **impact on the electrical and electronics sector of requirements relating to the disposal and recycling of electrical and electronic waste** and in relation to the types of chemicals that cannot be

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<sup>239</sup> Kellenberg, D. K. (2009) An empirical investigation of the pollution haven effect with strategic environment and trade policy. *Journal of International Economics*

<sup>240</sup> Carbone, J. C., and N. Rivers. (2017) The impacts of unilateral climate policy on competitiveness: evidence from computable general equilibrium model

<sup>241</sup> Dechezlepretre, A., Sato M., (2017) The Impacts of Environmental Regulations on Competitiveness

<sup>242</sup> Jantzen, J. van der Woerd, H. (2015) Environmental expenditures in EU industries, Time series data for the costs of environmental legislation for selected industries over time

used in production, as set out in the **WEEE Directive** and the **RoHS Directive** respectively.

**Box 3-2: Case study – the regulation of electrical and electronic waste through the WEEE Directive**

**Purpose of case study:** The aim is to show that aspects of the EU regulatory framework applicable to the European engineering industries demonstrate stability over time. However, whilst producers and wider economic operators in the value chain benefit from regulatory certainty, there are nevertheless changes over time due to the evolution in the legislation over successive iterations of European directives and regulations.

**Relevant engineering sectors:** producers of electrical and electronic equipment.

**Legal framework and its evolution over time:** The case study focuses on the directive on waste electrical and electronic equipment (**WEEE Directive**), whose objective is to protect the environment and human health through the prevention of generation of WEEE, its diversion from disposal or incineration, and the promotion of its recycling, re-use and recovery.

The legislation's rationale is that there is a growing volume of WEEE and negative externalities associated with hazardous substances in WEEE being sent to landfill. A further problem is that such waste is often at end of product lifecycle exported to countries that lack adequate controls for recycling). There are linkages between WEEE and the RoHS Directive (2011/65/EU), which form part of the regulatory regime on the environmental impact of electronic products in the EU. RoHS is covered in a subsequent case study.

The first WEEE Directive (**Directive 2002/96/EC**) entered into force in February 2003. The Directive provided for the creation of collection schemes where consumers could return their WEEE free of charge in order to increase the recycling of WEEE and/or re-use. The Directive was then revised to tackle the increasing volume of electrical and electronic equipment waste. The current **WEEE Directive (2012/19/EU)** entered into force on 13 August 2012, and became effective on 14 February 2014.

In April 2017, the Commission adopted the "WEEE package", which includes Commission implementing Regulation 2017/699 establishing a common methodology for the calculation of the weight of electrical and electronic equipment (EEE) placed on the national market in each MS. This established a common methodology for the calculation of the quantity of WEEE generated by weight in each MS. In February 2019, the Commission adopted Implementing Regulation (EU) 2019/290 establishing the format for the registration and reporting of producers of electrical and electronic equipment to the register.

**Analysis of the costs, benefits and impacts of the WEEE Directive on producers:**

**Costs of the WEEE Directive.**

According to some interviewees, the costs of collection, treatment, recovery, re-use, recycling, and environmentally-sound disposal of WEEE, are relatively high. Examples are: the cost to producers of establishing and implementing a take back scheme. If the collection target is not achieved, producers must pay a compliance fee. The registration process also means some degree of administrative burdens.

An industry association representing major manufacturers at EU level pointed out that *"Europe has one of the most stringent regimes on the waste of EEE. This could hamper the competitiveness of the industry due to the cost for treatment of the product and this cost is probably higher than in other regions globally"*.



Since the Directive's initial adoption in 2002, there has been one further iteration of the WEEE Directive in 2012. Even though the core legislation has been relatively stable since 2002, there have been changes to the requirements and obligations for manufacturers, and other economic operators in the value chain (e.g. authorised distributors) have been brought within the Directive's scope. Even though the legislation's objectives have remained stable, new requirements have been introduced since Directive 2012/19/EU came into force through ancillary legislation, such as the introduction of the additional implementing regulations in 2019 relating to the registration and reporting of producers of electrical and electronic equipment on a register. Such requirements have implications for producers. If there is greater transparency in the volume of electrical and electronic goods they place on the market, they will be under greater scrutiny to ensure that their obligations regarding WEEE recycling meet acceptable levels of compliance with the requirements.

#### **Benefits of the legislation (WEEE).**

- Reducing the amount of EEE waste, with positive impacts in terms of sustainability and contribution to the circular economy.
- There were not found to be any direct benefits for businesses in respect of industrial competitiveness.
- However, the Directive has helped businesses to avoid negative externalities, such as reputational risks associated with electrical and electronic waste, and inadequate arrangements for its disposal.

#### **Comparison between EU legislative requirements and those in third-country competitors:**

Regarding the international dimension, although all of the EU's key competitor countries have engaged on the types of issues relating to electronic and electrical equipment covered through RoHS and WEEE from a legislative perspective, the timelines of their engagement differ significantly. These third countries essentially fall into three camps:

- i) Countries with historically well-developed industrial legislative frameworks that have had relevant legislation on these issues for many years. For example, Japan's J-Moss system, which comprises the Japanese Recycling Law (2000) and the Japanese Industrial Standard JIS C 0950 (2005)<sup>243</sup>.
- ii) It was noted that other countries have various degrees of regulatory alignment with the EU. Many countries have adopted similar legislation to RoHS and WEEE legislation. For instance, India's RoHS legislation<sup>244</sup> (Decree 139), which covers both RoHS and WEEE elements, took effect in May 2014.
- iii) Countries that are still progressing such issues through the legislative process. Brazil, for example, published a draft RoHS legislative proposal<sup>245</sup> in May 2019.
- iv) In the Middle East, there are somewhat fewer restrictions on substances than in the EU and although the regulatory framework is broadly similar, there are more lenient exemptions. The EU was regarded as the strictest jurisdiction globally.

**Interviews:** International business association and an EU policy maker responsible for RoHS Directive.

*Source: desk research and interviews.*

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<sup>243</sup> [https://home.jeita.or.jp/eps/jmoss\\_en.htm](https://home.jeita.or.jp/eps/jmoss_en.htm)

<sup>244</sup> <https://www.rohsguide.com/india-rohs.htm>

<sup>245</sup> <https://www.ecomundo.eu/en/blog/rohs-brazil-2019>

In the following case study, the impact of the RoHS Directive on producers in the electronic equipment industry is considered. The main feedback on RoHS is that there is wide international acceptance of the need to restrict the usage of hazardous substances in electrical and electronic equipment. Therefore, although there are impacts for the engineering industries, there were equally found to be some benefits of REACH compliance, not least the fact that many jurisdictions globally have adopted similar regulatory regimes to the EU (e.g. REACH-type legislation has been adopted in Japan and South Korea, among other countries globally, and similar legislation will take effect in Russia in July 2021) (see results of mapping international legislation).

**Box 3-3: Case study – stocktaking on the impact of the RoHS Directive on producers in the electronic equipment industry**

**Purpose of case study:** The purpose is to take stock of the implementation of the **RoHS Directive**, which was designed to prevent the use of a number of hazardous substances in electrical and electronic equipment.

**Relevant engineering sectors:** producers of electrical and electronic equipment.

**Legal framework and its evolution over time:** EU legislation restricting the use of hazardous substances in electrical and electronic equipment (RoHS Directive 2002/95/EC) entered into force in February 2003. RoHS strictly limits the use of certain substances in electrical and electronic equipment (EEE), namely heavy metals such as lead, mercury, cadmium, and hexavalent chromium and flame retardants such as polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE) to be substituted by safer alternatives. As was the case for the WEEE Directive, the Directive has been revised through the RoHS recast Directive 2011/65/EU (published 2012), which became effective on 3 January 2013. A further four substances to complement the original six were added through a Commission Delegated Directive<sup>246</sup> from 2015. In 2017, the RoHS 2 scope review legislative proposal was adopted to adjust the Directive's scope, supported by an impact assessment. However, the 2012 Directive has not yet been revised through a further recast.

**Analysis of the impact of the RoHS Directive on producers:** The RoHS Directive affects industrial manufacturers, importers and distributors of EEE. An interesting aspect is that over time, there has been a shift towards making economic operators across the value chain responsible for compliance, whereas previously, the focus was on producers.

The key challenge for economic operators is clearly the need to find alternative substitutes to the ten hazardous substances restricted by the RoHS Directive. To manage this process, the Directive implements a mechanism for granting time-limited exemptions, which can be applied for by economic operators while they search for alternatives. For most categories of EEE, exemptions can be granted (upon application) for up to 5 years. An interviewee commented that substitution should be possible at some point in future for most products, however, in the interim, extensive use is still being made of exemptions, although these are gradually being phased out.

For more complex categories of EEE (e.g. medical devices), exemptions can last up to 7 years. Indeed, the sub-sector where industry reports greater incidence of problems the medical devices sector and other specialised areas. An interviewee noted that the exemption system, in its current state, takes a long time and is not particularly efficient, thereby increasing the burden on economic operators. However, there is also a tension between regulator and economic operators with regard to the durations of the exemptions: industry call for longer durations, but the purpose of the exemptions is to drive the search for alternative substances.

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<sup>246</sup> Commission Delegated Directive (EU) 2015/863 of 31 March 2015 amending Annex II to Directive 2011/65/EU of the European Parliament and of the Council as regards the list of restricted substances. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015L0863>

A further issue is that some sub-sectors in the machinery sector have many exemptions. For example, equipment sent into space and the car industry are both not presently covered by RoHS. Compliance requirements under RoHS have therefore had a significant impact on the electronics industry in the European market, as well as globally. Two additional areas of compliance that often require detailed advice are the registration schemes, which in the recast Directive have been made more uniform and the need for economic operators to respond to requests from market surveillance authorities for compliance documentation, such as the provision of a technical file to support the DoC. It has also been noted by an interviewee that SMEs are disproportionately impacted by the requirements, as compared with large firms, as they are less likely to have access to the resources necessary to understand and know how to comply with the legislation.

**Benefits of RoHS.** Most of the benefits of the legislation are environmental, although there are arguably some benefits associated with its role in fostering competitiveness by encouraging investment into substitutes (although this may be undermined by the common practice of giving lengthy exemptions for substances of 5-7 years). The recast Directive 2012 has contributed to:

- Further reducing the risks of adverse ecological consequences and human/animal health impacts of EEE containing hazardous substances within the scope of RoHS through the inclusion of additional product categories.
- The development of substitute chemicals for use in EEE products which may be more innovative and safer than legacy chemicals being used as a result of investments in substitutes. Safer chemicals used in EEE could have a positive impact on sales volumes, by inspiring greater trust in their safety among consumers.
- RoHS has established itself as an international global regulatory benchmark for restricting certain substances (e.g. lead, cadmium) regarded as being dangerous in products. This has contributed to fostering global regulatory alignment and collaboration on RoHS internationally.
- Promoting a supply-chain wide approach to legislative compliance, as the requirements extend to all economic operators in the value chain. This has resulted in greater knowledge of hazardous substances (and potential substitutes) across the supply chain than was previously the case.

An interviewee from the environmental policy field noted that RoHS legislation implemented across the globe is often similar, and that industry stakeholders are mainly organising their responses to RoHS compliance globally. Whilst it was acknowledged by industry stakeholders that RoHS has had a positive impact overall, an evaluation is needed to assess the impact of RoHS in phasing out substances and in protecting the environment and human health.

#### **The RoHS legislative review, 2019 - stakeholder views on the legislation's effectiveness:**

An April 2020 position paper <sup>247</sup> by **ZVEI, the German electrical industry association** responding to the new Circular Economy Action Plan – For a cleaner and more competitive Europe (CEAP) of March 11, 2020 expressed strong support for retaining RoHS as a separate law from the REACH Regulation. A risk-based approach should be applied to regulating broader substances and product groups. The industry association stated that a major advantage of the first RoHS Directive (2002) was that the Directive focused on only a few of the most relevant substances and tapped into the *"relatively broad international recognition of the risk posed by these substances"*. The Directive's simple structure was viewed as being *"easy to understand for small businesses and companies outside the EU, contributed to its international dissemination"*.

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<sup>247</sup> <https://www.zvei.org/en/press-media/publications/the-new-circular-economy-action-plan-position-paper/>

As regards the Directive's weaknesses, the same paper alludes to a lack of focus due to the incremental additional of additional substances. *"The addition of more and more substance bans, combined with an almost unmanageable list of exemptions with different scopes and expiry dates, is increasingly leading to the loss of this success criterion".* It is suggested that instead the revision of the RoHS Directive in a circular economy context must concentrate on the simple communication of requirements in globalised markets and a risk-based approach to regulating substances and product groups with the greatest environmental impact.

Further position papers were reviewed from a recent 2019 consultation on the future of RoHS. For example, neither ZVEI or **LightingEurope**<sup>248</sup> supported proposals to merge RoHS with other legislation (e.g. REACH). They also made practical suggestions as to how the Directive's effectiveness might be improved. It was suggested that additional resources are required to strengthen management of the restricted substances and exemptions under RoHS. *"The Commission must be allocated additional resources and expertise to manage the review of substances and exemptions under RoHS. The amount of restricted substances and exemptions and the great variety of EEE addressed under RoHS require additional human and financial capacity. Applicants must invest a significant amount of resources to collect and provide detailed data from across their value chain (suppliers and customers). The review of these applications requires time as well as technical and scientific expertise for the consultants awarded the evaluation contracts".* Exemption requests should be finalised in a shorter timeframe in their view.

Weaknesses were also identified in the **exemption review methodology** by the industry association Lighting Europe. *"The process and methodology for the decision on exemption applications should be reviewed to also clearly set out how to quantify and evaluate the total environmental and human health benefits of an innovative new technology (i.e. one that results in significant energy gains throughout the lifecycle compared to alternatives)".*

Regarding the evaluation of substitute technologies, the position paper noted that the RoHS exemption review process should make allowances for cases where no viable substitute/alternative technology is expected over a reasonable timeframe. *"Such exemptions should be renewed for the maximum period possible (5 or 7 years) and the Commission should put in place a fast-track process to assess whether any substitutes are available, before requiring a full renewal application to be submitted".*

Source: Desk research and interviews with EU policy makers and industry associations

#### **3.3.4.1 State aids and competition legislation – the role of Important Project of Common European Interest**

A company that receives government support gains an advantage over its competitors. Therefore, the TFEU (Arts. 101-109) generally prohibits state aid above a certain threshold, if such aid is likely to lead to competition distortions (with some exceptions). Specifically, the TFEU prohibits anti-competitive agreements and the abuse of market position by dominant undertakings.

Whilst industry stakeholders interviewed acknowledged the underlying rationale of EU state aids and competition legislation, concerns were expressed by some branches of the EU engineering industries, especially semi-conductors and components, as to **whether European industry could continue to successfully compete in the absence of a level playing field**, given significant grant subsidies and R&D&I expenditure in the US and China to the semi-conductor industry. Such investments have been made in recognition of the semi-conductor industry's strategic importance both as regards industrial applications, for instance, the race to achieve a globally-leading competitive position in 5G, as well as for national security reasons. In terms of market share, reflecting

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<sup>248</sup> Position Paper by LightingEurope, December 2019, [https://www.lightingeurope.org/images/publications/position-papers/LightingEurope-Position\\_on\\_the\\_RoHS\\_Directive\\_Legislative\\_Review\\_-\\_20191211.pdf](https://www.lightingeurope.org/images/publications/position-papers/LightingEurope-Position_on_the_RoHS_Directive_Legislative_Review_-_20191211.pdf)

the major scale of these investments, the US and China have both significantly strengthened their competitive position vis-à-vis Europe in the past five years, according to the EU industry association that represents manufacturers in this domain.

The EU has also invested in strengthening the competitiveness of the EU semi-conductor industry through R&D&I investments. Here, the important role of the Joint Undertakings funded under the Horizon 2020 programme 2014-2020 (e.g. the **ECSEL Public Private Partnership on innovation in electronic components and systems**) should be stressed. Support for this branch of engineering is likely to be continued under the future thematic **Institutionalised European Partnerships** <sup>249</sup> under **Horizon Europe 2021-2027**.

However, in an international trade context, neither the EU or individual Member States have been able to match the level of grants internationally. As such subsidies could be illegal under EU state aid rules if of sufficient scale, the EU policy response to address this challenge was the creation of a new legal mechanism, the **Important Project of Common European interest ("IPCEI")**.

A benefit of this approach is that **key sectors designated as being of key strategic importance to the European economy**, could be supported. Once designated as an IPCEI, there is greater flexibility regarding the interpretation of state aid and competition rules so as to allow Member State support for certain industries of strategic importance. IPCEIs have already been created in respect of **microelectronics**<sup>250</sup>, which includes semi-conductors, **batteries** and **hydrogen**.

#### **Box 3-4: Example of an IPCEI – leveraging EU and national resources through a public private industrial partnerships approach**

##### **Mechanism: Important Project of Common European interest**

##### **Sub-sector: Batteries**

**Description:** The **batteries IPCEI** <sup>251</sup> was announced in December 2019 by the European Commission, which has approved under EU State aid rules. It was jointly notified by **Belgium, Finland, France, Germany, Italy, Poland** and **Sweden**, who will support research and innovation in the common European priority area of batteries.

**Funding:** The level of resources that can be mobilised through an IPCEI can be significant. For example, in the case of the batteries IPCEI, seven member states concerned will provide in the coming years up to approximately €3.2 billion in funding for this project, which is expected to unlock an additional €5 billion in private investments. The completion of the overall project is planned for 2031.

**Key actors involved in public private partnership (PPP):** The focus is on scaling-up innovation under the European Battery Alliance with an emphasis on fostering strong industrial partnerships. The project will involve 17 mainly industrial actors, including small and medium-sized enterprises (SMEs), some of which with activities in more than one Member State. The direct participants will closely cooperate with each other and with over 70 external partners, such as SMEs and public research organisations across Europe. <sup>252</sup>

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<sup>249</sup> These are partnerships where the EU participates in research and innovation funding programmes that are undertaken by a number of EU countries. They are based on article 185 of the Treaty on the Functioning of the European Union (TFEU) which allows the EU to participate in such programmes.

<sup>250</sup> Through the IPCEI on Microelectronics, France, Germany, Italy and the UK intend to maintain and further expand European competencies in this field. See <https://ipcei-me.eu/>

<sup>251</sup> <https://battery2030.eu/news/news-detail/?tarContentId=824300>

<sup>252</sup> [https://ec.europa.eu/commission/presscorner/detail/en/ip\\_19\\_6705](https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6705)

These implementation modalities provide a useful instrument to be able to support the emergence of national and European champions capable of competing in the face of strong competition and state subsidies in some third countries (e.g. the US, China) that may undermine Europe's competitiveness. For some business associations, the strategy should be further developed in a more pro-active, faster and transparent process to make sure that the strategic value chains initiatives and IPCEIs exemptions to the EU state aid rules are guided by strategic considerations in a way that is agile enough to cope with fast-changing global competition.

However, an interviewee from a public private partnership (PPP) focused on the development of advanced manufacturing technologies pointed out that there is only **limited scope to extend the use of this instrument to other sectors**. There are only limited sectors where IPCEI could be applicable, and these already have IPCEIs (e.g. micro-electronics, batteries). There may only be one or two further sub-sectors where this could be useful, e.g. aerospace. Whilst flexibility on state aid interpretations of state subsidies may be welcomed by industry, it was pointed out that most national budgets in the EU Member States preclude any state subsidies from being allocated close to the ceiling in the existing state aid rules. Therefore, the impact of this initiative in future is likely to be confined to a small number of strategic sectors.

There are alternative means of supporting key strategic sectors. For example, new legislation will come into force on **batteries in support of the Strategic Action Plan on Batteries and the circular economy**. Interview feedback from EU level industry stakeholders confirmed the importance of batteries as a strategic sector.

#### **3.3.4.2 Gold-plating of EU legislation in national transposition and implementation**

The term 'gold-plating' needs to be defined, as there are some Directives where the EU sets minimum standards only (i.e. the differentiation between Minimum and Maximum Harmonisation Directives). In such cases, it is possible for Member States to go beyond these minimum requirements in national legislation. An example in this regard is the WEEE Directive, which is based on Article 192 TFEU rather than Article 114 TFEU. Another point is that part of the Commission's Better Regulation strategy to simplify the regulatory environment involves proposing greater use of directly-applicable regulations.

This would suggest that gold-plating is less of a problem today than it was 5-10 years ago as directly-applicable Regulations are much more commonly used as a legal instrument. Whilst Directives remain an important part of the applicable legislation, there are several examples where former Directives have been turned into Regulations as part of the revision and updating of EU legislation. An example in this regard are Medical Devices, which were initially regulated through Directives, in particular Council Directive 93/42/EEC of 14 June and the revised Directive 2007/47/EC, followed by a transition to Regulation (EU) 2017/745, the Medical Devices Regulation. Moreover, key legislation that was perceived as being quite burdensome for SMEs also includes directly applicable Regulations such as REACH.

The gold-plating of EU legislation following national transposition processes is often mentioned as a problem by industry associations, at least in several previous evaluations of EU legislation.

The following table provides a short summary as to i) the legal basis for each legislation, which denotes whether a legislation follows the Minimum (Art. 192 TFEU) or Maximum Harmonisation (Art. 144 TFEU) route; and ii) whether each legislation is a Directive or a Regulation. This provides useful context, as the extent to which gold-plating can take place is limited for maximum harmonisation Directives, such as most industrial product legislation, which are implemented under Art. 114 TFEU.



**Table 3-6: Summary overview of legal base for Industrial product legislation and type of legislation (whether directly applicable regulations or Directives).**

| Legislation                                                                                                                                                                                          | Directive or Regulation?                | Legal base                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------------------------------|
| <b>Industrial product legislation (core)</b>                                                                                                                                                         |                                         |                                      |
| Machinery Directive (MD) 2006/42/EC                                                                                                                                                                  | Directive                               | Art. 114                             |
| Low Voltage Directive (LVD) 2014/35/EU                                                                                                                                                               | Directive                               | Art. 114                             |
| Electromagnetic Compatibility Directive (EMCD) 2014/30/EU                                                                                                                                            | Directive                               | Art. 114                             |
| Radio Equipment Directive (RED) 2014/53/EU                                                                                                                                                           | Directive                               | Art. 114                             |
| <b>Industrial product legislation (wider legislation)</b>                                                                                                                                            |                                         |                                      |
| Explosive atmospheres equipment (ATEX) Directive 2014/34/EU                                                                                                                                          | Directive                               | Art. 114                             |
| Gas Appliances Regulation (GAR) 2016/426/EU                                                                                                                                                          | Regulation                              | Art. 114                             |
| Lifts Directive 2014/33/EU                                                                                                                                                                           | Directive                               | Art. 114                             |
| Outdoor Equipment Noise Emissions Directive 2000/14/EC                                                                                                                                               | Directive                               | Art. 114                             |
| Personal Protective Equipment (PPE) Regulation EU/2016/425                                                                                                                                           | Regulation                              | Art. 114                             |
| Pressure equipment (PED) Directive 2014/68/EU                                                                                                                                                        | Directive                               | Art. 114                             |
| Simple Pressure Vessels Directive (SPVD) 2014/29/EU                                                                                                                                                  | Directive                               | Art. 114                             |
| Ecodesign Directive 2009/125/EC                                                                                                                                                                      | Directive                               | Art. 114 (presently ex. Art. 95 TEC) |
| Energy-labelling of products Regulation 2017/1369                                                                                                                                                    | Regulation                              | Art. 194                             |
| Cableways Regulation EU/2016/424                                                                                                                                                                     | Regulation                              | Art. 114                             |
| Medical Device Regulation (Council Regulation 2017/745)                                                                                                                                              | Regulation                              | Art. 114                             |
| General Product Safety Directive, 2001/95/EC                                                                                                                                                         | Directive                               | Art. 114 (presently ex. Art. 95 TEC) |
| <b>Horizontal legislation</b>                                                                                                                                                                        |                                         |                                      |
| REACH Regulation (EC) No 1907/2006                                                                                                                                                                   | Regulation                              | Art. 114                             |
| <b>Environmental protection legislation</b>                                                                                                                                                          |                                         |                                      |
| RoHS Directive 2011/65/EU of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment. Legislative amendment RoHS 2 Directive (EU) 2017/2102 | Directive                               | Art. 114                             |
| WEEE Directive (Directive 2012/19/EU) (disposal of electronic equipment waste)                                                                                                                       | Directive                               | Art. 192                             |
| Implementing Regulation (EU) 2019/290 establishing the format for registration and reporting of producers of electrical and electronic equipment to the register.                                    | Regulation (supporting above Directive) |                                      |
| Future possible legislation – carbon tax                                                                                                                                                             | NA                                      | Art. TBC                             |



Some literature<sup>253</sup> points to gold-plating being a problem. Among the countries where gold-plating was identified more commonly were Denmark, France, Germany, the Netherlands and Sweden. Environmental protection legislation was found to be one of the areas where gold-plating was most common. During the webinar, it was mentioned that the implementation of existing environmental legislation has been problematic, due to divergent interpretation at national level, and differing detailed implementation requirements under Directives such as WEEE in the area of electronic waste.

A study on *Smart Governance of the internal market* found that five legal acts in the environmental area were subject to gold-plating, amounting to an additional 8% of total administrative costs (or € 58 million) stemming from national obligations going beyond minimum EU requirements. Furthermore, an industry association interviewed for this study noted that additional national level rules mean that economic operators working across the EU are required to tailor their approaches per Member State thereby fragmenting the single market and increasing the administrative and substantive costs faced by these economic operators.

Detailed case studies were carried out in respect of the applicable Directives, such as the REACH Regulation (1907/2006), Environmental Impact Assessment Directive (2011/92/EU) and the IPPC Directive (Directive 96/61/EC) concerning integrated pollution prevention and control, as codified in Directive 2008/1/EC. Not all of these are relevant to the engineering industries but the following example relating to REACH is a pertinent example of gold-plating as this affects different branches of engineering.

### **Box 3-5: Example of gold-plating – the REACH Regulation**

**Theme:** Chemicals legislation

**Legislation involved:** Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

**Characterisation of gold-plating:** Adding additional legislative requirements following the transposition of national legislation. Especially common in environmental protection legislation, as the Directives are often minimum harmonisation Directives.

**Gold-plating features/impact/lessons learned:** Though REACH is a regulation, which shouldn't be transposed into Danish law, the Danish authorities are adding supplementary requirements:

- **Supplementary regulation concerning phthalate.** The Danish Government has submitted a Notification of a draft Consolidated Act regarding the import and sale of products for indoor use which contain one or more of the phthalates specified in Annex 1 of the Regulation and products which contain these substances in parts of the products which may come into contact with skin or mucous membranes. The draft consolidated act covers four phthalates, namely DEHP, DBP, BBP and DIBP which are all already included in the range of application of the REACH regulation with harmonized requirements to production, marketing and use. The Danish act, however, introduces further requirements and a complete ban of products with such contents in other areas than the REACH Regulation (this is in contradiction with the provisions of Article 128 of the Regulation)

**Administrative burdens resulting from gold-plating.** The definition of an Article represents a significant burden, as the Danish economic actor might have to contact a high number of different manufacturers of the various components of the product in order to be able to inform the following actors in the supply chain of the contents.

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<sup>253</sup> Smart Governance of the internal market for business, A report to the European Economic and Social Committee – Group I, Prof. Lena J. Tsipouri, University of Athens, Department of Economic Sciences, available at <https://www.eesc.europa.eu/sites/default/files/resources/docs/qe-01-14-863-en-n.pdf>

Furthermore, if a consumer asks for such information, the Danish economic actor will have to provide it to the consumer.

**Lessons learned:** The business sector's perception is that the Danish government has broken the provision of Article 114 of the Treaty, reading that, if a Member State finds it necessary to introduce national rules in an area already harmonized in the EU, such rules are to be based on new scientific documentation on protection of environment or health and safety at work related to problems that are specific for the Member State in question and appearing after adoption of the harmonized rules in the EU. It does not appear that this has been the case with regard to the supplementary regulation regarding phthalate.

*Source: Smart Governance of the internal market for business, A report to the European Economic and Social Committee – Group I, Prof. Lena J. Tsipouri, University of Athens.*

However, other literature identified, including in the environmental field, suggests that gold-plating is a misunderstood term, which in the context of environmental law and minimum harmonisation Directives, can be justified as giving Member States regulatory flexibility, which can be positive<sup>254</sup>.

Concerns among stakeholders regarding the risk of gold-plating also has implications for regulators, such as DG GROW in its responsibility for industrial product legislation, where the mapping has shown that many of the applicable laws remain Directives, even if efforts have also been made to promote legislative simplification, for example through the New Legislative Framework (NLF).

A major study published in 2014 for DG ENTR to evaluate 25 different Regulations and Directives relating to industrial product legislation found that gold-plating was not a significant problem for this type of legislation.<sup>255</sup> However, there may be other challenges in selling cross-border within the internal market, having placed products on the market using the common rules set out under the NLF. For instance, whilst not a legal barrier, in some national markets, there is an expectation that products are tested to national standards not only to harmonised European technical standards in order to be able to display marking labels that are recognised by consumers and professional users. This is however an example of a non-regulatory barrier.

Some feedback has been received on gold-plating through the interviews. For instance, a national industry association pointed out that gold-plating was less a problem in respect of the transposition of industrial product legislation, but was seen as being particularly prevalent in the domains of workplace safety, and also in respect of environmental protection legislation, possibly reflecting the use of minimum harmonisation Directives as a legal instrument, which then allows Member States to introduce further national level requirements. However, the perception in relation to industrial product legislation was confirmed in an interview with a representative of a certification company. The interviewee stated that – in particular considering the RED and EMC Directive – gold-plating is not a significant issue, although minor examples exist. These examples include the additional requirement in France to include the Specific absorption rate (SAR) value for mobile phones in the user manual.

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<sup>254</sup> Squintani, L. (2019). Gold-Plating: A Misleading Overarching Concept. In *Beyond Minimum Harmonisation: Gold-Plating and Green-Plating of European Environmental Law* (Cambridge Studies in European Law and Policy, pp. 13-71). Cambridge: Cambridge University Press. doi:10.1017/9781108646055.002

<sup>255</sup> CSES and Panteia, Evaluation of the Internal Market Legislation for Industrial Products, January 2014, commissioned by the European Commission's DG for Enterprise and Industry. Last accessed on 25.11.2019 at: <https://ec.europa.eu/smart-regulation/evaluation/search/download.do?documentId=9966151>

### 3.4 FUTURE SCENARIO ANALYSIS – EVOLUTION IN LEGISLATION TO 2030

A key dimension of this study is to develop future scenarios as to how the situation is likely to evolve between now and 2030. This section is therefore structured as follows:

- Section 3.4.1 – considers the impacts of new technological developments and innovation on EU and international legislation.
- Section 3.4.2 – considers the impacts of planned and potential new EU environmental legislation on the EU engineering industries
- Section 3.4.3 – sets out possibilities regarding future scenarios, including positive and negative scenarios to 2030, and outlining our base case.

#### **3.4.1 Impact of new technological developments and innovation on EU and international legislation**

This section considers the impact on legislation of new developments linked to Industry 4.0 and new technological and innovation developments at the product and sector level. This encompasses:

- The **impacts of digitalisation** on the EU legal framework to ensure that legislation remains fit for purpose; and
- **Industry 4.0**, including advanced manufacturing processes, and the growing use of robotics, artificial intelligence, software and advanced automation, as well as the use of increasingly connected industrial processes and cloud-based computing to manage production.

There is a particular focus on AI, since the implications of digitalisation are covered in greater detail in Part 3 and are less specific in terms of the regulatory aspects, whereas AI and Industry 4.0 more broadly raise a number of legal issues.

##### **3.4.1.1 EU policy and regulatory context – digitalisation and the European engineering sectors**

There have been a number of EU policy developments to promote digitalisation and AI in the past few years. This section focuses on providing an overview of policy developments that potentially raise regulatory issues relating to the implications of the increasing digitalisation and digitisation of European industry.

The European Commission has been actively considering the impact of digitalisation from a policy and regulatory perspective. Indeed, digital transformation and fostering AI are among the top priorities of the new Commission in the 2019-2024 period, recognising AI's crucial importance to help the EU to maintain industrial and broader economic competitiveness. Accordingly, recent policy and regulatory developments have been reviewed (see next sub-section).

Other international organisations, such as the OECD, have also considered the impact of digitalisation, Industry 4.0 and AI. For instance, a recent OECD publication from June 2019<sup>256</sup> notes that *"Digital technologies affect societies and economies in many ways, including via new means of communication and collaboration; new products that feature a strong service component; the role of data as driver of economic growth; the automation of tasks with AI; and the emergence of new business models such as platforms"*. This has consequences for society and for businesses, but also for regulators, who are recognised

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<sup>256</sup> OECD, Regulatory effectiveness in the era of digitalisation, Research Paper (June 2019)

as having an important role to play in fostering *"digital innovation and in incentivising the development of these technologies for the benefit of society"*.

Whilst digitalisation is an area that has many societal and economic benefits, including those identified in Part 3 as being able to help contribute towards enhancing the competitiveness of the EU engineering industries, regulators have a responsibility to monitor broad consumer interests and the public good to limit any potential unintended negative consequences of these developments by providing general rules that reflect societal values and preferences. Often, however, *"regulatory frameworks lack the agility to accommodate the increasing pace of technological developments. Digital technologies also challenge deeply the way governments regulate: by blurring the traditional definition of markets; challenging enforcement; and by transcending administrative boundaries domestically and internationally"*<sup>257</sup>. These are important issues raised by the OECD.

As highlighted in Section 3.2.1 (mapping of EU legislation), core industrial product legislation applicable to the EU engineering industries have or are currently being reviewed to assess how well they are able to adapt to an evolving technological landscape. National and EU industry associations have also highlighted the importance of reviewing the existing EU legal framework to ensure its ongoing fitness for purpose, and published Position Papers in this regard.

Recent examples of European Commission reviews include the 2017 evaluation of the Machinery Directive (MD, 2006/42/EC)<sup>258</sup>, the 2020 impact assessment on strengthening cybersecurity requirements in the Radio Equipment Directive (RED, 2014/53/EU)<sup>259</sup> and the 2020 interim evaluation of the Low Voltage Directive (LVD, 2014/35/EU)<sup>260</sup>. In addition, an evaluation of the Electromagnetic Compatibility Directive (EMCD, 2014/30/EU) is being conducted in 2020 and an impact assessment on possible revisions to the Machinery Directive<sup>261</sup> is ongoing at the time of writing. The impact of new technologies, including AI, on the regulatory environment is an important focus for both ongoing assessments.

The findings from the completed assessments suggest that stakeholders are, for the most part, supportive of the existing regulatory framework for industrial product legislation and do not see the need for significant change as a result of new technologies. These stakeholders state that the combination of in-built technological neutrality and standards development are effective in ensuring the adaptability of the legal framework to technological developments.

However, there are slight differences in how some national and EU industry associations view the nature and scale of the problem, and appropriate solutions. Some industry associations, such as Orgalim, have stated support for retaining the current legal framework under the NLF to underpin product safety by relying on the legislation to be technologically-neutral, and technical standards to accommodate innovation and new technological developments. Conversely, others are open to new legislation, if it is able to create an enabling regulatory framework that could encourage digitalisation and

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<sup>257</sup> OECD, Regulatory effectiveness in the era of digitalisation, Research Paper (June 2019)

<sup>258</sup> European Commission, Evaluation of Directive 2006/42/EC on Machinery, <https://op.europa.eu/en/publication-detail/-/publication/2b213537-25a8-11e8-ac73-01aa75ed71a1/language-en/format-PDF/source-68663524>

<sup>259</sup> European Commission, 2020, Impact Assessment on Increased Protection of Internet-Connected Radio Equipment and Wearable Radio Equipment, <https://ec.europa.eu/docsroom/documents/40763>

<sup>260</sup> European Commission, 2020, Interim evaluation of the Low Voltage Directive 2014/35/EU, <https://op.europa.eu/en/publication-detail/-/publication/48c2118c-4d4d-11ea-aece-01aa75ed71a1/language-en>

<sup>261</sup> Machinery Directive – revision, 2019, <https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/2019-Revision-of-the-Machinery-Directive>

digitisation and the wider diffusion of new technologies and advanced manufacturing practices.

For example, a Position Paper<sup>262</sup> by the German Electrical and Electronic Manufacturers' Association, ZVEI, argued that *"A continuing review of European and national legislation is needed more than ever before because of the speed in advancing digital technology"*. Among the specific risks the paper identifies is the free flow of data across borders, ensuring high levels of data protection and privacy, and issues around data ownership, data mining and access of data, liability and safety. Several of these issues are examined in the next sub-section. Interestingly, the ZVEI also calls for extending the regulatory fitness check concept to any policy and legislative initiatives at European level relating to Industry 4.0 to *"check that these are based on business and consumer friendly principles"*.

Examples of some of the specific new technologies pertaining to Industry 4.0 – and their regulatory implications – are considered in the next section.

### **3.4.1.2 EU policy and regulatory context – Artificial Intelligence (AI), robotics and automation.**

The **EU's new digital strategy** was launched in February 2020. This was accompanied by the publication of the **White Paper on AI**,<sup>263</sup> which recognises the need for appropriate framework conditions. The White Paper considers not just the benefits, such as the plethora of potential industrial applications and use cases for AI, and the positive socio-economic impacts they can bring, but also the need to acknowledge ethical and legal implications. The publication of the White Paper represents the starting point in a debate as to how far AI should be regulated, how legislation might be framed in a way that enables the development of AI and its integration into industrial processes. As such, the outcome of this policy debate could lead to regulation and would have important impacts on the EU engineering industries. This sub-section first details the proposed EU approach to AI, as detailed in the White Paper, before discussing the possible impact of such a regulatory framework on the EU engineering industries.

Until the publication of the White Paper on AI, the EU's engagement with AI had not considered significant legislative intervention. Instead, policy documents such as the **Communication Artificial Intelligence for Europe** and the related **Coordinated Plan on Artificial Intelligence** presented non-legislative activities, including interventions to boost investment, strengthen AI research, ensure a well-functioning data ecosystem and adapt training and educational systems.

In addition, the Commission has been undertaking significant work on the ethical and legal considerations associated with AI through its **High-Level Expert Group on AI (AI HLEG)**.<sup>264</sup> To date, these activities have focused on understanding the challenges and developing the **Ethics Guidelines for Trustworthy AI**.<sup>265</sup> These guidelines establish that, in order to be trustworthy, AI applications must in the first instance satisfy three key components: they need to be lawful, ethical and robust. Furthermore, the guidelines detail seven key requirements that the development of AI systems should meet. These requirements relate to: human agency and oversight; technical robustness and safety; privacy and data governance; transparency; diversity, non-discrimination and fairness; environmental and societal well-being; and accountability. On this basis, the guidelines

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<sup>262</sup> Position Paper by ZVEI on Digitising European Industry, [https://www.zvei.org/fileadmin/user\\_upload/Presse\\_und\\_Medien/Publikationen/2016/juli/Digitising\\_European\\_Industry/Digitising-European-Industry-ZVEI-Position-Paper-July-2016.pdf](https://www.zvei.org/fileadmin/user_upload/Presse_und_Medien/Publikationen/2016/juli/Digitising_European_Industry/Digitising-European-Industry-ZVEI-Position-Paper-July-2016.pdf)

<sup>263</sup> White Paper On Artificial Intelligence - A European approach to excellence and trust, Brussels, 19.2.2020, COM(2020) 65 final [https://ec.europa.eu/info/sites/info/files/commission-white-paper-artificial-intelligence-feb2020\\_en.pdf](https://ec.europa.eu/info/sites/info/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf)

<sup>264</sup> <https://ec.europa.eu/digital-single-market/en/high-level-expert-group-artificial-intelligence>

<sup>265</sup> <https://ec.europa.eu/futurium/en/ai-alliance-consultation/guidelines#Top>



present an 'assessment list', which is designed to support the implementation of the seven requirements.

Building on this work, as well as significant standardisation efforts and industry-led codes of conduct and tools<sup>266</sup>, the White Paper on AI aims to place Europe at the forefront globally with regard to the development and application of safe AI systems. The White Paper presents a vision for the future of AI in Europe focused on: (i) capitalising on Europe's strengths in industrial and professional markets; and (ii) taking advantage of new waves of available data. To achieve this vision, the White Paper sets out two objectives:

**Ecosystem of excellence:** Actions under this objective aim to ensure the EU has a leading global position in AI development. The European Commission's **Communication on Artificial Intelligence**<sup>267</sup> (April 2018) was a seminal policy development in this regard, as it signalled the initial considerations of EU policy-makers on how to **optimise the use of AI in industry to maximise its economic and social benefits**. This is furthered by the AI White Paper, which presents a range of actions to further the advancement of AI technologies in the EU and their adoption. Actions include working with Member States; focusing on the research and innovation community; skills development; public-private collaboration; promotion by the public sector; securing access to data and computing infrastructures; global co-operation; and specific support for SMEs.

**Ecosystem of trust:** This objective highlights the importance of maintaining trust in AI among citizens and businesses. Under this objective, the Commission details the problem definition related to AI, highlighting risks to: i) fundamental rights, including personal data and privacy protection and non-discrimination; and ii) the safety and liability regimes. To address these risks, the White Paper discusses both possible amendments to the existing EU regulatory framework and the possible adoption of new legislation.

- Considering the **existing regulatory framework**, limited concrete developments are detailed. Instead, the Commission highlights a range of risks and situations that exist in the current legal framework that could be improved in light of AI developments. For instance, these risks include improving the effective application and enforcement of existing EU and national legislation to respond to transparency issues; and addressing limitations in the scope of existing EU legislation. On this basis, the White Paper states the Commission's intention to review existing legislation.
- The White Paper recognises that any **future new legislation** on AI should be adapted to the risks associated with an AI application, noting that it should be effective but not limit innovation and require 'high-risk' AI systems to be transparent, traceable and under human control. Considering the definition of 'high-risk', the White Paper recognises that such a risk-based approach requires clear, easily understandable and easily applicable criteria to ensure the regulatory approach is proportionate. In this respect, the White Paper states that AI applications should generally be determined to be 'high-risk' when both the **intended use** and the **sector of use** involve significant risks. The sectors referenced include healthcare, transport and the energy sector and the intended uses highlighted relate to AI applications with legal effects and those that pose risk of injury, death or significant damage.

With this established, the White Paper discusses the types of legal requirements that may be required of 'high-risk' AI applications. The types of requirements noted relate to training data; data and record-keeping; information to be provided; robustness and accuracy; human oversight; and specific requirements related to particular AI applications. Following

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<sup>266</sup> Optimity Advisors, (2018), algo:aware, [Raising awareness on algorithms, State-of-the-Art Report on algorithmic decision-making](#), commissioned by DG Connect, European Commission.

<sup>267</sup> Commission Communication on Artificial Intelligence - <https://ec.europa.eu/digital-single-market/en/news/communication-artificial-intelligence-europe>  
Brussels, 25.4.2018, COM(2018) 237 final

an examination of these possible requirements, the Commission discusses practical issues related to the legislation, including: the responsibilities of stakeholders, compliance and enforcement for AI applications considered to be high-risk, voluntary labelling for 'low risk' AI applications and governance.

Considering SMEs specifically, the White Paper considers SMEs as a key part of the envisaged ecosystem of excellence. In this context, the Commission discusses strengthening the Digital Innovation Hubs and the AI-on-demand platform to facilitate collaboration between SMEs. In addition, the Digital Europe Programme is highlighted as an important mechanism to support SME adoption of AI and the White Paper suggests that at least one Digital Innovation Hub per MS should be specialised in AI. Furthermore, the document recognises that SMEs and start-ups will require access to finance to incorporate AI solutions. For this, the Commission aims to scale up investment in AI through InvestEU, building on the forthcoming €100 million pilot investment fund in AI and blockchain.

### **International policy and regulatory context – Artificial Intelligence (AI)**

A key finding was that, whilst the EU has begun to review aspects of the legislative framework for industrial products, notably the Machinery Directive, so as to ensure that machinery continues to be safe, there are, **as yet, no horizontal legislation anywhere in the world focused on AI.**

Many countries, especially OECD countries, have begun to publish **National AI strategies, setting out principles, targets for investments and sectors they will be prioritising for AI development, which include industrial applications.** Within the EU, the European Commission has published a Communication, and **France, Germany, Sweden** and the **UK**, amongst others, have all published national strategies. All of the competitor countries for this study, bar Brazil, have also published national strategies, or documents to that effect. Whilst there are differences between these strategies, most notably the emphasis some countries place on ethics, these strategies have much in common, most including the importance of training and attracting people with the skills to develop AI. This overview discusses the national strategies and other non-binding policy developments implemented by the EU's key competitors, before going beyond policy to address the current legislative engagement with AI and other emerging technologies (such as robotics and autonomous systems) across these third countries.

In four of the countries examined to date (the US, Japan, South Korea and China), obligatory rules on the design and use of AI are the exception rather than the rule; non-binding product standards and guidelines are more common. In Japan, for example, the Ministry of Economy, Trade and Industry (METI) has been publishing non-binding industrial policy and safety guidelines on robotics since 2004.<sup>268</sup> Furthermore, the Japan Robot Association actively advocates the application of ISO 13482 and has developed its own safety standards to complement and build on those existing ISO standards.<sup>269</sup>

Another example of non-binding standards and guidelines originates from South Korea. In 2007, the South Korean government adopted the Korean Charter on Intelligent Robot Ethics. In the US, the Department of Transportation regularly publishes and updates guidance on the topic of autonomous vehicles.<sup>270</sup> More specifically, these guidance documents include recommendations and best practices for authorities, infrastructure operators and private sector stakeholders.

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<sup>268</sup> Robotics Business Review, *The Global Race to Robot Law: 1st Place, Japan*, September 2012. Available at: [https://www.roboticsbusinessreview.com/legal/the\\_global\\_race\\_to\\_robot\\_law\\_1st\\_place\\_japan/](https://www.roboticsbusinessreview.com/legal/the_global_race_to_robot_law_1st_place_japan/).

<sup>269</sup> Robotics Business Review, *The Global Race to Robot Law: 1st Place, Japan*, September 2012. Available at: [https://www.roboticsbusinessreview.com/legal/the\\_global\\_race\\_to\\_robot\\_law\\_1st\\_place\\_japan/](https://www.roboticsbusinessreview.com/legal/the_global_race_to_robot_law_1st_place_japan/).

<sup>270</sup> US Department of Transportation, *Preparing for the Future of Transportation: Automated Vehicles 3.0*, October 2018. Available at: <https://www.transportation.gov/av/3>.



Furthermore, as noted above, almost all third countries examined have some form of national AI strategy.

- For **China**<sup>271</sup> and **Russia**<sup>272</sup>, there is a large gulf between what is published and what is actually happening. Whilst Russia are finalising their strategy (due for publication in October 2019) and China has published various AI strategies, these may not reflect their actual aims or priorities in this area. Furthermore, China has established an AI Industry Development Alliance focused on the development of a public service platform to accelerate growth.<sup>273</sup> Given the forms of governance in Russia and China, it is a fair assumption that ethical considerations and protections for consumers, particularly with regards to privacy, are less of a concern.
- **Japan's AI Strategy**<sup>274</sup> sets out an industrialisation roadmap, and focuses on productivity, health medical care and welfare and mobility.
- **Korea's AI Strategy**<sup>275</sup> focuses on the transformation to the industrial sector and creating national digital infrastructure projects.
- **India's AI strategy**<sup>276</sup> is set out in a discussion paper. It doesn't highlight engineering or industry as an area of focus. Instead, agriculture is more of a priority, in part to reflect the nature of their economy, but also because they're a 'late mover' in this space.
- The **USA's strategy** is set out in the *American AI Initiative*<sup>277</sup>, established by Executive Order 13859 in February 2019. Alongside this strategy, the USA's engagement with the topic takes the form of annual White House Summits on AI,<sup>278</sup> which focus on 'removing barriers to innovation' – arguing that government legislation is not needed at this stage of AI's development. Whilst the summit report does try to guide the development of AI in America, because of the power of Silicon Valley and the major tech companies based in California, state legislatures, such as California, are also passing privacy legislation that is impacting AI and technology development.
- **Brazil** does not currently have an AI strategy.

In addition to these country specific efforts, the OECD has developed OECD Council Recommendations on AI<sup>279</sup> at the international level, which emphasise the importance of 'trustworthy AI,' and are focused on making AI transparent, human-centred, safe and accountable. The **OECD Principles on Artificial Intelligence promote artificial intelligence (AI)** adopted in May 2019 recognise that AI needs to be developed in a way that is innovative but at the same time trustworthy and respecting human rights and democratic values.<sup>280</sup> The principles were adopted by OECD member countries and wider countries (total 42 in total to date) when the OECD Council Recommendation on Artificial Intelligence was approved.

In addition, the ISO and IEEE are working to develop global standards on AI with a focus on market efficiency and ethics, with China and US also calling for global standards on AI.

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<sup>271</sup> <https://flia.org/notice-state-council-issuing-new-generation-artificial-intelligence-development-plan/>

<sup>272</sup> <https://www.defenseone.com/technology/2019/09/whats-russias-national-ai-strategy/159740/>

<sup>273</sup> <https://futureoflife.org/ai-policy-china/>

<sup>274</sup> Artificial Intelligence Technology Strategy (Report of Strategic Council for AI Technology) Strategic Council for AI Technology March 31, 2017

<sup>275</sup> Mid- to Long-Term Master Plan in Preparation for the Intelligent Information Society, Managing the Fourth Industrial Revolution, Government of the Republic of Korea, 2016.

<sup>276</sup> National Strategy for Artificial Intelligence #AIforAll, NITI Aayog, June 2018.

<sup>277</sup> <https://www.whitehouse.gov/presidential-actions/executive-order-maintaining-american-leadership-artificial-intelligence/>

<sup>278</sup> The White House Office of Science and Technology Policy, Summary of the 2019 White House Summit on Artificial Intelligence, September 2019

<sup>279</sup> <https://www.oecd.org/going-digital/ai/principles/>

<sup>280</sup> <https://www.oecd.org/going-digital/ai/principles/>

Beyond these policy developments, it is important to note how such countries are approaching the legislation of AI and other emerging technologies. As in the EU, many third countries, such as China, the US, South Korea and Japan, have advanced robotics and autonomous systems sectors that are evolving rapidly. All such countries are facing similar issues with regard to these emerging technologies. In particular, the four countries mentioned above, have all implemented legal measures to address the issues related to **robotics and Artificial Intelligence (AI)**. Here, examples of these measures are examined alongside key EU industrial product legislation to understand what similarities exist with regard to the gaps and challenges being faced and also to compare the approaches to dealing with these issues. First, we discuss approaches to liability, particularly in relation to AI, before the current preference for sector specific legislation over horizontal legislation is elaborated.

All four countries examined to date (China, the US, South Korea and Japan) have **general product safety and liability legislation**. However, the challenges AI brings to such legislation are not yet widely covered. In China, within the current legal framework, liability sits primarily with the manufacturer of a device.<sup>281</sup> In Japan, general criminal and civil rules on liability are, in some cases, applicable to autonomous robots. In such scenarios, the liability is mostly placed with the owner or operator of an autonomous device.<sup>282</sup>

The Road Traffic Act implemented in South Korea consistently refers to the driver of a vehicle and is thus not yet suitable to address liability, in particular, with regard to fully automated vehicles. Contrastingly, the South Korean Civil Code and Product Liability Act are applicable to intelligent robots, but they do not contain provisions specific to robots and impose strict liability on the manufacturers of such robots.<sup>283</sup> In contrast to this lack of AI-adapted liability legislation, the US is more advanced. This is primarily because case law plays an important role for the understanding of liability in relation to the use of AI technologies. This is evidenced by a small number of concrete cases, the earliest of which<sup>284</sup> established rather strict requirements for human control over the activities of autonomous devices. More recent cases,<sup>285</sup> however, seem to tend towards a more lenient understanding of manufacturer or operator liability.

When considering the **types of legislation implemented** in relation to AI in robots and other machines, it is clear that, to date, a sector-specific approach is preferable to horizontal legislation. In the third countries examined to date, comprehensive horizontal laws considering the use of AI do not exist. However, there are examples of countries focusing on the application of AI technologies in certain sectors and adopting tailored sectoral rules. In particular, the most advanced legislation can be found in the automotive sector, in relation to autonomous vehicles.

For instance, in South Korea, legislation related to issues arising from autonomous vehicles and aircraft has been implemented. The Motor Vehicle Management Act was amended in 2016, with a legal base for autonomous vehicle testing introduced.<sup>286</sup> In addition, US legislation on robotics and AI has, to date, focused on autonomous vehicles. Most US States have adopted legislation and/or issued executive orders in relation to such

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<sup>281</sup> ICLG, *Product Liability 2018 – China*, 2018. Available at: <https://iclg.com/practice-areas/product-liability-laws-and-regulations/china>.

<sup>282</sup> Matsuo, T., 'The Current Status of Japanese Robotics Law: Focusing on Automated Vehicles', in Hilgendorf, E., Seidel, U., *Robotics, Autonomics, and the Law*, Nomos, Baden-Baden, 2017, pp. 151-170.

<sup>283</sup> Kim, M., 'New Legislation and the Reform of the Rules on Robots in Korea', in Hilgendorf, E., Seidel, U., *Robotics, Autonomics, and the Law*, Nomos, Baden-Baden, 2017, pp. 129-150.

<sup>284</sup> For example *Brouse v. United States*, 83 F. Supp. 373 (N.D. Ohio 1949).

<sup>285</sup> *Ferguson v. Bombardier Services Corp*, 244 F. App'x 944 (11th Cir. 2007); *Royal Insurance Company of America v. Crowne Investments*, 903 So.2d 802 (Ala. 2004).

<sup>286</sup> Kim, M., 'New Legislation and the Reform of the Rules on Robots in Korea', in Hilgendorf, E., Seidel, U., *Robotics, Autonomics, and the Law*, Nomos, Baden-Baden, 2017, pp. 129-150.

autonomous and/or driverless vehicles.<sup>287</sup> Furthermore, the US Congress has introduced two major legislative proposals: the Safely Ensuring Lives Future Deployment and Research In Vehicle Evolution (SELF DRIVE) Act;<sup>288</sup> and the American Vision for Safer Transportation Through Advancement of Revolutionary Technologies (AV START) Act<sup>289</sup>. These proposals are currently undergoing the legislative procedure.

### **3.4.1.3 Regulatory implications of rapid technological advancements and take-up of AI**

In assessing the regulatory implications of rapid technological advancements and take-up of AI, this section discusses each of the following key issues in turn:

- What are the challenges in regulating AI?
- What implications would legislation of AI have for industry?

#### **What are the challenges in regulating AI?**

The challenges in regulating AI can be broken down into broader conceptual challenges of legislation, and issues that are more specific to AI. The broader conceptual challenges are:

- The *Pacing Problem* whereby innovation is occurring faster than legislation can be developed; underlying this issue is the lack of expertise, especially on technical issues, amongst policymakers.
- The *Uncertainty Paradox* whereby not enough is known about the impacts of AI to introduce legislation that will be productive. However, if regulators wait then it will become more difficult to regulate as AI will already be ingrained into society (which is what has happened, given AI has been incorporated into so many aspects of day to day life already).
- The *Prisoner's Dilemma* creating a regulatory race to the bottom with countries wanting to develop AI in case other countries develop applications of AI that could threaten them or put them at a competitive disadvantage.

More specifically, global governance is difficult within the context of AI as:

- Countries have different and competing priorities;
- The major tech companies (Google and Facebook) are so advanced and so influential in this field that regulating countries would arguably have little impact given the dominance of these companies;
- Countries are closing off their internets (e.g. China's firewall, development of country-specific internet spaces rather than a fully open internet), which is preventing the free flow of data and openness that would underpin global governance;
- The global shortage of talent and expertise in AI;
- It is unclear what aspects of AI should be regulated. The actual algorithms, the people or companies implementing them, how they are applied or all of the above. This is made more challenging by AI effectively operating as a black box – even developers don't know how the algorithms truly work and make decisions;
- There are a range of possible approaches, including regulating on a sector by sector basis, which may be faster in the short-term, or implementing more comprehensive horizontal legislation covering AI more generally.

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<sup>287</sup> NCSL, *Autonomous Vehicles/Self-driving Vehicles Enacted Legislation*. Available at: <http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx>.

<sup>288</sup> US Congress, *SELF DRIVE Act*. Available at: <https://www.congress.gov/bills/115/congress/house/bills/3388>.

<sup>289</sup> US Congress, *AV START Act*. Available at: <https://www.congress.gov/bills/115/congress/senate/bills/1885>.

## What impact on industry would legislation of AI have?

Deployment of AI applications across European industry is widely anticipated to bring significant economic and social benefits over the coming years. For instance, a recent study found that, in relation to manufacturing and the Industrial Internet of Things (IIoT), AI has an overall impact potential in Europe of up to €200 billion by 2030.<sup>290</sup> With that said, the various challenges associated with AI implementation, as highlighted in the White Paper, could cause direct negative impacts (for example on the protection of personal data) as well as indirect impacts (for example on trust and thus adoption of AI).

However, for the most part, industry stakeholders interviewed for this study do not anticipate the need for further legislative developments at present. Considering the ethical risks detailed in the Commission's AI White Paper, for instance, these stakeholders indicated that the vast majority of industrial AI applications do not pose ethical risks. For example, Orgalim has stated that "*a minority of industrial AI applications*"<sup>291</sup> can be identified as risky and highlighted that "*AI has been deployed safely in manufacturing for decades*"<sup>292</sup>.

Beyond the ethical risks, the Commission has highlighted the compatibility of the current safety and liability regime as a key issue to be reviewed. This is an issue that has particular relevance for the engineering industries. In this respect, as referred to above, **core EU industrial product legislation is being or has recently been reviewed for compatibility with technological developments.**

Recent examples include the 2017 evaluation of the Machinery Directive (MD, 2006/42/EC)<sup>293</sup>, the 2020 impact assessment on elements of the Radio Equipment Directive (RED, 2014/53/EU)<sup>294</sup> and the 2020 interim evaluation of the Low Voltage Directive (LVD, 2014/35/EU)<sup>295</sup>. In addition, an evaluation of the Electromagnetic Compatibility Directive (EMCD, 2014/30/EU) is being conducted in 2020 and an impact assessment on possible revisions to the Machinery Directive<sup>296</sup> is ongoing at the time of writing. The impact of new technologies, including AI, on the regulatory environment is an important focus for both ongoing assessments.

The findings from the completed assessments suggest that stakeholders are, for the most part, supportive of the existing regulatory framework for industrial product legislation and do not see the need for significant change as a result of new technologies. These stakeholders state that the combination of in-built technological neutrality and standards development are effective in ensuring the adaptability of the legal framework to technological developments.

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<sup>290</sup> European Commission, (2019), [Artificial intelligence – critical industrial applications](#): Report on market analysis of prioritised value chains, the most critical AI applications and the conditions for AI rollout, December 2019.

<sup>291</sup> Orgalim, (2020), [Orgalim Manifesto: a European Agenda on Industrial AI](#), Brussels, 15 January 2020.

<sup>292</sup> Orgalim, comments on the upcoming Impact Assessment of the Machinery Directive, Brussels, 8 February 2019. <https://www.orgalim.eu/sites/default/files/attachment/ORGALIM%20POSITION%20MD%20VS%20AI%208%20FEBRUARY%202019.pdf>

<sup>293</sup> European Commission, Evaluation of Directive 2006/42/EC on Machinery, <https://op.europa.eu/en/publication-detail/-/publication/2b213537-25a8-11e8-ac73-01aa75ed71a1/language-en/format-PDF/source-68663524>

<sup>294</sup> European Commission, 2020, Impact Assessment on Increased Protection of Internet-Connected Radio Equipment and Wearable Radio Equipment, <https://ec.europa.eu/docsroom/documents/40763>

<sup>295</sup> European Commission, 2020, Interim evaluation of the Low Voltage Directive 2014/35/EU, <https://op.europa.eu/en/publication-detail/-/publication/48c2118c-4d4d-11ea-aece-01aa75ed71a1/language-en>

<sup>296</sup> Machinery Directive – revision, 2019, <https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/2019-Revision-of-the-Machinery-Directive>

In addition, in relation to both ethical and safety and liability, industry stakeholders are keen to avoid legal uncertainty, which they stress will hinder deployment of AI and thus competitiveness. On this point, Orgalim issued a Position Paper on the upcoming Impact Assessment of the Machinery Directive stating that *"the [Machinery Directive] is a core piece of legislation for our industries, ensuring a high level of safety while providing legal stability to companies. Given the importance of a stable and predictable legal framework for attracting investment into key future tech like AI, we believe it will be crucial to pursue a prudent approach to regulation in this arena."*

Furthermore, this is highlighted as particularly pertinent considering the implications of the COVID-19 crisis as well as the significant public and private investment in key competitor countries.

Although industry stakeholders currently do not see a need to amend the current legal framework in light of technological developments, the survey of industry associations conducted for this study found that trust and reliability, as well as safety and security are perceived to be key medium- and long-term competitiveness drivers for the EU engineering industries. In this respect, being one of the first public authorities to regulate on AI to ensure a clear, ethical and climate-friendly legal framework for industry could in fact deliver competitiveness gains in the longer term.

### **3.4.2 Impact of planned and potential new EU environmental legislation on EU engineering industries**

This section outlines the potential impact of new EU policies, such as the European Green Deal, on the development of new, and the revision of existing environmental legislation and examines how this might be expected to affect the engineering industries in the coming decade.

It should be noted that some changes to the EU legal framework are already envisaged and due to come into force, whereas other legislation has only recently been announced and are only at the regulatory proposal stage. This distinction is important for the future scenario modelling, as some changes will already definitely take place, as for example, new reporting obligations are being introduced to support the implementation of existing legislation, whereas others may happen, but there might be uncertainty with the timing.

Moreover, some proposed regulatory developments, especially those linked to the new EU climate law have attracted some controversy in terms of the potential impacts on industry, and there is some uncertainty as to whether they go ahead in their initial proposed form. This distinction is also helpful due to the potential impacts of COVID-19.

#### **3.4.2.1 Overview – future changes to existing EU environmental legislation affecting the EU engineering industry**

An example of an existing piece of legislation where new reporting requirements are likely to come in is the Waste Framework Directive (WFD), Directive 2008/98/EC on waste. This sets out the basic concepts and definitions related to waste management, such as definitions of waste, recycling and recovery.

However, over time, there have been changes in reporting requirements on some pieces of environmental legislation such as the WFD. For example, this will require economic operators to provide reporting information on Substances of Concern in articles as such or in complex objects (Products) established under the WFD in the ECHA SCIP database. This was already foreseen under the WFD with a deadline of 5 January 2021 for suppliers of articles to provide the information pursuant to Article 33(1) of the REACH Regulation.

Some stakeholder feedback was received on this issue. Firstly, some industry associations would like the implementation date postponed due to COVID-19.<sup>297</sup> Secondly, some industry associations interviewed viewed the new ECHA SCIP database as being burdensome for industry. Furthermore, challenges relating to ensuring harmonisation in the requirements for producers across the EU-27 were noted. According to one major EU industry association *"The current draft WFD national transpositions are not harmonised, which will lead to different obligations being imposed on producers depending on the country in which their products are placed on the market"*.<sup>298</sup> Moreover, the workability and proportionality of the database has been questioned. There are other examples of changes to existing legislation regarding detailed implementation requirements, such as the WEEE Directive, where additional implementing rules were introduced in 2019 relating to national reporting on the volume of EEE equipment placed on the market, recycled etc. which are considered in the earlier case study on the WEEE Directive.

A key message from position papers by leading EU industry associations (and from the interviews and webinars) was to avoid introducing onerous reporting obligations for existing EU environmental legislation, as this can be as burdensome for industry as the introduction of entirely new additional EU legislation.

### **3.4.2.2 Overview – future changes to new EU environmental legislation affecting the EU engineering industry**

The **European Green Deal (EGD)**<sup>299</sup> is a package of measures designed to achieve a sustainable green transition to become the first climate-neutral continent by 2050. The Green Deal is expected to become a central driver in respect of the new EU growth strategy<sup>300</sup>. It is expected to involve all stakeholders by supporting investments in green technologies, sustainable solutions and new businesses. Through the identification of new, and further greening of existing policies and legislation, the EU wants to transform into *"a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use"*<sup>301</sup>.

The green policies will cover all industries and sectors of the economy and will affect all businesses, including notably SMEs. The challenge will require investment in innovation and research, the redesign of Europe's economy and the updating of the EU's industrial policy<sup>302</sup>. The report of the Industry Strategy 2030 "A vision for the European Industry 2030"<sup>303</sup> encompasses these goals and predicts that European industry will be a global leader in cutting-edge technologies and in respecting the environment. This will require the commitment of all stakeholders ranging from the EU institutions, bodies and agencies, as well as the Member States, regions and industry.<sup>304</sup>

To finance the Green transition, the EU has set a target of more than a trillion Euros through two instruments: **the Sustainable Europe Investment Plan** that will support €1 trillion of investment and the **Just Transition Mechanism (JTM)** that provides targeted support to help mobilise at least €100 billion over the period 2021-2027 in the most affected regions, to alleviate the socio-economic impact of the transition.

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<sup>297</sup>Orgalim letter to the Commission President of April 22nd, 2020

[https://www.ifsa.eu.com/uploads/1/2/0/2/120245019/orgalim\\_letter\\_to\\_ec\\_president\\_covid19\\_impact\\_commision\\_work\\_2020.pdf](https://www.ifsa.eu.com/uploads/1/2/0/2/120245019/orgalim_letter_to_ec_president_covid19_impact_commision_work_2020.pdf)

<sup>298</sup> Orgalim letter to the Commission President of April 22nd, 2020

[https://www.ifsa.eu.com/uploads/1/2/0/2/120245019/orgalim\\_letter\\_to\\_ec\\_president\\_covid19\\_impact\\_commision\\_work\\_2020.pdf](https://www.ifsa.eu.com/uploads/1/2/0/2/120245019/orgalim_letter_to_ec_president_covid19_impact_commision_work_2020.pdf)

<sup>299</sup> The European Green Deal, Brussels, 11.12.2019, COM(2019) 640 final

<sup>300</sup> Press remarks by President von der Leyen on the occasion of the adoption of the European Green Deal Communication. Brussels, 11 December 2019

<sup>301</sup> Ibid.

<sup>302</sup> POLITICAL GUIDELINES FOR THE NEXT EUROPEAN COMMISSION 2019-2024 (Political Guidelines) pg. 5

<sup>303</sup> European Commission (2019) A vision for the European Industry until 2030

<sup>304</sup> A vision for the European Industry until 2030 (Industry 2030 report) p. 4



Existing policies are therefore being reviewed against the EGD's objectives and new instruments are being rolled out in support thereof. The following table provides an overview of the current EU environmental legislation and policies that affect the EU engineering industry and the expected date for revision according to the Green Deal key actions roadmap<sup>305</sup>.

**Table 3-7: Currently applicable EU environmental legislation and forthcoming changes (Directives and Regulations)**

| Current EU environmental legislation (Directives and Regulations)                                                                                                                                                           | Proposal for revision                                                                                                                                                                                                                                                                                                                        | Indicative timeline for revisions of existing legislation |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| <b>Industrial emissions and climate change mitigation</b>                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                              |                                                           |
| <b>Industrial Emissions Directive (IED) Directive 2010/75/EU</b>                                                                                                                                                            | The EC will likely present a proposal to revise the Directive by the end of 2021 after collecting experts and stakeholders' opinions via an online survey <sup>306</sup> . The EC will also conduct an impact assessment to look at all economic, social and environmental impacts.                                                          | 2021                                                      |
| <b>European Union's Emissions Trading System (EU ETS)<sup>307</sup></b>                                                                                                                                                     | To achieve the EU's overall greenhouse gas emissions reduction target for 2030, the sectors covered by the EU Emissions Trading System (EU ETS) must reduce their emissions by 43% compared to 2005 levels. The revised EU ETS Directive, which will apply for the period 2021-2030, will enable this through a mix of interlinked measures. | 2021                                                      |
| <b>Energy</b>                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                              |                                                           |
| <ul style="list-style-type: none"> <li>• <b>Energy Taxation Directive</b></li> <li>• <b>Effort Sharing Regulation</b></li> <li>• <b>Energy Efficiency Directive</b></li> <li>• <b>Renewable Energy Directive</b></li> </ul> | The Commission plans to review all relevant EU laws and regulations to align them with the proposed new European Climate Law. <sup>308</sup> By June 2021, the Commission will review or propose the revision of all relevant EU policy instruments to deliver the additional emissions reductions by 2030.                                  | June 2021                                                 |
| <b>Vehicles</b>                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                              |                                                           |
| <b>Directive 2007/46/EC</b>                                                                                                                                                                                                 | Proposal for more stringent air pollutant emissions standards for combustion-engine vehicles                                                                                                                                                                                                                                                 | 2021                                                      |
| <b>Batteries</b>                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                              |                                                           |
| <b>Directive 2006/66/EC</b>                                                                                                                                                                                                 | Legislation on batteries in support of the Strategic Action Plan on Batteries and the circular economy.                                                                                                                                                                                                                                      | October 2020                                              |

<sup>305</sup> European Commission (2019) Annex to the Communication on the European Green Deal, Roadmap- Key Actions, COM(2019) 640 final

<sup>306</sup> <https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12306-EU-rules-on-industrial-emissions-revision>

<sup>307</sup> The aim of the EU Emissions Trading System (EU ETS) is to help EU Member States achieve their commitments to limit or reduce greenhouse gas emissions in a cost-effective way. Allowing participating companies to buy or sell emission allowances means that emission cuts can be achieved at least cost.

<sup>308</sup> [https://ec.europa.eu/clima/policies/eu-climate-action/law\\_en](https://ec.europa.eu/clima/policies/eu-climate-action/law_en)



The majority of these revisions and its timeline were supported by the stakeholders if they do not suppose a challenge for the recovery from the current crisis that the engineering industry is suffering due to the COVID-19 pandemic. As Orgalim highlighted in the requested directed to the Commission, “we strongly support the Green Deal actions as anchors for the recovery, including the Green Deal’s current timeline”. The EGD also envisages a set of new deeply transformative policies and legislation. The following **new initiatives envisaged in the Green Deal** have been identified as the most relevant to the engineering sector. This have been confirmed through interviews and an analysis of stakeholders’ position papers.

### The European Climate Law

On the 4<sup>th</sup> March 2020, the Commission launched the proposal for the European Climate Law<sup>309</sup> it aims to enshrine the goals set out in the EGD of becoming a climate-neutral continent by 2050. It will require the development of alternative, cleaner sources of energy and the improved efficiency of energy usage, since the production and use of energy accounts for more than 75% of the EU’s greenhouse gas emissions.

The main **objectives** of the Climate Law are:

- A legally-binding target of net zero greenhouse gas emissions by 2050.
- Ensure that all EU policies contribute to this goal and that all sectors of the economy and society play their part in a socially-fair and cost-efficiency manner.
- Provide predictability for investors and other economic actors.
- Creating an effective monitoring system for assessing progress and taking further action if needed.
  - Based on existing systems such as the governance process for Member States’ National Energy and Climate Plans, regular reports by the European Environment Agency, and the latest scientific evidence on climate change and its impacts.
  - Progress will be reviewed every five years, in line with the global stocktake exercise under the Paris Agreement.<sup>310</sup>

The Commission is expected to present a proposal for a Carbon Border Adjustment Mechanism (CBMA)<sup>311</sup> for selected sectors by summer 2021, depending on the outcome of the public consultation. The idea underlying CBAM is that energy-intensive industries in Europe that are subject to the EU’s Emissions Trading System (“ETS”) and other EU climate standards may be at a competitive disadvantage compared in global trade relations with third-country producers that are not subject to similar emission reduction requirements. In turn, this could result in third-country producers increasing their emissions, despite the efforts of European industries (“carbon leakage”).

The Commission’s consultation on the CBAM addresses a number of important climate, international trade, development and economic-related issues. The consultation also raises some strategic issues that are as yet unresolved, such as:

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<sup>309</sup> Proposal for a Regulation of the European Parliament and of the Council establishing the framework for achieving neutrality and amending Regulation (EU) 2018/1999 (European Climate Law) COM (2020) 80 final

<sup>310</sup> [https://ec.europa.eu/clima/policies/eu-climate-action/law\\_en](https://ec.europa.eu/clima/policies/eu-climate-action/law_en)

<sup>311</sup> The Inception Impact Assessment also clarifies that the development of a CBAM would be based on three building blocks: (i) a legal instrument, which could for example include a carbon tax on selected products, a new carbon customs duty or tax on imports, or the extension of the EU ETS to imports; (ii) a methodological approach to evaluate the carbon content and carbon pricing of imported products; and (iii) a possible limitation of the Mechanism to only some industrial sectors (e.g., cement).

- Should the adjustment mechanism **target specific industries** (e.g. cement, aluminium, steel, or chemicals), or instead be applied horizontally across all industrial production?
- What **methodological approach** the EU will take **to evaluate the carbon content and carbon pricing of imported products**?
- To what extent should the existence of an **emissions trading scheme** similar to the EU's ETS in the product's country-of-origin be exempted from the imported product from any border adjustment?

The European Climate Law will therefore directly affect the EU engineering sectors and influence the EU regulatory framework in which engineering firms operate. As yet, the fact that there is presently no detailed regulatory framework available means a degree of ongoing regulatory uncertainty for the EU engineering industries. **Regulatory uncertainty may risk jeopardising long-term investments in Europe**, including in the engineering sectors.

There are also **risks associated with implementing CBAM**, such as the fact that nothing similar to this proposed initiative has yet been implemented anywhere globally as yet, with the exception of California. There could be further risks of going ahead with CBAM in an international trade context as objections could be raised through the WTO as any costs levied on imports (products, raw materials) due to their carbon content.<sup>312</sup> A potential adverse consequence for the engineering industries is the degree of potential administrative burdens, depending how the legislation is drawn up. For instance, the **carbon content of imports would need to be measured and appropriate tax arrangements put in place**. Industry would have to implement these, and there would be a lot of familiarisation costs in the early stages of implementation. There could also be **knock-on effects in terms of the intermediate costs of production** (e.g. increased prices of raw material imported into Europe due to adjustments to reflect differences in carbon burden between different regulatory jurisdictions).

Nevertheless, some stakeholders also saw the EU's objective of achieving carbon neutrality by 2050 as representing an opportunity for industry to bring the benefits of clean energy and climate transition to EU citizens.<sup>313</sup> For example, if Europe could further consolidate its competitive position in CleanTech, then this would be positive for industrial competitiveness.

A plan for "smart sector integration" in the energy sector will be presented in 2020. This will bring together the electricity, gas and heating sectors (including renewable energy such as of offshore wind<sup>314</sup>) has been launched through a new initiative. Whilst this concerns primarily the structuring of the energy market, strategic considerations are being given which are relevant to the EU engineering industries, such as "How could greater electricity usage drive increased decarbonisation in other sectors?" e.g. transition to electric vehicles for transport and logistics which are important to the engineering sectors and Global Value Chains (GVCs).

Selected examples of stakeholder feedback are now provided. According to a German engineering association, the **European mechanical engineering industry can make a significant contribution to the climate-neutral objective** with its knowledge, innovations and concrete products as well as having a positive influence on other regions of the world. VDMA President, Carl Martin Welckler states: "We welcome the fact that the

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<sup>312</sup> [http://regulatingforglobalization.com/2020/01/30/the-eu-carbon-border-adjustment-mechanism-a-long-long-way-to-go/?doing\\_wp\\_cron=1589891540.5900709629058837890625](http://regulatingforglobalization.com/2020/01/30/the-eu-carbon-border-adjustment-mechanism-a-long-long-way-to-go/?doing_wp_cron=1589891540.5900709629058837890625)

<sup>313</sup> Orgalim (2020) European Climate Law - Achieving climate neutrality by 2050. Available at: <https://orgalim.eu/news/european-climate-law-achieving-climate-neutrality-2050>

<sup>314</sup> <https://www.euractiv.com/section/energy-environment/news/eu-commission-unveils-european-green-deal-the-key-points/>.

*EU Commission includes technologically feasible and responsible approaches, such as greenhouse gas capture and storage (CCS), in its definition of climate neutrality. One promising sign is the inclusion in the climate law of the uptake of greenhouse gases from the atmosphere by natural ecosystems in emission calculations.” However, in their opinion, the European Climate Law lacks the inclusion of “international mechanisms, which we hope will be adopted this year under the Paris Convention. VDMA views it as imperative that these components are taken into account and included in the legislative proposal.”<sup>315</sup>*

These comments were also reflected in interview feedback regarding the implications of the Green Deal for the EU engineering industry, such as the **importance of regulatory predictability** and the **negative impact of uncertainty** as to how the EU Climate Law might affect manufacturers. For instance, an interview with a Japanese business representative association mentioned that they were supportive of key priorities such as the Green Deal and digital transformation, however, implementing these priorities and industry playing its role will be contingent on greater clarity being provided as to how ambitious targets relating to climate change will be achieved, and how they will affect European industry and global industry operating in the EU.

In a position paper by **Orgalim**<sup>316</sup> on Energy & Climate: Delivering the Green Deal: the role of energy infrastructure, it is noted that “Europe’s technology industries, represented by provide innovative technologies for the generation, transmission, distribution and end use of energy. At the same time, our industries rely on continuous energy supply for their manufacturing activities in the EU, which provide innovative jobs for more than 11 million Europeans”. This statement points to the delicate trade-off between improving Europe’s energy infrastructure but in a way that does not jeopardise European industry, including engineering. AmCham EU produced a position paper<sup>317</sup> in response to the EU’s proposed European climate law – achieving climate neutrality by 2050. This makes a number of suggestions as to how industry as a whole in Europe – including inward investors and the EU engineering industries – can play a role in helping to achieve climate neutrality, such as:

- Removing administrative barriers to long-term energy contracts to increase corporate demand for renewable energy and secure access to cleaner and more affordable energy;
- Facilitating the business-to-business sharing of industrial data (within the boundaries of competition laws) and ensuring cross-border data flows in Europe and globally that will improve the way manufacturing operates and how energy is produced and distributed.

**SMEUnited**, the association of SMEs in Europe that represents their interests in discussions with EU institutions, expressed the view that an increase in the 2030 climate targets will require in-depth **impact assessments to assess the impacts on SMEs and on different industry sectors**. This should go hand in hand with an EU decarbonisation fund supporting SMEs in their transition to climate-neutral business models.<sup>318</sup> Therefore, arguably, SMEs in the EU engineering industries could be affected more significantly by any additional legislative burdens, such as any penalties on greenhouse gas emissions during production processes. However, at this early stage in implementation, everything will depend on how the new legal and policy framework is drawn up and implemented.

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<sup>315</sup> Ibid

<sup>316</sup> Energy & Climate: Delivering the Green Deal: the role of energy infrastructure - <https://www.orgalim.eu/position-papers/energy-climate-delivering-green-deal-role-energy-infrastructure>  
<sup>317</sup> [http://www.amchameu.eu/system/files/position\\_papers/climate\\_law.pdf](http://www.amchameu.eu/system/files/position_papers/climate_law.pdf)

<sup>318</sup> Veronique Willerms Green Deal: Lights and Shadows for SMEs. SMEUnited 11/12/2019. Available at: <https://smeunited.eu/news/green-deal-lights-and-shadows-for-smes>

Along with potential new legislation on new technologies (especially AI), the EU climate law was considered to be one of the greatest areas of regulatory uncertainty identified by stakeholders.

### The New Circular Economy Action Plan

The New Circular Economy Action Plan<sup>319</sup> launched in March 2020 aims to reduce the EU's consumption footprint and to double the EU's circular material use rate in the coming decade, while boosting economic growth. Central to the initiative is a sustainable product policy (SPP), based on the Ecodesign Directive, with mandatory requirements for certain types of product and horizontal requirements for electrical goods (e.g. in standby mode) on how to design products in order to use fewer materials and ensure that products can be repaired, reused and recycled.<sup>320</sup> There are also voluntary initiatives to support the sustainable product policy, such as the EU Ecolabel scheme, and the European green criteria in public procurement (GPP) scheme developed by DG Environment and the JRC of the European Commission. There are also action plans for electronics and ICT, textiles, plastics, building and construction, packaging, batteries and vehicles, food and waste.

The possible strengthening of the SPP through the proposed Sustainable Product Initiative, may lead in 2021 and beyond to the development of more of a product lifecycle and product lifecycle assessment approach, which could result in the revision of the mandatory ecodesign implementing regulations and possible changes to the **Methodology for the Ecodesign of Energy-related products (MEErP)**. This could result in additional burdens for industry, but the extent of burden (or conversely efficiency savings) will depend on how new rules are implemented, as existing methodologies relating to other aspects of product usage could be integrated and streamlined into ecodesign requirements (e.g. on waste, recycling).

The EU Industrial Strategy will need to be aligned with the Green Deal and with other relevant EU policies in order to be consistent and to achieve a clean and circular economy. Among the actions proposed in this context, some new legislation will come into force, such as legislation on batteries in support of the Strategic Action Plan on Batteries and the circular economy, and on waste reforms or the Single Use Plastic Directive. Interview feedback from EU level industry stakeholders confirmed the importance of batteries as a strategic sector, and one that could potentially benefit from being designated as an **Important Project of Common European Interest (IPCEI)**.

A benefit of this approach is that key sectors of strategic importance to the European economy, such as semi-conductors and microelectronics, can be supported. Once designated as an IPCEI, there is then greater flexibility as regards the state aid and competition rules to allow for Member State support of certain industries of strategic importance.<sup>321</sup> These implementation modalities provide a useful instrument to be able to support the emergence of national and European champions capable of competing in the face of strong competition and state subsidies in some third countries (e.g. the US, China) that may undermine Europe's competitiveness.<sup>322</sup> For some businesses associations, the strategy should be further developed as part of a more pro-active, faster and transparent process to make sure that the strategic value chains initiatives and IPCEIs exemptions to

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<sup>319</sup> For details see: European Commission (2020); Circular Economy Action Plan For a cleaner and more competitive Europe

<sup>320</sup> Simon, F.; EU Commission unveils 'European Green Deal': The key points, EURACTIV, 11 December 2019

<sup>321</sup> <https://vdivde-it.de/en/node/2283>

<sup>322</sup> An example is the IPCEI Microelectronics, which was Europe's first IPCEI.

the EU state aid rules are guided by strategic considerations and that are agile enough to cope with a fast changing global field.<sup>323,324</sup>

However, an interviewee from a public private partnership focused on the development of advanced manufacturing technologies and on embedding industry 4.0 into production processes across different sectors pointed out that there are only limited sectors where an IPCEI approach may be applicable, such as micro-electronics, batteries, and aerospace. However, whilst flexibility on state aid interpretations of state subsidies may be welcomed by industry, it was pointed out that most EU MS' national budgets preclude state subsidies from being allocated close to the ceiling within the existing state aid rules. Therefore, the potential impact of this initiative may be somewhat limited.

The EU sees this initiative as an opportunity for manufacturing firms to increase their profitability, since on average they spend about 40% on materials, including raw materials.<sup>325</sup> Some stakeholders such as **Orgalim** also see the New Circular Economy Action Plan as a chance to create space for new business models to emerge that could enable the optimisation of energy and resource use throughout the life cycle. However, they provide a series of recommendations such as *"creating the market through coherent policy objectives coupled with incentives throughout all strands of policies need to be prioritised since retail markets do not reward for circularity today; removing existing conflicts between EU waste, product and chemicals policy objectives and public authorities leading by example by buying sustainable products would be important first steps. The life cycle costing principle should be applied in public procurement."*; "Securing on the ground market surveillance and enforcement hand in hand with any new implementation measure, especially in the area of product policy."<sup>326</sup>

A further relevant position paper on the new Circular Economy Action Plan was produced by **ZVEI, the German Electrical and Electronic Manufacturers' Association**<sup>327</sup>. The Paper highlights the importance of maintaining a delicate balance between striving for a circular economy in a way that ensures that the *"upcoming transformation will only be truly "sustainable" if its implementation strikes a balance between competitiveness, environmental and climate protection and social responsibility"*.

The position paper makes some specific suggestions as regards both the existing and the new regulatory framework, such as: (1) retaining the RoHS Directive separate from the REACH Regulation (2) No mandatory use of recycled plastics without prior development of product-specific standards for quality criteria and (3) updating the Waste Shipment Regulation, which is seen as outdated as it hinders the creation of a functioning market for secondary raw materials by making it more difficult to transport waste between Member States, leading to inefficiencies in international waste management. Furthermore, it makes the link between digitalisation and the need to strengthen synergies with the circular economy.

Regarding the **Ecodesign Directive**<sup>328</sup>, one of the main pieces of industrial product legislation applicable to manufacturers and other EO in the EU engineering industry, Orgalim states that the Directive provides a harmonised framework at EU level for the setting of ecodesign requirements on energy related products and as such, ensures the functioning of the EU internal market for these products. "Upholding the Ecodesign

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<sup>323</sup> BusinessEurope (2019) An ambitious EU Industrial Strategy

<sup>324</sup> Orgalim (2019) Position Paper, Strategic Value Chains and Important Projects of Common European Interest

<sup>325</sup> European Commission (2020); Circular Economy Action Plan For a cleaner and more competitive Europe

<sup>326</sup> Orgalim (2019) Position Paper, A EUROPEAN GREEN DEAL OF STRATEGIC FORESIGHT: Reinvigorating Europe and driving an industrial renaissance for a clean planet for all,

<sup>327</sup> ZVEI Position Paper (April 2020), the new Circular Economy Action Plan (Position paper)

<https://www.zvei.org/en/press-media/publications/the-new-circular-economy-action-plan-position-paper/>

<sup>328</sup> Ecodesign Directive 2009/125/EC



Directive as the environmental product policy tool for our sector is essential from this point of view. The given criteria of “minimising life cycle impacts”, “based on scientific evidence”, “at least life cycle cost” and “setting measurable, enforceable requirements case by case” in “big savings areas” are the key criteria for continued implementation success and acceptance, including on circular economy related product parameters.”<sup>329</sup>

The above-mentioned position paper by ZVEI<sup>330</sup> also comments on the effectiveness of the Ecodesign Directive. It notes that the EU electrical industry is supportive of efforts to strengthen a sustainable product policy framework, and is *“committed to increasing resource efficiency and to ever better functioning material and product cycles. However, the freedom of companies to develop innovative products must be guaranteed in a framework that is open to technology”*. Looking ahead to the future, the paper also notes that *“manufacturers have to be able to find a balance between the use of primary and secondary raw materials, efficiency in the use phase, product life, reparability and recyclability”*.

Some feedback was received on the **Ecodesign Directive** through interviews and at the first webinar organised within the auspices of this study on May 15<sup>th</sup> 2020.<sup>331</sup> It was noted that whilst the focus on using Best Available Technologies (BATs) as a benchmark was welcome, in practice, the process of developing detailed implementation arrangements linked to Ecodesign implementing regulations at the product group level took too long. This meant that by the time these regulations were adopted, the BATs were often outdated, and constituted an inappropriate benchmark for best-in-class energy efficiency performance.

Clearly, the EU engineering industries have their role to play, as certain sectors are particularly influenced by Ecodesign requirements, wherever product-specific implementation requirements have already been introduced (either on a mandatory or voluntary basis, as the regulatory approach that has been implemented has adopted a sector by sector approach).

### Other initiatives to achieve the climate ambition

The Commission wants to address the challenges of energy efficiency, including in an industrial context. The actions will consist of:

- Assessment of the final National Energy and Climate Plans;
- Strategy for smart sector integration (to include strengthening and rationalising energy infrastructures to improve efficiencies and increase rate of use of renewables energies, including subsequently by industry); and
- Evaluation and review of the Trans-European Network – Energy Regulation.

From an engineering industry perspective, strengthening access to different energy sources (including renewables) in the European electricity market could help to reduce energy costs for the different branches of engineering, especially manufacturing-oriented activity, and reduce the industry’s carbon footprint, thereby reducing the risk of further legislation and/ or financial penalties linked to carbon emissions. It could also be an opportunity for SMEs, the electricity market is seen by SMEUnited as a key element for SMEs’ competitiveness, advocating a real decentralised production of energy by SMEs fuelled with renewables: *“This would allow the reduction of energy prices, fostering local*

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<sup>329</sup> Orgalim (2019) Position Paper, A EUROPEAN GREEN DEAL OF STRATEGIC FORESIGHT: Reinvigorating Europe and driving an industrial renaissance for a clean planet for all

<sup>330</sup> ZVEI Position Paper (April 2020), the new Circular Economy Action Plan

<sup>331</sup> Webinar 1- the impact of regulation on the EU engineering industries – current state of play and future scenarios to 2030

*SME jobs, fighting climate change and decreasing Europe's energy dependency, thus rendering the EU more competitive and cleaner."*<sup>332</sup>

Moreover, the Commission will launch a new strategy for sustainable and smart mobility committed to reduce the quarter of EU greenhouse gas emissions which the transport sector is responsible for. The strategy will explore automated and connected multimodal mobility, and a funding call to support the deployment of public recharging and refuelling points as part of alternative fuel infrastructure.

### **Zero pollution, biodiversity and toxic free environment initiatives**

A series of actions will be taken to address the issue of pollution, biodiversity loss and toxic environment, such as the EU biodiversity Strategy, the Chemicals Strategy for sustainability and the Zero pollution action plan for water air and soil.

There is a particular concern that new environmental legislation could lead to burdensome legislation being introduced that is very costly. For example, in 2018, a regulatory Proposal was made for a single-use plastics directive.<sup>333</sup> An international industry association representing their countries industrial firms in the EU commented that industry is concerned that they are being asked to do certain things that are not economic, such as using recycled plastic but the plastic available currently may be twice as expensive as new plastic or may not exist. One of the issues is that we have a very long-lived product so in the meantime, being asked to build the infrastructure for recycling that will only be needed in ~10 years. Some of these things are drafted based more on principles than practical considerations regarding the impacts on industry. This means that the requirements may be unreasonable, especially in instances where the EU is a first regulatory mover in terms of imposing greater burdens on European industry than competitors who do not face such costs, as such legislation does not presently exist.

## **3.5 CONCLUSIONS – REGULATORY ANALYSIS**

The conclusions in respect of the central study issues relating to the impact of EU legislation on the EU engineering industries, including on sectoral performance, are now outlined.

### **How has regulation affected the EU engineering industries in the past 10 years?**

The study found that a broad range of different types of legislation are applicable to the EU engineering industries, ranging from industrial product legislation, environmental legislation, through to labour market legislation. Some legislation was considered core to the engineering industries, especially product legislation, such as the Machinery Directive (MD), Low Voltage Directive (LVD), Electromagnetic Compatibility Directive (EMCD), and the Radio Equipment Directive (RED).

Over the past decade, there was a broad consensus among stakeholders that the legal framework has remained stable, but only insofar as the core applicable industrial product legislation is concerned. There was a concern however that requirements for economic operators concerning environmental and horizontal legislation are constantly evolving in terms of key aspects of their implementation, monitoring and enforcement, with evolving expectations regarding how EU legislation should be implemented by economic operators among regulatory agencies.<sup>334</sup> This was seen as posing additional administrative burdens on industry. Examples are the introduction of more onerous reporting requirements, such

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<sup>332</sup> Jenny Manin, SMEs are Fundamental for Sustainability, 26 March 2019, SMEUnited. Available at:

<https://smeunited.eu/news/smes-are-fundamental-for-sustainability>

<sup>333</sup> [https://ec.europa.eu/environment/waste/plastic\\_waste.htm](https://ec.europa.eu/environment/waste/plastic_waste.htm)

<sup>334</sup> An example cited was ECHA in the case of the REACH Regulation.



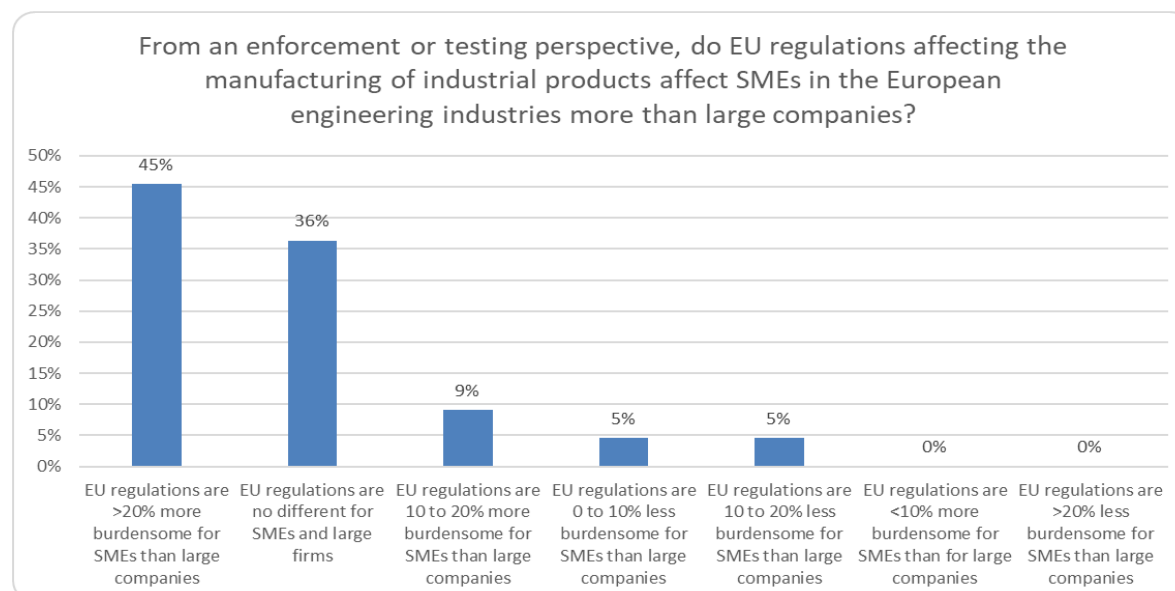
as requirements to provide additional reporting details for databases (e.g. in the case of the WEEE Directive).

The level of compliance costs and burdens of EU legislation collectively (across all types of legislation including product, environmental and horizontal legislation) was viewed by many survey respondents (industry associations, manufacturers, MSAs and notified bodies) as being more burdensome for SMEs than large firms.

As regards whether EU legislation affecting the manufacturing of industrial products **affect SMEs in the European engineering industries more than large companies**, as with the other categories of stakeholders, there were differing views. Some respondents, such as a notified body from Switzerland, perceived that EU legislation do not affect SMEs and large firms differently since *"all products from all manufacturers have to fulfil the same EHSR and standards"*. However, there were more respondents that perceived that EU legislation are >20% more burdensome for SMEs than large companies. An MSA from the Netherlands commented that according to the results of their investigations, they have found out that big enterprises are more likely to comply with the legislation than small enterprises and if large companies do not comply, they often fix the non-compliances in a short period of time. Whereas SMEs require more help, resources and time to fix non-compliance issues.

Other MSAs, such as an MSA from Liechtenstein and another from Malta, selected the option that EU legislation is >20% more burdensome for SMEs than large companies. They expressed the view that the main issue is awareness and willingness by SMEs to obey the law: *"Unfortunately, a lot of SMEs would not have dedicated personnel to deal with legal compliance and do not wish to expand financial resources to employ consultants in this regard. couple that with the fact that potentially non-compliant products are cheaper to buy making for a higher mark-up, then it is in the interest of most SMEs not to follow regulations"*.

**Figure 3-3 – From an enforcement or testing perspective, do EU regulations affecting the manufacturing of industrial products affect SMEs in the European engineering industries more than large companies?**



Source: CSSES' survey of testing and certification bodies (incl. notified bodies) and MSAs

The explanation for these findings, based on desk research and interviews, could be that SMEs have fewer specialist compliance staff available, have to use external testing laboratories for conformity assessment purposes (they lack in-house testing capabilities), produce in comparatively lower volume, and cannot therefore offset compliance costs against high unit volume (unlike their large manufacturing counterparts).

A further interesting finding from the survey of MSAs and notified bodies was that advanced technologies are already frequently used by MSAs to help test and certify products (testing bodies) or to undertake enforcement activities. Moreover, digitalisation was seen as having been useful in terms of improving efficiency in carrying out testing and certification activities by MSAs, but less so in facilitating market surveillance and enforcement activities, where it was either not considered relevant, or only to some degree.

Overall, stakeholders identified legislation as being both a driver and inhibitor of competitiveness, reflecting the complex interplay between the two. It was observed by some stakeholders that environmental and horizontal regulation has objectives that are primarily concerned with improving the environment and strengthening sustainability in a Circular Economy context, and whilst industrial competitiveness and innovation are considered (e.g. in impact assessments), these are secondary considerations.

Moreover, whilst a few examples of the positive role of EU legislation in stimulating innovation by firms in the EU engineering industries (e.g. investment in R&D&I due to the risk of substitution of chemicals in the case of REACH), there were concerns that the costs could often outweigh the benefits, especially as other jurisdictions globally do not always face as demanding legislation. However, it is difficult to generalise, as there is a very nuanced picture, not least because environmental and horizontal legislation such as REACH and RoHS have been adopted by many jurisdictions globally, and compliance with European legislation is often considered to be good enough to be able to sell products in many countries globally, notwithstanding the existence of different national legislation and standards in third-country competitors.

#### **How are different types of applicable EU legislation to the EU engineering industries likely to evolve in future?**

Looking ahead between now and 2030, there are likely to be at least some further regulatory changes that will impact the EU engineering industries. Some of these are reasonably predictable, as the need to align the 2006 Machinery Directive with the NLF is already foreseen (as most other product legislation have already been aligned), but there is also considerable uncertainty. For example, should the Machinery Directive also be updated to reflect new technological developments, such as the integration of AI and machine learning technologies into machinery and production processes, or if harmonised standards will be sufficient.

The study found that there are potential implications of the rapid development of new technologies in the EU engineering industries, and the accelerated pace of their take-up. New technologies have emerged relevant to the EU engineering sectors, such as the growing deployment of AI and the use of big data to optimise the efficiency of advanced manufacturing processes. Such developments raise important questions relating to the future direction of the EU regulatory framework, such as whether the core product legislation applicable to the EU engineering sectors are adept enough to accommodate scientific and technological progress, or if new legislation is needed, such as horizontal legislation on AI to create an enabling regulatory framework that addresses issues such as ethics and liability-related issues (the latter are important in some sectors, for instance, autonomous driving).

A further medium-term issue relating to the future development of the regulatory framework analysed was whether cybersecurity should be regulated in future through a horizontal piece of law covering all industrial products, or whether cybersecurity can be dealt with through the integration of minimum baseline security requirements into existing product regulations and directives. For instance, the Radio Equipment Directive (2014/53/EU) includes provision for the potential activation of several delegated acts, including security aspects of products (rather than cybersecurity in a broader sense). The growing interrelationship between product safety, covered by Art. 114 of the TFEU and mentioned in individual product legislation, and the security aspects of products, not currently covered in primary legislation, but one which may need to be explicitly recognised by EU regulators (and other regulators globally) in the next 10 years, given growing concerns about cybersecurity generally, and specific issues such as data protection and privacy of IoT devices and internet-based fraud often perpetuated through devices manufactured by the engineering industries. Whilst there have already been regulatory developments in this area, such as the adoption of the Cybersecurity Act in 2019, the development of product-specific cybersecurity certification schemes is presently voluntary.

To avoid the gradual accretion of cybersecurity rules in different pieces of EU industrial product legislation, many, but by no means all, manufacturing industry associations supported the concept of a horizontal cybersecurity law.

A key finding in relation to stakeholders' views on the desired future evolution of the EU regulatory framework was that there is a strong preference among industry associations and individual manufacturers to maintain the broad regulatory stability noted in the decade up to the present 2020 baseline. This could help to ensure that the EU legal framework benefits (or at least does not worsen) the competitiveness of the EU engineering industries by providing stability, and by avoiding imposing additional administration burdens that would arise from too many changes to EU legislation.

There was a broad consensus that the New Approach to product legislation in general, characterised by a technology-neutral approach to the development of EU legislation suits the EU engineering industries well. In particular, key EU and national engineering associations strongly appreciate the following: technology-neutral essential requirements, as these have been kept simple.

Moreover, they have been complemented by the implementation of the New Legislative Framework (NLF), which introduced common requirements through the NLF regarding placing goods on the market, integrated horizontally into industrial product legislation. The NLF was also viewed positively by stakeholders from the EU engineering industries, as once economic operators are familiar with the requirements for placing goods on the market, they know that other pieces of product legislation follow a common general framework (e.g. producing technical documentation relating to the product, flexible conformity assessment procedures, with self-certification except in instances where products, machinery or equipment is identified as being higher risk in the case of certain Directives).<sup>335</sup>

A strong preference was therefore expressed to continue to use harmonised standards as a means of regulating new technological developments, as an alternative to making revisions to existing, or introducing new legislation. Nonetheless, given concerns raised by MEPs at the European Parliament and by consumer associations about the additional risks that might be associated with the deployment of new technologies such as AI and machine-learning technologies in the workplace, and especially in factory setting, several legislative reviews have been launched by the European Commission as to whether the core

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<sup>335</sup> An example of a Directive where there are some exceptions for specific higher-risk product categories is the Machinery Directive, where Annex 4 does not allow the SDoC to be used.

applicable legislation to the EU engineering industries should be updated to reflect these new technological developments.<sup>336</sup>

Regulatory impacts to analyse how far changes will be necessary to existing EU legislation and international legislation to address new technological developments, such as Artificial Intelligence and the Internet of Things (i.e. Part 2).

### **What is the inter-relationship between legislation and the sectoral performance of the EU engineering industries?**

The interrelationship between the impact of EU legislation on the sectoral performance of the EU engineering industries is a highly complex one. Evidence was identified of legislation serving as both a driver and inhibitor of industrial competitiveness and innovation.

Horizontal legislation, such as the REACH Regulation, were primarily found to have health and safety and environmental protection objectives. However, since the legislation was adopted, this has had major implications for the EU engineering industries in terms of the necessity of investing in safer, substitute chemicals. This was posited when the legislation was adopted as driving innovation and industrial competitiveness.

The extent to which the expected benefits for industry actually materialised has been analysed through a case study, which found that whilst there are a few examples of ways in which REACH has promoted innovation, there are equally examples of how smaller producers have exited the chemicals production market, due in part to the administrative costs and regulatory burdens involved. Moreover, the compliance costs for engineering sector firms and firms that use chemicals were found to be significant. Therefore, whilst the regulation has partly promoted innovation in new chemical alternatives, there have been significant costs, which have required investment in R&D into viable chemical substitutes. On the one hand, this may serve to strengthen competitiveness over the medium and long term, as consumers (B2C) and other businesses (B2B) are becoming increasingly discerning and demanding regarding the necessity of products using safe chemicals, but on the other hand, having to invest in finding alternative chemicals for use in production could have had a diversionary effect by redirecting investment that could have been used for other purposes (including digitalisation) to investment in safe chemicals.

### **Future scenario outlook – how will future EU regulatory developments impact the engineering industries?**

Future EU regulatory developments that will impact the engineering industries are likely to be shaped by two key drivers:

- **New technologies:** As illustrated throughout this report (and in particular section 4), the emergence and deployment of new technologies, prominently including the IIoT, AI and big data and analytics, and industry 4.0 across the engineering industries will bring significant opportunities for firm-level efficiency, workforce and other benefits, as well as wider positive impacts on the economy (e.g. productivity and growth improvements) and society (e.g. environmental and health improvements). However, a range of challenges exist that could result in future regulatory developments. Considering AI, for instance, many applications face a range of ethical, legal and practical challenges, as highlighted in the White Paper on AI. These include, amongst

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<sup>336</sup> Examples mentioned in this report are the Impact Assessment of the Machinery Directive (2019-20), the Evaluation of the EMCD (2020), and three Impact Assessment of the Radio Equipment Directive (in 2019-20) to ascertain whether delegated acts contained in the 2014 Directive should be adopted, which would have implications for manufacturers from the engineering industries.

others, ensuring protection of personal data and privacy, ensuring transparency of AI systems and ensuring clarity on liability when automated decision-making is involved.

- Another challenge for AI, and for new technologies generally, is the security and resilience of such technologies. Cybersecurity is also an area of particular interest with regard to future regulatory developments. However, as many of the regulatory developments are very new or have not yet been implemented, it is not possible to assess legal implementation or impacts. For example, consideration is being given to activating delegated acts within the Radio Equipment Directive (2014/53/EU) (RED) on data protection and protection from fraud which could strengthen product security. But there is regulatory uncertainty given that some industry stakeholders have suggested that a horizontal approach to strengthening security in products rather than specific rules in individual safety Directives and in sectoral legislation could be more effective. Moreover, it is too early to assess the impacts of the July 2019 Cybersecurity Act, which is voluntary and involves the development of product certification schemes.
- In addition, as highlighted through the European strategy for data and the White Paper on AI, ensuring the European economy is data-agile is key to achieving the potential of digital transformation through the implementation of new technologies. As such, specific measures to improve data infrastructure and capabilities will be implemented, including the development of Common European Data Spaces. As for the Cybersecurity Act, the impact of the GDPR needs to be assessed and feed into these discussions on data.
- **Environmental considerations:** The key policy development driving regulatory changes in this regard is the European Green Deal. The Green Deal aims for European climate neutrality by 2050 through a review of existing policies and legislation and the identification of new policies and legislation such as the development of a European Climate Law, the implementation of the New Circular Economy Action Plan for sustainable product policy and a number of other initiatives such as the Chemicals Strategy for sustainability. The upcoming changes in the environmental regulatory framework will affect the engineering industry directly. Since the EU engineering sector could play a key role in achieving the climate ambition and sustainability targets, the main challenge will be to implement the new EU policy and legislative framework without imposing excessive compliance costs and burdens or barriers to the competitiveness of the EU engineering industry.

On this basis, the future regulatory scenario will likely comprise the following:

- **Review and possible amendment of existing legislation:** All core industrial product legislation has recently been reviewed or is being reviewed in 2020. Although industry stakeholders are generally keen to retain the current regulatory framework, these legislative reviews could lead to new technology-related amendments to both the RED and the MD. On the environmental side, potential legislative revisions are possible across a range of industrial emissions and climate change, energy, vehicle and battery legislation.
- **Adoption of new legislation:** Building on the White Paper on AI, a horizontal regulatory proposal on AI is expected in 2021. Furthermore, the European strategy for data states the aim of developing an enabling legislative framework for governance of the proposed common European data spaces, as well as a possible Data Act to govern interactions between actors in the data-agile economy. Although stakeholders have mixed views on the best way forward with regard to regulating on cybersecurity, there is the possibility for a future horizontal cybersecurity legislation or legislation-specific amendments on cybersecurity. With regarding to responding to environmental drivers, the key development is the proposal for a European Climate Law.

## 4. IMPACTS, CHALLENGES AND OPPORTUNITIES OF DIGITALISATION OF THE EU'S ELECTRONIC, ELECTRICAL AND MECHANICAL ENGINEERING INDUSTRIES

### 4.1 DEFINITION OF DIGITALISATION

The first step in the analysis of the interaction between digitalisation and the competitiveness of the EU engineering industries was to develop a clear concept and definition of digitalisation. In the course of this study, various definitions of digitalisation and ways to measure it have been reviewed, including the following:

- Accenture's Digital Density Index;
- The OECD, UNSTATS, WTO and BEA definitions and views on measuring digitalisation and identifying (enabling) digital goods and services;
- The concept of sectoral digital intensity as defined by Calvino, F., et al. (2018), in the OECD Working Paper on "A taxonomy of digital intensive sectors";
- The work done in relation to monitoring 'Advanced technologies for industry' which comprises 16 strategic technologies of which ten are related to digitalisation<sup>337</sup>;
- The definition of digital patents as indicated in Prognos' proprietary data set.

In view of the absence of an overall accepted definition, the approach was to monitor digitalisation at sectoral level, and to perform an analysis of publicly available data focussed on the assessment of the most feasible and relevant ways to analyse the EU engineering sector's competitiveness in a digitalized business environment.

Digitalisation was defined as relating to 11 different digital transformation technologies, as shown in Figure 4.1. Depending on data availability, these technologies were further identified in terms of digital goods and for digital patents. The latter built on the existing work and data of Prognos on digital patenting. The goods dimension was elaborated for one particular engineering subsector NACE 26: Manufacture of computers, electronic and optical systems building further on intermediate results of the EU Advanced Technologies for Industry project. Figure 4.1 indicates which technologies were taken into consideration for each of the analyses.

**Table 4-1: Digital technologies taken into consideration for each analysis**

| Digital Transformation Technologies                  | In terms of digital goods | In terms of digital patents |
|------------------------------------------------------|---------------------------|-----------------------------|
| Artificial intelligence (AI)                         | x                         | x                           |
| Augmented/virtual/extended reality                   |                           | x                           |
| Big data and analytics                               | x                         | x                           |
| Cloud-based services                                 |                           | x                           |
| Distributed ledger technologies (DLT) and Blockchain |                           | x                           |
| Internet of Things (IoT)                             | x                         | x                           |
| Cyber security                                       | x                         | x                           |
| Smart and enhanced mobility                          | x                         |                             |
| Robotics                                             | x                         |                             |
| 3D printing                                          |                           |                             |
| Network technologies                                 |                           | x                           |

<sup>337</sup> The project is at the time of reporting still on-going. The title is Monitoring digital transformation and key enabling technologies' (EASMA/COSME/2017/043).

A description of selected types of digital transformation technologies is provided in Annex 4. The description of the analysis of various relevant data sources on digitalisation can be found in Annexes 5 and 6.

## 4.2 THE ENGINEERING SECTOR AS A DRIVER FOR DIGITALISATION

Whereas in Section 2 **Error! Reference source not found.**, general competitiveness issues are examined across the European Engineering industries, Section 4 brings in the digital component more explicitly. This implies incorporating the ICT components of the value chain in terms of both hardware and software. Indeed, engineering is both an important enabler of digitalisation and user/client.

The digitalisation component in engineering can be identified in various ways e.g. in terms of functionality or in terms of technologies that underpin digitalisation. The Artemis report (Artemis Industry Association, 2019) uses the term Embedded Intelligence pointing to “*incorporating Systems of Systems, Embedded & Cyber-Physical Systems, Electronic Components and Embedded Software Technologies*” and points in its recommendations to focussing investments equally on the hardware and software component since future value added creation is expected to occur particularly in the latter part of the value chain. The report stresses that currently we are on the verge of creating a new General-Purpose Technology platform which integrates four areas of economic activity:

1. Communication (internet, cyberspace etc.);
2. Transportation (electric vehicles (EVs), autonomous vehicles, smart traffic systems etc.);
3. Energy (smart grids, renewable and clean energies, decentralised production etc.);
4. Production (the IoT, sensors, monitoring etc.).

The authors indicate that the platform “*is destined to become the distributed neural network prosthetic that complements today’s physical economy, ...*”.

Taking this viewpoint on board, the EU engineering sector does not only imply that the EU engineering sector is relevant for co-developing the physical economy yet also has an important part to play in the elaboration of ‘neural network prosthetic’<sup>338</sup>. Digitalisation does provide profound business opportunities for the EU engineering sector and at the same time is subject to the transformation that it brings across industries. In particular, one can distinguish the following transition areas that are gradually emerging:

1. Increased servicing, e.g. product-service systems;
2. Increased automation and embedded intelligence with automated e-sourcing, digital factory design, real-time factory scheduling, flexible factory automation, digital production processes, e-commerce, extended supply chain monitoring, digital product quality, digital supply network design and product life cycle management;
3. Fading of the relevance of conventionally defined borders as depicted in the economic activity classifications (e.g. NACE, ISIC etc.) and increased intertwining of sectors;
4. Extended disintermediation bypassing wholesalers and distributors servicing directly the customer;

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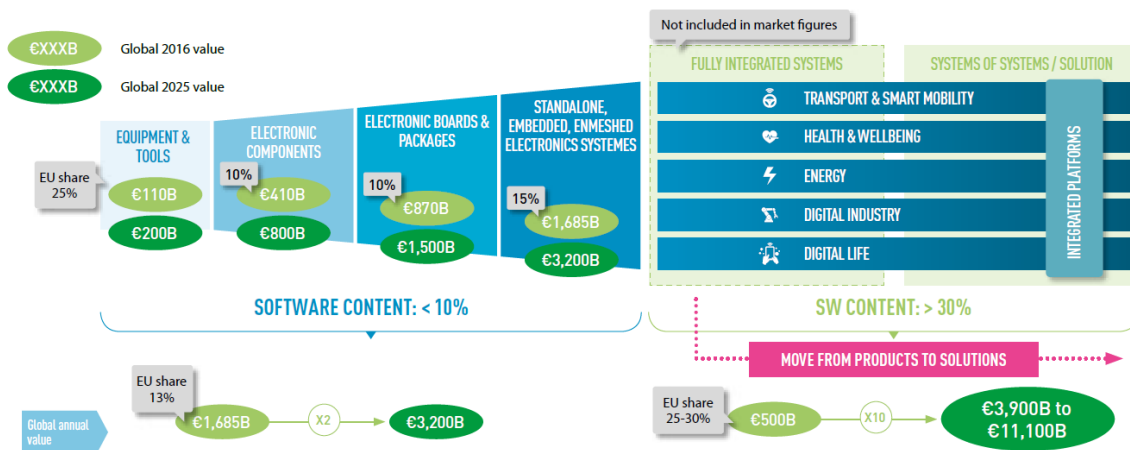
<sup>338</sup> In the context of this study, the term ‘neural network prosthetic’ can be interpreted as the interconnection of digital twins simulating, monitoring and analysing the operation of physical machinery both existing and that in development or concept phase.



5. Move from centralised to decentralised production systems (e.g. 3DP, renewable energy production, IoT etc.) with higher levels of customization and increased flexibility in comparison to conventional large-scale batch production;
6. Transition from proprietary solutions towards collaborative ones;
7. Transition from vertically integrated value chains in terms of hardware to laterally scaled ecosystems focussed on software.

As illustrated in the following figure, the above-mentioned recent study from Artemis shows that especially in the 'neural network prosthetic' part of the Embedded and Cyber-Physical Systems value chain, the highest future value-added increase is to be expected. Based on a meta-analysis taking the estimates of various studies into account, the authors assert that the EU currently captures 20% to 30% of the downstream value chain, yet add at the same time that this relative position may change quickly, especially in the light of the policy and funding initiatives made in Asia to invest in Cyber-Physical Systems.

**Figure 4-1: Estimated global market value by stage of the Embedded and Cyber-Physical Systems value chain and EU share**



Source: (Artemis Industry Association, 2019) p 17

### 4.3 THE USE OF DIGITAL TECHNOLOGIES IN THE ENGINEERING SECTOR

To assess the *upstream effects* of digitalisation in the engineering industry via the use of digitalised products and services (e.g. use of ERP-software, use of mobile devices, ...) a recent OECD (2018) study<sup>339</sup> offers a sectoral taxonomy of **digital intensity**. Based on seven different metrics, Calvino et al. (2018) proposed a taxonomy of sectors by digital intensity (see the following figures). The selected indicators highlight how the extent of digital transformation in sectors<sup>340</sup> is shaped by firms' investments in "digital" assets, as well as by changes in the way companies approach markets and interact with clients and suppliers, by the (type of) human capital and skills needed, and the way production is organised. The selected seven metrics used are:

<sup>339</sup> Calvino, F., C. Criscuolo, L. Marcolin and M. Squicciarini (2018), "A taxonomy of digital intensive sectors", OECD Science, Technology and Industry Working Papers, No. 2018/14, OECD Publishing, Paris, <https://doi.org/10.1787/f404736a-en>

<sup>340</sup> The framework is based on the following countries for which all indicators can be constructed or exist: Australia, Austria, Denmark, Finland, France, Italy, Japan, the Netherlands, Norway, Sweden, the United Kingdom and the United States

- Software investment
- ICT tangible investment
- Intermediate ICT goods
- Intermediate ICT services
- Robot use
- Revenues online sales
- ICT specialists

The study showed large differences between traditional sectors (agriculture, mining, food) being currently much less digitally-intensive and digital technology-intensive sectors like machinery and equipment, transport equipment or services like R&D and finance. However, it also showed that some traditional sectors like textiles, wearing apparel are more digitally-intensive than transportation or accommodation and food services. Differences in the ability to capture value from new technologies also exist between advanced and less advanced firms within the same sectors, which is not surprising.

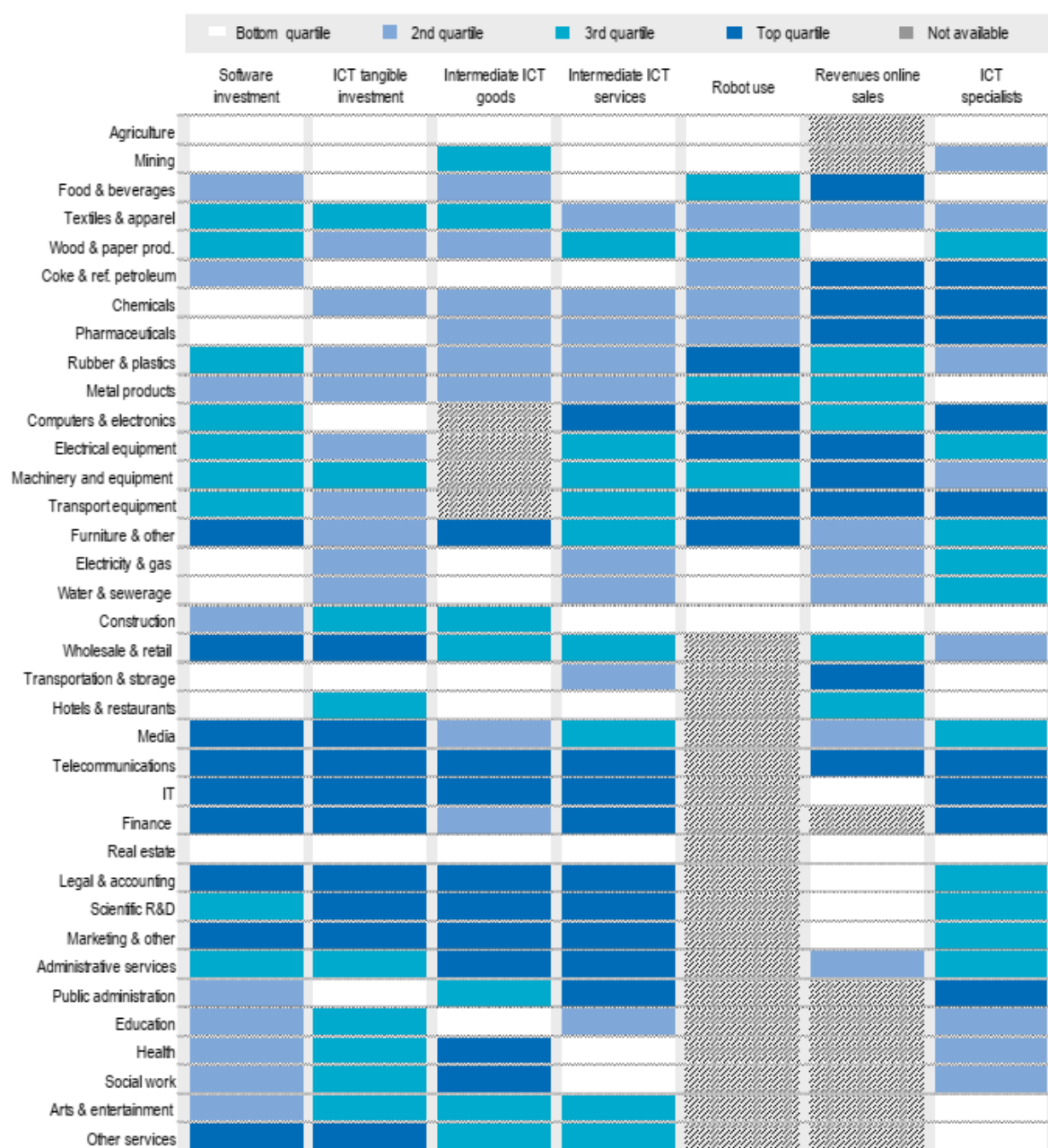
**Table 4-2: Sectoral taxonomy of digital intensity: 'global indicator'**

| Sector denomination                                      | ISIC rev.4 | Quartile of digital intensity:<br>2001-03 | Quartile of digital intensity:<br>2013-15 |
|----------------------------------------------------------|------------|-------------------------------------------|-------------------------------------------|
| Agriculture, forestry, fishing                           | 01-03      | Low                                       | Low                                       |
| Mining and quarrying                                     | 05-09      | Low                                       | Low                                       |
| Food products, beverages and tobacco                     | 10-12      | Low                                       | Low                                       |
| Textiles, wearing apparel, leather                       | 13-15      | Medium-low                                | Medium-low                                |
| Wood and paper products, and printing                    | 16-18      | Medium-high                               | Medium-high                               |
| Coke and refined petroleum products                      | 19         | Medium-low                                | Medium-low                                |
| Chemicals and chemical products                          | 20         | Medium-low                                | Medium-low                                |
| Pharmaceutical products                                  | 21         | Medium-low                                | Medium-low                                |
| Rubber and plastics products                             | 22-23      | Medium-low                                | Medium-low                                |
| Basic metals and fabricated metal products               | 24-25      | Medium-low                                | Medium-low                                |
| Computer, electronic and optical products                | 26         | High                                      | Medium-high                               |
| Electrical equipment                                     | 27         | Medium-high                               | Medium-high                               |
| Machinery and equipment n.e.c.                           | 28         | High                                      | Medium-high                               |
| Transport equipment                                      | 29-30      | High                                      | High                                      |
| Furniture; other manufacturing; repairs of computers     | 31-33      | Medium-high                               | Medium-high                               |
| Electricity, gas, steam and air cond.                    | 35         | Low                                       | Low                                       |
| Water supply; sewerage, waste management                 | 36-39      | Low                                       | Low                                       |
| Construction                                             | 41-43      | Low                                       | Low                                       |
| Wholesale and retail trade, repair                       | 45-47      | Medium-high                               | Medium-high                               |
| Transportation and storage                               | 49-53      | Low                                       | Low                                       |
| Accommodation and food service activities                | 55-56      | Low                                       | Low                                       |
| Publishing, audiovisual and broadcasting                 | 58-60      | Medium-high                               | Medium-high                               |
| Telecommunications                                       | 61         | High                                      | High                                      |
| IT and other information services                        | 62-63      | High                                      | High                                      |
| Finance and insurance                                    | 64-66      | High                                      | High                                      |
| Real estate                                              | 68         | Low                                       | Low                                       |
| Legal and accounting activities, etc.                    | 69-71      | High                                      | High                                      |
| Scientific research and development                      | 72         | Medium-high                               | High                                      |
| Advertising and market research; other business services | 73-75      | High                                      | High                                      |
| Administrative and support service activities            | 77-82      | High                                      | High                                      |
| Public administration and defence                        | 84         | Medium-high                               | Medium-high                               |
| Education                                                | 85         | Medium-low                                | Medium-low                                |
| Human health activities                                  | 86         | Medium-high                               | Medium-low                                |
| Residential care and social work activities              | 87-88      | Medium-low                                | Medium-low                                |
| Arts, entertainment and recreation                       | 90-93      | Medium-low                                | Medium-high                               |
| Other service activities                                 | 94-96      | Medium-high                               | High                                      |

Source: OECD (2018)

For each of the seven dimensions used in the taxonomy of the digital intensity of sectors, the Figure below summarises the classification of digital intensity according to the indicators considered. The engineering industries show on average middle-to-high digital intensities especially with respect to revenue and online systems, robotics, intermediate ICT services and ICT specialists.

**Figure 4-2: Sectoral taxonomy of digital intensity: by indicator (2013-2015)**



Source: OECD (2018)

#### 4.4 COMPARATIVE ASSESSMENT OF DIGITALISATION OF THE EU ENGINEERING INDUSTRIES COMPARED WITH GLOBAL COMPETITORS

This section compares the situation in respect of the digitalisation of the EU engineering industry with its major global competitors. Where possible, data from the EU engineering sectors is utilised. Where not possible, survey data comparing the extent of digitalisation among EU manufacturing firms and their global counterparts is provided, as such data also covers engineering.

##### 4.4.1 General preparedness for digitalisation in the EU manufacturing (including engineering sectors)

An April 2020 survey-based study from the EIB **compared firm-level preparedness in Europe and the US for digitalisation**.<sup>341</sup> The report analyses investments in, and the adoption of digital technologies by firms in the EU and the USA. It provides evidence on better performance of digital firms compared to non-digital ones. The report draws from two datasets, the **European Investment Bank Survey (EIBIS) 2019**<sup>342</sup>, and the EIBIS Start-up and Scale-up Survey 2019. The study covers **manufacturing in a broad sense**, including the engineering industries, as the sector accounts for approximately one-third of Europe's entire manufacturing sector).

The findings are highly relevant to the present study, and are therefore summarised in table form:

**Table 4-3: EIB comparative assessment between the EU and US on digitalisation**

| Key findings                                                                               | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1: European firms lag the US generally in the adoption of digital technologies.</b>     | Only 66% of manufacturing firms in the EU, compared to 78% in the US, report having adopted at least one digital technology. Digital firms perform better and are more dynamic, with higher labour productivity, grow faster and have better management practices. Larger firms have higher rates of digital adoption than smaller firms, while old-small firms tend to be persistently non-digital.                                                                                         |
| <b>2: Many small firms in the EU that do not invest in digital technologies.</b>           | Small firms consider labour market legislation, business legislation and the lack of external finance as major obstacles to investment, which may further exacerbate the delay in digital technology adoption.                                                                                                                                                                                                                                                                               |
| <b>3: EU firms have lower adoption rates of "Internet of Things" (IoT) than in the US.</b> | This was assessed based on the Share of firms that have implemented (or organised their entire business around) each of four technologies (3D printing, robotics, IoT in sense of connectivity between IoT devices and big data).                                                                                                                                                                                                                                                            |
| <b>4: Larger firms have higher rates of digital adoption than smaller firms.</b>           | Both in the US and in the EU in the manufacturing sector (and in other sectors too), The adoption of digital technologies increases with firm size and this effect is pronounced among manufacturing firms. Only 30% of EU firms with fewer than 10 employees adopted digital technologies, whereas this share increases to 79% for firms with more than 250 employees. In addition, the difference in digital adoption between the EU and the US seems to be mainly driven by smaller firms |

<sup>341</sup> European Investment Bank (EIB), April 2020, Who is prepared for the new digital age? - Evidence from the EIB Investment Survey, [https://www.eib.org/attachments/efs/eibis\\_2019\\_report\\_on\\_digitalisation\\_en.pdf](https://www.eib.org/attachments/efs/eibis_2019_report_on_digitalisation_en.pdf)

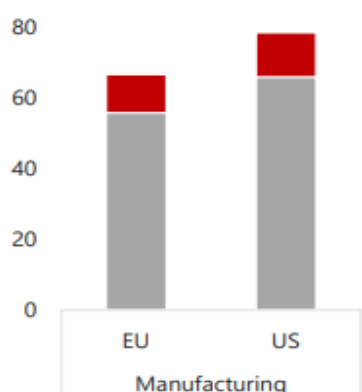
<sup>342</sup> EIBIS is an annual survey with 12 500 firms in Europe and 800 firms in the United States. This survey focuses on firms' assessment of investment and investment finance conditions.

| Key findings                                                                                                                 | Explanation                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>5: Lack of access to finance can be a barrier to the adoption of digital technologies in the EU, especially for SMEs.</b> | While most digital firms are less likely to report that limited availability of finance is an obstacle to investment activities, lack of access to finance tends to be a stronger barrier for small digital firms in the EU. |

Source: European Investment Bank (EIB), April 2020. *Who is prepared for the new digital age? - Evidence from the EIB Investment Survey. Edits by study team to identify findings relevant to the manufacturing sector (incl. engineering).*

In the following Figure, taken from the EIB study, the first column shows the comparative situation between the EU and the US on digitalisation adoption in the manufacturing sectors is relevant to the present study. The data shows that whilst over half of manufacturing firms in the EU are adopting digital technologies, the level of adoption nevertheless lags behind that of the US.

**Figure 4-3: Digital adoption in the EU and US (in % of all manufacturing firms)**

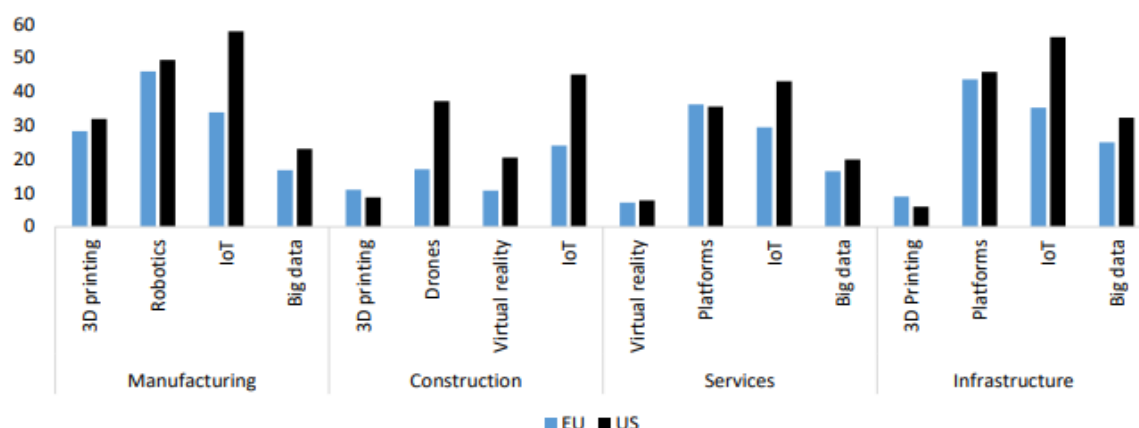


Grey scale - partially digital, red scale, fully digital.

Source: EIBIS 2019. Note: A firm is identified as partially digital if at least one digital technology was implemented in parts of the business; and fully digital if the entire business is organised around at least one digital technology. Firms are weighted using value added.

In the subsequent Figure below, survey data on the adoption of different digital technologies between the manufacturing sectors (and other sectors) in the EU and the US is shown. The data shows the percentage of firms that have adopted one or more different digital technologies, such as 3D-printing, robotics, IoT connected devices and use of big data.

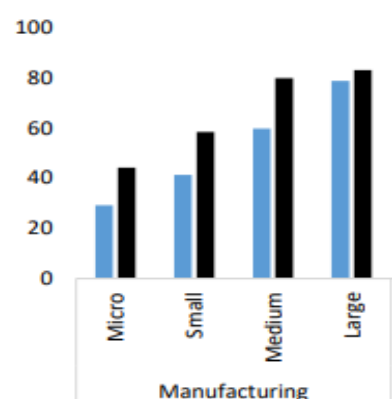
**Figure 4-4: Adoption of different digital technologies (in % of all firms)**



Source: EIB, April 2020. Who is prepared for the new digital age? Evidence from the EIB Investment Survey

Differences between the EU and US as regards digital adoption and firm size were also considered in the EIB Investment Survey. In the following Figure, digital adoption (as a % of all firms), by firm size, is shown:

**Figure 4-5: Digital adoption (as a % of all firms), by firm size**



Source: EIBIS 2019. Note: Share of firms that have implemented (or organised their entire business around) at least one digital technology. Firms are weighted using value added.

The major difference between the high percentage of large firms that are digitalised, which is not that significant a difference between the EU and the US, compared with the relatively low proportion of micro firms, can be noted. In Europe, less than 30% of micro firms were digitalised.

#### 4.4.2 Digitalisation in specific areas of engineering

Based on interviews, desk research, as well as on own expertise in the work on engineering industries we can make a set of pertinent observations regarding the digitalisation of the EU engineering industry and its comparative position worldwide.

Digitalisation in the engineering sector essentially evolves around the products and services of the subsector **computer, electronic and optical products (NACE 26)** which are further diffused to other subsectors in the engineering value chain, notably electrical engineering (NACE 27) and most of Machinery (NACE 28), as well as onto other industries



such as motor vehicles (NACE 29), Aerospace and transport equipment (NACE30). The diffusion process in the electronics value chain is illustrated in Figure 4-6.

In key areas of the **manufacture of computer, electronic and optical products (NACE 26)**, Europe has managed to keep dominant positions. However, this is a rapidly-changing industry where the core of the electronics ecosystem entails a wide product scope ranging from components, i.e. semiconductors to end-user equipment, which can be further subdivided into stand-alone devices (computers, smartphones, medical imagery, TV receivers...) and embedded devices (avionics, weapon systems, robotics, control equipment...).

The production structure of the European electronics industry is significantly different from that in other parts of the world. In Europe, the electronics production is predominantly geared towards **embedded devices and professional outlets** such as automotive electronics, industrial, building and service electronics, medical electronics, aerospace, defence and security, whereas in Asia the production structure has up to now mostly been driven by **mass-market consumer-type products** such as TVs, smartphones, PCs.

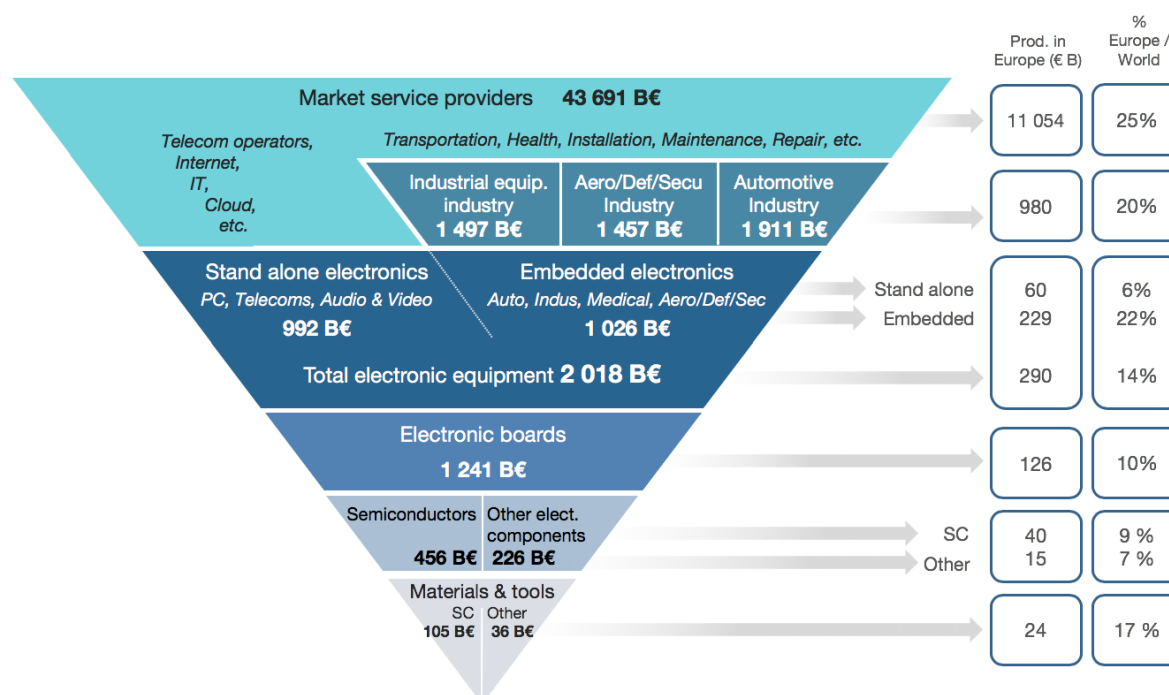
Historically, the largest end-user segments were those related to the consumer and mass markets that are described as "stand-alone electronics" in the value chain. These are commonly called the "3C" (Communications with mobile phones, Computers with PCs, Consumer with home appliances and audio-video), which accounted for €992 billion worldwide in 2018.<sup>343</sup> This is changing, however. For instance, in 2018, the embedded electronics segment which encompasses electronic devices, equipment and systems dedicated to professional applications or manufacturers (industrial and building, automotive, aerospace, defence, security, and health) accounted for €1,026 billion worldwide, becoming for the first time larger than the global stand-alone electronics production in value. Today the world production is about evenly balanced between mass-market stand-alone electronic products and embedded professional electronic equipment.

Figure 4-6 depicts the value chain of the global electronics ecosystem and digital components from the recent study on the electronics ecosystem of Decision Études et Conseil (2020). It clearly shows Europe's specialisation. In 2018, Europe's overall share of global electronics production was 14%. Yet for embedded professional devices the EU's share was 22%, and for stand-alone mass market devices the EU's share was markedly lower: 6%. For semiconductors, that are the very heart of all electronic systems, Europe's share is only 9%, and even 6% if only the wafer fab capacity is considered. In terms of competitiveness this implies a high dependency from non-EU suppliers.

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<sup>343</sup> DECISION Études & Conseil (2020), study "Emerging technologies in Electronic Components and Systems (ECS) Opportunities ahead (DG-CONNECT)"

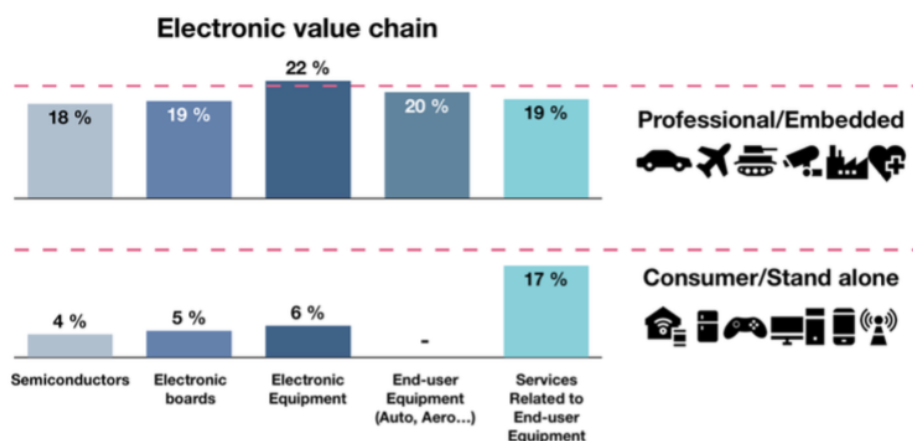
**Figure 4-6: World Electronics value chain in 2018 and digital components**



Source: DECISION Études & Conseil (2020) Study on the Electronics Ecosystem. Overview, developments and Europe's position in the world, - Final report, European Commission, p.11

Figure 4-7 provides further details on the different competitive position of the EU for the main product groups in the electronics value chain for embedded and stand-alone equipment respectively.

**Figure 4-7 : The EU's relative competitive position for main product categories in the electronics value chain for the embedded and standalone market segments in 2018**

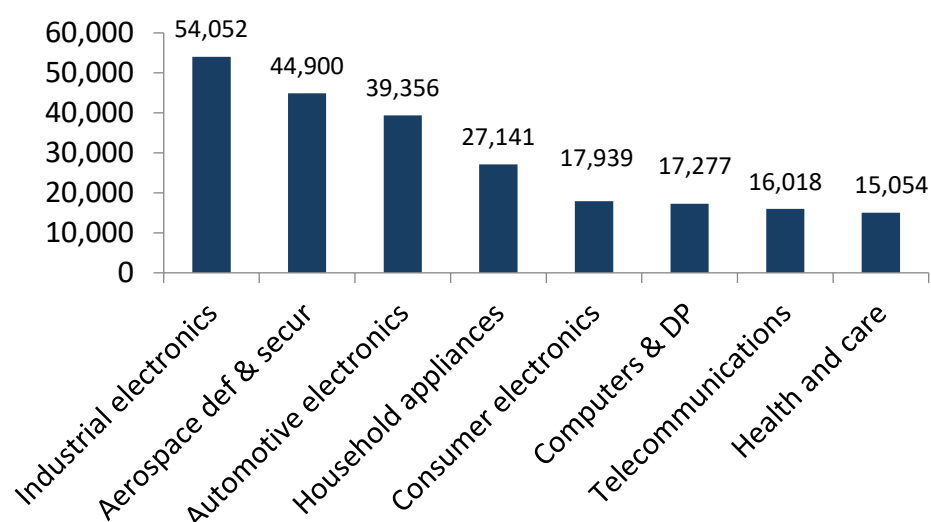


Source: DECISION Études & Conseil (2020) Study on the Electronics Ecosystem. Overview, developments and Europe's position in the world, - Final report, European Commission, p. 12

Note: Percentages refer to shares in worldwide production.

The strong position of the EU in the production of embedded and professional devices is very closely linked to the relatively strong position of the European end-user industries (automotive, aerospace, industry...). These industries are important clients for the EU electronics industry, as illustrated in Figure 4-8. The EU electronics industry is particularly oriented towards the embedded electronics market. According to Decision Études & Conseil, the semiconductor content of professional and embedded systems is growing but still substantially less (approximately 10%) than for mass market devices (around 30%). This helps to explain why the EU has a relatively small share of the semiconductor market globally.

**Figure 4-8 End user equipment production in the EU (2016, million €)**



Source: Decision Études & Conseil

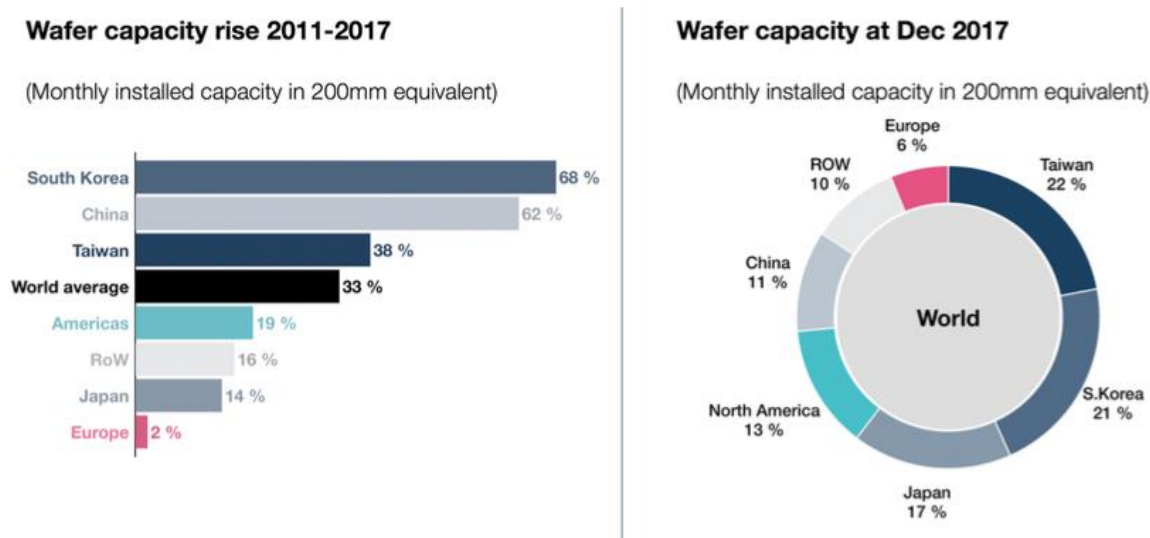
The EU production share of **micro and nano electronics**, especially in the field of **semiconductors**, has been declining over the last 20 years, from 22% in 1998 to 13% in 2010 and down to 9% in 2017<sup>344</sup>. This was mainly caused by the near-disappearance of the production in Europe of mass market consumer electronics (PCs, mobile phones, TVs, etc). This in turn caused difficulties and a lack of incentives for EU semiconductor producers to make the necessary investments into advanced technologies in the EU to produce the massive volumes of components for the mass market electronic products, and thus to achieve economies of scale. Evidence suggests that the capital intensiveness of semi-conductor production has increased substantially as consumer and business demands for more powerful semi-conductors have increased.

In this context, the EU semiconductor manufacturers focused on specific and older technologies to address the need for customised semiconductors across the automotive, industrial, aerospace and defence end-user segments. Such manufacturers have gained market shares in these areas where the European industry is competitive and has maintained its strong market position. As a consequence, between 2011 and 2017, the European semiconductor wafer production capacity only grew very slowly at 2% annually (in 200mm equivalent), compared to an average annual growth of 33% at world scale, and to 68% for South Korea and 62% for China. As a result, Europe has receded to the

<sup>344</sup> Decision Études & Conseil (2020), p. 14.

sixth world rank in wafer production capacity, behind all its major competitors, as is shown in Figure 4-9.

**Figure 4-9 : Wafer capacity growth for major economies and percentage share in 2017**



Source: IC Insights, DECISION Etudes & Conseil (2020) p. 14

Among the leading European semiconductor suppliers are STMicroelectronics (FR-IT), Infineon (DE), and NXP (NL), which was almost acquired by the American Qualcomm in 2016 by faced opposition to the purchase from China. ASML (NL) is a leader in the field of semiconductor production equipment (lithography). At the R&D level for nano and microelectronics, the EU boasts three world-class Research Institutes, CEA-Leti (FR), IMEC (BE) and Fraunhofer (DE). Europe also has a strong position in the field of miniaturization of sensors and their automatization and integration in industrial systems. Europe is however losing ground to North America, and more still to East Asia which has outpaced the rest of the world regarding the share of internationally filed patents in semiconductor technologies and related digital technologies. Controlling the semiconductor segment is strategic, since it is an input to many other engineering applications. The gigantic efforts made by China to build a domestic semiconductor champion (over \$100 billion) need to be perceived in this context.

**Personal computers (NACE 26.2)** have lost their status as the essential digital platform, which provided productivity gains, information, comfort and entertainment across the board from enterprises to households. The distinction between business and personal use has lost much of its significance. The smartphone is becoming the essential digital hub, and the new concept of "Internet Terminals" merges smartphones, PCs, tablets, set top boxes, TVs and audio devices.

There is practically no PC industry in Europe. Once being the undisputed master of the computing scene, today the US Data Processing production has dwindled to roughly the same level as Europe, and production in Japan is severely decreasing. Europe, Japan and the USA combined account for no more than 14% of Data Processing equipment production in the world. This reflects the near monopoly positions taken by Asia, and in particular, first by Taiwan, and now by China that today accounts for over half of the world production.

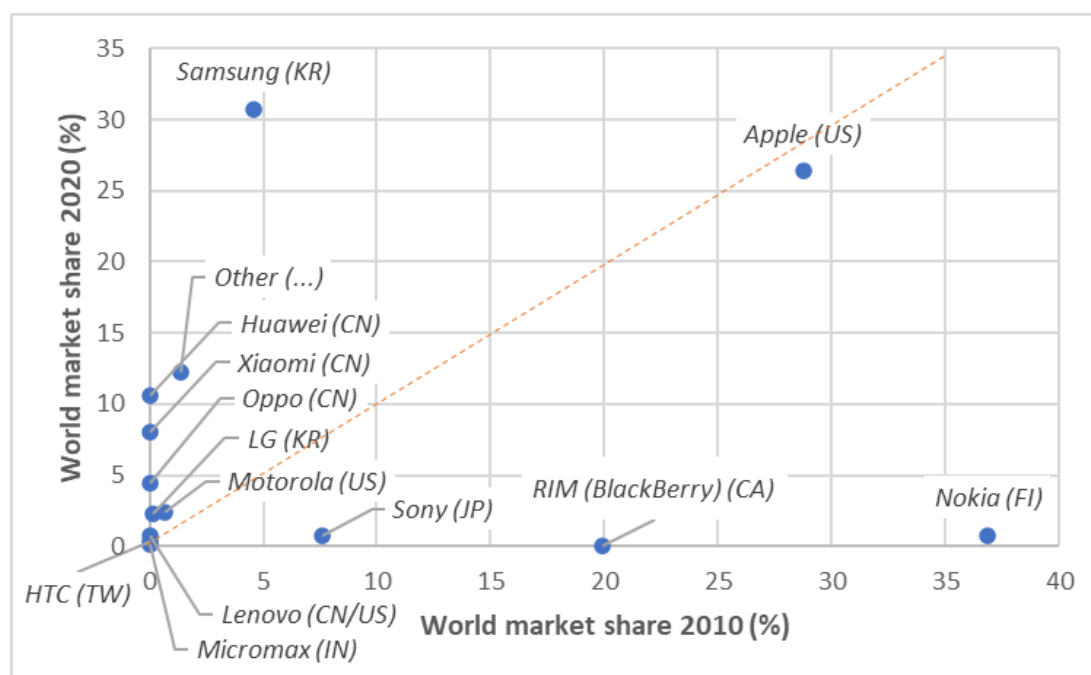
In the field of **high-performance computing (HPC)**, which is part of **NACE 26.20.14 and 26.20.15**, Europe is lagging behind the US and China. Both regions are in close competition. China is set to surpass the US in 2020 with the first exascale supercomputer – China has invested over \$1 billion since 2009, built the Sunway TaihuLight (the world's

fastest supercomputer) and set ambitious targets in terms of the market share of Chinese firms by 2020. However, in a major step towards making Europe a top supercomputing region globally, the European High-Performance Computing Joint Undertaking - EuroHPC has selected 8 sites for supercomputing centres located in eight different Member States to host the new high-performance computing machines<sup>345</sup>

To assess the position of the EU engineering in the subsector of **(tele)communications and network equipment (NACE 26.3)** one has to make a clear distinction between user terminal equipment at the one hand and network infrastructure on the other hand. The relative competitive position of the EU engineering companies is quite different in each of the market segments.

In the **user terminal equipment segment** EU suppliers practically left the scene after Nokia, which was at the time by far the world leader in mobile phones, missed the smartphone revolution. This gave ground to non-EU companies like Samsung to further develop their market shares. Also new companies entered this market notably Huawei, Xiaomi, Oppo, Lenovo, all of which are headquartered in China, and Micromax from India. A more detailed picture of the evolution of the relative market shares for major mobile vendors is shown in Figure 4-10. Beside Nokia, also Sony and RIM lost ground. However Apple managed to keep its market share over the decade and in fact is currently still the second largest player in this segment.

**Figure 4-10 : Market shares of major mobile vendors in 2010 and 2020**



Source: IDEA Consult based on Statcounter, <https://gs.statcounter.com/vendor-market-share/mobile/worldwide/#yearly-2010-2020>; accessed June 2020.

Note: all vendors with a minimum market share of 1% are presented. Vendors with a market share lower than 1% are aggregated in 'Other (...)'. Data are as of June 2020.

In the **infrastructure equipment segment**, EU suppliers are more prominent than in the terminal equipment segment with the companies Nokia, which includes Alcatel-Lucent, and Ericsson operating among other global players. Yet their relative competitive positions are under pressure as indicated in Figure 4-11. While in 2012 the EU suppliers together counted for about 40% of global top-ten providers' turnover, by 2017 it had shrunk to

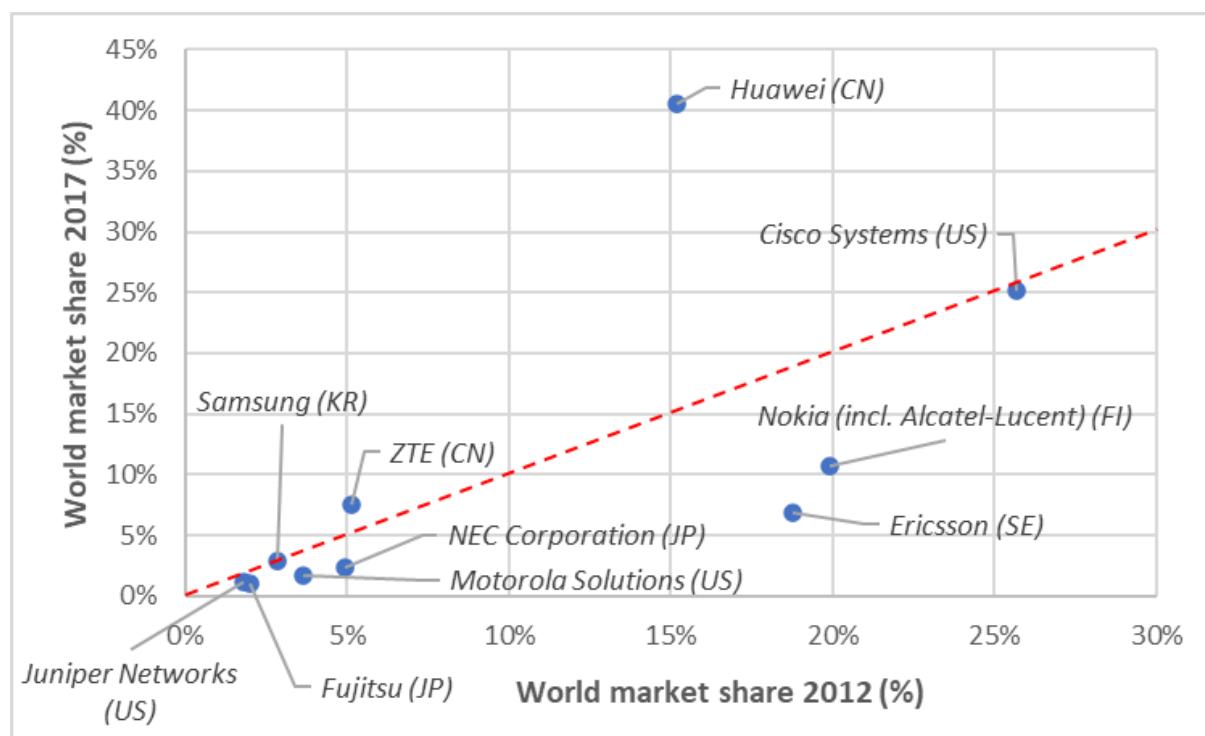
<sup>345</sup> [https://europa.eu/rapid/press-release\\_IP-19-2868\\_en.htm](https://europa.eu/rapid/press-release_IP-19-2868_en.htm)

18%. Cisco Systems and Samsung could preserve their relative positions over time. Yet Huawei became clearly the leading company in this market segment with an average CAGR of 29.5% compared to 6.4% CAGR for the top-10 companies as a whole.

However, this overall picture has to be somewhat qualified in the sense that the relative market positions change if an analysis of market share in niche markets is performed. In the **Carrier Networks segment**, the lead position of Huawei remains uncontested, yet is followed by Nokia after having acquired the equipment manufacturer Alcatel-Lucent in 2016. Ericsson is ranked third before the NEC Corporation and ZTE. In the **Telecoms Software Systems and Services segment**, the major suppliers are mostly US-based with the undisputed market leader Cisco Systems followed by Fujitsu and Juniper Networks. Ericsson and Huawei are also growing fast on this segment. In the field of **5G end-to-end manufacturing**, according to interviewees, there are only five major players including Qualcomm, Huawei, Nokia, Ericsson and Samsung. When looking at advanced modem technologies to be used in mobile vehicles and advanced Industry 4.0 applications where reliability is a key issue, there are apparently only non-European players: Huawei and Qualcomm which are dominating that particular market segment.

According to an expert from Qualcomm, they are not expecting this to be different in the coming five years due to the lead in specific know-how, patents, technologies and appropriate production facilities. Even when the technology is designed by Qualcomm, the production is mostly outsourced to Asia, notably Taiwan and South Korea, due to specific expertise and scale gained over the years.

**Figure 4-11 : Market share of top-10 global telecommunications infrastructure providers in 2012 and 2017**



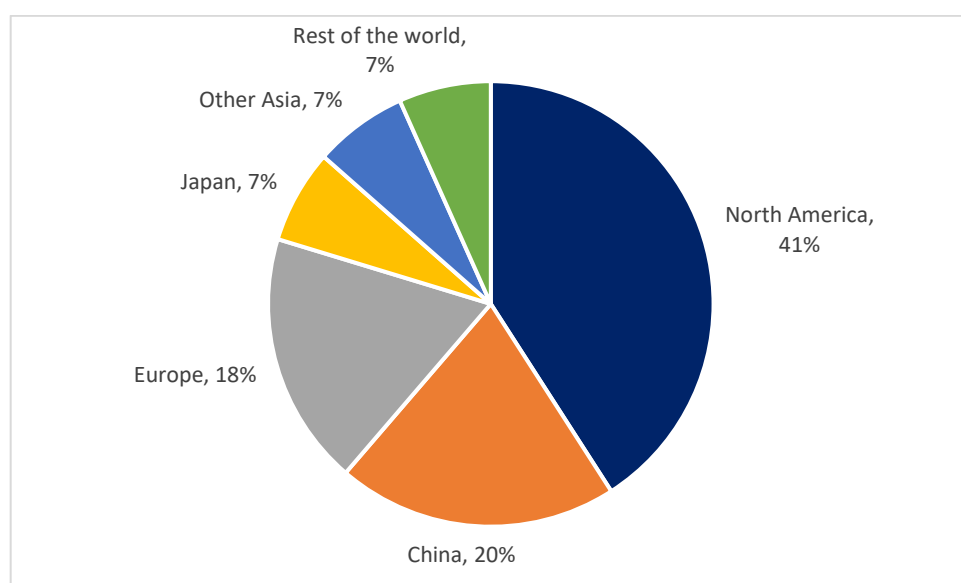
Source: IDEA Consult based on data from Decision Études & Conseil (2020) and updates.

Note: Data are derived from individual company reports. Figures cover the companies' net sales in telecommunication infrastructure only. Data are as of July 2020. Market shares are approximated by the company's net sales related to the total net sales of the global top-10 companies that have been identified.

Within the field of the sector of **Medical and dental instruments and supplies** (NACE 32.5) and its digitalisation, it has been argued that the EU still has some historical players but is not expected to lead. The US dominates this market segment with 41% of global

production, see Figure 4-12. This has been confirmed by interviews indicating that the US is typically stronger in digital innovations in this sector. The US is for instance leading on AIMD (active implantable medical devices) and is expected to retain the highest market share in the digital health market<sup>346</sup>. China and South Korea (Samsung) on the other hand have strong emerging players in diagnostic imaging and digital health. Europe has leading companies with Philips (NL), Siemens (DE), LivaNova (UK), Biotronik (DE). Japan also has strong historical players in this sector, but current surveys show low adoption potential for connected health devices in Japan. Overall new developments are expected in the areas of virtual reality, AI, IoT, connected wearables, e-health and virtual health care, nanomedicine, robot-assisted surgery and 3DP<sup>347</sup>.

**Figure 4-12 : Global healthcare electronics production by geographic area, data 2018**



Source: Décision Études & Conseil (2020)

In various Member States and non-EU countries the COVID-19 health crisis has given this subsector more visibility and policy focus. The European Commission has launched various initiatives to counter COVID-19 among which the set-up of an interoperability solution for mobile tracing and warning apps, access to medical devices, development of a platform for sharing clinical, virological and epidemiological data, the EU vaccines strategy, a needs overview of medical equipment, supplies and production facilities, support of joint procurement of medical equipment (protective equipment, ventilators, laboratory equipment, intensive care medicines<sup>348</sup>. It can be expected that these measures reinvigorate this subsector's demand which will ultimately have its positive effects higher in the value chain.

- In the field of **Artificial Intelligence** – a digital technology with disrupting effects on the entire engineering sector – Europe is in close competition with the USA (number one) and China (number three) with respect to the number of key players. The balance between industry and research players is, however, very different between the three.

<sup>346</sup> Embedded Intelligence: Trends and Challenges (2019). A study by Advancy, Commissioned by Artemis Industry Association.

<sup>347</sup> Gosh, I. (2019) 5 Ways Technology is Transforming the Healthcare Industry: <https://www.visualcapitalist.com/5-ways-technology-healthcare-industry/> and Decision Études & Conseil (2020)

<sup>348</sup> European Commission (2020) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Short-term EU health preparedness for COVID-19 outbreaks, COM(2020) 318 final, [https://ec.europa.eu/info/sites/info/files/communication\\_-\\_short-term\\_eu\\_health\\_preparedness.pdf](https://ec.europa.eu/info/sites/info/files/communication_-_short-term_eu_health_preparedness.pdf)



The US has three times more corporate players than research players. This corporate focus also translates in the number of AI start-ups that is highest in the US (almost half of all AI start-ups globally) and the size of venture capital (more than one third of the total). The opposite holds for China, where the number of research players is almost six times as high as the number of corporate players. The EU shows a balanced picture between corporate and research players. Regarding venture capital and start-ups, the EU holds a strong position with 27% of start-ups (versus 45% and 1% in the USA and China respectively) and 27% of venture capital (versus 37% in the USA and 14% in China)<sup>349</sup>.

- The EU shows the most balanced picture as to the AI topics it covers. The USA and Japan focus on speech recognition and natural language processing, while China primarily focuses on face recognition. Machine learning is popular in the EU and the US, closely followed by China. However, in terms of investments in AI, this is substantially higher in the US and China, compared to the EU. China has for instance put forward the explicit aim to become the global leader in AI by 2030 and has announced that \$150 billion is to be invested by the government over the coming decade<sup>350</sup>. In addition, local governments have already pledged \$7 billion to reach this target and the private sector is already very strong on AI. Baidu, for example, is becoming the global leader in speech recognition (DeepVoice-converted text, an almost humanlike voice and over 400x times faster than Google's DeepMind).
- According to some literature, and confirmed by some interviewees, the EU is falling behind the race in General AI (as China and the United States are becoming too dominant). It was however argued that the EU should leverage its dominant position in the B2B market, noting that Europe should better try to monetize the very valuable data generated in industrial processes in the B2B context. It was argued that Europe could still be a global leader in the field of Industrial AI (for example, companies such as Bosch and Siemens could play an instrumental role here).
- **Component and module makers (NACE 26):** Europe has a strong position in the areas of components and module manufacturing, especially in the field of semiconductors<sup>351</sup> (flanking policy measures have also been taken in Europe to keep semiconductors production in Europe, e.g. ECSEL-JU). Leading European companies include STMicroelectronics (which has a strong portfolio of sensors and similar components), Infineon (DE), ASML (NL, in the field of lithography), Telit (IT), and Cybus (DE). Europe also has a strong position in the field of the miniaturization of sensors and their automatization and integration in industrial systems. Europe is however losing ground to North America, but especially to East Asia which has outpaced the rest of the world regarding the share of internationally filed patents in semiconductor technologies and related digital technologies. Controlling these stages is strategic, as suggested by the gigantic efforts being made by China to build a domestic semiconductor champion (over \$100B)<sup>352</sup>.
- Within the field of the sector of **Medical and dental instruments and supplies** (NACE 32.5) and its digitalisation, it has been argued that the EU still has some historical players but is not expected to lead. It has been stated that the US is typically stronger in digital innovations in this sector. The US is for instance leading on AIMD (active implantable medical devices) and is expected to retain the highest market share in the digital health market<sup>353</sup>. China and South Korea (Samsung) on the other hand have strong emerging players in diagnostic imaging and digital health. Japan also has some strong historical players in this sector, but current surveys show low adoption

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<sup>349</sup> European Commission Joint Research Centre (2018). Artificial Intelligence: A European Perspective

<sup>350</sup> <https://www.cnbc.com/2017/07/21/china-ai-world-leader-by-2030.html>

<sup>351</sup> ATKearney (2016). Rebooting Europe's High-Tech Industry.

<sup>352</sup> <https://www.csis.org/analysis/chinas-pursuit-semiconductor-independence>

<sup>353</sup> Embedded Intelligence: Trends and Challenges (2019). A study by Advancy, Commissioned by Artemis Industry Association.

potential for connected health devices in Japan.

- Europe holds a strong position in innovative **advanced manufacturing technologies**<sup>354</sup>. Especially in the field of additive manufacturing or 3DP technologies, Europe is a leading region<sup>355</sup>. 3DP has important potential in medical electronics and equipment, as well as in other subsectors of the engineering and beyond that in non-engineering industries. It can be considered as a key element in Industry 4.0<sup>356</sup>. The applications in an IoT context are numerous, as well as the production possibilities in combination with robotics. Together these technologies allow for more decentralised production systems, reducing the risks of interruptions in global supply chains, as has been shown by the global COVID-19 crisis.
- In terms of **system and software technology and analytics** - which is becoming increasingly important for the entire engineering sector and is responsible for a growing share of value added – the EU is in a weak position compared to the US.<sup>357358</sup> Europe also has a relatively weak position in the field of enabling solutions providers (e.g. cloud, big data, interfaces, digital twins). Dominant players here are the US-based firms Google, Amazon and Microsoft. A notable example of a strong European player is SAP, which for instance has embedded IoT capabilities in many of its enterprise solutions.

Experts have also claimed that the EU is well positioned in the field of B2B, while the US is much stronger in the B2C market (which is also more driven by software developments). However, given that increasingly innovation is driven by the end-customer/client and that B2C players are gradually penetrating the market of typical B2B firms, Europe's positioning is of concern.

- Interviewees have also argued that the EU engineering industry is typically well placed in the digital domains **of predictive maintenance, machine learning, smart sensors, mechatronics, edge computing and digital monitoring**.
- In terms of (digital) innovations in application domains (which use intermediary inputs of the engineering industry) the EU stands out and is leading the changes in *transport & smart mobility, energy and digital industry*<sup>359</sup>. The EU also has a leading position in the automotive sector, but is being challenged on electrification, and V2X infrastructure. Europe is however lagging behind in the field of (cognitive) platforms for autonomous vehicles. Non-European leaders include Nvidia, Tesla and Baidu.
- In the field of **cloud computing**, several interviewees argued that Europe previously held a strong position but that this market is now dominated by non-European players (especially those from the United States). As documented by Gartner, the global public cloud computing market is currently dominated by Amazon Web Services (47.8%), followed by Microsoft Azure (15.5%), Alibaba (7.7%), Google (4%) and IBM (1.8%). None of these players are European<sup>360</sup>. Geopolitical tensions and trade wars, however, are stimulating European policy makers and larger enterprises to become more cautious about storing data in the cloud on American or Chinese servers. This was also observed by several interviewees. The interviewees welcomed the European Cloud Initiative<sup>361</sup> and the decision by France and Germany to work together to launch a

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<sup>354</sup> [http://europa.eu/rapid/press-release\\_MEMO-12-484\\_en.htm?locale=FR](http://europa.eu/rapid/press-release_MEMO-12-484_en.htm?locale=FR)

<sup>355</sup> Wohlers Report 2018

<sup>356</sup> See e.g. Van de Velde and Kretz (2020) Advanced Technologies for Industry – Product Watch 3D printing of hybrid components, European Commission, May 2020, <https://ati.ec.europa.eu/sites/default/files/2020-06/Product%20Watch%20Report%203DP%20Hybrid%20Components.pdf>

<sup>357</sup> ATKearney (2016). Rebooting Europe's High-Tech Industry.

<sup>358</sup> Bloomberg (2018). Why Can't Europe Do Tech? <https://www.bloomberg.com/news/features/2018-08-16/inside-europe-s-struggle-to-build-a-truly-global-tech-giant>

<sup>359</sup> Embedded Intelligence: Trends and Challenges (2019). A study by Advancy, Commissioned by Artemis Industry Association.

<sup>360</sup> <https://www.gartner.com/en/newsroom/press-releases/2019-07-29-gartner-says-worldwide-iaas-public-cloud-services-market-grew-31point3-percent-in-2018>

<sup>361</sup> <https://ec.europa.eu/digital-single-market/en/%20european-cloud-initiative>

European Cloud Service, called Gaia-X<sup>362</sup>. The aim is to make Europe more independent from American and Chinese providers.

A strength of Europe that is not linked to a particular industry or scientific field is Europe's culture and tradition of creating innovation ecosystems consisting of not only companies but also of higher education institutes, RTOs, policy institutes, sector organisations and public-private partnerships. This multiple helix innovation approach can prove to be a very valuable asset within the context of Industry 4.0 where collaboration among stakeholders is becoming increasingly important. On top of that, setting up and strengthening these ecosystems is a process of multiple years and it is not something that can be easily replicated in other regions.

#### **4.4.3 Role of big data in a smart factory/ industry 4.0 context in optimising production efficiencies and EU policy framework**

Technological advances in smart factories result in the **continuous collection of big data generated by production systems**. Such data can enable manufacturers in the engineering sectors to strengthen operational monitoring, identify any production anomalies that need addressing, provide enhanced security, predictive and preventative maintenance, and improve supply-chain management. Many companies invest in sensors that gather big data from smart factories which can report on manufacturing processes and any production problems, such as through non-conformance reporting.

Big Data in advanced manufacturing also helps to **facilitate IT systems' integration across different production facilities** that previously operated in siloes. This can give companies a clearer overall picture of manufacturing processes. Data collection and analysis can be automated. Big data can therefore help to optimise production efficiencies across different digital production hubs located in different countries globally and/ or in the EU. The **Industrial Internet of Things** plays an important role in connecting and integrating different IT systems and has different analytical capabilities. Production managers in engineering firms and data scientists working for such firms can obtain useful real-time data to strengthen the efficiency and effectiveness of production.

Looking to the next decade, the importance of **data analytics in digital manufacturing** is likely to grow. This will enable EU engineering firms to "make better decisions, minimise production risks, and improve their manufacturing processes by increasing efficiency, reducing waste, and improving product quality".<sup>363</sup> It may also increase the market power of large enterprises that own the data and control access to and sharing of data, which could be a disadvantageous for smaller enterprises. Data are also potentially vulnerable to being hacked, and some cases of malicious hacking leading to waste in factories and danger to staff have been recorded. A single cyberattack can negate the benefits derived from a smart factory, like real-time data monitoring, supply chain management, and predictive maintenance.<sup>364</sup> Ransomware demands can also paralyse a smart factory.

The **European Strategy for Data**<sup>365</sup> aims to bring about a Single Market for data by reducing the fragmentation of data; improving the availability of data for re-use; increasing the use of public sector data by the private sector; sharing and using privately-held data by other companies; and facilitating the use of privately-held data by government authorities; sharing of data between public authorities; reducing imbalances

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<sup>362</sup> <https://www.euractiv.com/topics/gaia-x/>

<sup>363</sup> <https://blog.datumize.com/big-data-in-smart-manufacturing>

Irving Wittenbur, a writer with DO Supply, Inc. who writes about Automation, Robotics, and Manufacturing.

<sup>364</sup> <https://www.trendmicro.com/vinfo/hk-en/security/news/internet-of-things/security-threats-and-risks-in-smart-factories>

<sup>365</sup> European Commission, 19.2.2020 COM(2020) 66 final A European strategy for data

in market power; improving data interoperability and quality; data governance; and, data infrastructures and technology.

The ability for EU engineering firms to share data confidentially on an interoperable basis with other firms in industry, and across borders, for example, to compare production efficiencies with industry peers, or to increase the volume of data available for big data analytics to help solve production problems or challenges is an example of the way in which an EU policy and regulatory framework – supported by practical data sharing initiatives to encourage industry to share data open access to the mutual benefit of the industry could be considered.

## 4.5 INVESTMENTS IN DIGITALISATION

Investments in digitalisation by the EU engineering industry are necessary to retain competitiveness with other major global competitor countries in the world.

Whilst there is an **absence of comprehensive data at EU level** about the actual amounts invested in digitalisation in the EU engineering industry across the different sub-sectors in comparison to other parts of the world, nonetheless, some surveys point to a **disparity between levels of investment in digitalisation by EU manufacturers (especially SMEs) compared with other competitor countries.**

Evidence from Eurostat suggests that **SMEs have little means or incentive to invest structurally into the digitalisation of their operations** with larger enterprises developing a strong interest in being capable to treat big data generated by their activities. Engineering sectors in particular use 3D printing to develop and produce new products and consequently invest in software and developing necessary skills. Of the sectors considered, this technology is used by two thirds of manufacturers of computer, electronic and optical equipment in the EU + UK. In ICT investment, relative to GDP, European countries rank well and over half are on par with The United States and Japan.

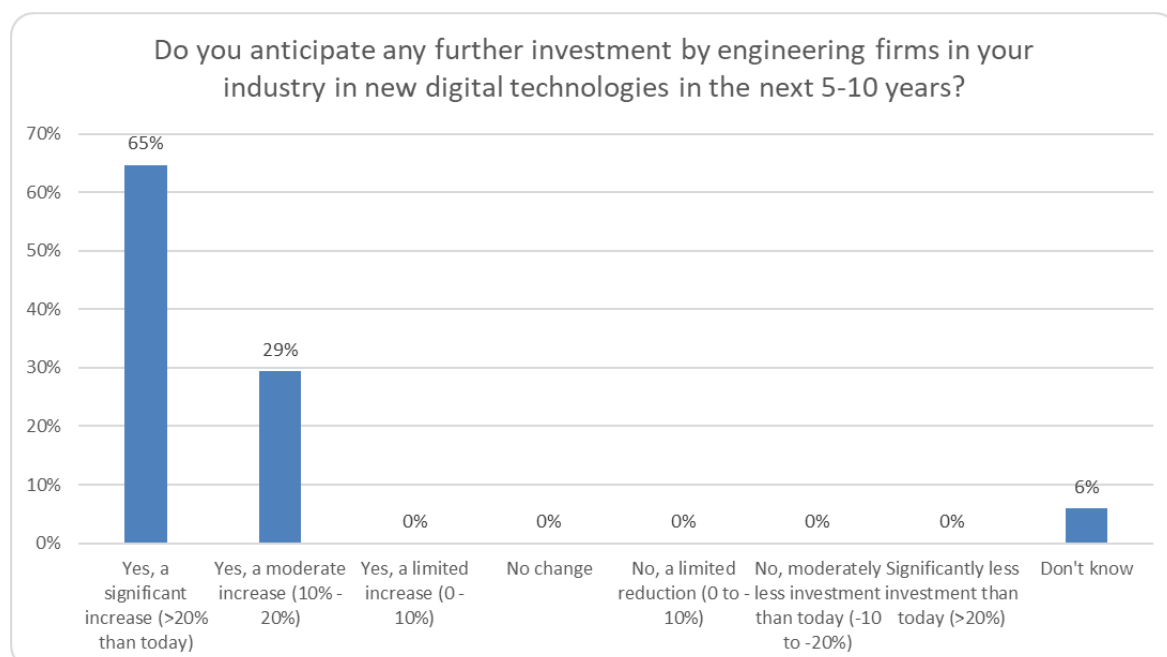
From a foreign direct investment perspective, it can be observed that the EU27 and the UK host an important group of large engineering and ICT multinationals, especially in the telecommunications and engineering sectors. Multinationals in computer and data processing are virtually all non-EU companies supporting the view that in the software segment of the digital market especially non-EU MNEs are present.

### 4.5.1 Evidence from surveys and interviews

Survey data has been reviewed pertaining to the extent of digitalisation by firms in Europe compared to other major competitors. Whilst this data often covers manufacturing in a broader sense, rather than engineering, it nonetheless sheds light on some of the challenges as regards making sufficient investments in digitalisation to remain competitive.

The **survey of manufacturers and the survey of industry associations** asked respondents whether looking ahead to the next 5-10 years, they **anticipated further investment by firms in new digital technologies.** As the figure below shows, industry associations expect an increase in the coming 5-10 years, with just under two-thirds stating a significant increase of more than 20% in investment, and 29% between a 10% and 20% increase (6% responded don't know).

**Figure 4-13- Do you anticipate any further investment by engineering firms in your industry in new digital technologies in the next 5-10 years?**



Source: Eurostat; digital economy and society; ICT usage in enterprises; e-business; 3D printing and robotics, 2020

Source: CSES' Survey of Engineering Industry Associations and Professional Associations of Engineers

Investment in digitalisation by the EU engineering industries is driven not only by the need to optimise production efficiencies and respond to challenges such as increased competition from competitors who have automated and robotised production, but also the fact that the products they are producing are becoming **increasingly smart and connected**. For example, a major 2018 global survey by Cap Gemini<sup>366</sup> looked at the future plans of over 1,000 engineering companies worldwide. It estimated that the size of the "smart, connected products globally will increase to \$685 billion by 2020. "Manufacturers estimate that close to 50% of their products will be smart and connected by 2020, a 35% increase from 2014".

Regarding the level of investment in digitalisation by firms surveyed, the data covered respondents globally rather than specifically in Europe. Nonetheless, the results are interesting. "Around 50% of manufacturers aim to spend more than 100 million euros in Product Lifecycle Management (PLM) platforms and digital solutions in the next three years". A qualitative finding from the Cap Gemini study was that digital technology investments are needed not only in hardware in factories but also in areas such as ensuring that digital twins are produced so that factories have a virtual inventory, and developing IoT platforms to enable seamless digital continuity.

In the absence of reliable EU-level sectoral quantitative data on the extent of digitalisation by the EU engineering industry, a **qualitative assessment** was also undertaken of issues raised relating to investments in digitalisation through the interview programme.

Interviews undertaken pointed to some competitor countries being considerably ahead as regards the level of digitalisation and the adoption of specific technologies, such as the

<sup>366</sup> Cap Gemini, 2018, Digital Engineering, The new growth engine for discrete manufacturers, by Capgemini Digital Transformation Institute, <https://www.capgemini.com/resources/digital-engineering-the-new-growth-engine-for-discrete-manufacturers/>

use of robotisation and automation in production processes. This was especially the case in high-technology industries, such as semi-conductors and components production.

Some feedback was received from interviews however in relation to the importance of making investments in digitalisation, and the challenges of doing so for SMEs. For instance, a national engineering association in Central and Eastern Europe mentioned that there were high costs of digitalisation, and therefore, large firms (and multinational inward investors) tended to be much more digitalised, especially as regard automation and robotisation in factories compared with SMEs. Moreover, the fact that digitalisation of production facilities is becoming more capital-intensive was also mentioned.

A particular problem raised from the perspective of some SMEs was that they are being required to invest in digitalisation as part of their supply chain responsibilities by larger firms and that this does not always lead to return on investment (RoI) that justifies the necessary scale of investment.

A further issue raised through the interview programme was that significant investments in digitalisation are needed not only at the level of individual manufacturers, but also in building appropriate infrastructure and technology platforms and investing in skills to enable a supporting enabling environment to be put in place that would support EU engineering firms to embrace digital transition.

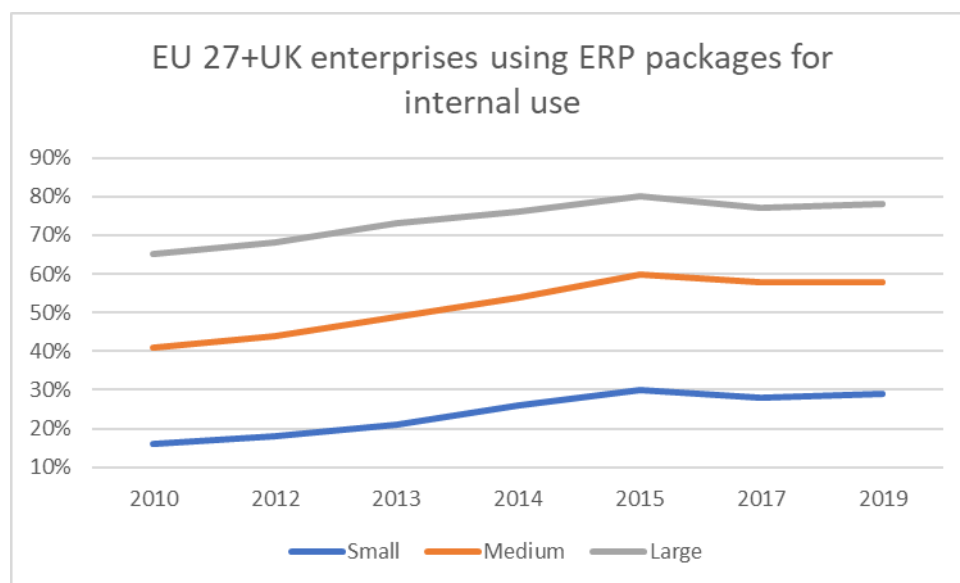
For example, transforming the academic breakthroughs to high TRL technology platforms. These will enable local technology uptake by existing European industry or via the creation of new industrial players. The three major RTO's have delivered a plan to the EC for structural collaboration on the key enabling technology platforms for distributed high performance computing and artificial intelligence. This will enable Europe's sovereignty in critical building blocks for the future deployment of AI and HPC from the cloud infrastructure, over the edge to the extreme edge or IoT components.

Lastly, Prognos' digitalisation patent data could also be used as a proxy for future investment behaviour (see Section 4.8).

#### ***4.5.2 Investments in digital technologies in Europe***

While specific investment amounts in Europe are context-specific to each country, the use of specific digital technologies over time indicates with more certainty into which digital technologies firms are investing into and European industries are interested in. As such, we look at the use of ERP software, big data, 3D printing as well as ICT investment in general.

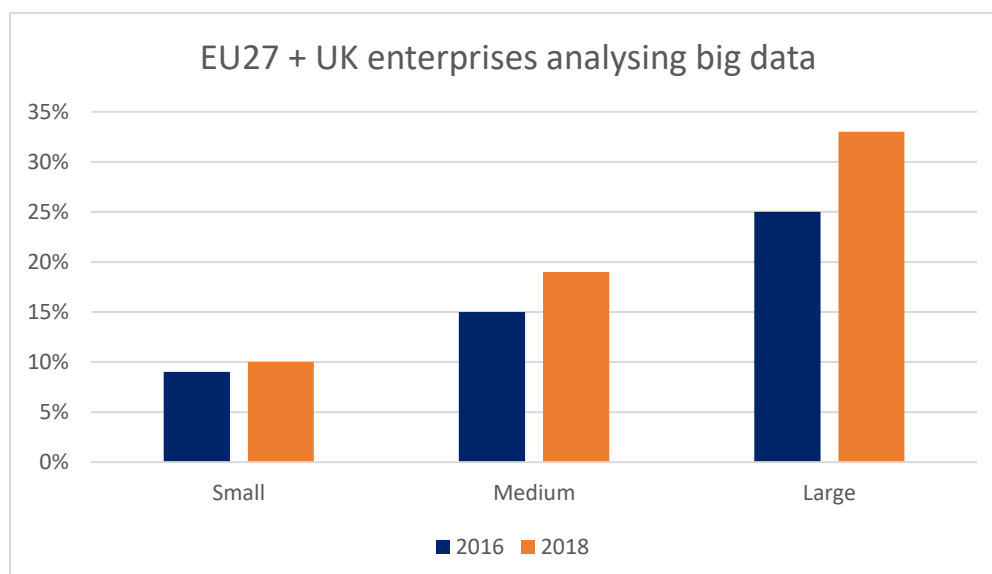
**Figure 4-14 Percentage of enterprises who use ERP software packages to share information between different functional areas**



Source: Eurostat; Digital economy and society; E-business; Integration of internal processes, 2020

The above figure shows an average uptake of 15% in ERP software usage between 2010 and 2019 for all EU + UK enterprises, not accounting for the financing sector. Small, medium and large enterprises in the EU + UK have continuously increased their use of 'ERP software packages to share information between different functional areas'. This demonstrates a wish of these enterprises to digitise their internal operations, in order to make them more efficient and effective as they create and process data allowing them to structure their work and operations not only qualitatively but also quantitatively. While 78% of large enterprises use ERP software packages, only 29% of small enterprises use them in 2019, suggesting a lack of funds, need or interest to invest in ERP software for internal use.

**Figure 4-15 Percentage of enterprises analysing big data from any data source**

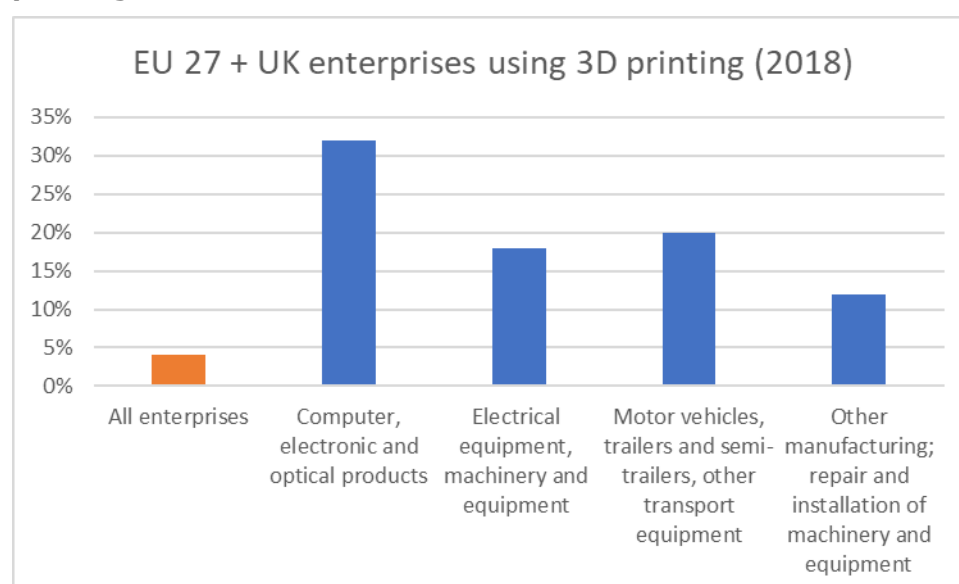


Source: Eurostat; Digital economy and society; ICT usage in enterprises; E-business; Big data analysis, 2020



For the time period available for analysis it is important to point out that enterprises employing over 250 people (Large) in the EU + UK invested relatively more into data analytics capabilities than smaller enterprises. In fact, the share of large enterprises analysing big data increased by 8% between 2016 and 2018, while it only increased by 4% for medium, and a mere 1% for small enterprises in the same timeframe. This suggests that large enterprises proportionally have a bigger incentive and more means to analyse big data than smaller firms, giving them more momentum. This observation is in line with the finding from interviews, as mentioned in the previous section as larger firms heavily invest especially into automation and robotization in their factories and warehouses, which SMEs do not. Evidently small enterprises would benefit as well from improved data analytic skills and capabilities yet the transition towards connectivity, collecting and valorising data, requires not only capital but a widened skills portfolio as well as adjusted business model. From the interviews and contributions to the webinar it became clear that one of the major hurdles for SMEs is the absence of free standard IoT protocols, language, platforms. Currently there is a myriad of proprietary solutions offered, mostly by larger companies, with substantial costs for SMEs and the danger of lock-in.

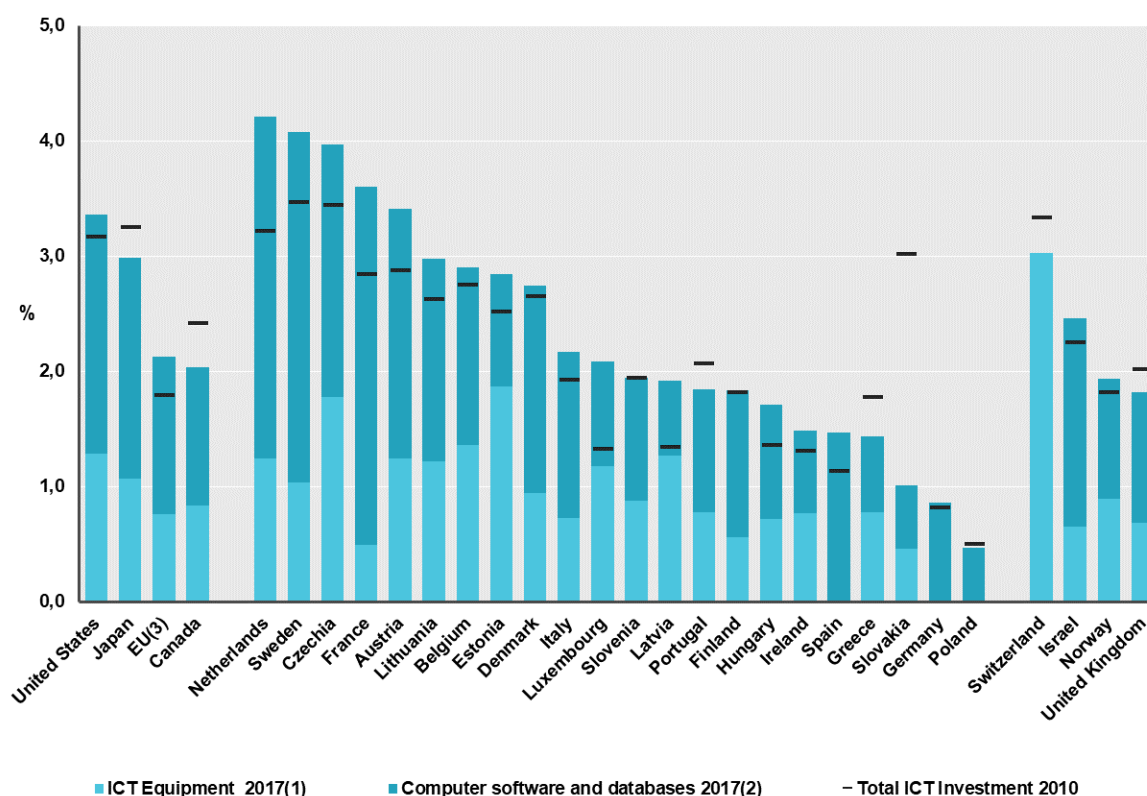
**Figure 4-16 Percentage of enterprises in different engineering sectors using 3D printing in 2018**



Source: Eurostat; digital economy and society; ICT usage in enterprises; e-business; 3D printing and robotics, 2020

With 3D printing experiencing considerable growth rates in industrial applications, it is worthwhile analysing which engineering-related sectors exactly are incorporating 3D printing technologies most enthusiastically. The Figure above shows that of the four sectors selected, 3D printing solutions are most sought after for the manufacturing of computer, electronic and optical products, with a third of enterprises (32%) in this sector seeking the technology. This requires enterprises to be able to design and/or advise on digital files containing product designs and consequently invest in software (CAD, CAM, CAE, etc.) as well as hardware (3D printers, finishing equipment, etc.). This form of digitalisation leads to a disruption in the manufacturing sectors' value chains as individual parts no longer need to be transported and stockpiled, but are manufactured on demand and to individual specifications on sight.

**Figure 4-17 - Investment in ICT as % of GDP by country, 2010 and 2017**



Source: OECD (Capital formation by activity ISIC Rev4) and Eurostat (online data code: nama\_10\_gdp).  
 Note: (1) DK: 2015. LV, NO: 2016. (2) DK, EE, EL, PL: 2015. IE, ES, LV, PT, SE, NO: 2016. (3) EU value estimated with the available countries.  
 The number of countries is not the same in both categories.  
 Stat. link: <https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter54/figure-54-3.xlsx>

The above graph shows which countries invest relatively more in ICT. As such, Sweden, the Netherlands and the Czech Republic invested over 4% of their GDP in ICT, while Poland, Germany and the Slovak Republic invested less than 1% in 2017. It is interesting to note that the Slovak's Republic's ICT investment relative to their GDP has decreased since 2010 from 3.0% to 1.0% and the Netherlands share has increased from 3.2% to over 4.2%. The United States and Japan rank among the top six European countries in terms of investment in ICT in relation to GDP.

#### 4.5.3 Foreign direct investments by engineering and ICT sector companies

Although systematic and comparable investment data on a company level are not available, foreign direct investments may provide another view on the investments in digitalisation, especially from a cross-border angle. This is particularly important for the global market segment of digitalisation and engineering where the largest companies operate. Table 4.4 provides an overview of the engineering and ICT companies that are listed in UNCTAD's top-100 non-financial multinational enterprises ranked by their foreign assets in the year 2018. From the 100 major companies 24 belong to engineering and ICT. Of these 24 multinationals, ten have a Member State of the EU27 or the UK as their home economy or headquarter domicile, indicating that the large EU-based engineering and ICT multinational enterprises (MNEs) do play an important role on the global digital and ICT market, yet not alone. The EU digital and ICT MNEs are mostly present in telecommunications (five enterprises) and contain four engineering giants Siemens AG, Schneider Electric SA, Johnson Controls International Plc and Medtronic Plc. Computer and data processing activities are mainly performed by non-EU MNEs, supporting the

observation made earlier that the software side of the digital market is mainly dominated by large companies from the US, China, Japan and Taiwan.

The share of foreign assets in relation to the total assets is for the ten EU engineering and ICT MNEs is significantly higher than that for the non-EU MNEs, namely 85% for the EU engineering and ICT MNEs and 49% for the non-EU engineering and ICT MNEs. This suggests that the degree of internationalisation has been stronger for the EU engineering and ICT MNEs while the non-EU MNEs have a relatively stronger home position. Taking the view that assets are the accumulation of investments over time, this implies that the EU MNEs have been relatively more active in investing on foreign markets than the non-EU companies. However, it should be borne in mind that the definition and delineation of a company's home country may influence the scope of what is considered 'foreign' investment in the data.

**Table 4-4 - Engineering and ICT companies in the list of UNCTAD's top-100 non-financial multinational enterprises ranked by foreign assets (million USD), 2018**

| Rank | Corporation                                 | Home economy             | EU27+UK | Industry <sup>c</sup>               | Foreign assets | Total assets | Foreign/total assets |
|------|---------------------------------------------|--------------------------|---------|-------------------------------------|----------------|--------------|----------------------|
| 4    | Softbank Group Corp                         | Japan                    | 0       | Telecommunications                  | 240 305        | 325 869      | 74%                  |
| 12   | Apple Computer Inc                          | United States            | 0       | Computer Equipment                  | 153 545        | 365 725      | 42%                  |
| 15   | Vodafone Group Plc                          | United Kingdom           | 1       | Telecommunications                  | 143 259        | 160 501      | 89%                  |
| 16   | General Electric Co                         | United States            | 0       | Industrial and Commercial Machinery | 134 637        | 309 129      | 44%                  |
| 17   | Siemens AG                                  | Germany                  | 1       | Industrial and Commercial Machinery | 133 891        | 160 800      | 83%                  |
| 26   | Amazon.com, Inc                             | United States            | 0       | E-Commerce                          | 115 397        | 162 648      | 71%                  |
| 27   | Microsoft Corporation                       | United States            | 0       | Computer and Data Processing        | 114 648        | 258 848      | 44%                  |
| 28   | Deutsche Telekom AG                         | Germany                  | 1       | Telecommunications                  | 112 360        | 166 447      | 68%                  |
| 31   | Hon Hai Precision Industries                | Taiwan Province of China | 0       | Electronic components               | 106 644        | 110 609      | 96%                  |
| 34   | Telefonica SA                               | Spain                    | 1       | Telecommunications                  | 100 094        | 130 578      | 77%                  |
| 36   | Medtronic plc                               | Ireland                  | 1       | Instruments and related products    | 88 435         | 91 393       | 97%                  |
| 39   | Samsung Electronics Co., Ltd.               | Korea, Republic of       | 0       | Communications equipment            | 84 717         | 304 057      | 28%                  |
| 42   | Nippon Telegraph & Telephone Corporation    | Japan                    | 0       | Telecommunications                  | 82 633         | 201 274      | 41%                  |
| 45   | Tencent Holdings Limited                    | China                    | 0       | Computer and Data Processing        | 77 594         | 119 824      | 65%                  |
| 52   | Orange SA                                   | France                   | 1       | Telecommunications                  | 69 489         | 110 593      | 63%                  |
| 54   | International Business Machines Corporation | United States            | 0       | Computer and Data Processing        | 68 772         | 123 382      | 56%                  |
| 68   | Intel Corporation                           | United States            | 0       | Electronic components               | 56 080         | 127 963      | 44%                  |
| 71   | SAP SE                                      | Germany                  | 1       | Computer and Data Processing        | 55 128         | 58 955       | 94%                  |
| 75   | Alphabet Inc                                | United States            | 0       | Computer and Data Processing        | 53 296         | 232 792      | 23%                  |
| 78   | Altice Europe NV                            | Netherlands              | 1       | Telecommunications                  | 50 010         | 51 902       | 96%                  |
| 88   | Johnson Controls International PLC          | Ireland                  | 1       | Electric equipment                  | 45 302         | 48 797       | 93%                  |
| 89   | Sony Corporation                            | Japan                    | 0       | Consumer electronics                | 45 051         | 189 416      | 24%                  |
| 90   | Schneider Electric SA                       | France                   | 1       | Electricity, gas and water          | 44 894         | 48 384       | 93%                  |
| 92   | Oracle Corporation                          | United States            | 0       | Computer and Data Processing        | 44 576         | 137 851      | 32%                  |

Source: UNCTAD (2019) World Investment Report, Annex table 19

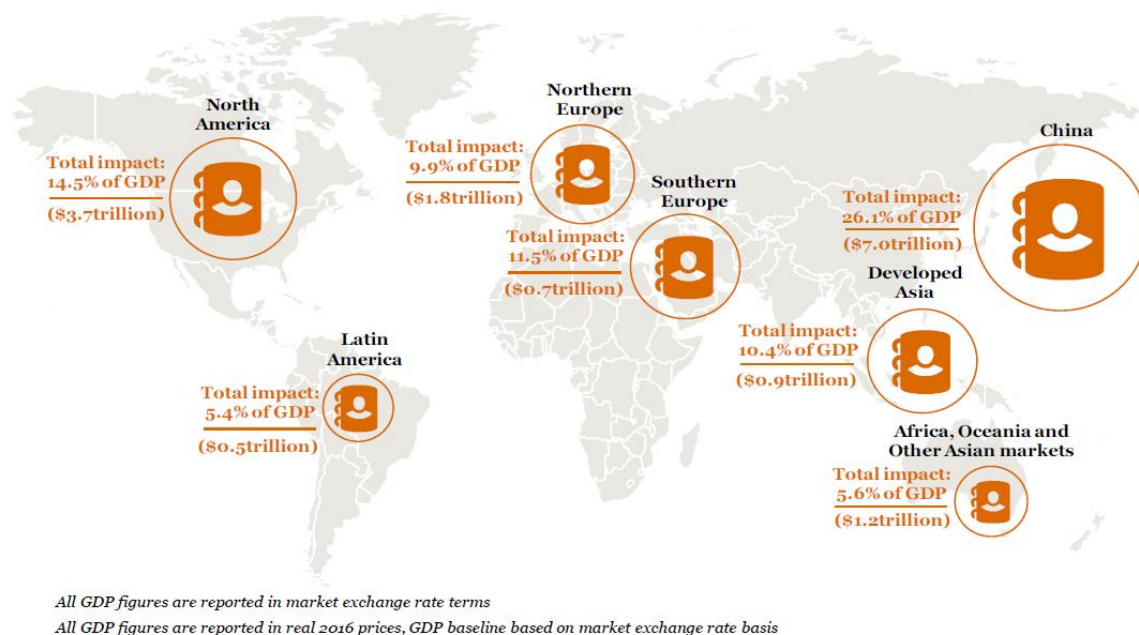
Note that Industry is defined here according to the US Standard Industrial Classification. The identification of the engineering and ICT companies is based on the sector classification in combination with expert insights of the companies. Although Schneider Electric SA has been classified by UNCTAD as a company in the Electricity, gas and water sector, it is classified in this study as an electrical engineering firm.

## 4.6 THE EFFECTS OF DIGITALISATION ON COMPETITIVENESS AND RESHORING

### 4.6.1 Competitiveness

Focusing on the AI technologies of digitalisation a recent report from PWC assessed the macro-economic impact in terms of GDP growth to be very positive for the US and China and moderately for Europe and Developed Asia with growth rates that range between 14% and 16% for the former group by 2030 and around 10% for the latter group for the same time period (also see next Figure).

**Figure 4-18: The economic impact of AI by geographic region according to PWC (2018)**



Source: (PWC, 2018), p. 48

Although the growth rates are impressive and need to be assessed in the context of the study methodology, these results suggest that the EU is expected to benefit less from AI and the transition that it generates than notably the US and China. This in turn renders the question what the effects in terms of competitiveness would be.

**Competitiveness can ultimately be perceived as a combination of cost efficiency on the input side and production, and the ability to tap into new business opportunities with profitable business models on the output side.** The effects of digitalisation run across all phases of the value chain. For instance, in the case of AI the following effects have been identified by the CREATE-IoT Large Scale Pilot Programme:<sup>367</sup>

- **Machine learning**, which is one of the main sub technologies of AI and Big Data analytics allows predictive maintenance especially if combined with sensors, leading to smaller error rates, and higher through put rates, focussing more on prevention of failures rather than solving them ex-post;
- Better **prediction of stock inventory needs**, more efficient response to demand changes, smarter and faster industrial processes;
- Application of **blockchain technologies** with improved traceability, increased

<sup>367</sup> Pérez-Freire L., Á.-D. M. (2017). IoT as a key pillar of EU digital economy. Brussels: European Commission.

reliability and potential for automatic B2B and B2C interactions;

- Enables **additive manufacturing** which in turn is more material efficient than conventional production methods generating less waste and uses less primary raw materials;
- Enables the **Internet of Things** generating shorter and faster communication, smart industrial processes, and automatic coupling with suppliers and distributors;
- Strengthens **automation and robotics** thereby reducing labour costs and allowing employees to undertake higher value-added work, with potentially higher wages and with better precision rates.

In the next phases of the project the intricacies of the effects of digitalisation on the competitiveness of the EU engineering sector will be further analysed and disentangled

#### **4.6.2 Reshoring**

There are several digital technologies that could have an impact on reshoring in the engineering industry. Interviewees have however indicated that these are mainly technologies that enable the automatization of industrial (production) processes (e.g. through robotics or advanced machinery) that have a positive impact on the reshoring of production activities of European industrial stakeholders. More specifically it has been argued that automatization and robotization processes make companies less dependent on labour. Accordingly, the ratio of labour versus capital in many production processes is shifting, making labour costs (which are typically considered as being very high in Europe) become less of an issue when a firm contemplates where its production facilities should be placed. On top of that, digitalisation makes many production processes more advanced, requiring at the same time increasingly more highly skilled labour. These factors make that production and assembly processes that were previously undertaken in countries abundant with low cost labour (typically is South East Asia), are increasingly reshored to Europe. At the same time, firms tend to locate these more advanced production facilities closer to their R&D facilities (which firms tend to locate typically close to HQ) to stimulate knowledge spill over effects.

Technological developments such as Digital Twins, which virtualize production lines and enable virtual prototyping and testing might also induce reshoring activities. Another factor that might be driving reshoring is the trend of customization and higher quality demands. This stimulates firms to produce closer to the customer and comply with higher (quality) standards. Finally, sustainability trends, higher logistics costs and shorter delivery terms might also play a role.

Examples of firms that are reshoring their engineering production activities are becoming more widespread. In the box below, we highlight the reshoring case of the production of razors by Philips. This case is becoming relatively old but is still very well known in Western Europe. Starting from 2011 onwards, the company reshored the production activities of its razors to Drachten in its home country. Previously, these activities were mainly located in China, but due to an increasingly strong focus on automatization and robotization it became more efficient to produce them in the Netherlands. At the same time, it safeguarded the local factory from closing.



#### Box 4-1: Reshoring example of Philips in Drachten



In 2011, Philips Drachten's management decided to focus substantially more on the automatization and robotization of its assembly and production processes of razors. This strategy has enabled Philips Drachten to reshore production from China. Initially only the mid – and high-end production has been brought back from China, but nowadays all production activities have been reshored. Currently, more than 150 highly advanced robots are working in Drachten's factory and the

management argues that these robots produce not only faster and better but are also cheaper. Furthermore, it enables the company to make more advanced products and takes customization more into account. This also enables more responsive production in the fashion driven shaver business.

Its assembly line is made up of dozens of glass cages housing robots made by Adept Technology that snake around the factory floor for more than 100 yards. Video cameras atop the cages guide the robot arms almost unerringly to pick up the parts they assemble. The arms bend wires with millimetric accuracy, set toothpick-thin spindles in tiny holes, grab miniature plastic gears and set them in housings, and snap pieces of plastic into place. In 2015, the factory received the Netherland Industrial Excellence Award and it was considered as one of the most efficient production facilities in Europe. The production facility also reaps the benefits from co-location with its R&D activities: product and process development are located in one site and literally "sit in one room". It has been stated that intense collaboration has led to tremendous cost reductions (via better design-for-manufacturing and more efficient product ramp-ups) but also to product innovation driven by process innovations (via enhanced design freedom through better manufacturing processes).

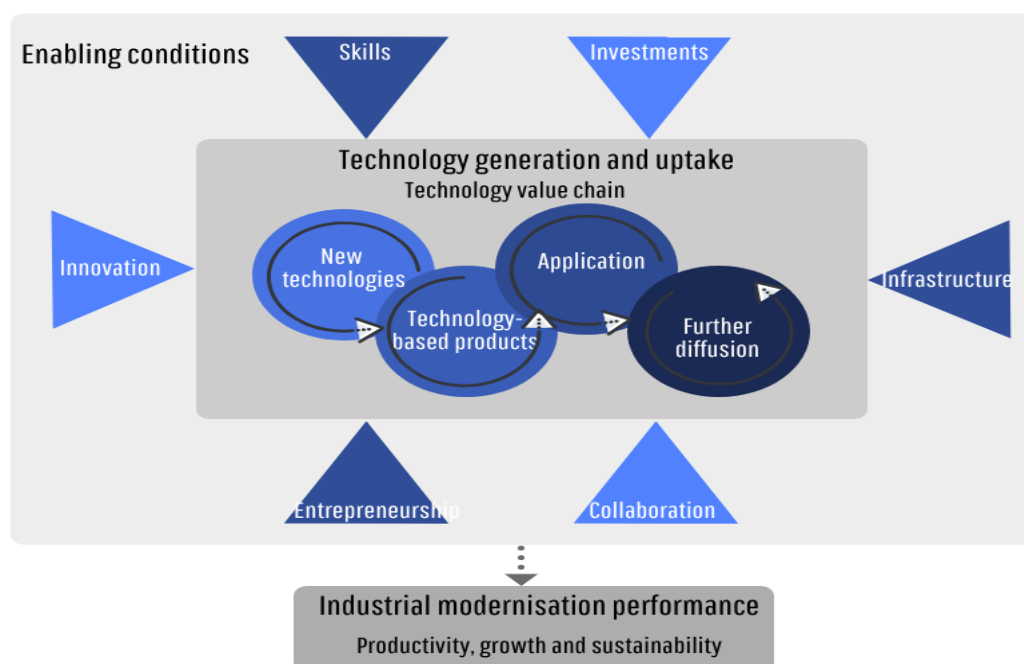
## 4.7 THE RELATIVE EXPORT PERFORMANCE OF THE EU ENGINEERING SUBSECTOR NACE 26 FOR DIGITAL GOODS

### 4.7.1 Identifying digital goods

For the quantification of *downstream effects* in other economic sectors via the use of digitalised products (components and final products) and services coming from the engineering industry, there is currently a lack of data. However, in the ongoing EASME-project on '**Monitoring digital transformation and key enabling technologies**' (EASMA/COSME/2017/043) a promising methodological framework has been developed to monitor '**Advanced technologies for industry**'. The main purpose of this study is to refine and align the monitoring activities of the Key Enabling Technologies (KET) Observatory, inventory and mapping of KETs Technology Centres, the Digital Transformation Monitor (DTM), the Digital Transformation Scoreboard and the mapping of city-models of technological transformation. The conceptual design of this project (further referred to as the ATI-project) focusses on the role of advanced technologies in industrial modernisation. In the context of industrial modernisation, advanced technologies are defined as recent or future technologies that are expected to substantially alter the business and social environment (4<sup>th</sup> industrial revolution).



**Figure 4-19: Conceptual building blocks to monitor advanced technologies for industry**



Source: Technopolis Group – further developed following TBM, KETs and DTM

The advanced technologies (having an enabling character) covered in the monitor of 'Advanced Technologies for Industry' include:

- Advanced materials
- Nanotechnology
- Micro- and Nanoelectronics
- Industrial Biotechnology
- Photonics
- Advance Manufacturing Technology
- **Robotics**
- **Internet of Things (IoT)**
- **Artificial Intelligence**
- **Security**
- Connectivity<sup>368</sup>
- Cloud Computing
- Blockchain<sup>369</sup>
- **Big data**

<sup>368</sup> Connectivity is not included in quantitative data collection efforts as it is considered to be mainly software based and therefore purely software-based components of these fields are hard to cover.

<sup>369</sup> Not included in quantitative data collection efforts as it is considered too narrow and not yet covering the full value chain.

- Advanced/Virtual Reality (AR/VR)<sup>370</sup>
- **Mobility technologies and enterprise mobility**

Among the above advanced technologies, the last 10 technologies can be classified as digital technologies of which the bold ones were quantified in the ATI-project. Referring to the definition used earlier in this engineering report, these advanced technologies (in bold) can be transposed to the engineering industry as these technologies were also identified as enabler for digital transformation and thus enabling the 4<sup>th</sup> industrial revolution.

Based on literature review and recommendations of the High-Level expert group on industrial technologies<sup>371</sup> each of the above-mentioned advanced technologies were defined (see Annex 4 of this report, which defines key terms across different advanced technologies). The definitions were chosen taking into account the objectives of the ATI-project, namely the creation of a data driven monitoring framework, and the context of industrial modernisation.

As a next step in the quantification each of the KETs and digital applications were assigned to manufacturing sectors to identify those sectors or activities (corresponding to NACE groups and classes) in which the particular KETs or digital applications are concentrated. This approach is based on the assumption that the invention of new technologies and their exploitation stick together<sup>372</sup>. Next, relevant digital and KETs based components were identified on the basis of existing literature, web searches, and expert views. The so-identified digital and KETS based components were used to compile lists of relevant Prodcom codes which represent digital and KETs components or - in a few cases - intermediary systems. Prodcom codes that represent end-products rather than components were excluded.

For identifying digitalisation goods coming from the engineering industry, a similar approach was used in order to assess how Europe and its Member States perform in the production of these digital components enabling the digitalisation of other sectors. However, since this is a time-consuming exercise this could not be done for the entire engineering industry within the scope of this study. Therefore, by way of illustration, the methodology was applied to subsector NACE 26 'Manufacture of computer, electronic and optical products' which is the third largest engineering subsector in terms of value-added creation and turnover.

#### ***4.7.2 EU relative export performance for digital goods from the computer, electronic and optical products engineering subsector (NACE 26): world leaders in particular niche markets***

##### ***4.7.2.1 World market share***

When looking at the relative importance of the EU engineering sector specialised in computers, electronic and optical products in terms of exports, both intra EU and extra EU, Figure 4-20 indicates that the EU27 + UK together counts for 16.9% of the total global trade in these goods. The far majority of the trade in digital goods of this subsector is captured by Asian countries. The Rest of the World category hosts Taiwan which counts for an estimated 8% to 9% of the global trade. Leading Taiwanese exporters of

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<sup>370</sup> Not included in quantitative data collection efforts as it is considered to be mainly software based and therefore purely software-based components of these fields are hard to cover.

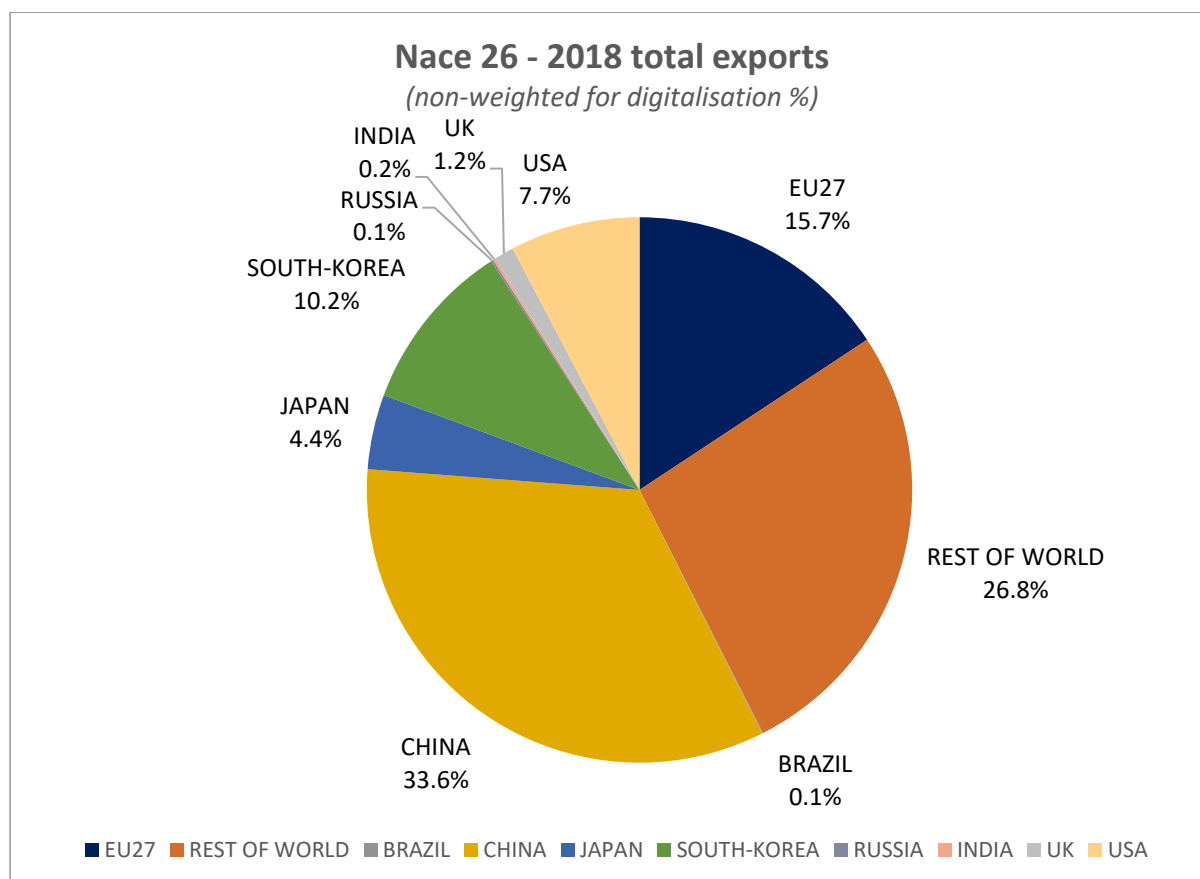
<sup>371</sup> [https://ec.europa.eu/info/research-and-innovation/research-area/industrial-technologies/industrial-research-strategy-key-enabling-technologies\\_en](https://ec.europa.eu/info/research-and-innovation/research-area/industrial-technologies/industrial-research-strategy-key-enabling-technologies_en)

<sup>372</sup> A similar reasoning can be found in classifying patents in patent families

semiconductors have been estimated to be 5 years ahead of Chinese semiconductor firms.  
373

The share of the EU27 as a whole is the double of that of the US, yet the shares of individual Member States are obviously smaller. The BRIC countries with the notable exception of China, have relatively small shares in the global export of this type of digital goods.

**Figure 4-20: The relative export performance in digital goods from the engineering subsector computers, electronic and optical products – data 2018**



Source: IDEA Consult, own calculations based on Eurostat

#### 4.7.2.2 Evolution over time

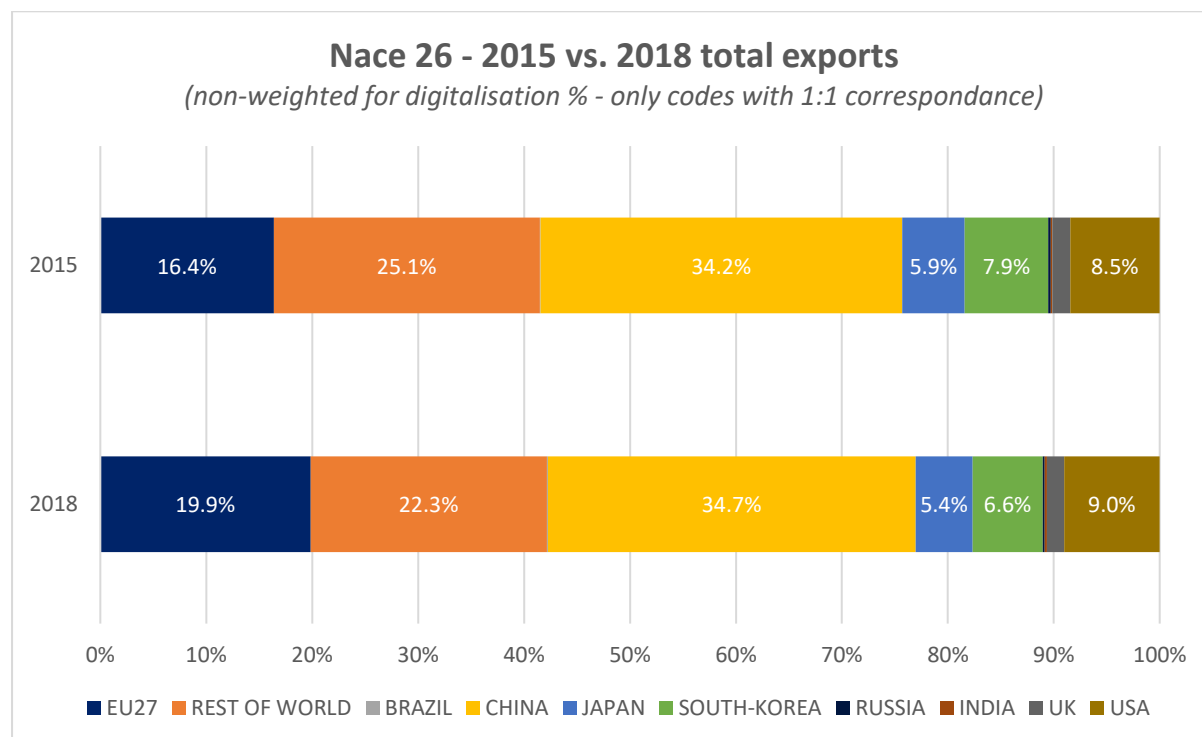
Evidently these numbers are only a temporary observation. In order to get a glimpse of the evolution over time a comparison was made with the situation in 2015. It has to be indicated that only for 59 out of 93 digital products data were available for making this intertemporal comparison. The 59 products represented 36.2% of total global export value in 2018, indicating that the results should be interpreted with care.

Figure 4-21 shows that the EU engineering sector gained ground with a share of 16.4% in 2015 and 19.9% in 2018. Compared to the growth patterns of other parts of the world this is a strong performance, as is shown in the subsequent Figure 4-22 which compares the % differences for each of the major countries.

<sup>373</sup> China's biggest chipmaker bets on Shanghai listing  
<https://www.ft.com/content/b60d7c99-1da1-452d-9396-68c5fa136fe1>

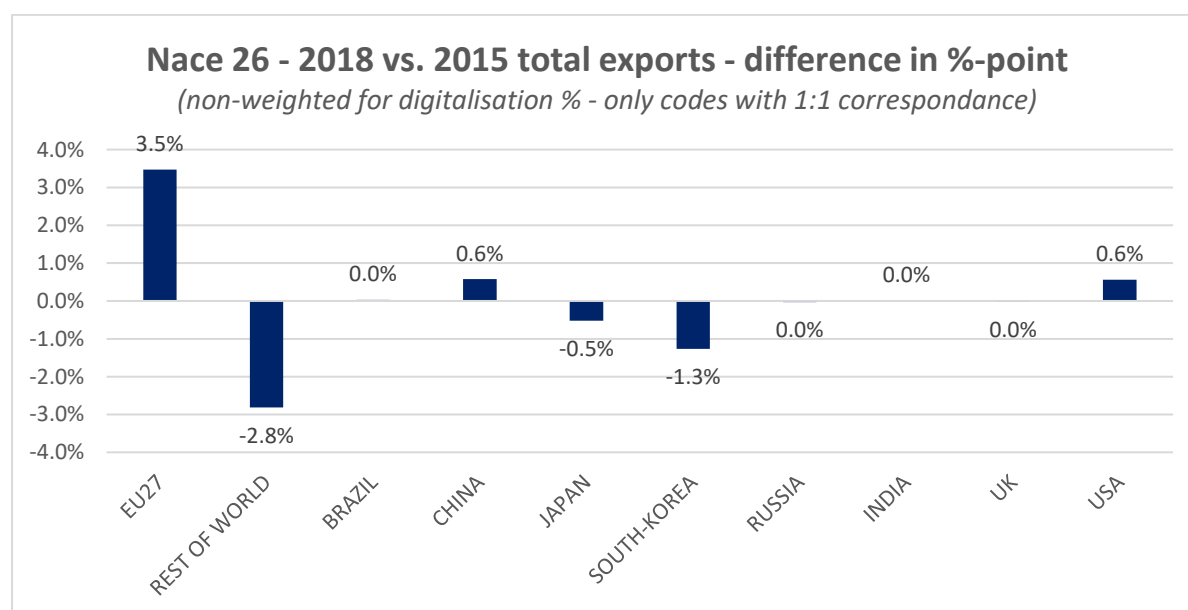
Again, one has to be on the side of caution since this analysis implicitly assumes that the 59 digital products for which data are available are representative for the entire group of 93 digital products.

**Figure 4-21: The evolution of the relative export performance in digital goods from the engineering subsector computers, electronic and optical products – data 2015 - 2018**



Source: IDEA Consult, own calculations based on Eurostat

**Figure 4-22: The percentage change of the relative export shares in digital goods from the engineering subsector computers, electronic and optical products by country– data 2015 - 2018**



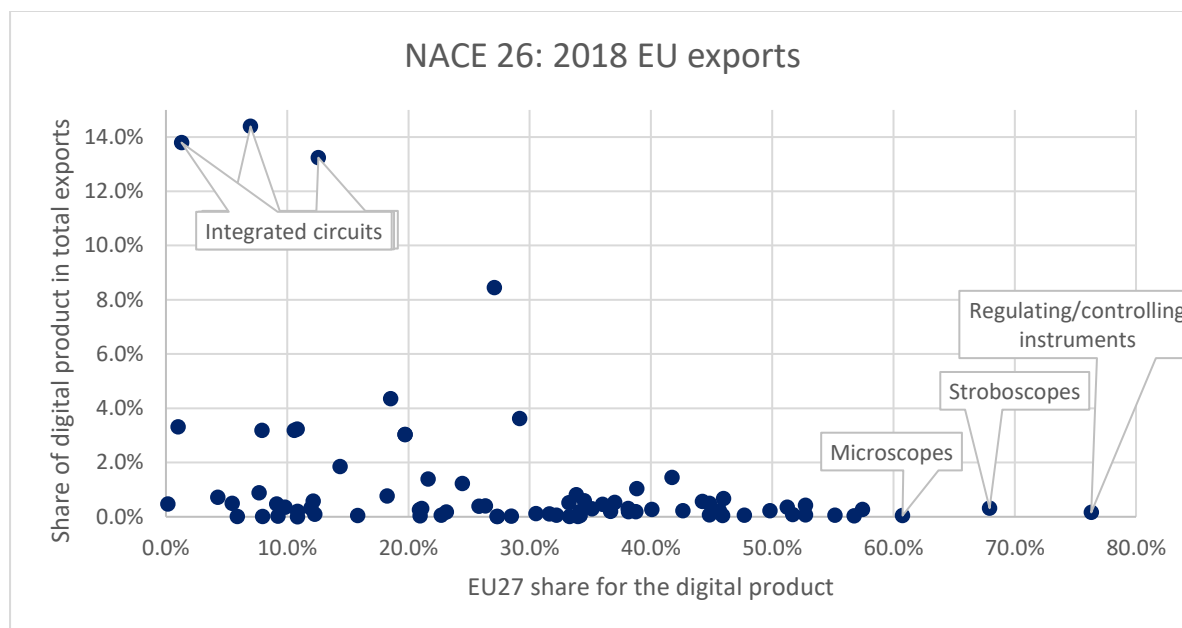
Source: IDEA Consult, own calculations based on Eurostat

#### 4.7.2.3 Specialisation pattern

Figure 4-23 provides an idea about the relative specialisation pattern for digital goods of the engineering industry specialised in computers, electronic and optical equipment. The vertical axis shows the relative importance of a particular digital product in the total world export in 2018. The horizontal axis shows the relative share of the EU27 for a particular product.

One observes that the EU27 is virtually not present in product niches with large export shares. These are the products on the top left, mostly integrated circuits.

**Figure 4-23: Relative specialisation pattern per digital product for computers, electronic and optical products – data 2018**



On the contrary the EU27 engineering industry shows leading positions for digital products with a rather small share in total exports (below 2%). These product codes mostly refer to "OPTICAL, PHOTOGRAPHIC, CINEMATOGRAPHIC, MEASURING, CHECKING, MEDICAL OR SURGICAL INSTRUMENTS AND APPARATUS; PARTS AND ACCESSORIES", which are oftentimes finished products put together with components elsewhere manufactured. Specifically, measuring devices, instruments, appliances and indicators are products that are in high demand from European manufacturers.

The digital products where EU27 engineering accounts for over 50% of exports are:

- 901420 Instruments and appliances for aeronautical or space navigation (excluding compasses)
- 852610 Radar apparatus
- 902610 Electronic flow meters (excluding supply meters, hydrometric paddle-wheels)
- 902810 Gas supply or production meters (including calibrated)
- 902820 Liquid supply or production meters (including calibrated) (excluding pumps)
- 902910 Revolution, production and entry counters, billiards meters, taxi-, mileometers, pedometers, hand-held counters, scalers, instruments/apparatus for measuring short time intervals
- 902920 Stroboscopes (including photographic or cinematographic cameras permanently incorporated in stroboscopes)

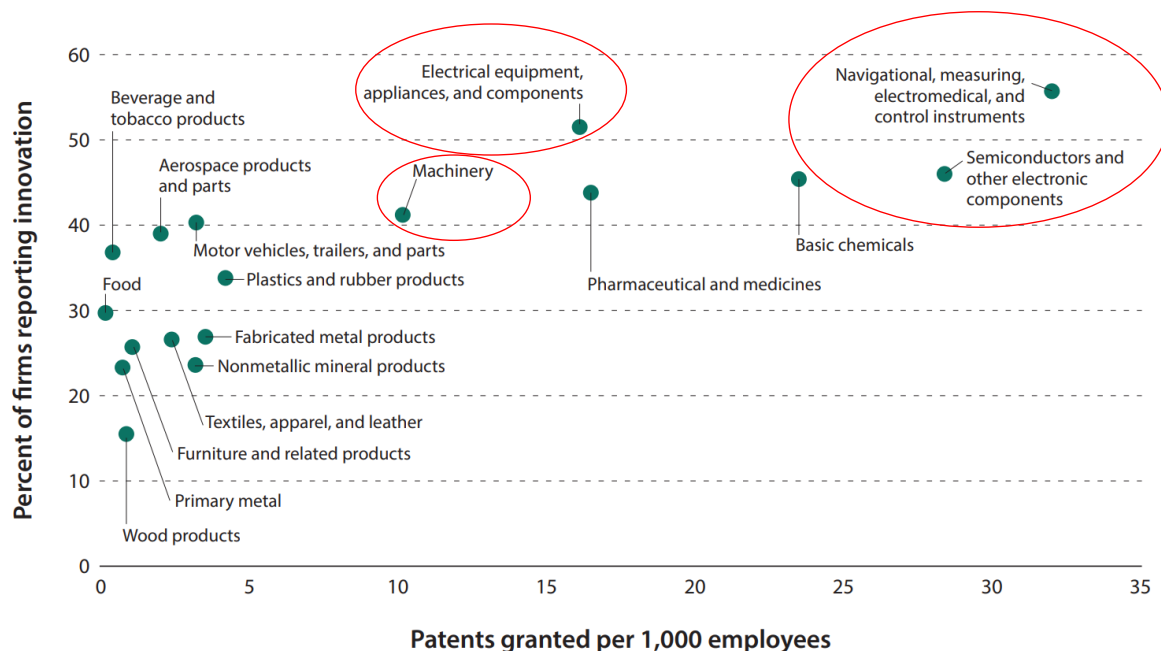
- 903180 Hydraulic or pneumatic automatic regulating or controlling instruments and apparatus
- 901820 Ultraviolet or infrared apparatus used in medical, surgical, dental or veterinary sciences
- 901110 Compound optical microscopes, including those for photomicrography, cinephotomicrography or microprojection

These data show that as far as the subsector of computers, electronic and optical equipment is concerned the EU engineering industry is a world leader in particular market niches, yet is virtually absent in digital product niches with the largest trade volumes. Although the data are not entirely comparable, a comparison with 2015 suggests that over time the relative competitive position has increased over time. This suggests that future innovation potential will be all the more important not only to sustain the current competitive position but to improve it as well.

#### 4.8 DIGITAL INNOVATION POTENTIAL OF THE EU ENGINEERING SECTOR

In light of the limits of the public data, Prognos' digital patents proprietary data fills in a real data gap. Innovation activities in digital areas are a key element for future competitiveness, productivity growth and economic growth worldwide. Patenting activities are key pillars of innovation activities in this respect, as the following Figure shows: **Patenting is closely related to other measures of innovative activity.** Especially those industries where patents are common, like the engineering industry, report that innovation (i.e. new and/or improved products, services, business models) is consistently higher.

**Figure 4-24: Patents Granted per 1,000 Employees and Share of Firms Reporting Innovation**

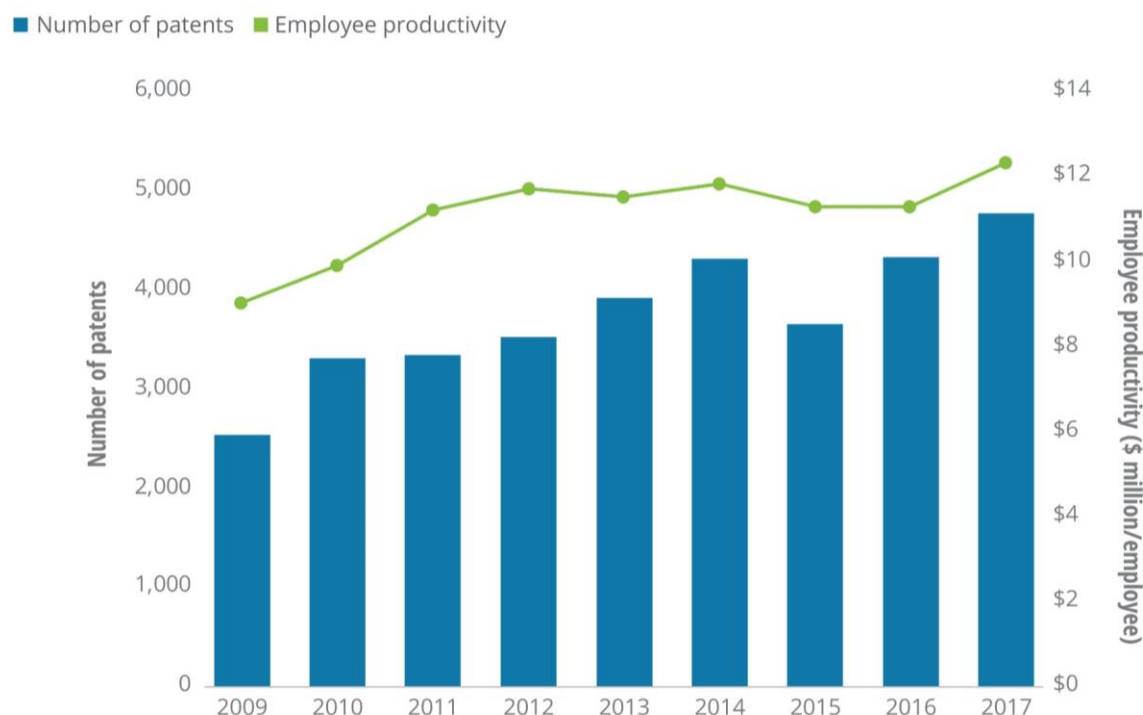


Source: Shambaugh J., Nunn, R. & Portman, B. (2017): *Eleven Facts about Innovation and Patents*. The Hamilton Project. p.2.

Even though patent-based innovation is only one type of innovation that many industrial companies are using to remain competitive, it continues to be an **important investment area and one that can deliver competitive differentiation**. One of the many direct

benefits of patent-based innovations are better production output and inventory optimization, which is directly related to reduced costs. For instance, innovation that automates material movement could yield labour savings. Recent patent data from Deloitte in this respect shows a **strong correlation (0.85) between employee productivity and patents** (see Figure 4-25).

**Figure 4-25: Process patents granted and employee productivity, 2009-2017**



Source: Deloitte (2019): [Tracing innovation in manufacturing. Spotlight on patent innovation investments in manufacturing.](#)

However, **most of these positive effects and applications today cannot be realised without digital solutions.** The EU engineering industry in this regard can be an important solution provider for itself and other industries. This, however, is a challenging task for the EU engineering companies given the fierce global competition in this field. To better assess the EU engineering sectors' endogenous digital innovation potential (i.e. its potential to be an important digital solution provider) we look at the **engineering industries digital patenting activity** (see box below). This perspective shows the relevance of digital innovation and solutions originated in this sector.

### i

#### Defining digital patents

The definition of digital patents is based on the work of Inaba, T. and Squicciarini, M. (2017). Their paper proposes a revised version of the initial OECD definition of ICT-related technologies from 2003. This new version stems from a careful analysis of ICT technologies and products and in addition relies on the in-depth knowledge of a Japan Patent Office expert specialised in the examination of ICT-related patents. This new taxonomy has also been used in more recent reports measuring digitalisation (e.g.



Colecchia, A. et al. (2019)<sup>374</sup> or Paunov et al. (2019)<sup>375</sup>). The new ICT taxonomy is subdivided into 13 main and 24 sub-technology areas, which are defined by their specific technical features and functions they are supposed to accomplish. The following table provides an overview of the main and sub-technology areas (the corresponding patent classes are provided in Annex 8, the standalone methodological annex):

| Main technology areas (sub technology areas)                                               |                                                                                                                 |
|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| 1. High speed network (digital communication technique, exchange / selecting, others)      | 8. Cognition and meaning understanding                                                                          |
| 2. Mobile communication                                                                    | 9. Human-interface                                                                                              |
| 3. Security (cyphering / authentication, electronic payment)                               | 10. Imaging and sound technology (imaging technique, sound technique)                                           |
| 4. Sensor and device network (sensor network, electronic tag)                              | 11. Information communication device (electronic circuit, cable conductor, semiconductor, optic device, others) |
| 5. High speed computing                                                                    | 12. Electronic measurement                                                                                      |
| 6. Large-capacity and high-speed storage                                                   | 13. Others (computer input-output, other related technique)                                                     |
| 7. Large capacity information analysis (database, data analysis / simulation / management) |                                                                                                                 |

Source: Prognos AG (2020) based on Inaba, T. & Squicciarini, M. (2017).

Every patent family which is described by at least one technology class that belongs to this core definition of digital technologies, will be considered as a digital patent family. This approach is referred to as “technological diffusion”. This means that for a patent family associated with a digital technology class, all other (a priori non-digital) technology classes are marked as digital as well. In this way, non-digital technology classes are defined as digital as far as these technology classes are associated with a patent family jointly with a digital technology class.

#### 4.8.1 Patent applications and digital patents – Comparison across EU competitor regions

Comparing patenting activities across important world markets and competitor regions of the EU engineering industry gives important insights into the future market perspectives of the sector in a global perspective. In particular when looking at key digital technologies originating from the engineering industry and future market perspectives, a detailed understanding of the endogenous innovation potential is important.

<sup>374</sup> Colecchia, A. et al. (2019): World Corporate Top R&D Investors – shaping the Future of Technologies and of AI. A JRC and OECD common report, Publications Office of the European Union, Luxembourg

<sup>375</sup> Paunov, C. et al. (2019): On the concentration of innovation in top cities in the digital age, OECD Science, Technology, and Industry Policy Papers, 2019/85, OECD Publishing, Paris

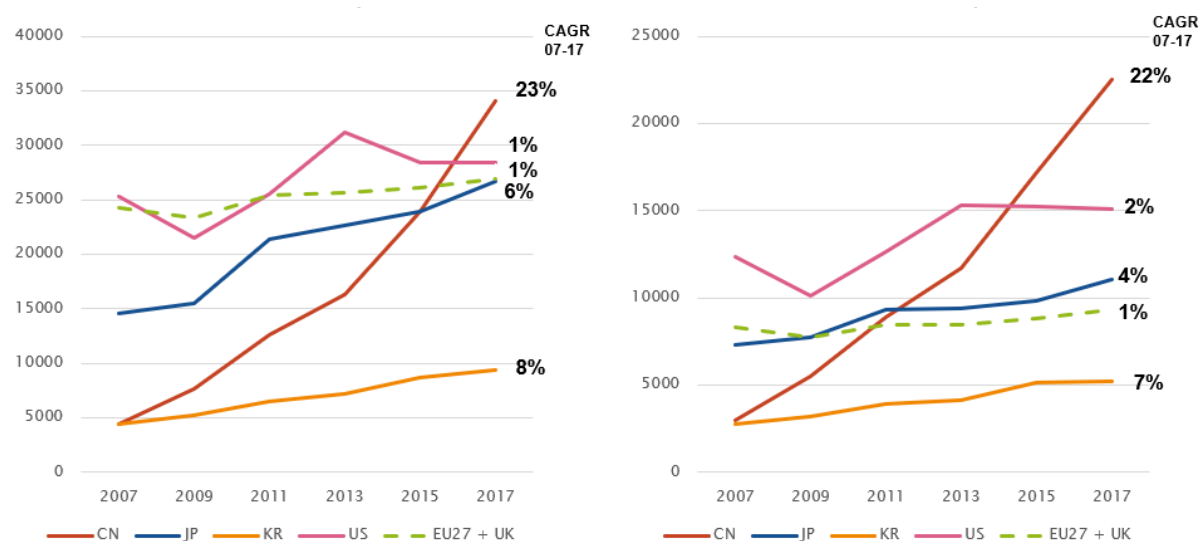
The figure below provides a **first comparative view on patent applications and digital patents**, including both the absolute volume of PCT patent applications over time and the Compound Annual Growth Rate (CAGR) from 2007 to 2017. It also shows the same parameter for digital patents.

When looking at the **general patenting volumes**, the European engineering industry has a good positioning among the competing regions and is ranked 3<sup>rd</sup> with an estimated number of around 25,000 PCT patent applications. Only the USA and, since 2015, China have a larger patent portfolio. When looking at the developments over time, one only observes very moderate increases of 1% p.a. in the EU27 (+UK) and the USA, whereas China has a CAGR of more than 20%.

The picture is quite different when assessing **digital patents** where the EU engineering industry is only ranked 4<sup>th</sup> out of the five key markets assessed and far below China, the USA, and also Japan. This is largely due to the steep increase of digital patents originating from China (CAGR: 22%) which enabled the Chinese engineering industry to overtake Europe's position in 2011 and the USA in 2013/2014 as the top location in digital patents. As such, China had a "market share" of digital patents of around 33% in 2017 (2007: 8%), whereas Europe's share dropped from 22% (2007) to 14% (2017). The USA also lost its frontrunner position and achieved a market share in digital patents in the engineering industry of around 22% (2007: 33%; Japan: 2007 = 19%, 2017 = 16%; South Korea: 2007 = 7%, 2017 = 8 %) (see Annex 7).

At the level of the different engineering sub-sectors, one can see that China especially drove up its digital patent "market shares" in the more digitalised sub-sectors of computer and electronics (NACE 26), electrical equipment (NACE 27) and machinery and equipment (NACE 28). In the other sub-sectors, i.e. fabricated metal products (NACE 25), medical and dental supply (NACE 32.5) and the more service-oriented repair and installation of machinery (NACE 33), China's (at least from a pure quantitative perspective) is less dominant when it comes to digital patent applications. Especially in the field of medical and dental supply the EU, US and Japan seem to have still a very strong position (see Annex 7).

**Figure 4-26: Estimated number of all patents (left) and digital patents (right) in the engineering industries across EU's (+UK) main competitors**



Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014)

All in all, it can be seen that **global competition on digital innovation in the engineering industry has significantly increased** over the last years and that the EU has lost some ground in this competition. In particular the dynamic developments in China, characterised by significant increase in (business) R&D and an upgrading of its value chains, have changed the competitive landscape. At the same time, there are still some questions about the quality of patents originating from China (see box below) and the potential bias resulting from strong state incentives for patenting (e.g. tax breaks).



### Quality of patents and the special case of China

The assessment on digital patenting in the engineering industry of this study uses so-called PCT-patent applications, as outlined in more detail in Chapter 1.

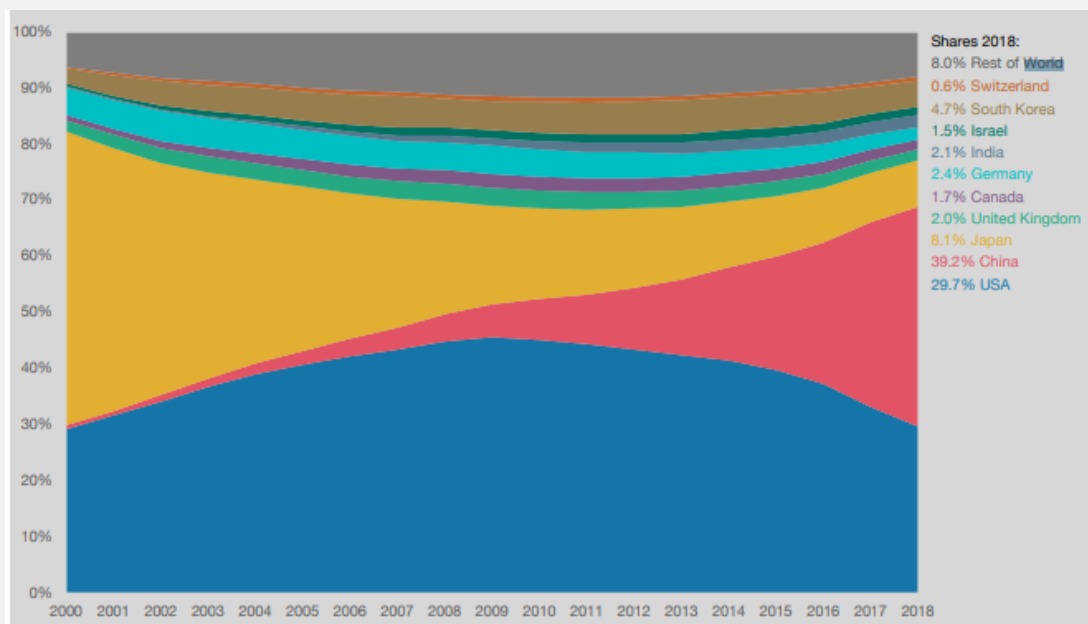
The Patent Cooperation Treaty (PCT) procedure is international by design and is administered by the World Intellectual Property Organization. Since 2004, each application filed through the PCT designates all signatory states of the PCT (currently the PCT has 153 contracting states). Therefore, PCT filing are often considered as a “worldwide patent application” and is much less biased than applications with national or regional offices. Any regional legal peculiarities like the previously mentioned situation of software patents therefore have fewer distorting effects. Regional differences are also mitigated by another advantage of PCT patent applications. Using PCT applications ensures a certain degree of quality of the patents (see Annex 8 for more information) since the cost of filing an international patent through the PCT is higher than that of a simple domestic application. Inventors in general only accept these costs if their invention has international commercial potential and is still commercially promising one year after the initial domestic filing.

This procedure is very important when comparing patenting activities around the globe. However, regarding some countries – most prominently China – some further considerations are important in the context of this study. Even though China has a strong patent portfolio, the quality of its patent applications may still vary even if measures have been taken to limit this effect (see use of PCT patents in Annex 8). The following two figures from a more recent study<sup>376</sup> show that e.g. for AI-patents, the number increased strongly in China but when looking at so-called “World Class patents” (TOP 10% patents in terms of their quality<sup>377</sup>), the positioning and increase of patent applications of China is less pronounced. Whereas the share of Chinese patents on AI overall is around 39% (from less than 5% in 2000), putting it head of the USA with around 30%, the share of world-class patents on AI originating from China is only 10% (USA: 53%). The top EU-27 country is Germany (3.2%).

<sup>376</sup> EconSight, IGE & PatentSight (2019). Artificial Intelligence. Global developments, fields of application, drivers of innovation and world-class research.

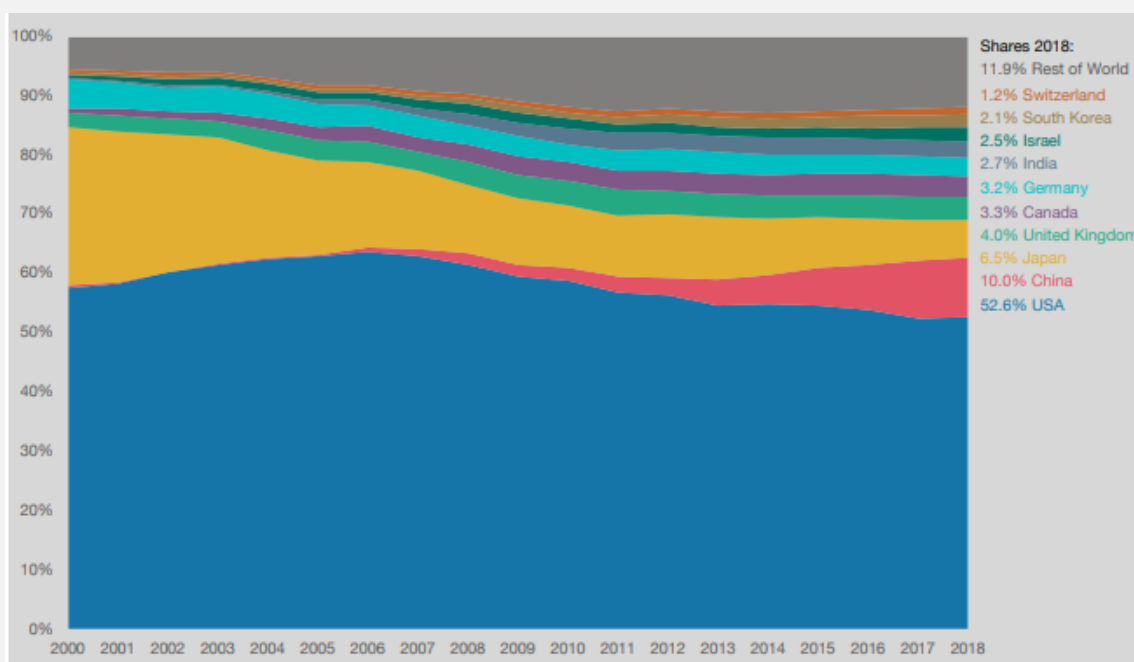
<sup>377</sup> The authors of the study developed a new valuation approach for their analysis to rank patents based on a specific Patent Asset Index. “From a technical perspective, worldwide patent quality is measured by market coverage and technology relevance. Market coverage calculates the worldwide legal coverage of patent protection by means of extension of the nationalization of intellectual property rights (scope and extension of the patent family) and shows how companies evaluate the significance of their own invention. [...] Technology relevance, on the other hand, demonstrates how important an invention is in comparison to other patents in a corresponding technology (external assessment), taking into account patent examiners’ references and citations. While market coverage and technology relevance together constitute the competitive impact of a patent family, the sum of all patent families with their individual impact values results in the Patent Asset Index. This is the valuation of the entire patent portfolio of a company or research institute.” (EconSight, IGE & PatentSight (2019), p.10)

**Figure 4-27: Overall development of the patent structure in Artificial Intelligence, selected countries (2000-2018)**



Source: EconSight, IGE & PatentSight (2019), sequence according to ranking of the following top 10 presentation

**Figure 4-28: Development of the world-class patent structure in Artificial Intelligence, selected countries (2000-2018)**



Source: EconSight, IGE & PatentSight (2019), sequence according to ranking of the following top 10 presentation

Thus, as the report from EconSight, IGE & PatentSight (2019) summarises: “Chinese dynamics is largely due to specific characteristics of the national patent system. As discussed in the chapter on approach and procedure, Chinese

researchers are encouraged by tax reductions to patent as much as possible to increase the relevance of China as a research location.” (p. 15)

But at the same time, it must be considered, regardless of the quality of patents, that unlike in the past, Chinese industry and research institutions make much more use of IPR to protect their ideas prior to external cooperation. Moreover, it can already be observed that China is making use of its huge IPR portfolio to define national and international standards which will force external solution providers to accept Chinese standards and legislation.<sup>378</sup>

When looking at the **share of digital patents among all patents in the engineering industry** (see figure below), a proxy for digitalisation levels in the patent portfolio, the European engineering industry ranks 5th among the compared countries with a digitalisation share of 35%. The USA and South Korea are far ahead of these shares with more than 50%, and in China, almost 2/3 of all patents in the engineering industry can be classified "digital". A similar picture exists for the different sub-sectors of the engineering industry. For all sub-sectors but one (medical and dental instruments and supplies) the digitalisation share is lower than in the four competitor countries (see Annex 7, which provides Additional Figures on Endogenous Digital Innovation Potential). Hence, it appears that, compared to the main competing regions, the EU engineering industries still focus their research and innovation activities on more traditional technologies and less on combinations with digital technologies, explaining its significantly lower digitalisation share as compared to competitors. This is in line with a recent report from the European Commission.<sup>379</sup> The report looked at all the ICT-related patent applications as a % of total PCT patent applications, albeit without a specific sectoral focus (see Figure 16 in Annex 7). Regarding the analysis of the engineering industry globally, China has by far the most digitised patenting activity followed by South Korea, the US and Japan.

However, the issue as to the prevailing culture in terms of approaches to patent registration could be a further factor in that some countries patent more frequently and widely than others. The conclusion is nevertheless that “the EU seems to trail behind other major economies when it comes to the relative innovativeness of the ICT sector.”<sup>380</sup>

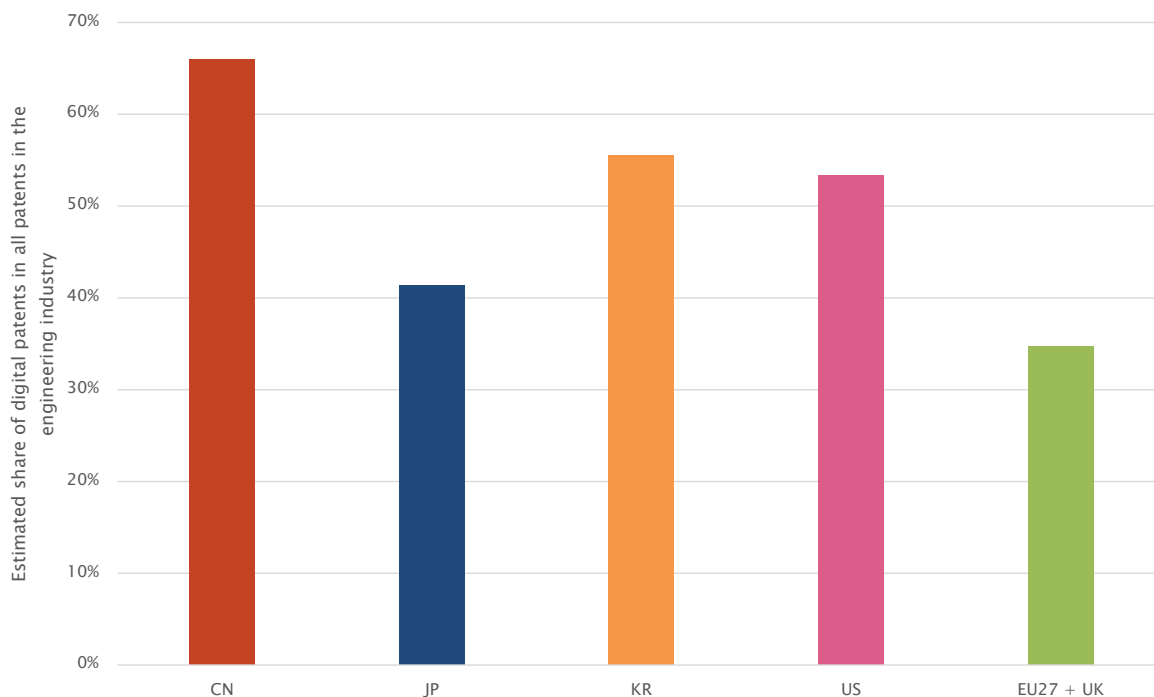
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<sup>378</sup> see, for instance, Fraunhofer IAO (n/a): Analysis of Industry 4.0 in China, White Paper 1: Analysis of Chinese patenting activities. Source: <https://www.iao.fraunhofer.de/images/iao-news/chinese-patenting-activities.pdf>

<sup>379</sup> European Commission (2020): Science, Research and innovation performance of the EU 2020 – A fair, green and digital Europe.

<sup>380</sup> ebd. p.349.

**Figure 4-29: Share of digital patents in all patents in the engineering industry across EU's main competitors, 2017**



Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014)

#### **4.8.2 Digital patents in the sub-sectors of the EU engineering industry**

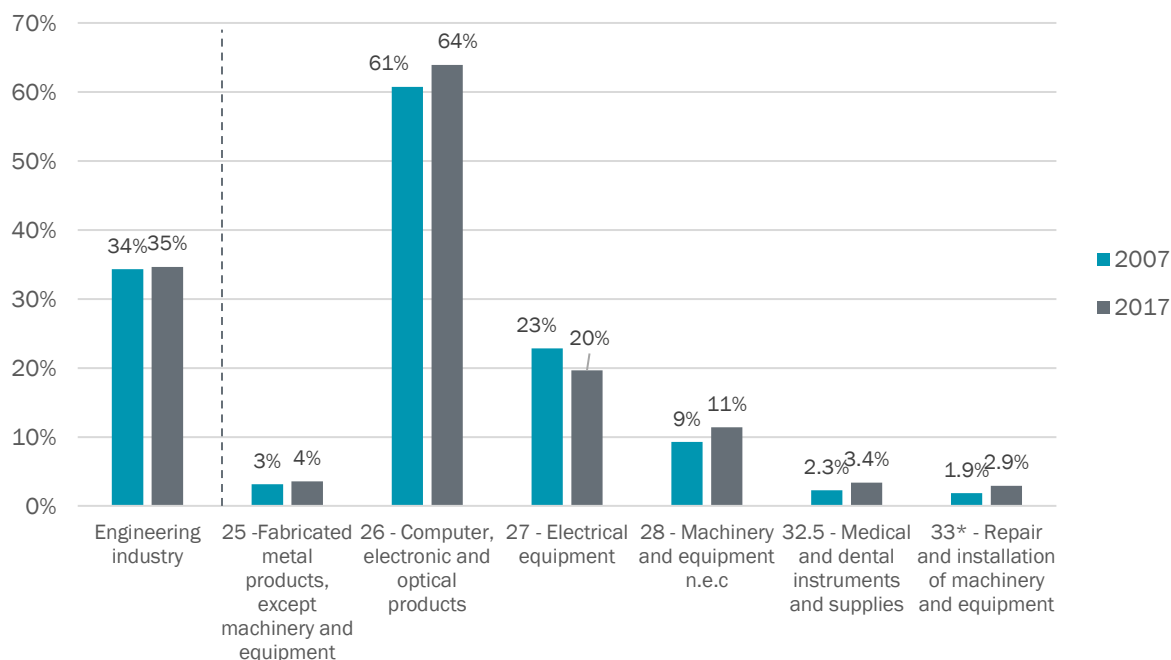
The analysis of digital patents covered six distinctive sub-sectors of the EU engineering industry, which are analysed more in detail below. All but one sub-sector of the EU engineering industries increased its share of digital patents in all patents from 2007 to 2017 (the exception being the electrical equipment sector, NACE 27). This indicates that the relative importance of digital innovation within the sector is increasing, even though increases were rather modest in the 1 to 2-digit percentage points. This rather modest increase of the share of digital patents in all patents can also be observed for other manufacturing industries like the chemicals, basic metals, or the automotive industry (see Figure 7 in Annex 7).

Within the EU engineering industry, the **"computer, electronic and optical products"** (NACE 26) sub-sector has been for the highest digitalisation shares in its patent portfolio with almost 64% of patents being "digital patents". This sub-sector therefore is the most important driver for digital innovations in the engineering sector. Around 80 % of all "digital patents" from the engineering industry can be assigned to the computer and electronics sector (NACE 26) (see Annex 7). The second highest digitalisation share (20 %) can be observed for the electrical equipment sector (NACE 27), followed by "machinery and equipment" (NACE 28) (11 %). Hence, these two sectors are the second most important drivers for digital innovations in the engineering sector. Together they generate around 17 % of all digital patents in the engineering industry (see Figure 8 in Annex 7). The lowest digital innovation potentials are in the "repair and installation of machinery and equipment" sub-sector (NACE 33), which is rather a user than producer of digital goods.

One peculiarity with regards to the **medical technology sub-sector** (NACE 32.5) needs to be mentioned, which is (surprisingly) characterised by relatively low digitalisation shares. A key reason for this observation is due to the fact, that two important medical technology segments, namely the "Manufacture of irradiation, electromedical and electrotherapeutic equipment" (NACE 26.6; digitalisation share up to 57%) and

“Manufacture of measuring, testing, navigating and control equipment” (NACE 26.5; digitalisation share 14%) are part of the computer/electronics subsector (NACE 26).

**Figure 4-30: Estimated share of digital patents in all patents in the sub-sectors of the EU engineering industry, 2007 vs. 2017**



Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014).

\*For sub-sector 33 a different approach was used for the computation of the digitalisation share (see Annex 8: Technical Methodological Note).

Considering the large share of SMEs (and particularly micro-enterprises with less than 10 employees; compare Chapter 2), an important policy question arises about the implications of enterprise sizes and (digital) patenting activities. Until now, regarding the importance of SMEs in the patenting activity of the engineering industry overall there is only very limited information is available. Moreover, there are several methodological challenges in analysing digital patents by enterprise size. Nevertheless, some early studies and qualitative work of this study (interviews, survey) provide some relevant indications. The info box below summarises some main findings in this regard.

### **i Patenting activities of SMEs**

The current study does not differentiate between large enterprises and SMEs. The main reason is that there exist major challenges in terms of data treatment and analysis, which were out of the scope of this study. A more detailed discussion on the topic of assigning patent data to SMEs is amongst others provided by Vervenne et al. (2014).<sup>381</sup>

Nevertheless, there exist some papers and reports that provide interesting results and figures on the patenting behaviour of SMEs and their importance in the overall patenting activity. Even though none of these papers and reports provide a specific sectoral view on the engineering industries or their digital

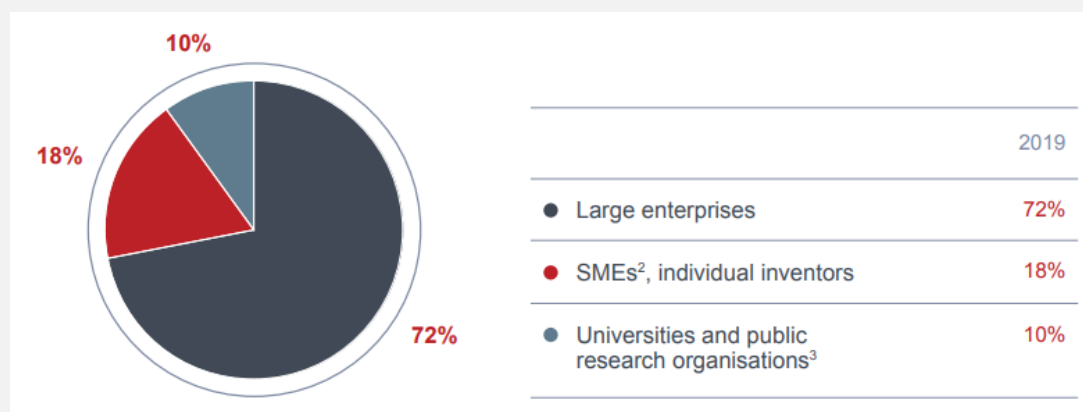
<sup>381</sup> Vervenne, J.-B., Callaert, J., and Van Looy, B. (2014). Patent Statistics at Eurostat: Mapping the Contribution of SMEs in EU Patenting. Eurostat; Luxembourg, 2014.



patenting activity, we summarise some of the findings to contextualise the results provided by the current report.

In general, the reviewed studies and reports confirm the fact that **large enterprises (LEs) account for the lion's share of patent applications**. The previously mentioned report of Vervenne et al. (2014) found that in the EU in 2011 around 80 % of all patent applications can be attributed to LEs and only 17 % to SMEs<sup>382</sup>. For 4 %, no size could be indicated. Frietsch et al. (2013a)<sup>383</sup> found somewhat larger shares. Their analysis revealed that worldwide between 2006 and 2008 nearly 30 % of all transnational patents (i.e. PCT patent applications) were filed by SMEs. This result, however, is partly due to their broader SME definition. They define SMEs as companies with less than 500 employees, which is closer to the German notion of the "Mittelstand". More recent reports on this matter from Talvela et al. (2018)<sup>384</sup> or the European Patent Office (2019)<sup>385</sup>, which both apply the EU definition of SMEs, found again that the SME share in overall patent applications is around 15-18%.

**Figure 4-31: Shares in patent applications at the EPO originating from Europe by type of institution & enterprise size, 2019**



Source: European Patent Office (2019)

Some of these papers in addition provide specific sectoral or technological views that give more detailed insights on the patenting activities of SMEs. **Overall, the results suggest that for technologies and sectors related to the engineering industry the share of SME patents in all patents seems to be lower than on average for all technologies or sectors.** Frietsch et al. (2013), for instance, differentiate patent applications by technology classes as defined by Schmoch (2008)<sup>386</sup>. Their results, again using the broader SME definition, show amongst others that for technology classes related to electrical engineering (mostly digital technologies), the share of SME patents in all patents is with 20% lower than the average across all patents (30%) or other technologies like instruments (i.e. optics, measurement, medical technology) and mechanical engineering, which both depict SME shares of around 30%. Vervenne et al.

<sup>382</sup> Following the EU definition of SMEs : [https://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition\\_en](https://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en)

<sup>383</sup> Frietsch, R., Neuhäusler, P., & Rothengatter, O. (2013). SME patenting: An empirical analysis in nine countries (No. 36). Fraunhofer ISI Discussion Papers-Innovation Systems and Policy Analysis.

<sup>384</sup> Talvela, J., Karvonen, M., & Kässi, T. (2018). Patents: The Case of Exploitation of the Patent System among SMEs and Private Inventors in Finland. Series on Technology Management, 30, 45-68.

<sup>385</sup> European Patent Office (2019). Patent Index 2019 – Statistics at a glance.

<sup>386</sup> Schmoch, U. (2008): Concept of a Technology Classification for Country Comparisons. Final Report to the World Intellectual Property Organisation (WIPO). Accessible here: [http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/pdf/wipo\\_ipc\\_technology.pdf](http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/pdf/wipo_ipc_technology.pdf)

(2014) provide a similar analysis by using the same technology classification of Schmoch (2008) but on a more detailed level. Using the EU SME definition, they found that across the different subsectors of the electrical engineering technologies the share of SME patents in all patents lies between 3% and 13%, which is again significantly lower than for the average across all patents (17%). Interestingly, their results also show lower than average SME shares for mechanical engineering technologies (between 4% and 11.4%) and some of the instruments technologies (i.e. optics, measurement, and control) that depict SME shares of around 7%. Finally, a more recent study of the European Patent Office<sup>387</sup> focussing on “high growth firms” in Europe provides a more sectoral view. Their results indicate that for high and medium-high industries, to which most of the engineering sub-sectors can be assigned<sup>388</sup>, the share of SME patents is respectively 11.8% and 9.2%.

#### **4.8.3 Digital patents in the Member States of the EU engineering industry**

Regarding the digital patenting activity in the overall patenting activity of the EU engineering industry, the results in Figure 4-32 display the **most important EU Member States regarding the digital patenting activity** in the EU engineering industry:

**Germany (DE), Finland (FI), France (FR), Italy (IT),  
Netherlands (NL), Sweden (SE). Outside EU27: United Kingdom (UK).**

Around 90 % of all digital patents in the EU engineering industry are estimated to be filed by these six EU-Member States plus the UK (see

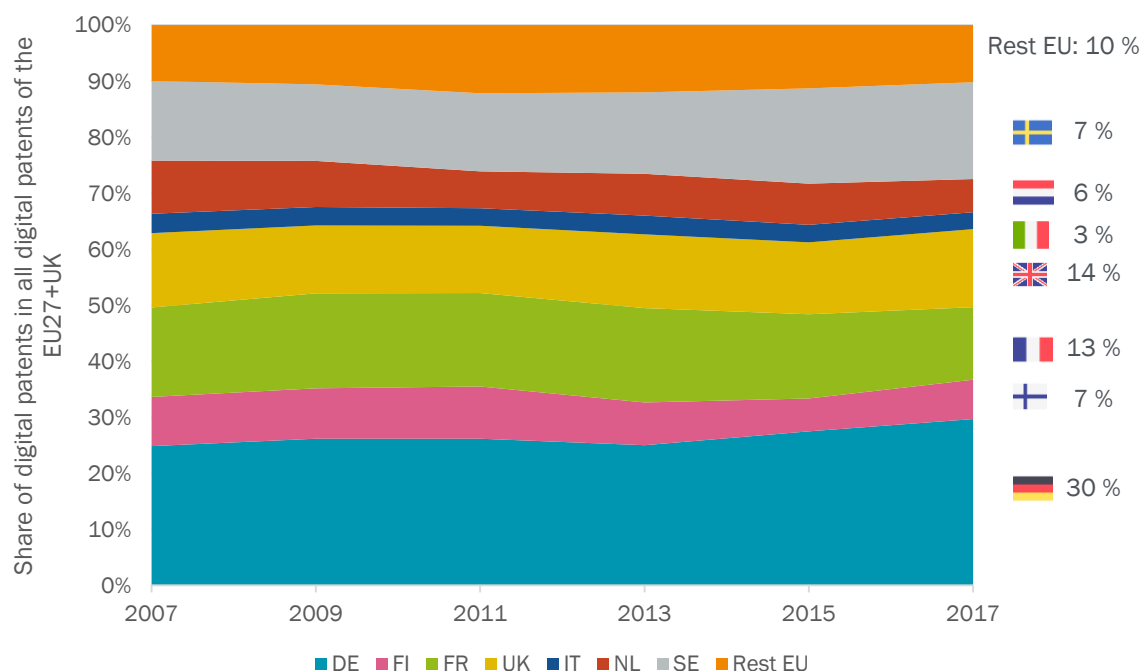
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<sup>387</sup> European Patent Office & European Intellectual Property Office (2019). High-growth firms and intellectual property rights - IPR profile of high-potential SMEs in Europe.

<sup>388</sup> *High technology*: NACE 26 - Manufacture of computer, electronic and optical products. *Medium-high-technology*: NACE 27 - Manufacture of electrical equipment, NACE 28 - Manufacture of machinery and equipment n.e.c., NACE 33 - Repair and installation of machinery and equipment.

Figure 4-32). The largest part of the digital patents comes from the German engineering industry (around 30 %), which corresponds to their employment share in the EU engineering industry (around 29 %). They are followed by Sweden (17 %), the United Kingdom (14 %), France (13 %), Finland (7 %), the Netherlands (6 %) and Italy (3 %). Apart from Italy and Germany, each of these (former) Member States has significant higher shares of digital patents as compared to their employment shares in the EU engineering industry. This shows that these Member States have quite strong digital R&D activities. This can also be shown by the number of digital patents per 1,000 employees. Especially the Scandinavian countries Sweden and Finland stand out. In Sweden we have around 7 and in Finland around 4.5 digital engineering patents per 1,000 employees. In Germany, France, the UK and the Netherlands the numbers are with 1 to 2 patents per 1,000 employees lower but still significantly higher than in the rest of the EU (excluding the 6 previously mentioned member states) with about 0.2 digital patents per 1,000 employees. In Italy, on the other hand, the number of digital patents per 1,000 employees does not exceed the average of the rest of the EU, indicating that there might be some difficulties in generating digital innovation activities (see Annex 7).

**Figure 4-32: Share of digital patents of selected EU member states and the UK in all digital patents in the EU27 + UK**

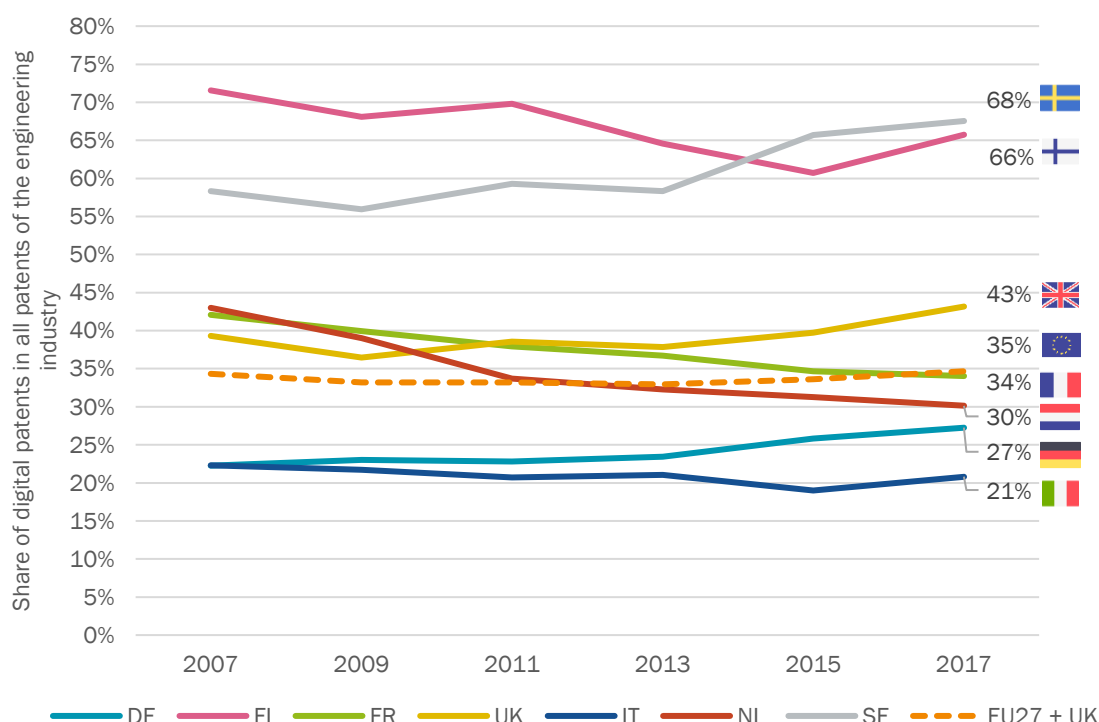


Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014).

Figure 4-33 shows that the differences regarding the digital patenting intensity per employee are also reflected by the digitalisation shares (i.e. estimated share of digital patents in all patents). In 2017, Sweden and Finland had shares of respectively 68 % and 66 %, which is higher or at least as high as in the EU main competitor countries (CN = 66 %, KR: 55 %, US: 53 %, JP: 41 %, see

Figure 4-29). In the UK still about 43 % of all patent applications in the engineering industry have a digitalisation link. This share, however, drops to below 35 % in France, the Netherlands, Germany, and Italy. Looking at the evolution between 2007 and 2017, one can see that three out of the 6 selected Member States were able to intensify their digital patenting activities: Sweden, Germany, and the UK. In the other Member States, the shares either stagnated (IT) or even decreased (FI, FR, NL).

**Figure 4-33: Estimated share of digital patents in all patents of the engineering industry in the EU member states, 2007 to 2017**



Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014).

It needs, however, to be stressed that there exist **differing developments at the more fine-grained sub-sector-level**. When looking at the three most important engineering sub-sectors for the digital innovation activities (i.e. computer and electronics, electrical equipment, machinery) following observations can be made (see Figure 11 to 13 in Annex 7): In the sub-sectors computer and electronics (NACE 26) and electrical equipment (NACE 27), Sweden and Finland still have by far the most digital patenting activities. However, in the sub-sector of machinery and equipment (NACE 28) the differences across the different Member States are less pronounced. After Finland (27% in 2017), the UK and the Netherlands have the highest digitalisation shares (respectively 25% and 19% in 2017). Especially the UK made some major progress with an increase of the digitalisation share of about 9 p.p. between 2007 and 2017.

As regards other developments over time, we see that the Netherlands and France lost some ground in each of the three important sub-sectors. In Finland, the engineering industry's decreasing digitalisation share is mostly due to weaker digital developments in the electrical equipment and machinery sectors. Germany on the other hand, even though having some of the lowest digitalisation shares, is the only Member state that shows for each of the three sectors an improvement of its digitalisation shares. This indicates that they are slowly but steadily increasing their digital innovation activities in the different sub-sectors of the engineering industry. Particularly in the computer and electronics sector Germany was able to increase their digital patenting activities as compared to their overall patenting (increase of 10 p.p.).

#### **4.8.4 Digital technology portfolio of the EU engineering industries and its main competitors**

Whereas the analysis so far looked at digital patenting in a more aggregated view across major competing regions or within the EU engineering industry and its subsectors, the following paragraphs will provide more detail insights on the digital technologies. As the section above has shown, the **computer, electronics and optical products** sub-sector is by far the most relevant sub-sector for digital innovation of the EU engineering industry and therefore the analysis below will focus on it, again from a comparative view across all major competing regions.

Thus, the following figure provides a **characterisation of the digital patenting portfolio** of the computer, electronic and optical products sector for the EU27 (+UK), the USA, Japan, South Korea, and China. It is important to highlight, that Figure 4 34 does not yet provide an assessment of the rank of these countries but rather an internal view on the distinctive technological focus of digital patents per region.

As the figure and its five images show, there are **four key digital technologies** which are overall the most important ones from the NACE 26 perspective in all five regions. Between 61% and 72% of the digital technology fields mentioned by the digital patent applications in the five competitor regions can be assigned to the following four categories<sup>389</sup>:

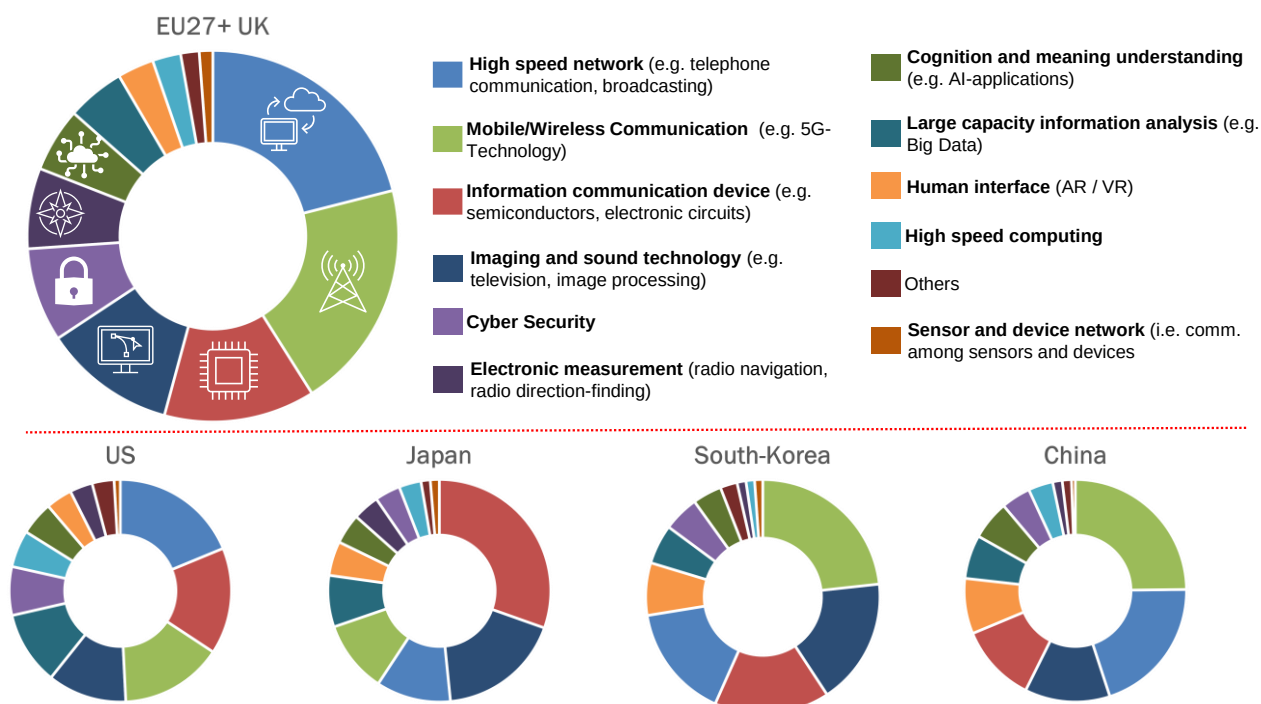
- High speed network (e.g. telephone communication, broadcasting technology)
- Mobile/wireless communication (e.g. 5G technology<sup>390</sup>)
- Information communication devices (e.g. semiconductors, electronic circuits)
- Imaging and sound technologies (e.g. television, image processing)

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<sup>389</sup> See Figure 14 in Annex 7 for a more detailed description of the different technology fields.

<sup>390</sup> Wireless communication networks are important enablers for 5G and its faster data speeds, reduced lag time, and increased density for smart devices. (European Patent Office (2019): Digitalisation triggers patenting growth. <https://www.epo.org/about-us/annual-reports-statistics/statistics/2019/digitalisation-triggers-patenting-growth.html>).

**Figure 4-34: Technological focus of the regions' digital patents for the "Manufacture of computer, electronic and optical products", 2017**



Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014)

Across the different regions, however, some differing degrees of specialisation as well as global importance for the respective technologies can be identified. Figure 4-35 shows on the Y-axis the technology **specialisation index** (SI) for the computer and electronics industry (NACE 26). The specialisation index shows the country's concentration on a specific digital technology field in comparison to the global average.<sup>391</sup> On the X-axis the **global share of digital patent applications** originating from the computer and electronics sector **citing the technology** is shown. The higher the share, the higher is the country's number of patent applications citing the specific technology. The number of patent applications citing the technology is represented by the size of the bubble. When taking these different metrics into account, the following patterns can be identified:

- **High speed network:** In the **EU** (SI = 1.2) and **China** (SI = 1.1) the specialisation index is slightly above 1. This indicates that the digital patenting activity in the NACE sector 26 is somewhat more oriented to high speed network technologies as in the rest of the world. However, in terms of the number of digital patent applications citing this technology China is dominating. Around 40 % of all patent applications related to this technology field come from China, followed by the **US** (24 %) and the **EU** (17 %).
- **Mobile / wireless communication:** The technology field is dominated by **China**. Next to the highest specialisation index (SI = 1.3) across the five competitor countries, China also delivers from a pure quantitative point of view the lion share of digital patent applications related to mobile /wireless communication (46 %). Hence, it is not surprising that two Chinese companies lead the EPO's 2019 top 10 applicants list for wireless communication network patents: *Huawei* and *Guangdong Oppo Mobile*

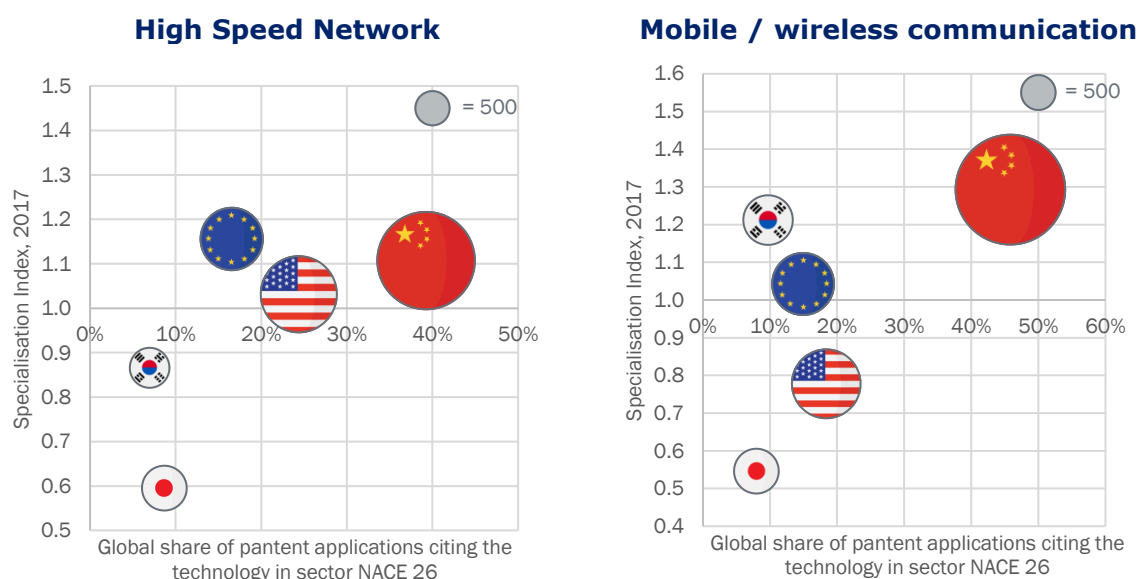
<sup>391</sup> The SI is defined as the country's share of the technology in its overall technology portfolio divided by the global share of the technology in the global technology portfolio. If the SI is equal to 1, then the technology field is as strongly represented in the country's technology portfolio as it is in the world on average. Values higher than 1 indicate an above global average specialisation in this technology field. Values lower than 1 indicate a below average technology focus.



*Communications.*<sup>392</sup> Next to China, we see that South Korea is more specialised in this field (SI = 1.2). With LG (n°5) and Samsung (n°8), they also have two companies in the EPO's top applicants list. Even though computer and electronics sector in the EU (SI = 1.0) and US (SI = 0.8) seems to specialise less in this digital technology, they remain the second and third driver in quantitative terms. With Ericsson (EU, n°3), Qualcomm (US, n°4), Sony (US, n°7) and Nokia (EU, n°9) they also provide four out of the ten EPO top applicants in this technology field.

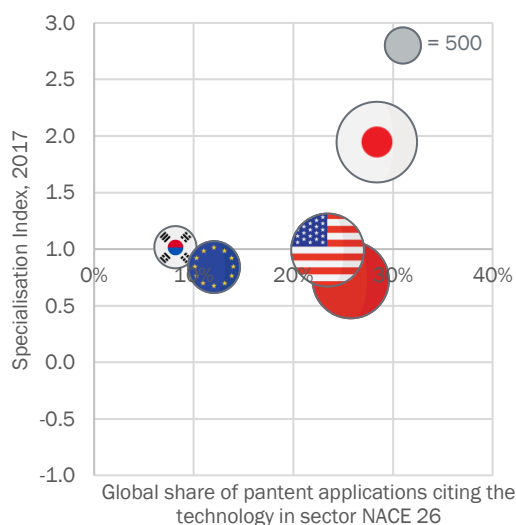
- **Information communication devices:** This technology field is particularly important for **Japan**, which is also the leading country in this regard. With a specialisation index of 1.9, the share of digital patents in the Japanese NACE 26 sector focussing on information and communication devices is around twice as high as the global average. Regarding the worldwide patenting activity of the computer and electronics industry in this technology field, Japan is followed by China and the US.
- **Imaging and sound technologies:** Figure 4-35 shows that especially the **Asian countries** dominate this field. Whereas in South Korea (SI = 1.3) and Japan (SI = 1.4) the technology portfolio is more specialised in this technology field as compared to the other competitor countries, China is dominating when it comes to the pure number of patent applications in this field. Around 33 % of all digital patent applications related to this technology field were filed by Chinese researchers.

**Figure 4-35: Specialisation index and global share of digital patent applications in selected technology fields (focus on NACE 26)**

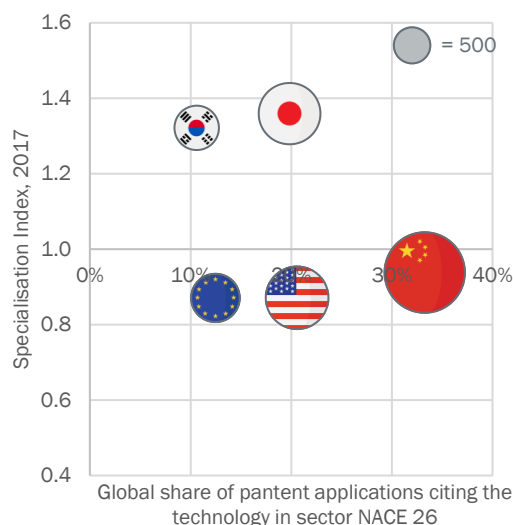


<sup>392</sup> European Patent Office (2019): Digitalisation triggers patenting growth. <https://www.epo.org/about-us/annual-reports-statistics/statistics/2019/digitalisation-triggers-patenting-growth.html>.

### Information communication device



### Imaging and sound technology



Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014)

Behind these four main digital technologies we see some further interesting specialisation patterns. For the technology fields **cyber security** and **electronic measurement** (e.g. radio navigation / radio direction-finding), the **EU (+ UK)** has a very strong competitive positions (see Figure 15 in Annex 7). On the one hand, the digital technology portfolio of the EU's computer and electronics industry is more specialised (cyber security – SI = 1.4; electronic measurement – SI = 2.2) into these fields as its main competitors. On the other hand, a large share of the digital patent applications in these two technology fields is filed by European researchers (cyber security = 20 %; electronic measurement = 32 %). Whereas for cyber security the US (29 %) and China (27 %) are also relevant global players, the EU is by far the most important region when it comes to digital innovations in the field of electronic measurement.

When looking at the other technology fields, one can see that the **US** computer and electronics industry especially stands out in the areas of **large capacity information analysis** (e.g. big data related technologies) and **high-speed computing** (see Figure 15 in Annex 7). Next to the highest specialisation patterns in these fields, they also provide most of the digital patent applications citing these technologies. In terms of the number of patent applications they are closely followed by China, whose overall technology portfolio, however, is less specialised into large capacity information analysis and high-speed computing. The EU on the other hand does not play a major role in both technology areas.

**China** again dominates the innovation landscape in the technology fields **human interface** and **cognition and meaning understanding** (amongst other AI related applications). Especially in the field of human interface it is the major driving force. Not only is China the most specialised country (SI = 1.4), it also provides by far most of the digital patent applications coming from the computer and electronics sector related to this technology (50 %) (see Figure 15 in Annex 7). Next to China, only **South Korea** (SI = 1.3) shows some above average specialisation into human interface technologies from the five competitor countries. The EU on the other hand shows the weakest position in the area of human interface technologies. In the field cognition and meaning understanding the specialisation patterns overall are less pronounced and the EU's competitive position is somewhat better. However, the EU still is behind China and the US when it comes to the absolute number of digital patent applications addressing technologies related to cognition and meaning understanding.

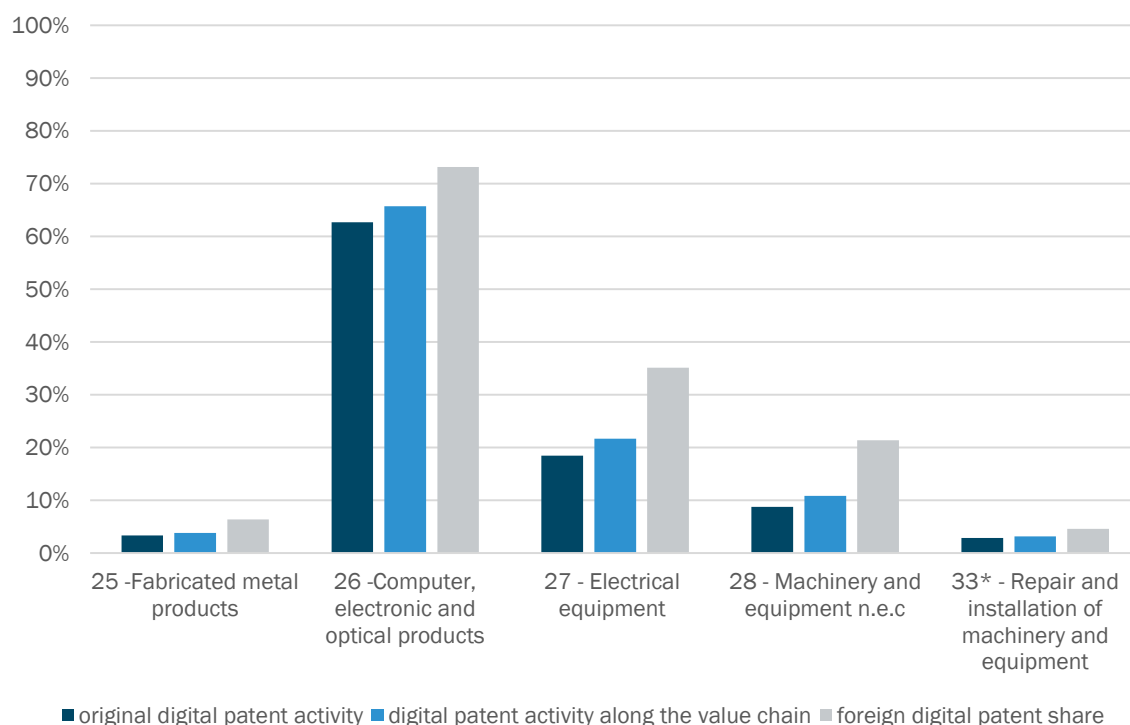
#### 4.8.5 Digital technology along the value chain of the EU engineering industry

The global structure of digital patent activity covered in this section reveals the advantage of the EU engineering industry in some digital technology aspects, but also the deficits in some other digital areas. However, the integration in global value chains can potentially compensate for these deficits if the EU takes advantage of relevant digital patent activity from abroad through value chain linkages.

A comparison of the **share of digital patents in the EU itself and along the value chain** reveals the advantage of a “digitalised” value chain. Five of the considered EU engineering sectors (NACE 25, 26, 27, 28, 33) show a higher share of digital patents along the value chain compared to the share of digital patents originating in these EU sectors. The reason for this is the high value chain contribution of countries with substantial digital patent activities. A closer look at sector 25 – Fabricated metal products – can explain this in more detail. The EU digital patent share is 3.3% in 2014 (the latest available year for data from the World Input-Output Database which is used to calculate value chain linkages for the EU engineering industry). However, this sector receives a substantial value-added contribution from China, Japan, the US and the Rest of the World. All mentioned regions have larger digital patent shares in sector 25. For instance, in Japan the digital patent share of sector 25 is 10%, and in Indonesia even 27%.

Combining the digital patent share of all countries along the value chain with its corresponding value chain contribution gives a measure of the digital patent share along the value chain (Figure 4-36). The external digital patent share, i.e. the value-added weighted digital patent share is 6.3% for sector 25 (the grey column in the figure) and, thus, almost twice as high as the EU-specific digital patent share in this sector. In sector 27 – Electrical equipment, the digital patent share from abroad is 35.1%, while the EU-specific digital patent share is 18.5%.

**Figure 4-36: Share of digital patents along the EU engineering industry value chains**



Source: Prognos AG (2020) based on PATSTAT and WIOD. \*For sub-sector 33 a different approach was used for the computation of the digitalisation share (see Annex 8). For sector 32.5 no value chain data is available.

The digital patent share in the individual engineering sectors in the EU could be even higher if value added connections would be further strengthened. Up to now, more than 80 % of value added in the EU engineering sector comes from Europe, mainly intra-sectoral. Expanding value chain linkages to countries leading in digital patent shares could give rise to a further increase in the digital patent activities along the value chain. Hence, from a point of view where the objective is to increase further the digitalisation in the EU engineering industry, it might not directly necessary for the EU to establish the domestic engineering industry as a global leader in each of the existing digital technologies but to strengthen value chain connections in chosen areas across the globe, where the EU might not have a competitive advantage (i.e. foster technology absorption).

## 4.9 CHALLENGES AND BARRIERS TO DIGITALISATION

### 4.9.1 *Challenges in assimilating digital technologies for engineering firms*

Various challenges for assimilating digital technologies in the EU engineering sector could be identified:

- **Skills.** The use and implementation of these new digital technologies calls for people with a specific skill set. The use and exploitation of artificial intelligence (AI) capabilities and big data methods for instance requires data scientists possessing specific new skills, for instance with reference to algorithms, data interpretation, regression analysis, and statistical classification methods. People with programming skills also become increasingly important. These profiles and skills are however increasingly difficult to find, and this skill gap is likely to widen in the coming years. This is often considered as the most important challenge in assimilating digital technologies. It is often stated that many firms that are embarking on new digital projects are increasingly having problems finding sufficient people with the necessary skills to further develop their businesses. On top of that, the large demand for people with these skill sets, also drives up the labour costs, which could also make them less affordable for smaller firms with limited resources.
- **Lack of standards.** Another challenge in assimilating digital technologies is the lack of standards and the limited interoperability between systems, programmes and machinery. This brings along a lot of uncertainty and duplication of efforts. There are for instance already a lot of working (software) platforms linking machinery and operators (increasingly also based on big data analytics or artificial intelligence), but most of these platforms have different procedures and standards making it risky for companies to engage with such platforms as there is the danger to get locked-in by adopting the wrong platform (especially given that it is not easy to switch platforms or service providers). Interoperability and standardization are however critical to maximize the value of digital solutions and ecosystems.
- **Large capital investment needs.** The literature shows that the costs of hardware components such as sensor nodes, actuators and suitable computer power (HPC) can still be substantial, which hampers the further development and deployment of digital technologies, especially for SMEs and Midcaps<sup>393</sup>. This has been confirmed by interviewees. The increasing amount of data that needs to be processed, stored and analysed also put an increasing pressure on storage and management costs.
- **Cybersecurity.** Cybersecurity concerns is also mentioned as a factor that is challenging the further assimilation of digital technologies. With the advent of digital technologies, engineering firms are increasingly relying on (digital) systems, networks and platforms. However, if knowledge and data stored in these networks get compromised, this will substantially lower the trust in these networks and will hamper the further deployment of these systems. As such, it will be a key challenge for further

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<sup>393</sup> Telit (2018). Manufacturing IoT Deployment Concerns and Cost Sensitivity.  
<https://www.telit.com/blog/manufacturing-iot-deployment-concerns-and-cost-sensitivity/>

deployment to ensure that networks and systems are adequately secured. The level of maturity of cybersecurity technologies is however still relatively low in Europe, mainly because of a lack of skills and limited collaboration within the value chain. Furthermore, despite significant investments in cybersecurity over the past decade, organizations in various industries are facing a growing cyber risk gap and most of the observable innovation in the EU cybersecurity markets is described as incremental.

- **Evolving business models.** It is often argued that Industry 4.0 and digital transformation are also leading to servitization and the demand for new business models<sup>394</sup>. However, not all firms can cope with these new business models and often it is considered as difficult to change to new business models since it has an impact on the entire firm organisation. As such, it is often considered as a major challenge.
- **Increasing dependence on others.** Embracing and implementing digital technologies often implies that one has to deal with increased complexity or capital intensity in the industrial processes. To successfully accomplish this, one has to increasingly collaborate with others and there is an increased dependence on other stakeholders. As such, there is also more alignment needed.

#### 4.9.2 Specific challenges for SMEs

The challenges faced by SMEs in respect of digitalisation are a key research issue, especially in the view that the engineering sector harbour a substantial number of SMEs. Literature, interviews and interventions from the webinar show that especially the adoption of digital technologies by SMEs can be problematic and is actually lagging in comparison with large enterprises. It is argued that SMEs are typically in an unfavourable position as they lack critical resources (financial, HR, size) compared to larger firms. Below we further elaborate on this.

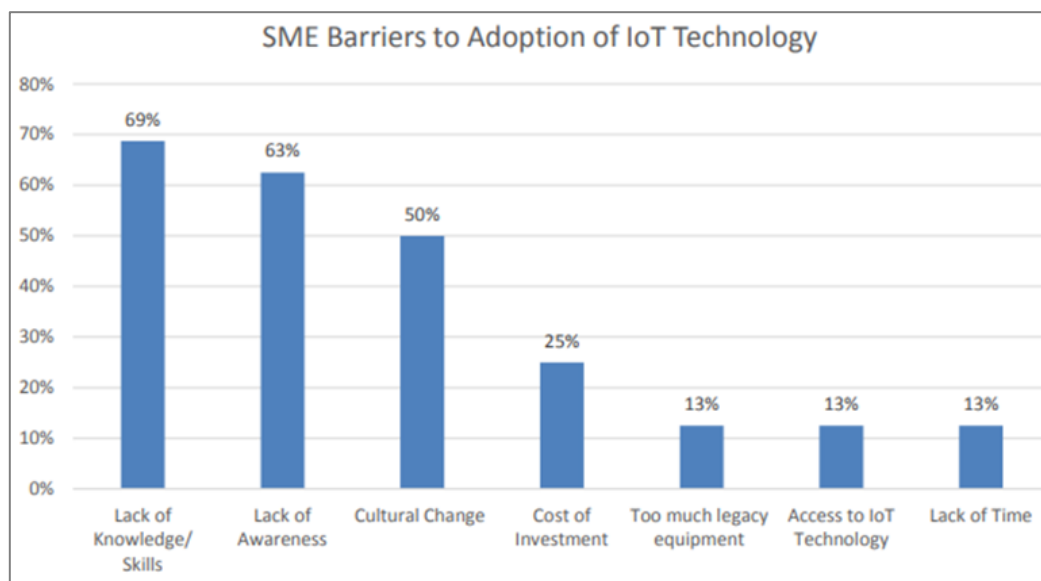
- The IoT4Industry<sup>395</sup> project “*which supports EU growth and competitiveness through the development of a new cross-sectoral industrial value chain based on the integration and use of IoT and related components (Digital Security, Cloud Computing, Big Data, Artificial Intelligence...) into manufacturing tools, machines and robots, industrial processes, factories environment, through the cross-border collaboration between SMEs and other RDI actors of the ICT and advanced manufacturing sectors*” recently organized a survey to pinpoint the barriers that SMEs face in their adoption of IoT technologies. Based on the survey, it was clear that the majority of SMEs indicate the **lack of knowledge/skills and the lack of awareness** as the most critical barriers. Other important barriers are the **needed cultural change** and the **costs of investment**.

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<sup>394</sup> See also: Servitization and Industry 4.0 convergence in the digital transformation of product firms: A business model innovation perspective (2019). Technological Forecasting and Social Change

<sup>395</sup> See: <https://www.iot4industry.eu/>

**Figure 4-37: SME barriers to adoption of IoT**



Source: IoT4industry

- Another study by IoT Analytics<sup>396</sup> shows that many SMEs struggle with the implementation of Industrial Internet of Things (IIoT) solutions due to a **lack of internal talent** (46% of the SME respondents confirmed this) and a **lack of technology expertise** (40%).
- An issue raised by interviewees and stakeholders during the webinar is that for SMEs it is difficult to find their way to relevant (digital) infrastructure in the EU and that they have **difficulties with setting up partnerships** with others.
- SMEs often **do not have their own IT department**; this implies that often the managers have to assess the various digital technologies with regard to their technological maturity and business potential. Accordingly, it is no surprise that SMEs frequently encounter difficulties in selecting the right solution and complain of a lack of user transparency. On top of that, SMEs often do not have a comprehensive strategy for implementing digital technologies. A study by VDMA documented that four out of ten SMEs have no comprehensive strategy for implementing Industry 4.0, while among larger companies the proportion is only two out of ten<sup>397</sup>.
- SMEs are typically also engaged in value chains of other larger companies. Consequently, they often have to adapt to the standards of the larger companies of which they are suppliers. The lack of general standards makes it hard for SMEs to join value creation networks with different standards and norms and thus narrows their room to manoeuvre. On top of this comes a worry that high investments will have to be written off if they fix on an interface technology that ultimately is not implemented.

To support SMEs in the adoption of digital technologies, the European Commission has launched the **Digital Innovation Hubs (DIHs)**<sup>398</sup> as one of the key priorities of the Digitising European Industry Initiative (adopted in 2016). DIHs are set up to ensure that every company, small or large, high-tech or not, can fully grasp digital opportunities. DIHs act as one-stop-shops (with technical universities or research organisations at the core) where companies (especially SMEs, start-ups and mid-caps) can get access to technology-

<sup>396</sup> IoT Analytics (2017). Guide to IoT Innovation (SME focus). Achieving Innovation Performance.

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[https://industrie40.vdma.org/documents/4214230/26342484/Industrie\\_40\\_Readiness\\_Study\\_1529498007918.pdf/0b5fd521-9ee2-2de0-f377-93bdd01ed1c8](https://industrie40.vdma.org/documents/4214230/26342484/Industrie_40_Readiness_Study_1529498007918.pdf/0b5fd521-9ee2-2de0-f377-93bdd01ed1c8)

<sup>398</sup> See <https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs>



testing, financing advice, market intelligence and networking opportunities. DIHs are also playing a key role in the training and development of digital skills. For this purpose, they rely on the EIT Digital network<sup>399</sup>. Funding for the European Digital Innovation Hubs will be set aside in the Digital Europe Programme in the 2021-2027 period.

Recognising the problem that SMEs and other types of businesses face in adjusting to the challenges of digitalisation, a number of national programmes have been launched which aim to help firms to digitalise. Whilst SMEs are often not only the target group, they are often a key area of focus.

For example, in the **Belgian national strategy and programme to support digitalisation**, “Made Different”<sup>400</sup>, one of the key proposed actions was to set-up a guidance programme for disseminating good practices towards SMEs to become Factories of the Future. Whilst not engineering-specific, the programme targets Belgian manufacturing companies from all economic sectors, in particular SMEs. Among the sectoral targets are: end-to-end engineering to facilitate transformation to optimise value throughout the entire value chain by implementing an integrated design approach regarding processes such as sales, production, use of virtual models and simulations. Smart production systems: in order to make production systems more flexible and adaptive, manufacturing companies should interconnect various production components and devices, notably with the integration of cyber-physical systems.

In the **Dutch Digitalisation Strategy**, SMEs are a strong target group, recognising their economic importance. The government provides support for SMEs in their transition to a digital economy. Digitalisation is viewed as a means of increasing productivity and central to **‘Accelerating the digitalisation of SMEs’ (Versnelling digitaliserende mkb) programme**. The focus is on the development of technologies that contribute to digitalisation, such as big data, automation and online sales and marketing. The programme relies on the identification and dissemination of best practices to enable businesses to learn from one another in respect of digitalisation approaches. Cooperation involves stakeholders from business, regional authorities, industry organisations and educational institutions, among others.

It should be noted that further desk research is being undertaken to identify and analyse further initiatives that support Industry 4.0, such as the Catapults in the UK, Platform I4.0 (Italy), Industrie du Futur (France), and Smart Industry initiatives funded through the Eurostars programme such as between the Netherlands and Nord-Rhein Westphalia <sup>401</sup>.

#### **4.9.3 Digital transformation paradox**

It has been argued that new digital technologies carry with it seemingly limitless opportunities—and seemingly limitless options for technology investments. As such they have both expanded the possibilities of digital transformation and increased its importance to the organization.

The reality is that although executives are well aware of the power and importance of drawing up a digital strategy and taking the step towards implementing innovative digital technologies, many do not do so. According a global survey, only a third of the 75% of respondents who believe that digital transformation could be widespread in their organizations are actually committed to the implementation of critical digital business applications in their company<sup>402</sup>. It could be stated that organizations are stuck in a **paradox of digital transformation**. While employees and executives believe in the

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<sup>399</sup> See <https://www.eitdigital.eu/>

<sup>400</sup> See Belgium – Digitalisation Transformation Monitor, 2017

<sup>401</sup> <https://eurostars-smart-industry-2019.b2match.io/>

<sup>402</sup> <https://www.spie-ics.be/nl/de-paradox-van-de-digitale-transformatie/>



power and benefits of digital transformation, most executives admit that their company does not take the right actions to implement new technology and digital strategies.

To seize the full potential of digital technologies, it is also important to acknowledge that digital transformation should not happen in a vacuum and does not end simply with implementing new technologies and letting them run. A recent study by Deloitte<sup>403</sup> based on a survey with 361 executives in 11 countries argued that digital transformation typically has profound implications for an organization—affecting strategy, talent, business models, and even the way the company is organized. This study shows that while digital transformation is increasingly taking shape in most organisations, paradoxes can be observed around strategy, supply chain transformation, talent readiness, and drivers for investment.

- **Strategy paradox.** Nearly all respondents indicated that digital transformation is a top strategic objective for their organization (94 percent). They are however not fully exploring the realm of strategic possibilities made possible by new digital technologies and only 68 percent of the respondents see digital transformation as an avenue for profitability.
- **Supply chain paradox.** Executives identified the supply chain as a top area for both current and prospective digital transformation investments, indicating that supply chain initiatives can be considered a top priority. Yet, when it comes to taking decisions about digital transformation investments, supply chain executives and operational managers typically have limited decision power.
- **Talent paradox.** Most executives feel quite confident that they have the right talent in place to support digital transformations, but at the same time they admit that talent poses a vexing challenge. In the global survey, only 15 percent of respondents indicated they need to dramatically alter the composition and skill sets. At the same time, however, executives point to finding, training, and retaining the right talent as their top organizational and cultural challenge in assimilating digital technologies (see also above).
- **Innovation paradox.** Executives report their digital transformation initiatives are driven largely by productivity improvement and operational goals—essentially, leveraging advanced technologies primarily to do the same things better. This finding is in line with previous studies, suggesting a wider pattern around using advanced technologies for near-term business operations, rather than truly transformative opportunities. Yet, innovative opportunities abound—and should not be discounted. Organizations driven by other factors, such as an increased desire for innovation and internal strategy focus, reported an equally positive return on investment.

#### **4.9.4 The opportunities and solutions for flexible adaptation to digitalisation**

A set of opportunities and solutions for a more flexible implementation of digital technologies within the engineering industry can be identified:

- As argued before the development and deployment of certain digital technologies can be hampered by the lack of **standards and interoperability**. Accordingly, by investing more in standardisation processes and communication protocols, one can significantly stimulate the adaptation of digital technologies and reduce uncertainty. A notable example of a successful initiative is the launch of the *umati* platform in Germany. This platform has been developed with the aim of stimulating data exchange and interlinkages between machine tool manufacturers and relies on a common communication protocol. See box below.

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<sup>403</sup> Deloitte Insights (2018). The Industry 4.0 paradox. Overcoming disconnects on the path to digital transformation.

**Box 4-2: Umati – universal machine tool interface**

- Over two years ago, VDW (Verein Deutscher Werkzeugmaschinenhersteller – German Machine Tool Builders' Association) launched a standard interface to allow machines in the production environment to communicate with IT systems.
- This universal machine tool interface – labelled umati - was set by the companies Chiron, DMG Mori, Emag, Grob, Heller, Liebherr-Verzahntechnik, Trumpf and United Grinding. Its goal is to achieve an open standard for data exchange based on the global interoperability standard OPC UA. It also defines all necessary framework conditions to ensure seamless and secure integration of customers' machines and software. The ultimate goal of the umati brand is to provide international visibility and support its partners' marketing and quality assurance efforts. The standardisation activities of the Joint Working Group set up with the OPC Foundation are now followed by almost 100 companies all over the world. [www.umatinfo](http://www.umatinfo).
- At the umati press conference on 16 September 2019 in Hannover (EMO Hannover) 70 companies from ten countries have connected 110 machines and 28 value-added services at EMO Hannover2019 via the umati standard interface. The chairman Dr. Heinz-Jürgen Prokop stated that *"The interface enables machine tool manufacturers to fulfil another Industry 4.0 promise: the simple, fast and secure exchange of data. Creating a connection and providing a uniform language for machines, systems and software are essential prerequisites for reaping the benefits of digitalisation in production. The fact that individual companies no longer have to concern themselves with the correct functioning of the network interconnection represents a tremendous step forward"*.
- Umati has also already made a strong impression internationally. Three international consortia from major machine tool manufacturing countries have joined the interface: ProdNet from Switzerland, Edgecross from Japan and NCLink from China. In addition, the machine tool associations from China, the United Kingdom, Italy, the Netherlands, Austria, Switzerland, Spain and Taiwan as well as the European machine tool association Cecimo are supporting the project.

Source: Press Release: Global machine tool community paving the way for Industry 4.0. Extensive international involvement in VDW's umati presentation at EMO Hannover 2019

- To stimulate a widespread adoption of digital technologies, it can also be worthwhile to invest more in **experimentation labs and demonstration infrastructure**. Interviewees have indicated that these initiatives are important to show the potential of digital technologies and to inspire companies. Especially for SMEs this can be very important. Given their limited resources, it will be essential for them to test certain technologies or operational processes before they invest ("test before you invest"). Within this context, the European Commission's increasing focus on the Digital Innovation Hubs in Europe was cheered.
  - Good practices such as the ADMA Initiative<sup>404</sup> were also mentioned. Carried out for the European Commission (DG GROW, EASME), a consortium of 9 countries is developing since July of 2018 a virtual European Advanced Manufacturing Support Centre with a duration of 36 months. Support Centre to help SMEs assess the possibility of adopting advanced manufacturing solutions in order to transform their organisations towards next-generation factories with more competitive, modern and sustainable production.
- As capital investment needs to implement specific digital technologies can still be substantial, it is important to have smooth access to (external) capital. However as argued by one of the interviewees capital markets in Europe for new (digital) innovative technologies are still not functioning well. As such, it will be important to further

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<sup>404</sup> <http://www.adma.ec/>

improve access to finance. Here it is however important to remark that the European Commission is taking measures to improve **access to finance** and especially for small business in Europe<sup>405</sup>. The European Commission for instance collaborates with financial institutions to improve the funding available to SMEs by stimulating the provision of loans and venture capital through financial instruments. The European Commission also supports EU Member States in sharing good practices and policy instruments on improving access to finance. The 2014-2020 programme for the Competitiveness of Enterprises and Small and Medium-Sized Enterprises (COSME) is also partly designed to make it easier for SMEs to access loans and equity finance. The SME Instrument<sup>406</sup> within Horizon 2020 also offers funding and support for innovation projects that enable SMEs to grow and expand their activities into other countries.

- **Good connectivity** can be considered as one of the key building blocks of the competitiveness of European industry and a pre-requisite for agile connection of machinery on the shop floor, for managing complex supply chains and lean production. As such, it will be important to invest more in digital infrastructure. More specifically, this implies for instance that the further roll-out of **5G** networks in Europe will be essential. Luckily, the European Commission recognizes the crucial importance of 5G in Europe and it has become one of the more important priorities within the Digital Single Market Strategy. Within this context, the European Commission has launched the 5G for Europe Action plan<sup>407</sup>. This action plan aims to boost EU efforts for the deployment of 5G infrastructures and services across the Digital Single Market by 2020. For this purpose, a clear roadmap for public and private investment on 5G infrastructure in the EU has been set up. However, at this moment, only a limited number of EU Member States has defined a clear-cut strategy to roll out 5G or even to allocate 5G spectrum to telecom operators or other industrial stakeholders. When allocating spectrum, it is also important to take into account the connectivity needs and attributes/frequencies needs in the different sectors. As such it is important to involve industrial stakeholders in the process of allocating spectrum and standardisation. This should be done in a harmonized way and with taking legacy systems into account.
- As the safe transfer and communication of data is becoming increasingly important, **cybersecurity** is becoming a priority. The European Commission has also taken this up as one of the priorities of the Digital Europe Programme (to be launched in 2021)<sup>408</sup>. Of the proposed budget of €9.2 billion, €2 billion will flow to cybersecurity.
- As the access to and retention of talent in Europe is considered as one of the key challenges for implementing digital technologies, appropriate measures need to be taken to address this. More specifically, policy makers should create the right framework conditions for turning Europe into a world-leading centre of excellence for **skills** in digital technologies (e.g. by revising curricula to align them more with the evolving industrial landscape), while firms could invest more in talent attraction, retention and training programmes.
  - An example of how companies can invest more in the upskilling or reskilling of employees is given by Arcelik. This Turkish company (with affiliates in Europe) has developed a roadmap to improve the digital competencies of the employees. A total of 1,200 person\*day training sessions were held under different functional programs to prepare, strengthen or transform these competencies. Arcelik has also created the TechPro Academy, which aims to offer competencies of the future to all engineers, experts and senior experts

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<sup>405</sup> See: [https://ec.europa.eu/growth/access-to-finance\\_en](https://ec.europa.eu/growth/access-to-finance_en)

<sup>406</sup> See also: <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/eic-accelerator-pilot>

<sup>407</sup> <https://ec.europa.eu/digital-single-market/en/5g-europe-action-plan>

<sup>408</sup> See <https://ec.europa.eu/digital-single-market/en/news/digital-europe-programme-proposed-eu92-billion-funding-2021-2027>

working in the Production and Technology Group, and to carry these competencies to a higher level<sup>409</sup>

- **Create trustworthiness.** Given that users' needs and expectations are becoming increasingly important when developing new digital solutions, it is important to create user trustworthiness. If users have the choice to use one service or another, decisions will depend on the degree of trustworthiness. Specifically for that reason, the European AutoPilot project<sup>410</sup> has developed a trust framework that consists of attributes and related properties based on the perspectives of the users need to be addressed. More specifically, the "Autonomous vehicles and IoT Trust Framework" has been developed, which intends to provide a set of principles and the underlying structure that exhibit the trustworthiness, dependability and privacy for autonomous vehicles and IoT solutions into a holistic manner. The framework integrates the concepts of availability, reliability, safety, security, resilience, privacy and sustainability best practices, embracing "privacy and security by design" as a model for an implementable autonomous vehicle and IoT code of conduct and engagement.
- Given that firms have to increasingly collaborate with others to succeed in the digital economy, it can also be worthwhile to invest more in **matching platforms** or the building of **ecosystems**. A good example of this can be found in the Reboot IoT Factory, see below.

#### Box 4-3: Reboot IoT Factory

Reboot IoT Factory offers a unique opportunity to be a part of the next generation of Industry 4.0 and beyond. The organisation brings together forerunner factories, IoT solution providers and top-class research organizations to revolutionize the competitiveness of Finnish manufacturing industry.

The Reboot operative model is based on agile co-creation and experience sharing within real-world production environments. Each forerunner factory commits as a research and development platform for proof-of-concept experiments, which combine technology research and factory digitalization needs. Productization of these proof-of-concepts with forerunner factories as reference customers represents new domestic and export-driven business opportunities for IoT solution providers. Business impact for forerunner factories comes through the adoption of tailored IoT solutions and shared best practices, resulting in major advancements in the respective digitalization strategies.

Source: <https://rebootiotfactory.fi/>

#### 4.10 THE EFFECTS OF THE REGULATORY FRAMEWORK ON DIGITALISATION

The increased use of digital technologies in the EU engineering industries has witnessed the increased digitalisation of production processes and transition to Industry 4.0 manufacturing approaches, using a range of different technologies, such as AI and machine learning, robotisation and automation, and the sharing of big data across digitalised and interconnected production hubs.

This has enabled engineering firms to develop new and disruptive business models. However, the use of these technologies raises considerations regarding whether there may be additional risks associated with their integration into production processes, as well as into the industrial products being produced. There is a strategic question mark as to how best the Commission should create an enabling regulatory framework to encourage the wider adoption of such technologies so as to maintain the competitiveness of the EU engineering industries, whilst at the same time ensuring that legislation is sufficiently

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<sup>409</sup> See <http://www.arcelikglobal.com/en/technology/rd/techpro-academy/>

<sup>410</sup> See <https://autopilot-project.eu/>

technology-neutral to avoid hampering the emergence of new technologies and/ or imposing unnecessary regulatory burdens on industry.

The extent to which existing core applicable EU legislation for the EU engineering industries needs to be updated, or should continue to be addressed through harmonised standards to accommodate 'state of the art' technological developments was examined in detail in *Section 3.4.1 - Impact of new technological developments and innovation on EU and international legislation*.

Based on the literature review, interviews and survey results, a number of key findings are now presented regarding the current regulatory framework conditions to promote digitalisation, as well as how these might evolve in future. This in turn will have an ongoing impact on the future competitiveness of the EU engineering industries.

- Whilst there is an effective regulatory framework overall, an appropriately tailored regulatory framework to facilitate digitalisation by industry is still lacking. Consequently, there remains regulatory uncertainty for engineering firms.
- The main finding was that most industry stakeholders perceive the existing regulatory framework to be broadly fit for purpose. In particular, the preference was to retain the overarching regulatory approach of common rules across industrial product legislation through the NLF. This was partly due to industry's preference to avoid changing the essential requirements and instead to use harmonised standards as the mechanism to address any additional risks and safety considerations.
- Equally, there was a concern that if individual pieces of industrial product legislation are reviewed and recast to incorporate digitalisation and any risks associated with the use of new technologies in production processes, or in the industrial products being manufactured, this could lead to a period of major regulatory changes, with legislation being updated on a piecemeal basis.
- A further argument against regulating digitalisation (at least through industrial product legislation) was that it could compromise the technology-neutral principle in that as soon as an attempt was made to regulate the use of particular digital technologies, the technologies may become superseded by newer and more advanced technologies. This is a problem which industry stakeholders viewed technical standards as being better equipped to address than making amendments to EU industrial product legislation. An example given was the Machinery Directive, where an impact assessment was conducted in 2019-2020 regarding the Directive being updated, but there were concerns that it could hamper innovation. It was also pointed out that the use of automation technologies pre-dates AI technologies, and any risks can be dealt with in harmonised standards rather than by rewriting the essential requirements.
- There may nevertheless be ways of strengthening attention to digitalisation and new technologies in existing EU product legislation. For instance, the importance of addressing safety risks linked to digitalisation and new technologies could also be explicitly mentioned in the recitals. Consideration could also be given to the possible inclusion of Articles within directives and regulations under EU industrial product legislation relating to the need for economic operators to consider any new risks associated with these technologies.
- There was however some support for the introduction of horizontal EU legislation, for instance on cybersecurity and AI to create an enabling regulatory framework that fosters increased digitalisation by the EU engineering industries. A horizontal regulatory approach was advocated by many stakeholders to help ensure a level playing field across different types of industrial products (e.g. wireless vs. wired).
- Notwithstanding the caution of the engineering industries and reluctance to see too many changes to the existing regulatory framework, a supportive regulatory framework conducive to fostering digitalisation and the wider adoption of new



technologies could be envisaged over the decade to 2030. For instance:

- Progress has already been made at an EU policy level in anticipating future technological changes, for instance through the publication of the February 2020 **White Paper on AI**, which may lead to a future horizontal regulatory proposal. Such initiatives could help in addressing problems and issues such as liability and privacy, and the need for a trust-based approach.
- Moreover, the development of in parallel of a **European Data Strategy**, could in the context of big data usage through the development of the industrial IoT facilitate data sharing and provide clarity on data ownership. The strategy could be conducive to the development of digitalised production hubs in different EU countries as it facilitates data-sharing across borders.
- There is also a lack of transparency and clarity in terms of **data ownership**. The increase in data generated, collected, recorded and transferred within IIoT systems raises questions as to who owns the data, how the data may be legally shared, including across borders, and who is allowed to use the data. Currently, data ownership is not clearly defined or covered in contracts<sup>411</sup>. Accordingly, a thorough understanding is required of the rights when data is produced by various connected devices/nodes, in order to unleash the full potential of IIoT systems. Regulation (EU) 2019/1807, applicable from 28.5.2019, aims to establish the free movement of non-personal data inside the EU to overcome data restrictions and to facilitate the portability of data. The regulatory approach follows the principles of transparency, interoperability and taking into account open standards.<sup>412,413</sup> Such regulations should help to eradicate barriers and obstacles, at least within the EU.
- Recognising the globalised nature of value chains in which multi-regional digital production hubs are increasingly prevalent, a key issue is whether a future EU regulatory framework could facilitate data-sharing between production hubs both within, and outside the EU. This implies reaching international data sharing agreements – possibly through trade deals or other bi-lateral agreements – with third countries. This would enable data sharing across production hubs for EU manufacturers with production facilities say in both the EU and Asia, and would help to optimise the potential operating efficiencies from big data analytics. Big data-sharing could also be considered *between* industry players to the mutual benefit of participant economic operators.
- Some agreements on data sharing already exist, such as the EU-US data shield, however, this provides a mechanism to comply with data protection requirements when transferring personal data. International agreements on non-personal data are arguably needed.
- Furthermore, the EU's **2019 Market Surveillance Regulation**,<sup>414</sup> which replaces the 2008 Regulation under the NLF puts a strong emphasis on adapting Market Surveillance and enforcement for the digital age. This includes provisions to strengthen surveillance of online platforms, requirements for economic operators outside the EU selling via e-commerce to appoint an authorised representative in the EU to strengthen traceability. In addition, there is a focus on strengthening traceability for surveillance purposes through accessing data and information

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<sup>411</sup> See for instance: Study on emerging issues of data ownership, interoperability, (re-)usability and access to data, and liability (2016). Study prepared for the European Commission, DG CNCT by Deloitte.

[https://www.wik.org/fileadmin/Studien/2018/EU\\_Data\\_ownership\\_en.pdf](https://www.wik.org/fileadmin/Studien/2018/EU_Data_ownership_en.pdf)

<sup>412</sup> <https://ec.europa.eu/digital-single-market/en/policies/building-european-data-economy>

<sup>413</sup> <https://ec.europa.eu/digital-single-market/en/free-flow-non-personal-data> Regulation (EU) 2018/1807 of the European Parliament and of the Council of 14 November 2018 on a framework for the free flow of non-personal data in the European Union OJ L 303, 28.11.2018, p. 59–68 <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018R1807>

<sup>414</sup> Regulation (EU) 2019/1020 of the European Parliament and of the Council of 20 June 2019 on market surveillance and compliance of products and amending Directive 2004/42/EC and Regulations (EC) No 765/2008 and (EU) No 305/2011

available through digital supply chains. This could benefit the EU engineering industries by 1) reducing the amount of time taken to obtain compliance information requested by Market Surveillance Authorities (MSAs) from across a manufacturer's value chain thereby reducing uncertainty as to whether they will face a more detailed investigation by an MSA. The Regulation will also give MSAs more powers to reduce the level of non-compliant products sold on the European market that circumnavigate existing EU law by using e-commerce channels direct from third countries and the abdication of responsibility for checking compliance of online platforms. This will also benefit engineering firms as it will strengthen the level regulatory playing field, and ensure that it is more difficult for very cheap, low-quality, non-compliant products to enter the European market. However, the anticipated benefits will take time to materialise, as the new Regulation comes into force from July 2021.

- In addition, policy makers are being called upon to regulate entirely new sub-sectors that have evolved due to new technologies<sup>415</sup>. A good example of this challenge is autonomous vehicles, which the EU engineering industries provide specialist electronic components and sensors to. Policy makers have not (yet) created transparent rules that would enable a widespread launch and use of these vehicles. Government regulation should evolve swiftly along nascent technologies to stimulate new activities and business models, but this has proven to be a severe stumbling block.
  - Interviewees have also stressed that one should harmonize the legislation across the different EU Member States. As an example, we can state that the legislation on autonomous vehicles and drones is very heterogeneous among EU Member States. Differences relate among others to standards, certification processes, testing procedures, and liabilities. This can have a substantial negative effect on the speed of development in these sectors.
- The regulatory framework should also make a **distinction where appropriate between B2B and B2C** due to differences in focus, different stakeholders, and less dealing with personal information. An example in this regard is that the regulatory framework for the sharing of non-personal data is necessarily differentiated from that pertaining to personal data. However, stakeholders pointed to difficulties in such differentiation in core industrial product legislation due to the blurring of the distinction between professional and consumer products, which limits the scope for regulatory differences between B2B and B2C.
- A good **holistic approach** to improving the regulatory framework is also needed given that applications and solutions rely on an increasing number of underlying technologies.

#### **4.11 CONCLUSIONS – EUROPE'S DIGITAL INNOVATION POTENTIAL, CHALLENGES AND FUTURE OPPORTUNITIES IN THE ENGINEERING INDUSTRIES.**

As can be observed from the (digital) patent analysis, the EU engineering industry remains a strong innovator but appears less dynamic in (digital) patenting activities compared to its main global competitors. Innovations from the EU engineering sector address significantly fewer digital technologies as compared to the major global competitors, which is in line with other research results. However, we can also observe some relative strengths in digital patenting. On the one hand, some European countries like Sweden and Finland show dynamics that keep up with EU's main competitor regions when it comes to the digital patenting activities. On the other hand, the EU – esp. compared to Asian countries – has still a strong competitive advantage in some key digital technologies such as cyber security technologies and electronic measurement, which hint at some degree of good future market perspectives in these fields. In addition, the value chain analysis shows

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<sup>415</sup> <https://iiot-world.com/connected-industry/industrial-iiot-legal-and-regulatory-aspects/>

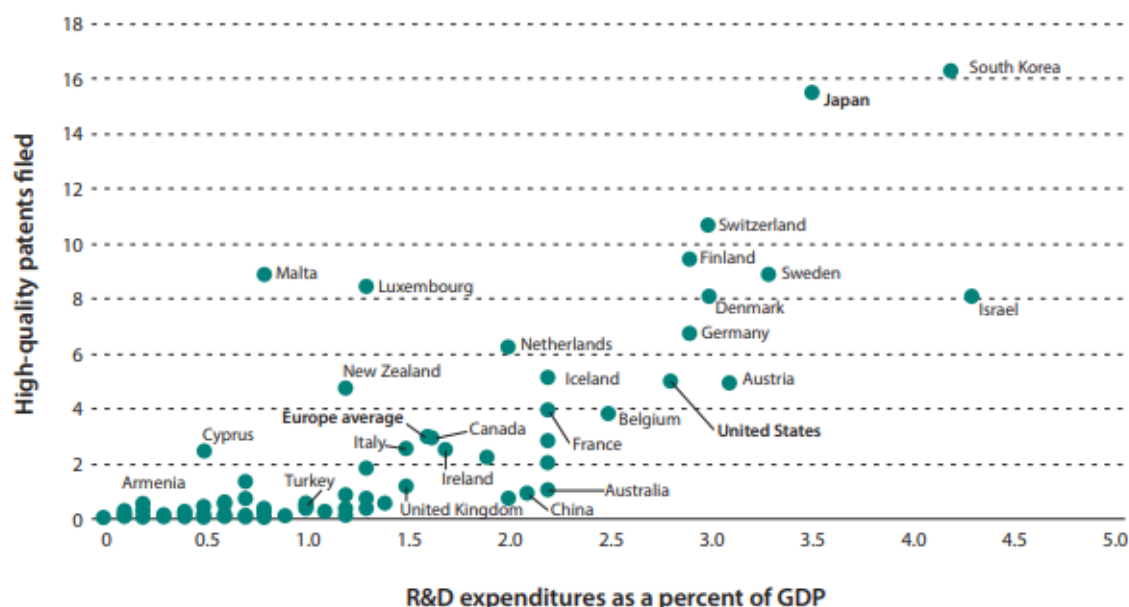


that the EU can profit from the more dynamic developments abroad to push forward the digitalisation of its own engineering industry, especially in fields where it does not have a strong position or missing knowledge.

Against the background of these results, it will be important for the future to strengthen further the EU's position in those technologies where it has still a competitive advantage (cyber security and electronic measurement). In addition, developments in critical digital technologies like high speed network and mobile / wireless communication (both important e.g. for 5G) need to be further supported to keep up with the EU's major competitors US and China. Given that the innovation pipeline (including patents as one of the potential outcomes) requires large inputs of R&D spending and highly skilled labour, the following will be necessary:

The EU should continue to **push forward R&D&I investments in the EU engineering industry**, which are strongly below those of the main competitor countries (see Part I on R&D expenditures). This even more important given the fact that higher investments are strongly correlated to higher quality patents (see Figure below).

**Figure 4-38: Total R&D Expenditures and High-Quality Patents Filed, by Country**



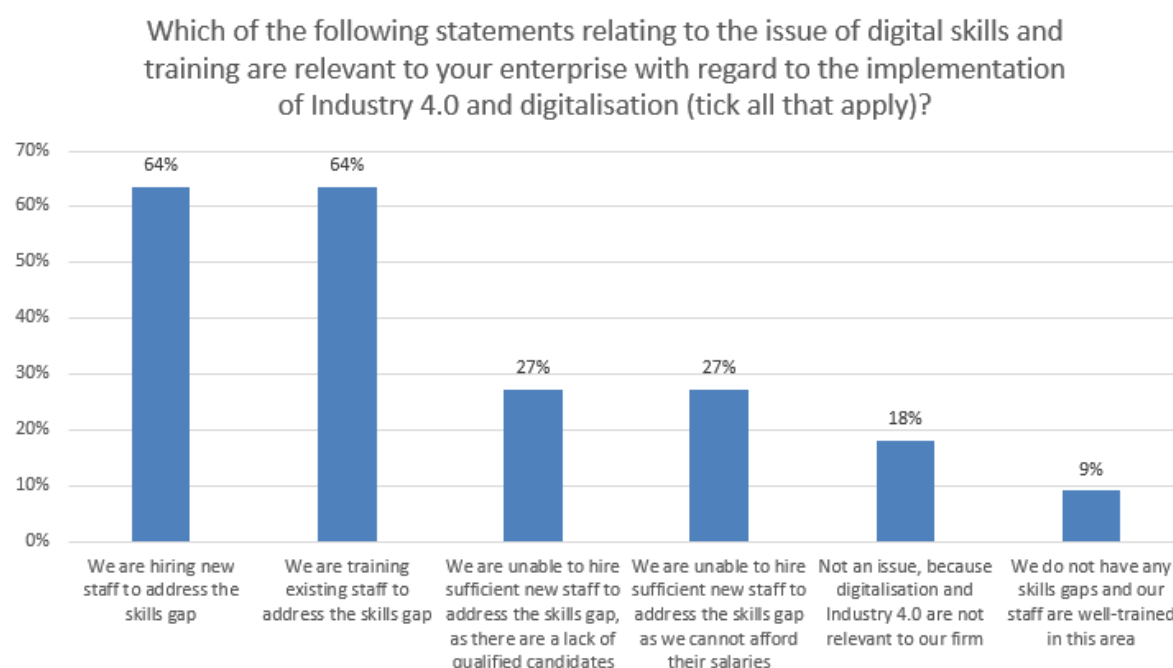
*Note:* R&D data are for 2015, patent data for 2013. "European average" is for European Patent Office member states: it excludes Lichtenstein, Monaco, and San Marino (data not available). High-quality patents are defined as patent families (set of patents in multiple countries to protect a single invention) filed in at least two offices, reported per billion dollars of PPP-adjusted GDP.

*Source:* Shambaugh J., Nunn, R. & Portman, B. (2017): *Eleven Facts about Innovation and Patents*. The Hamilton Project. p.3.

In this regard, the online survey across the industry associations has shown that especially a **level playing field when it comes to public R&D&I support** is of great importance. For instance, for the electronic components and semi-conductor sectors, it was pointed out by the industry association that in the US and China, there has been significant national government support through subsidies and grants to the industry itself as well as major scale investment in R&D&I. Even though the EU has addressed this issue to some extent, e.g. through the ECSEL initiative, the **perception remains that in certain strategic sub-sectors, firms in some countries have an unfair competitive.**

A second important element when it comes to supporting digital innovations are **digital skills and competencies**. As mentioned before, beyond R&D spending a crucial input into producing patents is education. High quality patent activity—is almost exclusively accomplished by people with advanced degrees.<sup>416</sup> This is even more true for digital innovations where more specific digital / STEM related skills are needed. In this regard, the survey of manufactures shows that around 1/3 of the surveyed companies are unable to hire sufficient new staff to address the digital skills gap that exists in their company (see Figure 4-39). A problem that is even more pronounced in SMEs as the online stakeholder workshop revealed. Therefore, it is crucial to support the digital skills development in during the workers' education (as early as possible) and in the companies themselves (e.g. by supporting specific training measures).

**Figure 4-39: Digital skills and industry 4.0 implementation / digitalisation**



Source: Manufacturers and economic operators survey.

Next to R&D spending and skills, the survey across the industry associations revealed another important element, which needs to be considered for strengthening the EU engineering industry's digital innovation activities. To fully grasp the opportunities of the digital transformation appropriate framework conditions are needed. This means ensuring that there is a **supportive regulatory framework** to facilitate wider take up of new digital technologies and to accommodate new technological developments, such as in the field of Artificial Intelligence.

<sup>416</sup> Shambaugh J., Nunn, R. & Portman, B. (2017): Eleven Facts about Innovation and Patents. The Hamilton Project.

## 5. IMPACTS OF COVID-19 ON THE EU ENGINEERING INDUSTRIES AND DIGITALISATION

The COVID-19 pandemic is already having a significant impact on Europe's industrial landscape and manufacturing base, including on the EU engineering industries. As the impacts of the pandemic are fast-changing, the analysis relates to the situation up to the end of July 2020. Ways in which the EU, through the European Recovery Plan (ERP), might be able to alleviate the negative impacts of the crisis, are also considered.

### 5.1 INTRODUCTION

#### 5.1.1 The effects of COVID-19 on the EU engineering industries and digitalisation

The COVID-19 pandemic has already significantly impacted the EU engineering industries, both *directly*, on the three branches of the engineering sectors within scope, and *indirectly* on the level of demand from key vertical sectors which the engineering industries provide intermediate inputs to, such as **pharmaceuticals, automotive, aerospace and the food industry**. Moreover, the pandemic is likely to have ongoing effects over the medium and longer-term.

The research has considered the impacts on the:

- **Supply side:** supply chain dislocations due to the temporary non-availability of crucial components and parts necessary for final production due to factory closures during lockdowns and greater difficulties in obtaining raw materials; and
- **Demand side:** the economic effects from national lockdowns across different EU Member States, as well as lockdowns in many countries internationally, leading to a reduction in economic activity, with a fall in demand across the different branches of the EU engineering industries within scope and a reduction in GDP.

The implications for the EU engineering industries of the crisis are considerable. Examples of the types of impacts and the key research issues examined in this section are provided in the following table:

**Table 5-1 - Overview of the impacts of COVID-19 and key research issues**

| Impacts of COVID-19 on....                          | Key research issues for exploration                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>The European economy</b>                         | <ul style="list-style-type: none"> <li>• What is the impact to date on European GDP of COVID-19 in 2020? What are likely to be the impacts in 2021 and beyond?</li> <li>• What are the labour market impacts of COVID-19?</li> <li>• To what extent is the economic recovery – and EU and national stimulus packages (notably the EU's Next Generation EU Recovery Plan) – likely to help to mitigate the adverse impacts on the European economy overall, and on the EU engineering industries?</li> </ul> |
| <b>Impacts on the EU engineering industries</b>     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>The demand side</b>                              | <ul style="list-style-type: none"> <li>• How far is the expected reduction in European and global GDP in 2020 expected to impact the demand side in the EU engineering industries?</li> <li>• To what extent are the intra-EU demand-side effects different from extra-EU?</li> </ul>                                                                                                                                                                                                                       |
| <b>The free movement of goods and people within</b> | <ul style="list-style-type: none"> <li>• How far has the pandemic impeded the free movement of products and machinery produced by the EU engineering industries within the Single Market?</li> </ul>                                                                                                                                                                                                                                                                                                        |

| Impacts of COVID-19 on....                                                           | Key research issues for exploration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>the Single Market</b>                                                             | <ul style="list-style-type: none"> <li>• To what extent has the temporary closure of national borders due to the pandemic had an impact on the free movement of skilled personnel, such as machinery installers, servicing and maintenance technicians?</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>The supply chain and degree of risks associated with supply chain dislocation</b> | <ul style="list-style-type: none"> <li>• To what extent was supply chain dislocation a problem during the pandemic's first wave? Did this relate to GVCs and supply chain linkages between Europe and third countries, intra-EU supply chains, or both?</li> <li>• Which specific branches of engineering were affected, and how? What types of supply chain disruptions were encountered?               <ul style="list-style-type: none"> <li>– Did this mainly relate to the non-availability of electrical components, other parts and components or both?</li> <li>– How far were there also shortages in critical raw materials and in the availability of industrial chemicals?</li> </ul> </li> <li>• To what extent were vertical industries that the EU engineering industries serve (e.g. pharma, automotive) also subject to supply chain dislocations?</li> <li>• How far are supply chain challenges likely to remain a problem for the EU engineering industries, during the second wave, or in further potential waves?</li> <li>• To what extent are EU manufacturers seeking to diversify their supply chains as a result of COVID-19?</li> </ul> |
| <b>Reshoring</b>                                                                     | <ul style="list-style-type: none"> <li>• How far has supply chain dislocation led manufacturers in the EU engineering industries to conduct strategic reviews of their global supply chains to assess the risks?</li> <li>• To what extent is the pandemic (and the impact on supply chain dislocation) likely to drive reshoring to Europe?</li> <li>• Which areas of production might be reshored, specifically due to COVID-19? Or are other reasons exercising a greater influence?</li> <li>• Is the impact on reshoring likely to be short-lived, or to have a more enduring impact?</li> <li>• Are there likely to be any other impacts, such as a reconfiguration of global value chains (GVCs)?</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Exporting</b>                                                                     | <ul style="list-style-type: none"> <li>• To what extent are export trends likely to be affected by COVID-19?</li> <li>• How is COVID-19 affecting intra-EU and extra-EU exports from the EU engineering industries?</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Industrial competitiveness and innovation</b>                                     | <ul style="list-style-type: none"> <li>• What effects is COVID-19 likely to have overall on the industrial competitiveness of the EU engineering industries?</li> <li>• How will the economic impacts on Europe, as opposed to key competitor countries, influence competitiveness?</li> <li>• What impacts is COVID-19 likely to have on the behaviours of individual market participants? Is there likely to be market consolidation as a result of the drop in demand and economic downturn?</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

These issues are explored in the subsequent sub-sections.

### 5.1.2 Methodology to assess the impacts of COVID-19

The research draws on a combination of primary and secondary data and information sources.

Primary data collection includes interview feedback and observations made by key engineering industry associations at the validation webinars held in May 2020. Additionally, survey-based data is primarily available from snapshot surveys carried out by national engineering industry associations and EU-level engineering and broader umbrella manufacturing associations. Secondary data includes relevant studies and surveys identified through desk research that assess the immediate impacts of the pandemic on the EU engineering industries. Some qualitative feedback has also been

gathered through the online surveys conducted for this study<sup>417</sup>, by assessing the open survey responses gathered in the March – May 2020 period.

Macro-economic data has also been reviewed, for instance GDP and unemployment projections from Eurostat, the IMF and the ILO. The analysis only provides a snapshot of the initial impacts based on official statistics. The situation is however fast-changing, and longitudinal analysis will be needed in future. Sectoral business statistics data has also been examined, and whilst for many indicators, there is a time lag in data availability, an analysis of monthly year-on-year comparative data on production and on international trade in goods (especially exports) for the EU engineering industries has been conducted.

**5.1.3 Relevant documents consulted through the literature search are listed in Annex 1 (see last sub-heading in bibliography). Macro-economic impact of COVID-19**

The macro-economic impacts of COVID-19, notably the expected rate of decline in gross domestic product (GDP), changes in unemployment levels and in inflation rates, are now considered.

The scale of the current economic crisis is likely to be severe. Regarding the **impact on GDP**, in the euro area, GDP contracted by 3.8% in the first quarter of 2020.<sup>418</sup> However, this only included one month of impact of COVID in the quarter. During 2020 as a whole, the IMF predicts a **decline in GDP in Europe of circa 7.5%**,<sup>419</sup> before an economic rebound expected in 2021, with a slower economic recovery forecast in the 2022-24 period. The projected decline of 7.5% overall masks differences between Member States at the national level. For instance, France's GDP is expected to decline by 10.3% in 2020, but to increase by 7.8% in 2021, leading to an overall net decline in GDP over two years compared with 2019 data. The figures for Italy are even worse, with a decline of 11.7% in GDP anticipated in 2020, with a rebound of 7.9% in 2021, a net decline of 3.8% compared with 2019 over two years.

In the European Economic Forecast, Spring 2020<sup>420</sup>, the level of severity of the GDP decline in comparison with the economic and financial crisis of over a decade ago is highlighted. *"The contraction in EU GDP this year is expected to be 7.5%, far deeper than during the financial crisis in 2009"*. The report also notes that *"provided that the policy measures taken to support incomes, jobs, liquidity and investment are effective, economic activity should rebound once the confinement is gradually relaxed. Even so, demand is set to remain subdued for longer as workers concerned about their employment prospects will tend to save a higher share of their income, and firms faced with uncertainty about future sales will delay or cancel investment"*. On the demand side, the issue of delayed or cancelled investments was raised by engineering sector stakeholders during the two May 2020 webinars carried out during this study.

The macro-economic projections for real GDP, inflation and the unemployment rate contained within the European Economic Forecast, Spring 2020 are presented in the below figure.

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<sup>417</sup> The online surveys were finalised and launched in September 2019 so by definition, did not explicitly include any questions about the impact of the pandemic, which only occurred in Europe from February 2020. However, some respondents mentioned COVID-19 in their survey responses.

<sup>418</sup> Eurostat, (2020), Newsrelease euroindicators, GDP and employment flash estimates for the first quarter of 2020, 15 May 2020, [https://ec.europa.eu/eurostat/documents/2995521/10294864/2-15052020-AP-EN.pdf/5a7ea909-e708-f3d3-8375-e2510298e1b8#:~:text=GDP%20growth%20in%20the%20euro,office%20of%20the%20European%20Union.https://www.imf.org/external/datamapper/NGDP\\_RPCH@WEO/EU/EURO/EUQ](https://ec.europa.eu/eurostat/documents/2995521/10294864/2-15052020-AP-EN.pdf/5a7ea909-e708-f3d3-8375-e2510298e1b8#:~:text=GDP%20growth%20in%20the%20euro,office%20of%20the%20European%20Union.https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/EU/EURO/EUQ)

<sup>420</sup> European Commission (DG ECFIN), European Economic Forecast, Spring 2020, [https://ec.europa.eu/info/sites/info/files/economy-finance/ip125\\_en.pdf](https://ec.europa.eu/info/sites/info/files/economy-finance/ip125_en.pdf)

**Figure 5-1 – Real GDP, inflation and the unemployment rate**

|                  | Real GDP   |             |            | Inflation  |            |            | Unemployment rate |            |            |
|------------------|------------|-------------|------------|------------|------------|------------|-------------------|------------|------------|
|                  | 2019       | 2020        | 2021       | 2019       | 2020       | 2021       | 2019              | 2020       | 2021       |
| Belgium          | 1.4        | -7.2        | 6.7        | 1.2        | 0.2        | 1.3        | 5.4               | 7.0        | 6.6        |
| Germany          | 0.6        | -6.5        | 5.9        | 1.4        | 0.3        | 1.4        | 3.2               | 4.0        | 3.5        |
| Estonia          | 4.3        | -6.9        | 5.9        | 2.3        | 0.7        | 1.7        | 4.4               | 9.2        | 6.5        |
| Ireland          | 5.5        | -7.9        | 6.1        | 0.9        | -0.3       | 0.9        | 5.0               | 7.4        | 7.0        |
| Greece           | 1.9        | -9.7        | 7.9        | 0.5        | -0.6       | 0.5        | 17.3              | 19.9       | 16.8       |
| Spain            | 2.0        | -9.4        | 7.0        | 0.8        | 0.0        | 1.0        | 14.1              | 18.9       | 17.0       |
| France           | 1.3        | -8.2        | 7.4        | 1.3        | 0.4        | 0.9        | 8.5               | 10.1       | 9.7        |
| Italy            | 0.3        | -9.5        | 6.5        | 0.6        | -0.3       | 0.7        | 10.0              | 11.8       | 10.7       |
| Cyprus           | 3.2        | -7.4        | 6.1        | 0.5        | -0.2       | 1.0        | 7.1               | 8.6        | 7.5        |
| Latvia           | 2.2        | -7.0        | 6.4        | 2.7        | 0.2        | 1.9        | 6.3               | 8.6        | 8.3        |
| Lithuania        | 3.9        | -7.9        | 7.4        | 2.2        | 0.8        | 1.5        | 6.3               | 9.7        | 7.9        |
| Luxembourg       | 2.3        | -5.4        | 5.7        | 1.6        | 0.7        | 1.6        | 5.6               | 6.4        | 6.1        |
| Malta            | 4.4        | -5.8        | 6.0        | 1.5        | 0.7        | 1.1        | 3.4               | 5.9        | 4.4        |
| Netherlands      | 1.8        | -6.8        | 5.0        | 2.7        | 0.8        | 1.3        | 3.4               | 5.9        | 5.3        |
| Austria          | 1.6        | -5.5        | 5.0        | 1.5        | 1.1        | 1.5        | 4.5               | 5.8        | 4.9        |
| Portugal         | 2.2        | -6.8        | 5.8        | 0.3        | -0.2       | 1.2        | 6.5               | 9.7        | 7.4        |
| Slovenia         | 2.4        | -7.0        | 6.7        | 1.7        | 0.5        | 1.2        | 4.5               | 7.0        | 5.1        |
| Slovakia         | 2.3        | -6.7        | 6.6        | 2.8        | 1.9        | 1.1        | 5.8               | 8.8        | 7.1        |
| Finland          | 1.0        | -6.3        | 3.7        | 1.1        | 0.5        | 1.4        | 6.7               | 8.3        | 7.7        |
| <b>Euro area</b> | <b>1.2</b> | <b>-7.7</b> | <b>6.3</b> | <b>1.2</b> | <b>0.2</b> | <b>1.1</b> | <b>7.5</b>        | <b>9.6</b> | <b>8.6</b> |
| Bulgaria         | 3.4        | -7.2        | 6.0        | 2.5        | 1.1        | 1.1        | 4.2               | 7.0        | 5.8        |
| Czechia          | 2.6        | -6.2        | 5.0        | 2.6        | 2.3        | 1.9        | 2.0               | 5.0        | 4.2        |
| Denmark          | 2.4        | -5.9        | 5.1        | 0.7        | 0.3        | 1.3        | 5.0               | 6.4        | 5.7        |
| Croatia          | 2.9        | -9.1        | 7.5        | 0.8        | 0.4        | 0.9        | 6.6               | 10.2       | 7.4        |
| Hungary          | 4.9        | -7.0        | 6.0        | 3.4        | 3.0        | 2.7        | 3.4               | 7.0        | 6.1        |
| Poland           | 4.1        | -4.3        | 4.1        | 2.1        | 2.5        | 2.8        | 3.3               | 7.5        | 5.3        |
| Romania          | 4.1        | -6.0        | 4.2        | 3.9        | 2.5        | 3.1        | 3.9               | 6.5        | 5.4        |
| Sweden           | 1.2        | -6.1        | 4.3        | 1.7        | 0.4        | 1.1        | 6.8               | 9.7        | 9.3        |
| <b>EU</b>        | <b>1.5</b> | <b>-7.4</b> | <b>6.1</b> | <b>1.4</b> | <b>0.6</b> | <b>1.3</b> | <b>6.7</b>        | <b>9.0</b> | <b>7.9</b> |
| United Kingdom   | 1.4        | -8.3        | 6.0        | 1.8        | 1.2        | 2.1        | 3.8               | 6.7        | 6.0        |
| China            | 6.1        | 1.0         | 7.8        | :          | :          | :          | :                 | :          | :          |
| Japan            | 0.7        | -5.0        | 2.7        | 0.5        | 0.0        | 0.2        | 2.3               | 4.3        | 4.5        |
| United States    | 2.3        | -6.5        | 4.9        | 1.8        | 0.5        | 1.5        | 3.7               | 9.2        | 7.6        |
| World            | 2.9        | -3.5        | 5.2        | :          | :          | :          | :                 | :          | :          |

The potential economic rebound anticipated in 2021 is dependent on a number of different variables, with considerable uncertainty as to whether economic forecasting can be relied upon, due to the constantly evolving nature of the pandemic. Uncertain variables include, *inter alia*, whether a second and subsequently further waves of new infection cases materialise both in Europe and in third countries, and if this is the case, the degree of severity in comparison with the first wave, the duration of lockdowns, the degree to which national borders can be kept open or are subject to prolonged or temporary closures, the extent to which economic recovery strategies, funding and measures implemented at European and national level are effective, and the timeliness of rolling out their implementation, etc.

In terms of regionalised economic impacts on the EU engineering industries, this depends on the extent of exposure to global value chains (GVCs). According to the desk research and interview feedback, the sectors most affected by COVID-19 are those either with complex GVCs (e.g. automotive), an over-dependency on a single supplier (e.g. electronic components from Asia, where lockdown led to factory closures), and over-dependency on particular geographic regions for key components.

From a sectoral perspective, it is clear that the impacts are and will continue to be uneven and divergent, although mostly negative. In its Staff Working Document (SWD) accompanying the recovery plan,<sup>421</sup> the European Commission presents an analysis of Joint Harmonised EU Programme of Business and Consumer Surveys data, focusing on confidence indicators across the EU industrial ecosystems. Of the EU industrial ecosystems examined by the Commission, the impacts on ecosystems strongly related to the mechanical, electrical and electronic engineering industries were found to differ, although the Commission notes that *'confidence in service sectors [...] has been more affected than in manufacturing'*<sup>422</sup>.

As highlighted throughout this section, some industrial ecosystems that rely heavily on the engineering industries for intermediate inputs are facing significant current and future supply and demand challenges. For instance, the Commission analysis illustrates that this is particularly true for the 'Mobility-Transport-Automotive' industrial ecosystem, which has the second lowest overall confidence indicator (behind tourism), driven by extremely low current and future expected weaknesses in both supply and demand. As illustrated through a case study later in this section, the automotive sector is heavily reliant on the engineering industries and has suffered significant negative impacts from the COVID-19 crisis due to factory closures amidst national, regionalised and localised lockdowns and the non-availability of key components especially from Asia but also intra-EU during February – May 2020.

Considering the electronics ecosystem, which is of key relevance to this analysis, it is clear that confidence in current demand factors (such as order-book levels) has been affected more acutely by the COVID-19 crisis than supply factors (such as production trends and developments in the business situation). However, looking forward, this perception is expected to switch as future confidence in demand factors is much higher than expected confidence in supply factors. The digital industrial ecosystem, which is an important competitiveness dimension for this analysis, is however one of the least affected ecosystems monitored and reported on by the Commission. Although confidence in current supply factors is relatively low, current demand factors appear to be more robust.

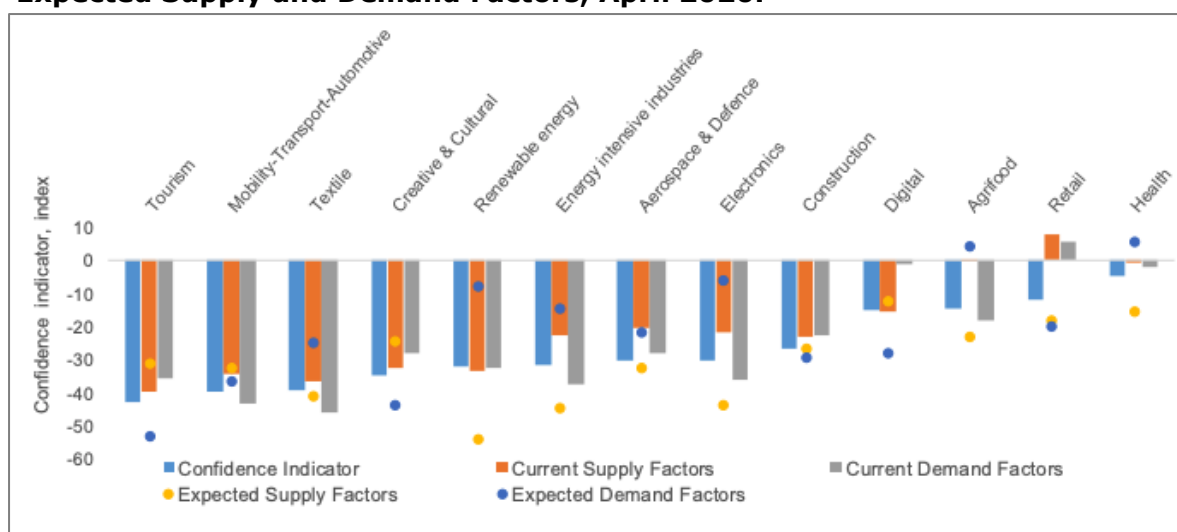
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<sup>421</sup> European Commission, (2020), Staff Working Document: Identifying Europe's recovery needs, Accompanying the document: Europe's moment: Repair and Prepare for the Next Generation, SWD(2020) 98 final

<sup>422</sup> European Commission, (2020), Staff Working Document: Identifying Europe's recovery needs, Accompanying the document: Europe's moment: Repair and Prepare for the Next Generation, SWD(2020) 98 final



**Figure 5-2 – Confidence indicator of EU Industrial Ecosystems: Current and Expected Supply and Demand Factors, April 2020.**



Turning to the impact of COVID-19 on **unemployment in Europe**, this is expected to be significant across the European economy as a whole, and in the engineering industries. In its first findings report on 'Living, working and COVID-19' from April 2020, Eurofound highlighted that 28% of respondents that were part of the EU27 labour force had either lost their job temporarily (23%) or permanently (5%).<sup>423</sup> However, Eurofound also noted that unemployment impacts are difficult to forecast accurately at this stage due first and foremost to the uncertain duration of furlough schemes. Such schemes are common in many EU countries, and have received EU support through the scheme announced in April 2020, **Support to mitigate Unemployment Risks in an Emergency (SURE)**.<sup>424</sup>

Furthermore, an analysis by the JRC attempted to estimate the impact of confinement measures on EU labour markets and workers.<sup>425</sup> The analysis first categorises different economic sectors based on the extent to which they have been impacted by confinement measures. By applying this categorisation to EU Labour Force Survey data, the JRC has estimated the share likely impact of COVID-19 by Member State and different socio-economic groups. Considering sectors subject to forced closure, the EU average is that around 11% of employment is in sectors subject to forced closure. However, there is a noticeable difference between Member States. Southern European countries – including MT (15.7%), ES (14.2%), CY (14.2%), GR (13.0%) – and Ireland (12.7%) have higher percentages of employment subject to forced closures. Considering the socio-economic composition of the sectors affected as described above, the JRC noted clear asymmetric impacts, with the negative effects concentrated on the most vulnerable and disadvantaged workers. A summary of the findings in this regard is now presented:<sup>426</sup>

- **Wage percentile (as a proxy for job quality):** Wages are found to be lowest in the sectors that have been subject to forced closure.
- **Gender:** Women are overrepresented in forcefully closed sectors in all Member States except GR and MT. However, women are also overrepresented in essential sectors, and

<sup>423</sup> Eurofound (2020), Living, working and COVID-19: First findings – April 2020, Dublin.

<sup>424</sup> <https://www.europarl.europa.eu/news/en/headlines/society/20200416STO77205/covid-19-s-economic-impact-EU100-billion-to-keep-people-in-jobs> During the crisis, the EU will provide financial assistance under the SURE programme, announced 1<sup>st</sup> April, 2020 in the form of loans granted on favourable terms to EU countries that request support. Assistance would finance national short-time work schemes, unemployment benefits and similar job protection measures. Up to €100 billion will be available to all 27 member states.

<sup>425</sup> Joint Research Centre (JRC), (2020), The impact of COVID confinement measures on EU labour market, Science for Policy Briefs.

<sup>426</sup> Joint Research Centre (JRC), (2020), The impact of COVID confinement measures on EU labour market, Science for Policy Briefs.

those that can be done through teleworking whereas men are overrepresented in mostly non-essential sectors such as manufacturing and construction.

- **Age:** Younger workers are more likely to be employed in the most affected sectors and less likely to be employed in essential and sectors where teleworking is possible.
- **Employment type:** Self-employment and temporary contracts are more common in forcefully closed sectors, although there are significant differences between Member States.

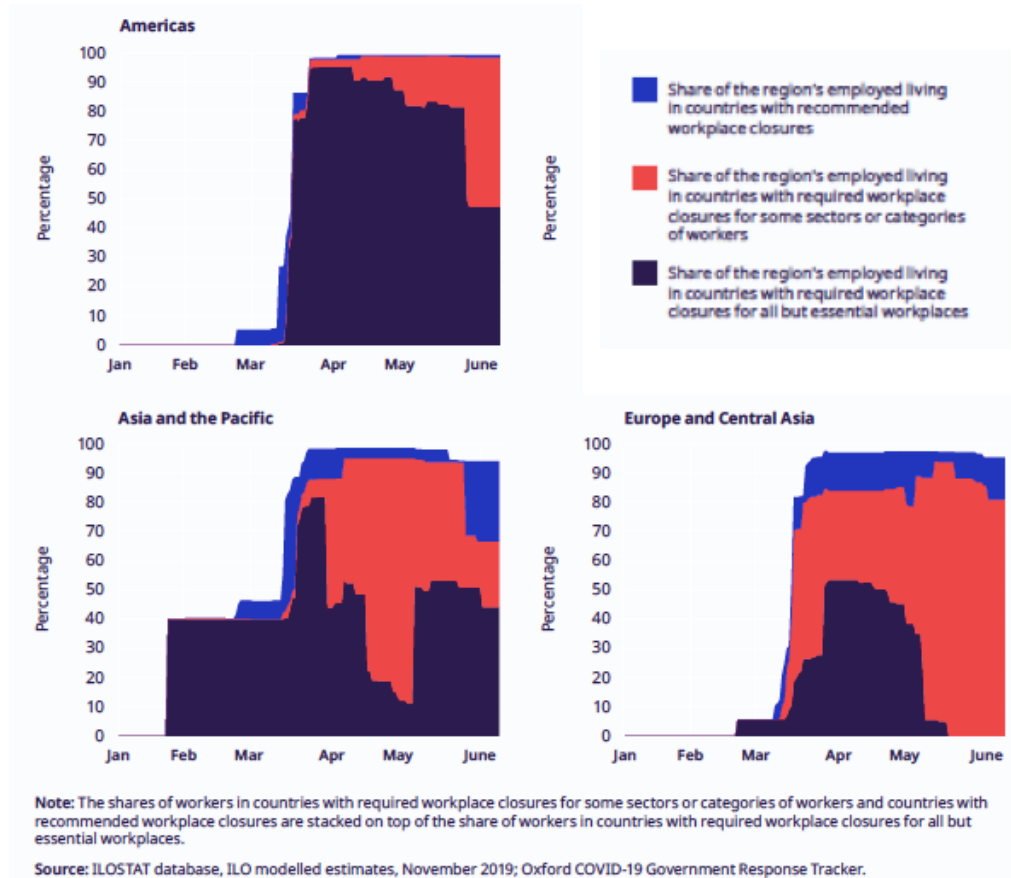
Although not focused on the EU, the International Labour Organisation (ILO) has also been reporting on the situation with regard to workplace impacts through multiple editions of its 'COVID-19 and the world of work' publications.<sup>427</sup> More specifically, the ILO has reported on the global differences in workplace closures, as well as findings on experienced and projected working-hour losses.

- **Workplace closures:** As of 15 June 2020, 74% of workers globally were living in countries with required workplace closures for some sectors or categories of workers, with 32% of these workers in countries with required workplace closures for all but essential workers. Considering the latter figure, the percentage of workers in countries with required workplace closures for all but essential workers peaked at around 70% in late March. The vast majority of workers currently under such restrictions are from the Americas and Asia and the Pacific, with all European countries removing these restrictions. The workplace closure trends for key regions are illustrated in the below figure.

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<sup>427</sup> International Labour Organisation (ILO). (2020). ILO Monitor: COVID-19 and the world of work. Fifth edition: Updated estimates and analysis, 30 June 2020.

**Figure 5-3 – Share of world's employed in countries with workplace closures, by key regions, 1 January-15 June 2020 (percentage)**



Source: ILO. (2020). *ILO Monitor: COVID-19 and the world of work. Fifth edition: Updated estimates and analysis*, 30 June 2020.

- **Working-hour losses** (Q1 & Q2, 2020): In the first quarter of 2020, the ILO reports that Europe and Central Asia lost around 3.4% of its working hours, rising to 13.9% in the second quarter. This equates to a total of 56 million full-time jobs (48 hours/week), of which 30 million can be attributed to Northern, Southern and Western Europe and a further 15 million to Eastern Europe. Although the equivalent number of full-time jobs lost is significantly greater in Asia and the Pacific (360 million across Q1 and Q2), the percentage of working hours lost was greater than Europe and Central Asia in Q1 (7.1%) but slightly lower in Q2 (13.5%). Considering the Americas, the loss of working-hours was similar to Europe and Central Asia in Q1 (3%) but was much greater in Q2 (18.3%). This equates to a total of 81 full-time jobs across the two quarters.

Within Europe, Southern Europe has experienced the greatest impact, losing 5.3% of its working hours in Q1 and 18% in Q2. Also notable is that Northern Europe experienced a relatively lower impact compared to Western Europe in Q1 (3.1% vs. 4%), but a higher impact in Q2 (15.3% vs. 14.3%). Comparatively, Eastern Europe has fared well to date, losing 2.6% of its working hours in Q1 and 11.6% in Q2.

- **Projected working-hour losses:** For the fourth quarter of 2020, the ILO baseline scenario projects that 5.4% of working-hours will be lost in Europe and Central Asia (representing 18 million full-time jobs), compared with the last pre-crisis quarter (i.e. Q4 2019). These figures are 4.5% for Asia and the Pacific (80 million full-time jobs) and 7.8% for the Americas (29 million full-time jobs), suggesting that, across the world, labour markets will still not be fully recovered, with a greater impact, in terms

of percentage of working-hours lost, on the Americas in the latter part of 2020 and similar impacts across Europe and Asia.

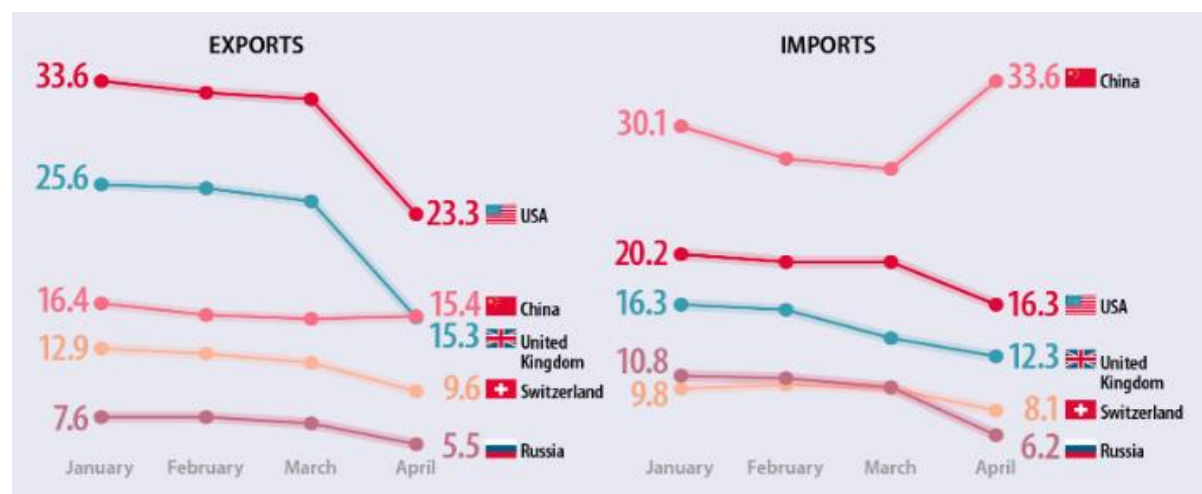
In terms of the impact of COVID-19 on **inflation**, the pandemic has had a deflationary impact, due mainly to the decline in energy prices, with marked falls in global oil and gas prices. However, to some extent, this has been relatively temporary as by end of June 2020, prices had recovered somewhat, albeit to levels well below the pre COVID-19 situation. An article about the inflationary impact of COVID notes that “Following the outbreak of COVID-19 and an unprecedented oil price shock, the euro five-year, five-year inflation-linked swap is currently hovering around an all-time low of just below 1%”.<sup>428</sup> Such swaps are a proxy of future expected inflation trends. However, during lockdowns, it has been difficult to accurately measure inflation.

Whilst there were some concerns regarding the impact on inflation of the European Central Bank's measures since the outset of the crisis on inflation, given its price-stability mandate, these are not expected to be that inflationary, given downwards inflationary pressures due to the economic downturn and lower energy prices.

It is also worth considering the **impact of COVID-19 on EU trade with major competitor countries**, such as China and the U.S. This was affected by supply chain dislocation outside the EU and within the EU, due to the prevalence of lockdowns globally during the first wave in the period January – March 2020 (China) and early March 2020–May 2020 (Europe and globally).

According to Eurostat,<sup>429</sup> in April 2020, decreasing levels of trade were observed for imports from all 5 main trade partners of the EU, with the exception of China (+12% compared with January 2020), as shown in the following figure. Regarding exports from Europe, a significant decline over the period January – April 2020 can be observed in trading relationships with all major non-EU countries in the Figure, such as with China (-66.2%) and with the USA (-44.2%).

**Figure 5-4 - EU imports and exports of goods with 5 main trade partners (€ billion, seasonally adjusted, January 2020 – April 2020)**



Source: Eurostat, International trade in goods - ext\_st\_eu27\_2020sitc

<sup>428</sup> Gauging the impact of COVID-19 on market-based inflation expectations, Dirk Broeders, Gavin Goy, Annelie Petersen, Nander de Vette 19 May 2020

<sup>429</sup> <https://ec.europa.eu/eurostat/web/products-eurostat-news/-/EDN-20200622-1?inheritRedirect=true&redirect=%2Feurostat%2F>

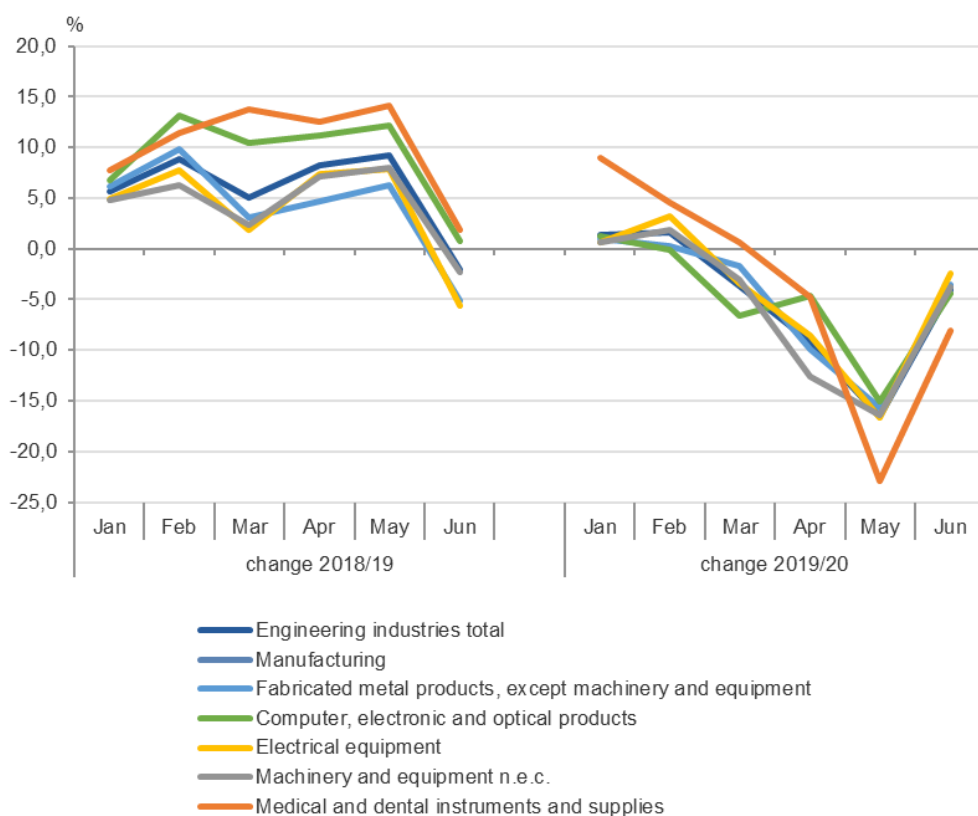
As for the timings of the impact on trade between the EU and the five competitors mentioned above, it can be observed that although the pandemic mainly hit Europe from late February 2020 onwards, the impacts in terms of trade with China and other Asian countries extend back to January, when even if the coronavirus mainly affected Asia initially, this impacted supply chains and consequently, imports to and exports from Europe over the same period. This downturn also coincides with a turning point in the economic boom Europe experienced in 2018 and partly in 2019

Further observations based on an analysis of relevant trade data (especially exports) are made in the next sub-section on the sectoral impacts of COVID.

#### 5.1.4 Sectoral impacts of COVID-19

The sectoral impacts of the pandemic on the EU engineering industries are now examined, drawing on international trade in goods data, with a focus on exports. Monthly trade data from 2020 was already presented in Chapter 2.2.1 (International trade performance). The following figure is repeated here, as it highlights the considerable impact of the COVID-19 crisis on extra-EU exports in the EU engineering industries across different sub-sectors.

**Figure 5-5: Recent developments in extra-EU exports of the EU-27 (annual changes 2018/19 vs. 2019/20)**

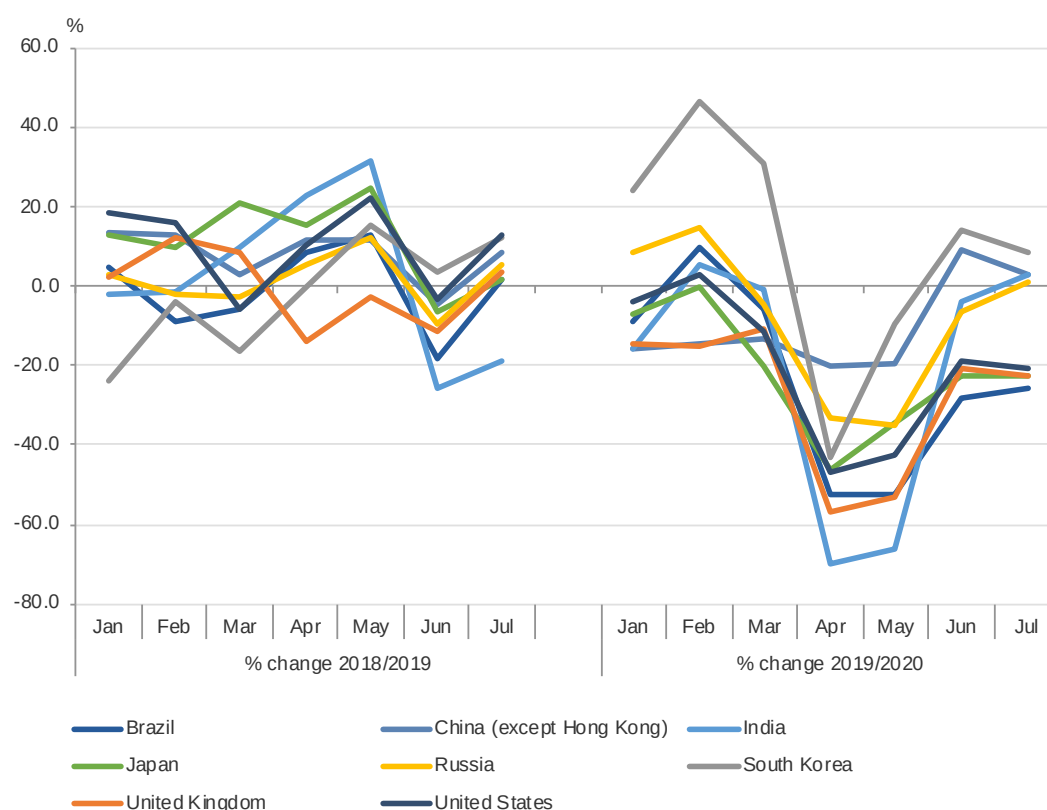


Source: Eurostat international trade in goods data (exports).

The data shows that all engineering product groups experienced a sharp decrease in extra-EU exports compared to the previous year. The low point was reached in May 2020 when all sectors experienced a reduction in exports of between 15-17% (medical and dental instruments and supplies however fell by 23%). By June 2020, the year-on-year change on extra-EU-27 exports was still negative across all product groups, but was already showing an upward trend, suggesting a partial recovery.

In the figure below, the impact of COVID-19 on exports based on monthly trade data can also be discerned through a review of exports data by major competitor country based on the SITC product data for machinery and transport equipment as a whole.<sup>430</sup> Across the EU engineering sectors, there has been a significant decline in exports of machinery and transport equipment, especially in April–May 2020. However, there has subsequently been a significant pick-up in exports in late May and June 2020, though this tapered off in July 2020.

**Figure 5-64: Recent developments in extra-EU exports of machinery and transport equipment to main competitor countries (annual changes 2018/19 vs. 2019/20)**



Source: Eurostat, EU27 (from 2020) trade by SITC product group [EXT\_ST\_EU27\_2020SITC], Status: September 2020

The scale of the decline in EU engineering sector exports was extremely significant during the pandemic. In April 2020, for example, there was a decline in exports in the engineering sectors from the EU to India (-69.7%), Japan (-46.5%), China (-20.2%), South Korea (-43.0%), Brazil (-52.4%) Russia (-33.0%), the UK (-57.0%) and the US (-46.9%). By July 2020, the scale of decline in exports year-on-year had reduced considerably and in some cases was actually positive. The corresponding EU exports figures for machinery and equipment in July are: India (+2.8%), Japan (-22.7%), China (+2.8%), Brazil (-25.7%) Russia (+1.3%) South Korea (+8.6%), the UK (-22.6%) and the US (-20.5%).

<sup>430</sup> The SITC product group "Machinery and transport equipment" from the aggregated data source includes most engineering products: Power-generating machinery and equipment, Machinery specialized for particular industries, Metalworking machinery, General industrial machinery and equipment and machine parts, Office machines and automatic data-processing machines, Telecommunications and sound-recording and reproducing apparatus and equipment, Electrical machinery, apparatus and appliances and electrical parts thereof (including non-electrical counterparts of electrical household-type equipment), Road vehicles (including air-cushion vehicles) and Other transport equipment.



It is noticeable that the level of exports to China and South Korea had recovered by June 2020 to a level higher than the previous year-on-year figures. Whereas EU exports to China had declined year-on-year by -20.2% in April 2020, they had increased by June 2020 to +8.9%, with +2.8% (annual) growth in exports registered in July 2020. In South Korea, a similar trend was discernible, with an annual reduction of -43% in April 2020, but increases of +14.3% in June 2020 and +8.6% in July 2020. This shows both that the exports situation continues to be volatile, and it is unclear how far any recovery in exports month-on-month is sustainable. Moreover, the data from June 2020 suggests that the rebound may partially be explained by pent-up demand from the three-month period March–May 2020, due to major national lockdowns in Asia and Europe. A further issue that cannot be overlooked during this period is that data collection on business statistics is likely to be more difficult and less reliable during a pandemic situation, and therefore, the exports data could be analysed in a future study on a quarterly basis to get a more accurate picture as to how the evolution of the pandemic is impacting the EU engineering industries.

An overview of the underlying export data contained in the above figure from the EU27 to key competitor countries is provided in the following table for *SITC7, machinery and transport equipment*.

**Table 5-2 - Export data from the EU27 to key competitor countries – Percentage change – 2018/2019 and 2019/2020**

|                                      | Brazil | China except Hong Kong | India | Japan | Russia | South Korea | United Kingdom | United States |
|--------------------------------------|--------|------------------------|-------|-------|--------|-------------|----------------|---------------|
| <b>Percentage change – 2018/2019</b> |        |                        |       |       |        |             |                |               |
| Jan                                  | 4.8    | 13.5                   | -1.8  | 12.8  | 2.6    | -23.6       | 2.2            | 18.2          |
| Feb                                  | -9.0   | 13.0                   | -1.7  | 9.6   | -2.1   | -4.0        | 12.2           | 16.1          |
| Mar                                  | -6.1   | 2.7                    | 9.9   | 20.8  | -2.7   | -16.6       | 8.2            | -6.0          |
| Apr                                  | 8.5    | 11.3                   | 22.9  | 15.1  | 5.2    | -0.4        | -13.7          | 10.1          |
| May                                  | 13.0   | 11.4                   | 31.2  | 24.9  | 12.3   | 15.3        | -3.0           | 21.9          |
| Jun                                  | -18.0  | -4.7                   | -25.7 | -6.3  | -9.3   | 3.5         | -11.2          | -3.6          |
| Jul                                  | 1.5    | 8.3                    | -18.6 | 1.7   | 5.1    | 12.1        | 3.8            | 12.7          |
| <b>Percentage change – 2019/2020</b> |        |                        |       |       |        |             |                |               |
| Jan                                  | -9.0   | -15.8                  | -15.8 | -7.2  | 8.7    | 24.2        | -14.4          | -3.7          |
| Feb                                  | 9.6    | -14.3                  | 5.5   | -0.1  | 14.7   | 46.2        | -15.1          | 2.6           |
| Mar                                  | -5.8   | -13.4                  | -1.0  | -20.2 | -4.8   | 30.9        | -11.0          | -11.4         |
| Apr                                  | -52.4  | -20.2                  | -69.7 | -46.5 | -33.0  | -43.0       | -57.0          | -46.9         |
| May                                  | -52.1  | -19.6                  | -66.1 | -34.5 | -35.2  | -9.8        | -52.9          | -42.7         |
| Jun                                  | -28.4  | 8.9                    | -4.0  | -22.3 | -6.7   | 14.3        | -20.6          | -19.0         |
| Jul                                  | -25.7  | 2.8                    | 2.8   | -22.7 | 1.3    | 8.6         | -22.6          | -20.5         |

Source: Eurostat, EU27 (from 2020) trade by SITC product group [EXT\_ST\_EU27\_2020SITC], Status: September 2020

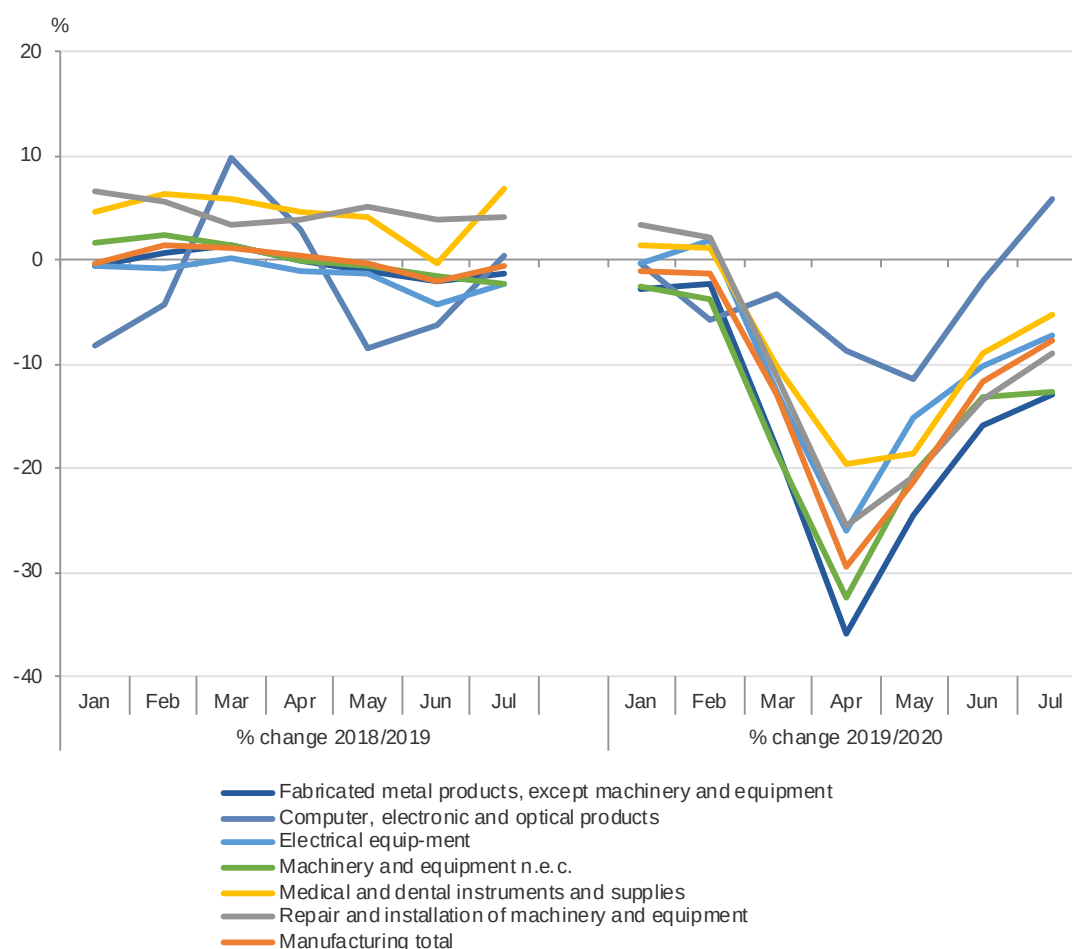
More detailed export data (country by country) is provided in Annex 2. This shows that major manufacturing countries, such as France and Germany, which account for a significant share of the EU engineering industries overall, have been considerably affected by the crisis, with a decline in intra and extra-EU exports during the period March – May 2020, with a recovery again discernible in June 2020. Taking exports to China from Germany as an example for the engineering sub-sectors covered within SITC 7, exports declined from a baseline of 5.8 billion EUR in December 2019 prior to the pandemic to 4.4 billion EUR in February 2020 (the low-point reflecting supply-chain and export market dislocations due to national and regional lockdowns in China and Europe), 4.6 billion by April 2020, recovering to 5.8 billion EUR in June 2020 (pointing to lagging demand catching-up). From peak to trough, this is a decline of 24.7%. The corresponding figures for other major engineering manufacturing countries such as France are 1.15 billion EUR from December 2019 (pre-pandemic) to a low-point of 292.2 million EUR in February 2020,



recovering to only 439.8 million EUR by June 2020, a decline of 61.8% compared with December of French engineering exports to China. The data demonstrates firstly that some EU countries have suffered a worse fall in the export of European engineering manufacturing to key markets than others. It also demonstrates that whilst there has been partial recovery in European export markets, these have not yet recovered fully. It also shows that global dislocations in engineering industry markets do not only affect the supply chain, but also damage exports.

Turning to **production data**, the significant impact of the pandemic during the first half of 2020 is demonstrated by engineering sub-sector in the following figure.

**Figure 5-7: Development<sup>1</sup> of production in the engineering industries and manufacturing in the EU-27 (excl. UK), January – July, percentage change 2018/19 and 2019/20**



<sup>1</sup> Development is in 2015 prices, calendar adjusted data: Volume index of production (Short-term business statistics for industry)

Source: Eurostat, Short-term business statistics for industry; own calculations; September 2020 (full data table in Annex 2)

In the **machinery and equipment sub-sector**, the percentage decline in the volume index of production was -32.5% in April, -20.5% in May, but this had been reduced to a gap of only -12.6% by July 2020. Taking the **fabricated metal products sub-sector**, the impact was of a similar degree of magnitude with similar trends month on month, with a decline of -35.8% in April, -24.5% in May and -12.9% in July. Other sub-sectors were less severely impacted. For example, in **computer, electronic and optical products**,

**the decline was** -8.8% in April, -11.5% in May, but a decline of only -2.0% was recorded in June and a year-on-year increase of +5.8% was experienced in July 2020.

Whilst the general trend in this period is clear (a major reduction in production across the engineering sectors during the peak of the pandemic in Europe (March – May 2020)), the value of examining data on a quarterly and annual basis in future is also clear, as the monthly data during this period exhibits signs of considerable volatility. Stakeholder feedback and literature on the impact of COVID-19 on the EU engineering industries

In this sub-section, the feedback received from different stakeholders, especially national and EU industry associations is considered, alongside the results from the desk-based literature review. It should be noted that as the majority of the data collection had already been completed in Q3 and Q4 2019, and the first half of Q1 2020, only the later stage interviews provided feedback on the impacts of COVID-19. In order to strengthen the quality and availability of data and information in this regard, some dedicated interviews were undertaken.<sup>431</sup>

Since the onset of the pandemic in Europe, the scale of reduction in industrial activity in particular branches of engineering during the first wave has been significant.

For example, in the mechanical engineering sector in **France**, according to a research paper published by FIM<sup>432</sup> in May 2020, the decline in mechanical industry activity reached 21.1% in March 2020 (year-on-year comparison) according to the mechanical industries barometer.<sup>433</sup> The temporary decline in industrial output is estimated at 47% in April 2020 year-on-year. The magnitude of the decline is expected to intensify in the second quarter, 2020. It was nevertheless pointed out in an interview with FIM that exporters were already experiencing the initial impacts of COVID-19 earlier, as the level of exports declined by -2.4% in January and by -3% in February 2020.

FIM notes in the same research paper that all major national markets in Europe have been affected by the sharp decline in industrial activity: by 22.4% in Germany, 26.4% in Italy, 32.8% in Spain, 26.4% in Portugal, 26.3% in Belgium and 9.6% for the Netherlands.

Regarding the level of decline in exports, data from FIM showed that exports from France to the United States were 25.9% lower, 16.4% lower to China and 35.8% lower to Japan compared with the same period a year earlier. In a survey of FIM's members in April 2020, views on export orders were very unfavourable, as the decline in exports was expected to continue during the remainder of 2020.

According to the VDMA in **Germany**, there has also been a significant reduction in European exports in key sectors where Europe has global competitive strengths, such as the manufacturing of machinery. It should be stressed however that the duration of the current health pandemic and the ensuing economic crisis is not known. There are many possible outcomes ranging from a V-shaped, to a U-shaped economic crisis, and the timeframes for economic recovery are currently completely speculative due to the fast-changing nature of the crisis. These possible outcomes are likely to differ significantly across different sectors of the economy. A key difference with the previous crisis, however, is that whilst an economic downturn is likely and an economic crisis possible, there are

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<sup>431</sup> Dedicated interviews were carried out for instance with the VDMA, Orgalim, the IPC (Association Connecting Electronics Industries) and FIM on the impacts of COVID-19. Other interviewees in March and April 2020 also provided some feedback on this issue.

<sup>432</sup> Fédération des Industries Mécaniques (FIM) represents the economic and technical interests of French professional associations and their members.

<sup>433</sup> <https://www.fim.net/fr/accueil/actualites/business/statistiques-economiques/note-de-conjoncture-de-mai-2020>

likely to be key differences compared with the economic and financial crisis that characterised the previous global economic and financial crisis in 2008-2010.

A May 2020 position paper from the VDMA looks into the **extent to which the pandemic will impact the EU engineering industries**, both demand and supply side. It also considers how the emerging challenges identified through member surveys could best be addressed from an EU policy perspective, with reference to the European Recovery Plan. The paper recommends, for example, re-establishing and safeguarding the EU Single Market as the basis for ensuring resilience, noting that “the more volatile the international environment and the more difficult it is to access other markets, the more important it is to have a functioning, open and non-discriminatory single market”<sup>434</sup>. It stresses that borders must be opened to ensure free movement of goods. The VDMA also commented during the webinars conducted in May 2020 as part of this study that keeping national borders open goes beyond logistics and the transportation of goods alone, and extends to the free movement of persons. For instance, new machinery needs highly-skilled installers, some of whom travel across land borders within the EU to install machinery for clients. Moreover, existing machinery needs to be serviced. Barriers to the cross-border movement of goods and people has thus been seen as a major problem inhibiting the full and effective operation of the Single Market, and one which unless resolved soon could lead to damage to Europe’s industrial competitiveness.

Throughout the pandemic, ZVEI (the German Electrical and Electronic Manufacturers’ Association) has also been conducting snapshot surveys to understand the impact of COVID-19 and governmental responses to their industry. In June 2020, the fourth iteration of the ZVEI *ad hoc* survey on the Corona crisis was conducted.<sup>435</sup> A total of 158 firms took part, which together account for around 30% of the sector’s 2019 turnover of EUR 190 billion.<sup>436</sup> The individual responses were each weighted by the turnover of the companies and aggregated to form overall results. The results of these surveys are integrated throughout the subsequent analysis, although key findings include:

- **Supply-side:** Operational challenges have been experienced throughout by German electrical and electronic manufacturers, including problems with suppliers of preliminary products and vendor parts. However, in April and June 2020, the majority of firms reported only slight challenges. Furthermore, most firms will not position their supply chains differently as a result of the crisis, although some will consider either greater diversification or increased regionalisation.
- **Demand-side:** Firms reported a decrease in new orders and production throughout the crisis, with sales for 2020 Q2 anticipated to be 13% lower than 2019 and around 7% lower for the whole year. However, the situation has improved through April-June with regard to demand, with the majority of firms reporting recovery of demand during that period. Perceptions of demand from other geographies, including the German and eurozone markets, but particularly the US market, are less positive.
- **Employment:** Although the situation with regard to redundancies looked positive in April 2020, the position of many firms had changed by June 2020. More specifically, 42% of firms were planning to, or had already reduced their staff by the June 2020 survey.

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<sup>434</sup> VDMA, (2020), a Restart for Europe: VDMA recommendations for a resilient Europe during and after the corona crisis, May 2020

<sup>435</sup> The results of the 2<sup>nd</sup> (April 2020), 3<sup>rd</sup> (end of April 2020) and 4<sup>th</sup> (June 2020) iterations of the ZVEI *ad hoc* surveys on the Corona crisis, although not available publicly, were made available to the study team by ZVEI.

<sup>436</sup> The 3<sup>rd</sup> ZVEI *ad hoc* survey on the Corona crisis received response from 114 firms, comprising 41% of industry turnover from 2019. The 2<sup>nd</sup> ZVEI *ad hoc* survey on the Corona crisis received responses from 128 firms, comprising 24% of industry turnover from 2019.

The **impact not just on turnover, but also on the profitability of the mechanical and plant engineering sectors** was stressed in an article <sup>437</sup> by Roland Berger consultants. It was pointed out that "cost structures are mainly fixed, but some possibilities exist for adjusting these quickly when orders are cancelled or delayed. In the area of profitability, companies have few options for countering the effect of cancelled projects. This will make their service business increasingly important for supporting their bottom line".

A number of key messages were ascertained relating to the supply and demand-side impacts, the impacts on digitalisation and on EU legislation were obtained. The findings are outlined in the following sub-sections.

#### **5.1.4.1 Supply-side impacts of COVID-19**

**Disruption in and breakdown of Global Value Chains (GVCs):** Especially in the automotive and aerospace industries, which are important vertical sectors that depend on inputs from the EU and global engineering industries, evidence of supply chain dislocations was detected in the availability of key parts and components, especially electronic components.

Automotive firms and firms in sectors with longer supply chains dependent on the procurement of key components from China (and to some extent elsewhere in Asia) have been especially adversely affected. Other vertical sectors that the engineering industries provide specialist machinery to, such as pharmaceuticals and the food production industry were also affected by the non-availability of electronic components.

Supply chain dislocations were initially mainly confined to European manufacturers that were reliant upon electronic components suppliers from Asia as part of their GVCs. This was a particular problem in the period January – March 2020. However, such dislocations did not only affect European manufacturers dependent on GVCs, but also those dependent on suppliers within the EU. Supply chain dislocations were encountered in regards to intra-European trade, especially in the period March – May 2020, due to national lockdowns, national temporary border closures, and the non-availability of key parts from suppliers in other European countries.

Where design is carried out in Europe, and the whole manufacturing process is undertaken in lower cost locations (often in Asia), there have also been problems in the non-availability of products for periods of time, along with considerable business uncertainties.

Examples of supply chain dislocations within Europe are now provided. It should be stressed that whilst several examples were identified by interviewees, there has as yet not been much literature to identify the scale of intra-EU supply chain dislocations, so it is difficult to ascertain how far such dislocations were widespread.

A French manufacturing industry association interviewed gave the example that a French automotive manufacturer was dependent on a key component from an Italian components supplier. Due to the prolonged lockdown in Italy, this factory had been closed for a two month period, meaning that automotive production had experienced considerable problems. A further example was provided by Orgalim, who reported that a Swedish company could not get parts and inputs from an Italian supplier due to factory closures. As a result, this Swedish company had to look within Sweden and to non-European countries for alternative suppliers. This potential replacement of European suppliers with economic operators in non-European countries was further aided by the fact that factories in China and other Asian nations started functioning again as most European countries were in the midst of lockdowns.

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<sup>437</sup> <https://www.rolandberger.com/en/Point-of-View/Covid-19-Priorities-for-mechanical-engineering.html>

Examples of supply chain-related problems were also identified in survey feedback of the members of some national industry associations in the engineering sectors. For instance, in a flash survey by the VDMA in March 2020, the German mechanical engineering association, almost 60% of German mechanical engineering firms were already feeling the effects of disrupted supply chains caused by the coronavirus pandemic. More than 1,000 companies answered the survey, which classified the effects from the disruption as 'low to medium',<sup>438</sup> but nonetheless discernible. Among survey respondents, Italy and China caused the greatest concern in terms of the reliability of suppliers during the pandemic.

However, the extent of supply chain dislocations has been in regular flux, reflecting the unprecedented situation. For example, a flash survey by the VDMA in May 2020<sup>439</sup> indicated that there had been a continued easing of supply chain problems since April 2020. Over 80% of the companies reported either no problems at all, or only minor disruptions.

A study on the *Impact of COVID-19 on the Global Manufacturing Industry* noted that the electronics industry globally has especially been affected by supply chain dislocations. The following quote is especially revelatory<sup>440</sup>:

*"The electronics industry is being significantly affected due to the COVID-19 epidemic, as China accounts for nearly 85% of the total value of components utilized in smartphones and nearly 75% in the case of televisions. All critical components, such as printed circuit boards, mobile displays, LED chips, memory, open cell TV panels, and capacitors are imported from China. Most of the Chinese factories were shut down due to the coronavirus pandemic. As a result, in January 2020, Chinese vendors have increased component prices by nearly 2-3% owing to shortage of supplies due to factory shutdown. Therefore, it has negatively affected the electronics manufacturing sector across the globe".*

An ILO briefing report on the impact of COVID-19 on the automotive sector also pointed to an over-dependence on China during the outbreak, due to "China's role as the world's main supplier of intermediate inputs for manufacturing companies abroad".<sup>441</sup> This is especially the case for components.

At the end of April 2020, 86% of the companies surveyed by the ZVEI, representing the German electrical and electronic industry, continued to report slight problems with their suppliers of preliminary products and vendor parts. Seven percent even experienced serious problems. Similarly, in June 2020, the fourth iteration of the ZVEI survey found that slight operational challenges were still being experienced by 87% of firms, although the proportion of firms facing significant operational challenges had reduced slightly to 5%. However, for the majority of German firms, the operational challenges experienced as a result of the pandemic will not lead to supply chain changes. In ZVEI's June 2020, 58% of firms stated that they will not position their supply chains differently in the future. Of the remaining firms, 21% will consider increased diversification and 27% will consider greater regionalisation, while 10% will consider holding greater inventory.

Many chips and semi-conductors are more readily available in Asia, and the capital-intensiveness of the semi-conductor industry has seen a gradual decline in Europe's competitiveness in this sector. Although it will be possible to source certain components

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<sup>438</sup> <https://www.imveurope.com/news/vdma-says-60-members-feeling-corona-supply-chain-disruption>

<sup>439</sup> VDMA Flash Survey: Drive digitization forward, especially in the crisis, <https://www.vdma.org/en/v2viewer/-/v2article/render/48792978>

<sup>440</sup> Impact of COVID-19 on the Global Manufacturing Industry, 2020, Research and Markets, Apr 16, 2020. <https://www.prnewswire.com/news-releases/impact-of-covid-19-on-the-global-manufacturing-industry-2020-301042150.html>

<sup>441</sup> [https://www.ilo.org/wcmsp5/groups/public/---ed\\_dialogue/---sector/documents/briefingnote/wcms\\_741343.pdf](https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/briefingnote/wcms_741343.pdf)

in Europe or elsewhere globally outside Asia (for example, in the case of a second or third wave of the existing or potential future new pandemics in Asia), Europe mainly has more specialist component and sensor manufacturers servicing sectors such as the automotive sector. Nonetheless, as the following case study box makes clear, the automotive sector is one of the worst affected sectors. A short case study focusing on sectoral-level impacts is now provided, focusing on the automotive and aerospace sectors:

### Box 5-1 – Impacts of COVID-19 on the automotive sector

#### Sectoral impacts of COVID-19 – automotive

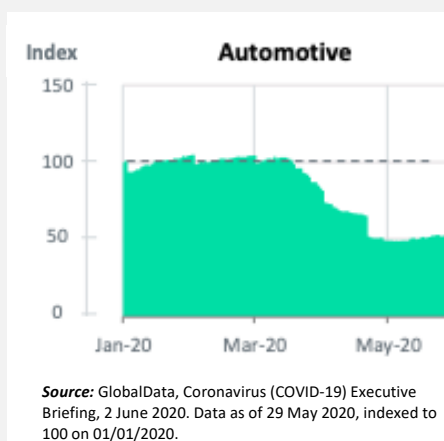
Although the impacts of COVID-19 have been experienced across almost all sectors of the economy, as highlighted above, certain sectors have experienced greater adverse impacts as a result of supply chain disruptions and reduced demand. This box highlights the examples of the automotive and aerospace sectors, which rely heavily on the EU engineering industries.

**Automotive sector:** As highlighted above, the automotive sector has experienced significant adverse impacts as a result of COVID-19. The ZVEI survey from April 2020 revealed that 68% of companies from the transport sector expressed that they are experiencing slight difficulties, and a quarter of them reported that the difficulties were considerable due to the disruptions in the transport supply chain. Within an industry that, in 2017, provided direct employment to nearly 14 million workers worldwide, and an industry that holds particular importance in Europe, the COVID-19 crisis has created both supply and demand-side challenges.<sup>442</sup>

- **Production impacts:** According to data from the European Automobile Manufacturers Association (ACEA), EU-wide (including the UK) production losses amount to at least 2.4 million motor vehicles and the average shutdown duration is 30 working days.<sup>443</sup> Considering production loss, this is most prominent in Germany (amounting to at least 600,000 vehicles); Spain (at least 450,000 vehicles); France (at least 275,000 vehicles); and the UK (at least 260,000 vehicles).

- **Employment impacts:** As of 20 April 2020, ACEA estimates that at least 1.1 million Europeans working automotive manufacturing have been or are being impacted by the COVID-19 crisis (more than 40% of direct manufacturing jobs in the sector).<sup>444</sup> This impact appears to be disproportionately experienced in Germany (568,518 employees affected) compared with the other countries with significant production losses (e.g. a reported 60,000 employees affected in Spain; 90,000 in France; and 65,455 in the UK).

The workforce impacts are also illustrated in the figure presented to the right. Here, GlobalData illustrate the significant reduction in active jobs in the automotive industry indexed against the 1 January 2020.<sup>445</sup>



<sup>442</sup> ILO, (2020), ILO Sectoral Brief: COVID-19 and the automotive industry, 8 April 2020

<sup>443</sup> <https://www.acea.be/news/article/interactive-map-production-impact-of-covid-19-on-the-european-auto-industry>

<sup>444</sup> <https://www.acea.be/news/article/interactive-map-employment-impact-of-covid-19-on-the-european-auto-industry>

<sup>445</sup> GlobalData, (2020), "Coronavirus (COVID-19)", Executive Briefing report, updated on 2 June 2020.



- **Impacts on SMEs:** Employment in the sector and provide intermediate inputs and services to multinational carmakers, are expected to be severely affected (backward linkages).
- **Impacts on the Single Market:** The temporary closure of national borders within the EU (due to lockdowns) is a barrier to the normal operation of the single market.
- **Economic impacts of the crisis on the automotive sector and wider economy:** An ILO sectoral brief attests to negative multiplier effects on the global economy “through backward and forward linkages, particularly in countries such as Canada, China, Germany, India, Japan, South Korea, Mexico, Morocco, South Africa and United States, where the automotive industry is a major driver of economic growth”.

In addition to these clear production and employment impacts, it is important to note that SMEs, that provide vital intermediate inputs and services and comprise the majority of employment, are expected to be significantly affected. Furthermore, significant knock on impacts on transportation (e.g. freight, ground passenger transport etc.) and services (e.g. car rental and repair etc.) are being experienced.<sup>446</sup>

#### **Potential mitigation measures to offset the negative impacts of COVID-19.**

In terms of potential means of mitigating the adverse impacts of COVID-19 on the automotive sector,<sup>447</sup> a number of sectoral stakeholders (e.g. the ACEA, CLEPA and CLECRA) published a letter to the Commission President with a small number of suggestions. Examples were:

1. Issuing guidelines regarding the health and safety conditions under which workers can return to the factories, dealership and workshops so that this occurs in a uniform manner across the EU;
2. Mitigating economic impacts and supporting the competitiveness of the European industry as much as possible, not least in view of enabling society to pick up on the twin transformation of decarbonisation and digitalisation again in full force; and
3. Defending the integrity of the Single Market, specifically with regards to the freedom of movement of goods and workers. *“Solutions will be needed for employees in border regions where businesses depend on cross-border commuters in their workforce but also for the movement of specialist workers who keep machines running and supply chains intact”.*

A further example of the impacts at sectoral level is now provided for the aerospace sector.

#### **Box 5-2 – Impacts of COVID-19 on the aerospace sector**

##### **Sectoral impacts of COVID-19 – aerospace**

**Aerospace sector:** The COVID-19 crisis has and will continue to have significant implications for aviation. As a result of significant travel restrictions across the globe, global air traffic has reduced significantly in early 2020. According to the International Air Transport Association (IATA), year on year figures for both revenue passenger kilometres (RPKs – a proxy for traffic) and available seat kilometres (ASKs – a proxy for capacity) have been in decline since January 2020. More specifically, in April 2020, RPKs had decreased by 94% versus 2019, with ASKs 87% down versus April 2019. In addition, passenger load factors (i.e. actual percentage of available seat kilometres)

<sup>446</sup> ILO, (2020), ILO Sectoral Brief: COVID-19 and the automotive industry, 8 April 2020

<sup>447</sup> [https://www.acea.be/uploads/news\\_documents/COVID19\\_auto\\_sector\\_letter\\_Von\\_der\\_Leyen.pdf](https://www.acea.be/uploads/news_documents/COVID19_auto_sector_letter_Von_der_Leyen.pdf)



decreased to an all-time April low (36.6%) compared with the all-time high experienced in April 2019 (83.1%).<sup>448</sup>

However, the IATA further reports that early data from May 2020 (for example, on bookings, google searches, daily flights and business confidence) suggest the sector is at a turning point,<sup>449</sup> particularly with regard to domestic flights in Asia.<sup>450</sup>

Beyond commercial air travel, air cargo has also been impacted. In its April 2020 Air Cargo Market Analysis<sup>451</sup>, the IATA noted the continuing decline in industry-wide cargo tonne kilometres (CTKs). In Europe, CTK figures for April 2020 were 33.8% lower than April 2019 (for March 2020, CTKs were 18.5% lower than March 2019). Notably, these figures are higher than the North America (year on year CTK decrease of 20.1% in March 2020) and Asia Pacific (28.1% year on year CTK decrease in March 2020) regions. Furthermore, industry-wide cargo capacity declined by 42%.

Resulting from this significant drop in demand for air travel and cargo transport, the **demand for new aircraft and maintenance repair and overhaul (MRO) services, and therefore the EU engineering industries, are being significantly impacted.** On this basis, a range of consultancies have modelled the future impact of the COVID-19 crisis on the demand for new aircraft and MRO services. For instance, anticipating a baseline of 21,760 new aircraft to be delivered by 2030, an analysis by Roland Berger<sup>452</sup> suggests that the most positive future scenario (a prolonged V-shape rebound) will see a reduction in the cumulative demand for new aircraft of 4% to 2030. In a recession scenario, however, a reduction in demand of almost 50% is anticipated to 2030, with significant restructuring and downsizing necessary across the entire industry and supply chain.

Similarly, Oliver Wyman highlighted that Boeing and Airbus had both announced production slowdowns of 30-50% resulting in a noticeable supply-demand imbalance, with 100-200 aircraft possibly being built without identified customers.<sup>453</sup> Furthermore, 2020 MRO demand is forecasted to be more than 50% lower than the pre-COVID baseline (\$42.7 billion compared with \$91.2 billion).

Overall, this analysis anticipates no growth in the global in-service fleet until 2023 and estimates a return to pre-COVID production rates will take five years.

### Box 5-3 – Impacts of COVID-19 on the mechanical engineering sector

#### Sectoral impacts of COVID-19 – mechanical engineering

Prior to the COVID-19 crisis, the mechanical engineering sector has already been experiencing a difficult period. Beginning in 2018, a wide range of contextual factors conspired to cause a downturn in the sector. More specifically, these factors included: reduced growth in China compared to expectations, reportedly as a result of weak

<sup>448</sup> IATA, (2020), COVID-19: Air travel reaching a turning point, 3 June 2020, <https://www.iata.org/en/iata-repository/publications/economic-reports/air-travel-reaching-a-turning-point/>

<sup>449</sup> IATA, (2020), COVID-19: Air travel reaching a turning point, 3 June 2020.

<sup>450</sup> <https://www.iata.org/en/iata-repository/publications/economic-reports/domestic-asia-pacific-recovery-points-to-improving-demand-in-may/>

<sup>451</sup> IATA, (2020), [Air Cargo Market Analysis](#), April 2020.

<sup>452</sup> Roland Berger, (2020), [COVID-19 – How we will need to rethink the aerospace industry](#).

<sup>453</sup> Oliver Wyman, (2020), [Update: Impact of COVID-19 on commercial MRO, Global Fleet and MRO Market Forecast](#), May 14 2020.

domestic markets and the ongoing trade war with the US; sanctions on Russia and Iran; Brexit;<sup>454</sup> and the move by automobile manufacturers toward electric mobility.<sup>455</sup>

Adding to this existing situation, the mechanical engineering sector has experienced significant adverse impacts as a result of the COVID-19 crisis, on both the supply-side and the demand-side. As noted above, the German Mechanical Engineering Industry Association (VDMA) has been conducting flash surveys throughout crisis. Through these surveys, the VDMA found that there had been a gradual transition from **supply chain dislocations**, which characterised the initial period of lockdown and consisted of the closure of manufacturing facilities, to **demand-side disruptions**, characterised by the cancellation of existing orders and reductions in new orders.

To illustrate this at a general level, research conducted by the IFO institute and Deutsche Bank Research found that business expectations in the mechanical engineering sector fell 32 points from -12 points in February 2020 to -44 points in March 2020 (see below figure).<sup>456</sup> In addition, the VDMA reported that, at the end of March 2020, 84% of its membership were already reporting adverse effects; either supply chain problems, adverse demand-side effects, or both. This figure had risen to 89% by mid-April and had reached 98% by the end of May.

Considering **supply chain impacts** specifically, almost 60% of German mechanical engineering firms surveyed by the VDMA were already feeling the effects of disrupted supply chains caused by the pandemic in March 2020. The survey classified the effects from the disruption as 'low to medium',<sup>457</sup> but nonetheless discernible. Among survey respondents, Italy and China caused the greatest concern in terms of the reliability of suppliers during the pandemic. This reflects the fact that existing supply chains within the mechanical engineering sector are complex and rely heavily on Chinese suppliers.<sup>458</sup>

In the initial months of the lockdown, industry stakeholders anticipated future negative supply chain impacts; for instance, more than 75% of stakeholders surveyed by the VDMA in March 2020 agreed that there would be **no likely easing of supply chain disruptions in the next three months**. Moreover, 28% of companies expected the situation to deteriorate. However, a flash survey by the VDMA in May 2020<sup>459</sup> indicated that there had been an improvement in supply chain challenges. Over 80% of respondents reported either no problems at all or only minor disruptions.

As the sector began to address its supply-side challenges, the **demand-side impacts** became more prominent. For instance, an analysis by Roland Berger noted that, although orders in January 2020 were higher compared with January 2019, companies were reporting an 88% reduction in offers by 30 March 2020 as a result of the pandemic.<sup>460</sup> The VDMA also reported on order losses or cancellations in Germany, noting that, in April 2020, 32% of companies reported noticeable order losses or cancellations. This figure increased to 44% in May 2020.<sup>461</sup> On the whole, about 60% of companies expect 2020 to produce a decline in turnover of 10-30% compared with 2019.

<sup>454</sup> <https://www.rolandberger.com/en/Point-of-View/Covid-19-Priorities-for-mechanical-engineering.html>

<sup>455</sup> Auer, J. (2020). [Mechanical engineering sector feels the effects of the coronavirus](#). Ifo Institute, Deutsche Bank Research.

<sup>456</sup> Auer, J. (2020). [Mechanical engineering sector feels the effects of the coronavirus](#). Ifo Institute, Deutsche Bank Research.

<sup>457</sup> <https://www.imveurope.com/news/vdma-says-60-members-feeling-corona-supply-chain-disruption>

<sup>458</sup> <https://www.rolandberger.com/en/Point-of-View/Covid-19-Priorities-for-mechanical-engineering.html>

<sup>459</sup> VDMA Flash Survey: Drive digitization forward, especially in the crisis, <https://www.vdma.org/en/v2viewer/-/v2article/render/48792978>

<sup>460</sup> <https://www.rolandberger.com/en/Point-of-View/Covid-19-Priorities-for-mechanical-engineering.html>

<sup>461</sup> <https://www.vdma.org/en/v2viewer/-/v2article/render/48281066>

A key driver of this reduction is the dependency on key industries, such as automotive industry, that, as highlighted above, are facing significant difficulties themselves.<sup>462</sup> Another key driver is the negative impact coming from the USA.

In addition, enterprises in the mechanical engineering sector have experienced postponement or cancellation of planned capital investments as a result of the crisis.<sup>463</sup>

The COVID-19 crisis has negatively affected companies in the vast majority of mechanical engineering segments. However, there are **differences in the extent to which different segments have been impacted**. In particular, as discussed above, many of the segments that will reportedly experience greater negative impacts are those that provide inputs to the automotive and other sectors facing significant difficulties themselves. Examples include the machine tool segment, manufacturers of precision tools, robotics and automation, and plastic and rubber machinery. Furthermore, foundry machinery and measuring equipment manufacturers will likely experience below average performance.<sup>464</sup>

Although still expected to experience adverse impacts, industry researchers anticipate that a selection of segments are faring better. These sectors include manufacturers of fittings and the drive technology segment.<sup>465</sup>

#### **5.1.5 Impact of weaknesses and critical dependencies identified in engineering supply chains.**

The previous section identified examples of supply chain dislocations that have occurred in situations where European manufacturers are dependent on components suppliers in Asia and elsewhere. The over-reliance on too narrow a range of suppliers has also been exposed, including through the dislocations experienced in intra-EU trade.

Such dislocations point to weaknesses in European manufacturers' Global Value Chains (GVCs), which highlights the need for greater supply chain resilience. More specifically, the relative weakness of Europe's competitiveness in the electronic components sector in general, and in semi-conductor and chip manufacturing in particular means that the COVID-19 pandemic has exposed structural weaknesses in European industrial supply chains.

This raises a question mark as to whether strategic value chains need to be rethought by European industry at a sectoral and individual firm level to avoid continued reliance on a limited number of third countries both regarding manufacturing the whole product and where manufacturing takes place in Europe, a dependency for key parts and components from outside the EU-27.

During two to three months of lockdowns, there were factory closures, transportation and logistics difficulties, and hence, major delays in key components and parts being available from Asia on which European manufacturers commonly depend. Whilst the situation in China and in other Asian countries has normalised since March / April 2020, as the pandemic has subsided in that part of the world, the non-availability of crucial components and intermediate inputs on which European manufacturers were dependent has highlighted the precariousness of over-dependence on China and other Asian countries in

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<sup>462</sup> <https://www.rolandberger.com/en/Point-of-View/Covid-19-Priorities-for-mechanical-engineering.html>

<sup>463</sup> <https://www.rolandberger.com/en/Point-of-View/Covid-19-Priorities-for-mechanical-engineering.html>

<sup>464</sup> Auer, J. (2020). [Mechanical engineering sector feels the effects of the coronavirus](#). Ifo Institute, Deutsche Bank Research.

<sup>465</sup> Auer, J. (2020). [Mechanical engineering sector feels the effects of the coronavirus](#). Ifo Institute, Deutsche Bank Research.

the global supply chains of European manufacturers, especially for crucial electronic components, such as semi-conductors and chips.

Such an over-dependency is not a new phenomenon, but a problem that has grown over time, reflecting the offshoring of manufacturing to the far East since the 1980s, and the gradual, but increasing globalisation of supply chains. Moreover, some countries in Asia – such as China, Taiwan, Singapore etc.- have made very significant capital investments in semi-conductor plants and in chip manufacturing. The same is true of the US, which has invested significantly, so as not to lose the race to develop technological leadership in 5G and in AI, which are dependent on high processing power and therefore on global leadership in semi-conductors.

Although Europe does retain some capacity in key sectors such as electronic components, Europe's market share was shown in Section 2 to have declined in the past decade. It would take very significant investment to catch-up with the accelerated pace of development in the US and Asia. Nonetheless, Europe is already making progress through public-private funding support for industrial research. Examples are through the ECSEL Joint Undertaking, an EU-driven, public-private partnership, which funds innovation in electronic components and systems.<sup>466</sup> In addition, the strategic role of the IPCEIs in strengthening Europe's strategic autonomy in areas such as batteries and microelectronics can be noted. These were examined in detail in Section 2.2.4.3 - Modernisation of state aid for R&D&I and the role of the IPCEIs.

The recent supply chain dislocations experienced by European industry due to the pandemic also arguably present a strategic opportunity.

Major European and global manufacturers may reconsider in the coming months and years whether their existing global supply chains are sufficiently resilient. This may in turn lead them to **consider reshoring at least some aspects of production**. It could also present opportunities for alternative suppliers to win new contracts as a result of large manufacturing firms in Europe and multinationals seeking to diversify their supplier base and avoid too narrow a reliance on a small number of key suppliers. This may be a natural consequence of risk management processes put in place to mitigate COVID-19 supply chain risks.

However, whilst there is some scope for reshoring of production to Europe, the evidence gathered through desk research and interviews is that the crisis is unlikely to lead to significant reshoring for various reasons, such as that:

- The severity of the pandemic and its global impact on supply chains was seen as an unprecedented event, but one that as industry puts in place risk mitigation measures and adapts to the "new normal" is unlikely to be repeated on the same scale.
- For example, lockdowns may become less of a national phenomenon and more localised, meaning that production can continue, especially as suppliers become used to operating under the new normal, for instance, implementing social distancing measures in the workplace.
- Labour costs. Whilst some high-end manufacturing and early-stage manufacturing e.g. prototyping as part of new product development may take place in Europe, it was seen as unlikely that mass manufacturing would be reshored, due to significant differential costs between Europe and Asia.
- However, there may be some scope to reshore production facilities to Central and Eastern Europe, where labour costs are lower in specialised industries, such as automotive, where nearshore outsourcing and production rather than offshoring

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<sup>466</sup> ECSEL Joint Undertaking is a EU-driven, public-private partnership, funding innovation in electronic components and systems. <https://www.ecsel.eu/>

production to Asia may become increasingly attractive to increase the reliability and resilience of supply chains.

Further evidence that the impact of the pandemic on reshoring is not likely to be significant is now provided. The majority of German electrical and electronic manufacturers responding to a ZVEI monthly survey of its members stated that they will not strategically alter their supply chains as a result of the crisis. In addition, representatives of Orgalim interviewed for this study do not anticipate significant alterations of supply chains as a result of COVID-19, noting that: i) GVCs do not reorganise quickly at a reasonable cost; and ii) China and other non-European countries were (re-)opening production facilities while Europe was still in lockdown which allowed the production of goods that would otherwise not have been possible. Nonetheless, the scope for such reshoring would depend on the area within the value chain, the scale of production, and any limitations in the availability of critical components outside China and / or Asian manufacturing hubs.

The Commission President's five-year policy agenda for 2019-2024 has recognised the importance of Europe strengthening its strategic autonomy, including in key industrial sectors. Arguably, the COVID-19 pandemic has accentuated the need to ensure that Europe remains autonomous in key sectors of the economy, given that these will be crucial to the speed of economic recovery, and to ensuring future economic growth and jobs. Without such autonomy, there is a risk that other competitor economies become stronger and that the differential between Europe and major competitors grows. This is especially the case in sectors such as electronic components and semi-conductor manufacturing.

Accordingly, the EU policy framework on industrial competitiveness and on the economic recovery both reference the importance of Europe investing in ensuring that certain sectors receive the necessary investments to preserve Europe's strategic autonomy and to remain globally-competitive.

The March 2020 New Industrial Strategy Communication<sup>467</sup> and the May 2020 SWD accompanying the European Recovery Plan<sup>468</sup> by the Commission identified a number of sectors that are crucial from a strategic autonomy perspective. This includes sectors that are crucial to the European economy in their own right as they are fast-growing (e.g. 5G, AI, advanced manufacturing and digital technologies) as well as sectors that are of strategic importance in providing intermediate inputs to other sectors and in preserving Europe's strategic autonomy. These include:

- **Strategic digital infrastructures** - 5G, cybersecurity, quantum communication infrastructure);
- **Key enabling technologies** - robotics, microelectronics, high-performance computing & data cloud infrastructure, blockchain, quantum technologies, photonics, industrial biotechnology, biomedicine, nanotechnologies, pharmaceuticals, advanced materials;
- **Defence & Space – defence industrial value chains, space technologies, data and services, cross border cooperation and synergies between civil, space and defence industries;**
- **Critical raw materials** crucial for e-mobility, batteries, renewable energies, pharmaceuticals, aerospace, defence and digital applications, medical products & pharmaceuticals.

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<sup>467</sup> A New Industrial Strategy for Europe, Brussels, 10.3.2020, COM(2020) 102 final

[https://ec.europa.eu/info/sites/info/files/communication-eu-industrial-strategy-march-2020\\_en.pdf](https://ec.europa.eu/info/sites/info/files/communication-eu-industrial-strategy-march-2020_en.pdf)

<sup>468</sup> COMMISSION STAFF WORKING DOCUMENT, Identifying Europe's recovery needs, 27.5.2020, SWD(2020) 98 final - [https://ec.europa.eu/info/sites/info/files/economy-finance/assessment\\_of\\_economic\\_and\\_investment\\_needs.pdf](https://ec.europa.eu/info/sites/info/files/economy-finance/assessment_of_economic_and_investment_needs.pdf)



It should be noted that these areas were identified as being key to ensuring strategic autonomy prior to the COVID-19 pandemic and the economic downturn that has resulted since. However, given the need to ensure Europe's economic and societal recovery, ensuring that these areas are prioritised has become even more important. Other sectors mentioned are among those that have been especially adversely hit by the economic impacts of the pandemic and may therefore need additional EU support. An example is the aerospace industry (see earlier case study).

Some of these sectors, such as pharmaceuticals, are among those that have been especially affected by supply chain dislocations, and also national self-interest interrupting GVCs, such as the supply of paracetamols and other everyday medications running out and only being available in selected countries for a period of time.<sup>469</sup> For example, there is a major transition ongoing towards electric vehicle (EV) technologies, and if Europe were unable to remain at the forefront of research or be able to obtain the critical raw materials necessary for battery production, then the energy and transportation transition to cleaner energy could not take place. Moreover, EV is likely to be key to growth and jobs, as it represents a major growth market of the future, as evidenced by the growth in EV sales and the exceptionally high market capitalisation for pure EV companies on the US stock market, such as Tesla (EV cars) and Nikola Motor Corp (EV zero-emission trucks).

In the context of the Next Generation EU Programme (NGEU), financial support was proposed to strengthen Europe's strategic autonomy, in particular through the InvestEU Programme, which is also largely financed under the MFF 2021-2027. Further information is provided in the following box:

**InvestEU's Strategic European Investment Window – proposed funding support to overcome vulnerabilities in global supply chains**

A fifth window of InvestEU has been proposed by the European Commission in May 2020 through the new strategic European investment window. This will cater for the future needs of the European economy and promote and secure EU strategic autonomy in key sectors. As of end of May 2020, it had been allocated 31 billion EUR provisionally.<sup>470</sup>

The outbreak of the pandemic has shown the interconnectivity of global supply chains and exposed some vulnerabilities, such as the over-reliance of strategic industries on non-diversified external supply sources. Such vulnerabilities need to be addressed, to improve the resilience of the EU's economy, while maintaining its openness to competition and trade in line with its rules. The strategic European investment window will focus on building stronger European value chains in line with the strategic agenda of the Union and the New Industrial Strategy for Europe, as well as supporting activities in critical infrastructure and technologies.

The new window would target specific projects (e.g. supporting large consortia or public-private partnerships aimed at developing a specific technology and building critical infrastructure) and provide financing to support the emergence of whole ecosystems of entrepreneurs active in targeted sectors (e.g. innovative SMEs working on technologies of potential relevance to industrial biotechnology and pharmaceuticals).

However, the EU budgetary negotiations are ongoing and it is unclear if this Window will remain. Nonetheless, it provides an example of the types of support that might be envisaged. Some funding for public-private partnerships to carry out industrial research also ought to be available through the Horizon Europe programme.

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<sup>469</sup> <https://health.economictimes.indiatimes.com/news/pharma/coronavirus-outbreak-your-paracetamol-supply-depends-a-lot-on-china/74521507>

<sup>470</sup> 31 billion EUR has been proposed for the Strategic European investment window by the Commission. The details are subject to negotiation with the Member States and European Parliament. - (see [https://ec.europa.eu/commission/presscorner/detail/en/qanda\\_20\\_947](https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_947))

As noted in earlier sections, there is already funding available to support some of these sectors, for instance through the joint public-private partnerships in semi-conductors and through the **establishment of IPCEIs** in areas such as **batteries, microelectronics and High-Performance Computing**. As noted in Section 2.2.4.3 on the Modernisation of state aid for R&D&I and the role of the IPCEIs, these provide a mechanism through which major support can be provided to particular sectors to enable them to undertake industrial R&D&I and are designed to be a flexible means of avoiding state aid problems. As such, in areas crucial to Europe's strategic economy, they could provide a mechanism to develop cross-country industrial clusters and R&D&I centres of excellence and hubs of expertise, such as to allow Europe to remain cutting-edge both in terms of research and industrial competitiveness in these areas. This in turn will better enable Europe to withstand the economic crisis due to the pandemic.

#### **5.1.5.1 Demand-side impacts of COVID-19**

Monthly surveys are conducted by the VDMA and the ZVEI of its members across the German mechanical engineering industries and the electrical and electronic industry, respectively. At the end of March 2020, for instance, the VDMA found that 84% of its member companies were already reporting adverse effects either supply chain problems, adverse demand-side effects, or both, which had risen to 89% by mid-April. In April 2020:

*In nine out of ten companies, sales of their own products and services are affected. In half of the cases, orders have collapsed. In almost one third of the companies, sales are also disrupted due to their own production losses. Half of the companies expect a drop in sales as a result of the corona pandemic. As in the second ad hoc survey conducted at the beginning of April, the expected loss of sales is – on average – again 14 percent. The development of the other half cannot yet be predicted. And again, only half of the companies assume that they will be able to make up the declines (completely or partially) in the foreseeable future.*

Interestingly, the VDMA's survey analysis observed that there had been a gradual transition in problems from **supply chain dislocations which characterised the initial period of lockdown** in major global manufacturing hubs such as China and elsewhere in Asia, to **demand-side disruptions**, i.e. a drop in new, and cancellations of existing orders.

On the supply side, more than three-quarters of mechanical engineering companies surveyed viewed there as being **no likely easing of supply chain disruptions in the next three months**. Moreover, 28% of companies expected the situation to deteriorate. Most respondents were however **especially concerned regarding the demand side** and the significant reductions in their order books, which emerged unexpectedly due to COVID-19, following a period of relative strength in the European economy.

In April 2020, *"Overall, 45 percent of the companies report noticeable order losses or cancellations, and 32 percent of those surveyed even serious ones. However, the supply chains are also still under strong pressure"*. On the demand side, the VDMA snapshot survey notes that *"there is a strong negative impact coming from the USA (47 percent). In China, on the other hand, the situation appears to be stabilising"*. 43% of respondents in the March and 45% in April 2020 monthly surveys of VDMA members expected the situation to worsen on the demand side, and about 60% of companies expected a decline in turnover of between 10% and 30% in 2020 as a whole. The expectations for the magnitude of decline are on a par with, or in many cases, even worse than those experienced during the economic and financial crisis.

ZVEI has also reported on demand-side data. Considering sales, the fourth iteration of the ZVEI survey on the COVID-19 crisis, conducted in June 2020, found that firms anticipated sales to reduce by 13% for Q2 2020 as compared to 2019. Moreover, for the entire year 2020, firms anticipated reduced sales of 7% compared with 2019. Nevertheless, the



majority of the electric companies surveyed by ZVEI in April 2020 were already seeing the first positive impulses from China – 84% in demand and 56% in the supply of inputs. By June 2020, firms responding to ZVEI were experiencing a (strong) recovery in the demand for products and services from China (65% of firms reported a recovery, with 20% reporting a strong recovery in demand). However, results on demand from Germany and the Eurozone, as well as the US and other American countries were less positive. Considering Eurozone demand specifically, 46% of respondents believed that the low point for demand had been reached, with 17% experiencing signs of recovery but 37% still believing the low point had not yet occurred. In the US, the situation appears to be worse, with 52% of firms believing the low point was still to come and only 2% seeing signs of recovery.

In addition, in April 2020, almost 90% of the companies had not had to make any redundancies and were not currently planning to do so. In ZVEI's June 2020 survey, 57% of firms reported that they will not reduce their staff. However, 36% of firms were planning redundancies and 6% had already reduced their staff.

In the flash monthly survey of VDMA members, whereas at the end of March, 84% of member companies surveyed by the VDMA were reporting adverse effects, this figure has since risen to 98% by the end of May. The shift towards demand-side disruptions has continued with order losses and / or cancellations. As the VDMA wrote: *"Overall, 39 percent of the companies report a noticeable drop in orders or cancellations, 44 percent of those surveyed even serious ones".*<sup>471</sup> Considering serious drops in orders or cancellations, this represents a 12% increase from April to May 2020.

Regarding machinery exports to third countries, considered as one of Europe's competitive strengths, the VDMA also mentioned a -21% decline in German machinery exports to EU Member States in March 2020 at the webinar.

One of the aspects laid bare by COVID-19 is that **value chain transparency is key for being able to achieve scale effects**. COVID-19 promoted the demand for more flexibility in production systems with an increased demand for Augmented Reality (AR), cybersecurity, and big data applications. 3D Printing (3DP) could also provide solutions to help manufacturers overcome supply chain dislocation, for instance, when crucial components are unavailable due to lockdowns. Euromonitor, for example, forecasts 30% annual growth in the 3DP market in the next few years, a trend it recognised had been accelerated by COVID-19.<sup>472</sup> Increased value chain transparency will remain a key element for reaping the benefits.

Whereas the three main branches of the EU engineering sectors have been experiencing supply and demand-side difficulties, other sectors to whom the EU engineering industries may provide at least some intermediate inputs, such as the pharmaceuticals and consumer goods sectors have benefited from increased turnover during the crisis. As the engineering sectors provide machinery to manufacturing facilities in these sectors, this may to some extent help to mitigate the adverse demand-side impacts being experienced in 2020 (and possibly beyond, depending on the scale of the recovery).

#### **5.1.5.2 Impacts at the level of individual firms**

Evidently, in the first instance, engineering companies have a duty of care to protect the health of their staff. In addition, it is essential that mitigation measures are put in place at the firm level. For instance, they will need to adjust their capacity and make structural adjustments to their operations. Both the demand and supply-side factors mentioned in

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<sup>471</sup> <https://www.vdma.org/en/v2viewer/-/v2article/render/48281066>

<sup>472</sup> Source – Euromonitor presentation on the supply chain impacts of COVID-19 made at the webinar held on 20th May, 2020 as part of this study. Also consult - <https://blog.euromonitor.com/economies-2018-key-insights/>

the previous sub-sections will have an impact on European industry. Looking ahead, some firms have already reduced their staff headcount due to cancelled orders and a slowdown in new orders. Others have however been able to take advantage of support from national governments to help them retain staff. For instance, national funding has been made available for the temporary furloughing of staff, with significant funding subsidies towards salaries. However, this is not the case in all EU Member States, and some staff have already lost their jobs, or will end up doing so once the national furlough schemes come to an end.

The importance of strengthening business and innovation support services has also been stressed in various desk research, so that firms can receive quality advice on how best to navigate the present crisis. For instance, in the **electrical engineering sector in Germany**, the ZVEI has set up a COVID-19 helpdesk<sup>473</sup> to assist engineering firms.

#### **5.1.5.3 Impact of COVID-19 on digitalisation**

The EU engineering industries are already relatively digitalised, although they are behind US and Asian manufacturers in terms of the level of deployment of Industry 4.0 technologies. However, as in other sectors of the European economy, there is expected to be an **increased pace of adoption of digitalisation** both in terms of the adoption of digital manufacturing technologies, and in working practices due to COVID-19. According to the ZVEI survey, half of the companies participating in the April 2020 survey intend to invest even more in digitization in the future than already planned due to the corona crisis.<sup>474</sup>

This relates not only to manufacturing processes themselves, but also regarding the **organisation of more digitalised production hubs**. Moreover, the pandemic is viewed as being likely to foster the accelerated take-up and adoption of AR and VR technologies by engineering firms (as well as by firms in other vertical sectors that use intermediate inputs from the different branches of the EU engineering industries). Such technologies enable early-stage product development to be carried out locally, which implies reshoring certain aspects of the initial production process, such as proof of concept and prototype development. This in turn could potentially accelerate lead times to market, and contribute towards Europe's strengthened industrial competitiveness.

A further driver of change partially due to the epidemic is the more widespread adoption of 3D Printing (3DP). Whilst additive manufacturing technologies have been around for a decade, the rate of the adoption of such technologies has been increasing in part due to reduced costs, but also continually improving technologies. According to insights from **Euromonitor International**,<sup>475</sup> take-up of 3DP is likely to accelerate rapidly in the next five years, which in part is COVID-related given the **importance of strengthening global supply chain resilience**.

Although 3DP and other digital technologies promote a network of semi-independent production hubs across the globe – in contrast to the existing network of large suppliers and factories – it was considered as important, especially for SMEs, to realise networks at the EU scale. This in turn requires that harmonised EU standards are developed in the area of digital technologies, as standards are an evolving area for these technologies. Moreover, common general-purpose technology platforms where both SMEs and large companies can share data to the benefit of both need to be supported to enable SMEs to take advantage

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<sup>473</sup> <https://www.zvei.org/themen/corona/>

<sup>474</sup> [https://www.zvei.org/fileadmin/user\\_upload/Presse\\_und\\_Medien/Newsletter/NL\\_2020/3\\_20/Ergebnisse-Dritte-ZVEI-Coronaumfrage-April-2020.pdf](https://www.zvei.org/fileadmin/user_upload/Presse_und_Medien/Newsletter/NL_2020/3_20/Ergebnisse-Dritte-ZVEI-Coronaumfrage-April-2020.pdf)

<sup>475</sup> Euromonitor International participated and presented in the webinar held in May 2020 on competitiveness and digitalisation. The authors thank Euromonitor for their insights into the impact of COVID-19 on European manufacturing generally, and on the EU engineering industries in particular.

of the opportunities of big data in a way that could help them to overcome the impacts of the potential economic crisis following the COVID-19 epidemic.

Regarding the **potential opportunities for European industry of strengthening supply chain resilience**, if, for instance, prototyping can be carried out in Europe, largely digitally, and if key components can be digitally recreated using a digital inventory and ensuring that digital twins are made of crucial components ordinarily produced outside Europe, then this would allow EU engineering firms, and manufacturers in other sectors dependent on such firms, to avoid plant closures through diversification of the supply chain. Of course, this does not preclude plant closures in Europe due to lockdowns and social distancing rules, but could at least avoid the level of supply chain dislocation experienced in Europe in January – March 2020.

More generally, as in many other sectors, COVID-19 has already had an **impact in terms of accelerating the take-up of new forms of work organisation** by the EU engineering industries, such as remote working and the use of video conferencing.

#### **5.1.5.4 Impact of COVID-19 on EU legislation**

Evidently, the core existing EU legislation applicable to the EU engineering industries will remain in place (indeed, a competitive advantage is considered to be the relative regulatory stability at least in terms of industrial product legislation). Nonetheless, COVID-19 is also likely to have an impact on the EU engineering industries. For example, responses from key engineering stakeholders to the Commission's consultation process linked to the publication of the Economic Recovery Plan suggest that engineering industry associations (including umbrella organisations representing the interests of many different engineering firms) are in favour of **maintaining a stable regulatory framework, retaining a technology-neutral approach** based on the NLF approach. **Slowing down the pace of regulatory change** (including postponing planned changes. The rationale is that the engineering industries are having to cope with not only major international competition, but an existential crisis to survive the emerging crisis. For instance, the VDMA paper on the impact of COVID-19 and role of the European Recovery Plan notes that:

*"Companies not only have to cope with structural adjustments, but also have to ensure their own survival. This requires considerable effort and resources. Especially restrictive or onerous measures – such as the SCIP database or the mandatory CSR reporting – must be deferred or pared back". VDMA position paper on COVID-19 and the ERP.*

As Orgalim highlighted in the request directed to the Commission *"We are not calling for a stop to all legislative action. We are however asking for the political framework to support the ability for our industries to focus all required resources on the immediate challenges of the recovery from the crisis, so that a solid and sustainable industrial basis can be rebuilt, and our long-term competitiveness can be reinforced."*<sup>476</sup> Moreover, Orgalim pointed out that they strongly support the Green Deal and the Digital actions as anchors for the recovery, including the Green Deal's current timelines. In this regard, the German electric companies surveyed by the ZVEI in April 2020 were in favour of a demand-side stimulus package that could provide impetus, especially in the areas of "Mobility and Transport Infrastructure", "Digital Infrastructure and Industry 4.0" and "Climate Protection and Energy Efficiency". When asked how any stimuli in the area of individual mobility should be designed, most of the respondents were in favour of prioritising the electrification of transport.<sup>477</sup>

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[https://www.ifsa.eu.com/uploads/1/2/0/2/120245019/orgalim\\_letter\\_to\\_ec\\_president\\_covid19\\_impact\\_commission\\_work\\_2020.pdf](https://www.ifsa.eu.com/uploads/1/2/0/2/120245019/orgalim_letter_to_ec_president_covid19_impact_commission_work_2020.pdf)

<sup>477</sup> [https://www.zvei.org/fileadmin/user\\_upload/Presse\\_und\\_Medien/Newsletter/NL\\_2020/3\\_20/Ergebnisse-Dritte-ZVEI-Coronaumfrage-April-2020.pdf](https://www.zvei.org/fileadmin/user_upload/Presse_und_Medien/Newsletter/NL_2020/3_20/Ergebnisse-Dritte-ZVEI-Coronaumfrage-April-2020.pdf)

Further suggestions regarding how to minimise the risk of any adverse impacts on the EU engineering industries are provided in the next sub-section, which summarises suggested mitigation measures by the stakeholders themselves.

## 5.2 Existing and future possible EU and national measures to mitigate the crisis

### 5.2.1 Stakeholder feedback on EU measures that could mitigate the crisis

A number of key messages were identified from engineering stakeholders regarding how the growing demand-side crisis in the EU engineering industries due to the economic fallout from the pandemic might best be mitigated. Some of the engineering industry associations at national level have also issued position papers on the impact of COVID-19 and the ERP. Regarding EU legislation, they advocate more thorough scrutiny of proposed legislation and the avoidance of any restrictive or burdensome measures, especially mandatory reporting as part of compliance processes.

- **Maintaining a stable regulatory framework**, as the engineering industries in general, and individual firms in particular do not have the resources to cope with fighting to survive whilst adapting to new EU legislation;
- **Slowing down the pace of regulatory change** (including postponing planned changes) and allowing much more time for the process of reviewing existing legislation to assess its fitness for purpose to enable EU industry – and their representative organisations – in the EU engineering industries, to focus on maintaining Europe’s economic competitiveness in these sectors<sup>478</sup>;
- **Retaining a technology-neutral approach** regarding product legislation and avoiding introducing burdensome new legislation in areas such as AI (though considering cybersecurity legislation only over the medium term when the crisis has been overcome);
- Whilst supporting the concept of the Green Deal and growing attention to sustainability-related issues, advocating a more **pragmatic and realistic approach by EU regulators** that avoids burdening industry with overly complex reporting requirements, and avoiding introducing new environmental legislation beyond the existing body of legislation.
- **Providing support to address short-term liquidity needs to get SMEs through the crisis.** For example, liquidity support can be provided in a number of ways, such as temporary relaxation of the state aid rules, greater use of investment guarantees, soft loans and at national level, tax breaks for engineering firms. As supply-side stimuli, companies in the electrical and electronic industry prefer above all tax cuts, the assertion of tax loss carry-forwards and carry-backs, as well as better depreciation options such as immediate or declining balance depreciation, in order to boost the economy again.<sup>479</sup>
- The continued importance of **pursuing international trade agreements and open trade**, despite growing protectionism and economic nationalism.
- **Supporting SMEs in value chain repositioning.** Large industry players, including medium and large engineering firms, and multinationals that use the intermediate inputs produced by the EU engineering industries will be looking to

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<sup>478</sup> Orgalim and Applia for instance have both caused for a regulatory pause to allow the industry to concentrate most of its efforts on overcoming the present crisis for the engineering sectors, and for the European economy more broadly. See: [https://www.ifsa.eu.com/uploads/1/2/0/2/120245019/orgalim\\_letter\\_to\\_ec\\_president\\_covid19\\_impact\\_commision\\_work\\_2020.pdf](https://www.ifsa.eu.com/uploads/1/2/0/2/120245019/orgalim_letter_to_ec_president_covid19_impact_commision_work_2020.pdf) and also [https://applia-europe.eu/images/position-papers/2020-04-30\\_Joint\\_Letter\\_to\\_President\\_von\\_der\\_Leyen.pdf](https://applia-europe.eu/images/position-papers/2020-04-30_Joint_Letter_to_President_von_der_Leyen.pdf)

<sup>479</sup> [https://www.zvei.org/fileadmin/user\\_upload/Presse\\_und\\_Medien/Newsletter/NL\\_2020/3\\_20/Ergebnisse-Dritte-ZVEI-Coronaumfrage-April-2020.pdf](https://www.zvei.org/fileadmin/user_upload/Presse_und_Medien/Newsletter/NL_2020/3_20/Ergebnisse-Dritte-ZVEI-Coronaumfrage-April-2020.pdf)

review their global supply chains to minimise the risks of supply chain dislocation happening in future. Strengthening the resilience of value chains provides an opportunity for European SMEs to reposition themselves to attract new orders from firms looking to diversify their supplier base.

### **5.2.2 EU approach to mitigating the economic impacts of the COVID-19 crisis: the European Recovery Plan**

On 21 July 2020, EU leaders reached a political agreement on the EU recovery plan and long-term budget for 2021-2027. This budget aims to support the recovery of the EU from the COVID-19 crisis and ensure significant investment in the green and digital transitions. In structure, the envisaged EUR 1.82 trillion expenditure for the period is separated between: i) the multiannual financial framework (MFF), worth EUR 1,074.3 billion; and ii) Next Generation EU (NGEU), worth EUR 750 billion.<sup>480</sup> NGEU represents the EU's temporary recovery instrument, building on the European Commission's proposed recovery plan of 27 May 2020. To fund NGEU, EU leaders authorised the Commission to borrow funds for the EU on the capital markets; the first time this has been permitted in European history.<sup>481</sup> An overview of NGEU is provided in the below box.

#### **Box 5-4 – Next Generation EU (NGEU): Financing Overview**

NGEU financing will be divided between the following three pillars and programmes:<sup>482</sup>

- **Pillar 1: Supporting Member States to recover**
  - **Recovery and Resilience Facility (RRF, EUR 672.5 billion):** By far the largest of the programmes funded under NGEU, the RRF is divided further between loans (EUR 360 billion) and grants (EUR 312.5 billion). The RRF will aim to support the implementation of investments and reforms by the Member States in order to drive sustainable recovery. To achieve this, Member States shall 'prepare national recovery and resilience plans setting out the reform and investment agenda of the Member State concerned for the years 2021-23'<sup>483</sup>, in line with EU investment and reform priorities.
  - **ReactEU (EUR 47.5 billion):** This new initiative aims to provide Member States with additional cohesion support. Available across all sectors, this funding will be targeted at key crisis repair measures and support for the most deprived (e.g. workers and SMEs, health systems and the green and digital transitions).<sup>484</sup>
  - **Rural Development (EUR 7.5 billion) and Just Transition Fund (JTF, EUR 10 billion):** The focus of support in these areas will be provided additional support to the green transition.
- **Pillar 2: Kick-starting the economy and helping private investment**
  - **InvestEU (EUR 5.6 billion):** This programme, which brings together the European Fund for Strategic Investments and 13 other EU financial instruments (e.g. Innovfin Equity, CEF debt instrument etc.), aims to improve the efficiency of EU funding for European investment projects across four key policy areas: sustainable infrastructure; research, innovation and digitisation; small and

<sup>480</sup> [https://ec.europa.eu/commission/presscorner/detail/en/ip\\_20\\_940](https://ec.europa.eu/commission/presscorner/detail/en/ip_20_940)

<sup>481</sup> <https://www.consilium.europa.eu/media/45109/210720-euco-final-conclusions-en.pdf>

<sup>482</sup> The proposed EU recovery plan (27.05.2020) also noted financing for the Solvency Support Instrument and the Strategic Investment Facility under Pillar 2 and the Health programme, Neighbourhood, Development and International Cooperation, and Humanitarian Aid under Pillar 3 of NGEU. However, these initiatives are not included in NGEU, as reported in the European Council Conclusions related to the political agreement on the EU recovery plan and long-term budget for 2021-2027.

<sup>483</sup> <https://www.consilium.europa.eu/media/45109/210720-euco-final-conclusions-en.pdf>

<sup>484</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1590732521013&uri=COM:2020:456:FIN>



medium-sized businesses; and social investment and skills.<sup>485</sup> NGEU financing will bolster InvestEU, with the recovery plan highlighting specific support for the following areas: the renovation of existing building stock; the implementation of green transition measures, such as charging points, clean fleet renewals and sustainable transport infrastructure; and the implementation of digital transition measures, including investment in AI, cybersecurity and 5G and 6G networks.<sup>486</sup>

- **Pillar 3: Learning the lessons from the crisis**

- **Horizon Europe** (EUR 5 billion) and **RescEU** (EUR 1.9 billion): Additional funding will be provided to support these existing EU programmes.

Alongside its proposed recovery plan, the European Commission published an **adjusted Commission Work Programme for 2020**. In the updated Work Programme, delays are envisaged across a wide range of new initiatives. From the perspective of the engineering industries, a number of new initiatives remain on track (for example, the proposed Strategy for sustainable and smart mobility), while certain other new initiatives will experience minor delays (for instance, the follow-up to the White Paper on AI, initially planned for Q4 2020 will now be delivered in Q1 2021).<sup>487</sup> Considering REFIT initiatives, the adjusted Work Programme also confirms the intentions to proceed with key engineering-related initiatives, including the Revision of the Machinery Directive (2006/42/EC) in Q1 2021, the Revision of the General Product Safety Directive (2001/95/EC) in Q2 2021, and the evaluations of the ROHS (2011/65/EU) and Low Voltage (2014/35/EU) Directives. As such, across the adjusted Work Programme, significant engineering-relevant changes are not foreseen.<sup>488</sup>

In the **short-term**, European state aid rules and fiscal rules have been temporarily suspended and the EU has supported COVID-19 response actions through two packages of measures, launched in April 2020: The Coronavirus Response Investment Initiative (CRII) and the Coronavirus Response Investment Initiative Plus (CRII+). Regarding fiscal measures, the Commission has made a recommendation to activate the general escape clause of the Stability and Growth Pact to allow fiscal expenditure to exceed the maximum ceiling of 3%.<sup>489</sup> This is already allowing national governments throughout the EU to announce and implement various fiscal measures to contain the economic fallout from COVID-19. In addition, the CRII and CRII+ allow Member States to use cohesion policy funds for COVID-19 crisis related actions in a more efficient manner, including specifically in the health sector, and to support SMEs and workers.<sup>490</sup>

Considering EU industry and the EU engineering industries more specifically, the Commission SWD accompanying the recovery plan<sup>491</sup> highlights that EU industry is being challenged by the following key investment needs which need to be addressed:

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<sup>485</sup> [https://ec.europa.eu/commission/priorities/jobs-growth-and-investment/investment-plan-europe-junker-plan/whats-next-investeu-programme-2021-2027\\_en](https://ec.europa.eu/commission/priorities/jobs-growth-and-investment/investment-plan-europe-junker-plan/whats-next-investeu-programme-2021-2027_en)

<sup>486</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1590732521013&uri=COM:2020:456:FIN>

<sup>487</sup> [https://eur-lex.europa.eu/resource.html?uri=cellar%3Af1ebd6bf-a0d3-11ea-9d2d-01aa75ed71a1.0006.02/DOC\\_2&format=PDF](https://eur-lex.europa.eu/resource.html?uri=cellar%3Af1ebd6bf-a0d3-11ea-9d2d-01aa75ed71a1.0006.02/DOC_2&format=PDF)

<sup>488</sup> [https://ec.europa.eu/info/sites/info/files/cwp-2020-adjusted-factsheet\\_en.pdf](https://ec.europa.eu/info/sites/info/files/cwp-2020-adjusted-factsheet_en.pdf)

<sup>489</sup> The Commission has also made a proposal to direct €37 billion under EU cohesion policy to the fight against the coronavirus crisis as well as the initiatives taken by the European Central and the European Investment Bank to maintain liquidity in the financial system and the economy.

<sup>490</sup> [https://ec.europa.eu/regional\\_policy/sources/newsroom/coronavirus-response/crui\\_state\\_of\\_play\\_072020.pdf](https://ec.europa.eu/regional_policy/sources/newsroom/coronavirus-response/crui_state_of_play_072020.pdf)

<sup>491</sup> European Commission, (2020), Staff Working Document: Identifying Europe's recovery needs, Accompanying the document: Europe's moment: Repair and Prepare for the Next Generation, SWD(2020) 98 final.

- **Basic macroeconomic investment** gaps due to the COVID-19 crisis, forecasting a cumulative drop in investment of €846bn in 2020 and 2021, the vast majority of which is private investment (€831bn).
- **Additional investment needs revealed by the crisis.** In this respect, the Commission highlights that the crisis has exposed vulnerabilities of EU industry, in particular reliance on third countries for strategic supply chains and 'excessive dependence on imports of critical goods and services'<sup>492</sup>. While noting that for some sectors autonomy can be achieved through diversification and strengthening of global supply chains, the Commission states that increasing capacity within the EU may be necessary for more strategic ecosystems. The SWD refers to the New Industrial Strategy Communication, listing the following relevant sectors for strategic autonomy: strategic digital infrastructures (e.g. 5G, cybersecurity, quantum communication infrastructure); Key enabling technologies (e.g. robotics, microelectronics, high-performance computing & data cloud infrastructure, blockchain, quantum technologies, photonics, industrial biotechnology, biomedicine, nanotechnologies, pharmaceuticals, advanced materials); Defence & Space; Critical raw materials crucial for e-mobility, batteries, renewable energies, pharmaceuticals, aerospace, defence and digital applications; and Medical products & pharmaceuticals.
- **Investment needs that remain crucial regardless of the crisis**, including additional needs to ensure progress on the green and digital transitions.

As such, in response, key observations from the EU's approach to recovery from the COVID-19 crisis are:

- **The green and digital transitions, including of EU industry, are integral to the EU's approach to COVID-19 recovery.** Within the framework of the Recovery and Resilience Facility, Strategic Investment Facility and the InvestEU programme, the Commission foresees tools to stimulate investment in the digital and green transformation of industry.
- **Another key focus is on the recalibration of existing EU funding programmes to maximise support for mitigation efforts.** The planned Digital Europe Programme in Horizon Europe has a budget of EUR 9.2 billion and could be utilised to support the digital transition of engineering firms (especially SMEs). This could enable such firms, for instance, to become part of a regional digital hub connecting other enterprises. In regions where smart specialisation has focused on different branches of the engineering industries, these could be capitalised on to consolidate, and further strengthen existing regional competitive strengths through ongoing support for smart specialisation in the new MFF in 2021-2027.
- **Provision of wide-ranging and flexible financing to Member States** in order to support national efforts to mitigate the impacts of COVID-19 and support national industrial recovery. For instance, the CRII and CRII+ has been accessed by 26 Member States and the UK. The following subsection summarises the nature of national measures implemented by the Member States and provides examples of such measures.

### **5.2.3 National measures to mitigate the economic impacts**

Given the scale of the crisis, the importance of providing support to the EU engineering industries at national level too should be highlighted. Examples of national mitigation policy and funding measures to offset the impacts of the crisis have already been put in place at the **national level**. For example:

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<sup>492</sup> European Commission, (2020), Staff Working Document: Identifying Europe's recovery needs, Accompanying the document: Europe's moment: Repair and Prepare for the Next Generation, SWD(2020) 98 final.



- **Bridging the funding gap by improving access to short-term finance.** Engineering firms face funding challenges for a variety of reasons, such as supply chain dislocation, temporary factory closures due to key components from China and Asia being missing (although the situation is improving), social distancing requirements in the workplace often preventing a return to normal levels of production and operations, and difficulties due to temporary border closures, meaning key installation, servicing and maintenance staff are unable to serve cross-border customers. When combined with order cancellations and a decline in new orders, collectively, these measures require access to short-term finance to enable the engineering sector to get through the crisis. It should be stressed that some problems identified relating to cashflow are concerned with short-term temporary problems, which may be quickly addressed (e.g. supply chain dislocation is much less of a problem than in the earlier part of 2020, and many factories are also opening up as lockdowns are gradually eased). However, other problems may be longer lasting, such as demand destruction, where it is unknown if this is a temporary or longer-lasting problem.
- **Furlough schemes to subsidise salaries temporarily.** Such policy initiatives are costly but are seen as a means of getting firms through short-term demand side shocks and problems such as factory closures due to a combination of social distancing and lockdown measures alongside supply chain dislocations.
- **Loan repayment holidays for consumers and sometimes also businesses.** For example, in Belgium there is a €4.4 billion (Bruegel estimate) Business loan repayment holiday scheme: non-financial companies, SMEs, the self-employed and non-profit organisations are all eligible.
- **Deferrals of taxes and social security contributions:** as the Bruegel institute points out, several national governments have *"decided to defer certain payments, including taxes and social security contributions, which in principle should be paid back later. These measures improve the liquidity positions of individuals and companies but do not cancel their obligations. Therefore, these measures cause deterioration of the budget balance in 2020, but improve it later"*.<sup>493</sup>
- **Tax breaks for firms (especially those investing in R&D&I).** Tax is solely a national competence and various measures, such as temporary reduction in corporate taxes, are already being considered in some Member States.
- **Social dialogue is also needed to better inform national governments and the EU regarding what funding and policy measures and initiatives** could best support the engineering industries to weather the crisis.

**Selected** examples of national initiatives are provided in the following boxes. The first example from **Lithuania** concerns strengthening access to finance for firms experiencing short-term liquidity problems whilst the second from **Germany** showcases the importance of social dialogue between national governments and industry associations.

**Box 5-5 – Business Support Fund to address the liquidity of SMEs and large firms in Lithuania to address COVID-19 impacts.**

To reduce the economic impact of COVID-19, the Lithuanian government has set up a Business Support Fund, which should help ensure the liquidity of small and medium-sized enterprises (SMEs), their access to finance and their faster recovery from the crisis. All sectors can benefit not only engineering. The Fund will be operated by two newly established state-owned companies: the private limited company "Valstybinis investicinis kapitalas" (managed by the Ministry of Economy and Innovation) and the private limited company "Valstybinis investicijų valdymo agentūra" (managed by the Ministry of Finance). State funds will be invested in the capital of these companies, EUR

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<sup>493</sup> <https://www.bruegel.org/publications/datasets/covid-national-dataset/>

100 mln. and EUR 1 million respectively. Initial investments from the state have already been planned, and the aim will be to also attract funds from private investors.

The fund will only invest in companies that have experienced financial difficulties due to COVID-19 and do not have access to borrowing or financing from the market. The fund will also seek to help medium-sized and large Lithuanian companies, the closure of which would cause a chain reaction and affect the entities involved, as well as have significant social and economic consequences.

A follow-up scheme for micro enterprises was also initiated (minimum of 1 and a maximum of 9 employees) in May 2020.

**Source:** <https://www2.deloitte.com/lt/en/pages/legal/articles/covid-19-crisis--incentive-measures.html>

#### **Box 5-6 – The role of social dialogue in bringing stakeholders together to develop effective mitigation solutions.**

An example of social dialogue on the economic impacts of COVID-19 and on optimising responses to the crisis to mitigate the impacts from Germany is now presented.

In response to an economic stimulus plan from the German Federal Government, the ZVEI issued a joint press release<sup>494</sup> from VCI, VDA, VDMA and the ZVEI regarding the need for an impetus to stimulate the German economy (the most important in Europe for the engineering industries). The press release recommends the need for various priority measures to facilitate the stimulus, such as **tax relief for companies**, the imperative of **joint public-private investments**, rather than relying on the public sector alone to avoid building up too much debt, through investments to **strengthen the productive potential of the economy** and **additional incentives to innovate by expanding tax breaks for research funding**. The press release also pointed out that "companies need **sufficient liquidity to be able to cope with the direct and indirect consequences of the pandemic** and to bridge the time before the economy recovers"<sup>495</sup>.

### **5.3 Conclusions – the impact of COVID-19 on the EU engineering industries**

**Overall, COVID-19 has already a significant impact on the EU engineering industries.** Whilst supply chain dislocation globally, especially in electronics and components manufacturing is dissipating, a transition from a supply-side to a demand-side crisis can be discerned in the period February 2020 to July 2020.

**However, the situation regarding the economic impacts of COVID-19 is changing rapidly at the time of writing (July 2020), and there are some grounds for optimism.** Lockdowns have been partially lifted in most EU Member States, and national land borders have once again largely reopened, although there remain challenges regarding air travel, given ongoing quarantine restrictions.

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<sup>494</sup> Joint press release from VCI, VDA, VDMA and the ZVEI May 20, 2020 regarding the need for an impetus for stimulating the economy in Germany. <https://www.zvei.org/presse-medien/pressebereich/impulse-fuer-die-stimulierung-der-wirtschaft/>

<sup>495</sup> Joint press release from VCI, VDA, VDMA and the ZVEI May 20, 2020 regarding the need for an impetus for stimulating the economy in Germany. <https://www.zvei.org/presse-medien/pressebereich/impulse-fuer-die-stimulierung-der-wirtschaft/>

**Nonetheless, looking ahead, there remain risks of a second (and even third, fourth etc.) wave in the autumn and winter 2020-2021.** This could exacerbate the situation regarding both the demand and supply side in the engineering industries, as well as lead to renewed lockdowns and potential closures at national borders. The situation may however improve more quickly than expected if there is no second wave, at least regarding the opening of national borders, which would prevent obstacles emerging within the single market.

**The greatest risk is of a demand-side worsening of the situation and strong possibility of an economic recession.** If this materialises, there could be worsening difficulties due to short-term liquidity problems for engineering firms, with a loss of employment, turnover and tax revenues due to lower profitability in the European manufacturing sector.

**Notwithstanding, the competitive strengths of the EU engineering industries may be maintained if the integrity of the Single Market is preserved, especially regarding the free movement of products and people.** If engineering firms take steps to strengthen their supply chain resilience, for example, through greater recourse to reshoring, especially of higher-value added aspects of manufacturing, and also ensuring diversification of the supplier base.

#### **Box 5-7 – A tentative global recovery?**

An example of the beginnings of a global economic recovery can be seen, for example, in global commodity prices. These declined very significantly between February and April 2020 but have since rapidly recovered. Similarly, unemployment has risen exponentially in both Europe and the U.S., but recent figures from the U.S. for example suggest that many jobs temporarily lost are being rehired,<sup>496</sup> although unemployment levels remain very high at least for now, with EU-27 unemployment at 6.6% in April 2020<sup>497</sup> and at 13.3% in the US, although other estimates from the US put the figure at closer to 20%.<sup>498</sup> An article by S&P Global notes that although the “US regained one-tenth of the jobs eliminated in March and April. Still, 19.6 million jobs remain lost, twice as many as during the Global Financial Crisis”.<sup>499</sup>

These examples show the fast-moving nature of the economic impacts of the pandemic, whose lasting impacts on the EU engineering industries are difficult to anticipate. Macro-economic projections continue to show a major decline in GDP for 2020, yet a strong rebound in 2021. However, this is contingent on the economy avoiding a second (and possibly third, fourth etc.) wave of coronavirus cases.

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<sup>496</sup> <https://www.wsj.com/articles/may-jobs-report-coronavirus-2020-11591310177>

<sup>497</sup> [https://ec.europa.eu/eurostat/statistics-explained/index.php/Unemployment\\_statistics#](https://ec.europa.eu/eurostat/statistics-explained/index.php/Unemployment_statistics#)

<sup>498</sup> Data released from the Department of Labor’s Bureau of Labor Statistics indicated that 2.5 million jobs were added in May. However, other commentators have pointed to an under-counting of unemployment, possibly due to statistical errors. <https://www.forbes.com/sites/jackkelly/2020/06/08/theres-a-glaring-misleading-error-in-the-may-jobs-report-us-may-be-at-20-unemployment/#6f6b7fe560d3>

<sup>499</sup> <https://www.spglobal.com/ratings/en/research/articles/200204-coronavirus-impact-key-takeaways-from-our-articles-11337257>

## 6. FUTURE SCENARIO ANALYSIS AND STRATEGIC OUTLOOK

### 6.1 Future Scenarios – competitiveness of the EU engineering industries

This section provides reflections on the overall strategic outlook on the competitiveness of the EU engineering industries, taking stock of the current baseline situation and considering future competitiveness drivers and inhibitors between 2021 and 2030. Scenario modelling is provided to examine both positive and negative scenarios. A base case is then outlined as to the most likely scenario, which may include a combination of positive and negative elements.

Based on Sections 2-4 of this report, the most relevant factors potentially influencing the engineering industries' competitiveness over the next 5 to 10 years (key drivers), and posing either opportunities or threats, have been identified. These external factors or key drivers include:

- Continuing and increasing **digitalisation** and its manifold aspects;
- Shift towards **decarbonisation and the circular economy**;
- **Demographic changes** (e.g. ageing of the population);
- The **degree of ongoing access to a well-qualified workforce with digital skills**;
- Development of **international trade** regimes;
- The **degree of re-shoring** in the European manufacturing industries;
- The degree to which there is **regulatory stability or uncertainty**, and the extent to which there is new proposed EU legislation, and / or changes to existing EU legislation; and
- The economic and social impacts of the **Covid-19 pandemic**.

#### 6.1.1 Overall competitiveness dimension

Based on the various consultations conducted during this study, a set of hypotheses regarding how the above factors could impact on the performance and evolution of the EU engineering industries (positively, negatively) has been developed. The plausibility and significance of the different possible impacts has then been assessed and validated in the framework of two expert webinars held with industry stakeholders.

This resulted in a positive and a negative scenario with regard to possible impacts of the above-mentioned key drivers.

- Demand for European engineering products/services is increasing as:
  - **digitalisation** raises the need, in all areas of economy and society, for technical devices (e.g. robots) supplied by engineering companies. [high]
  - **decarbonisation** and the circular economy require extensive investments into cleantech solutions across the entire European economy. [medium]
  - some degree of **re-shoring** of general manufacturing to the EU takes place, to strengthen the resilience of supply chains, the engineering sector's local user/customer industry base in Europe will be strengthened. [medium]
  - the EU's European Recovery Plan and national programmes **help industry to overcome the economic effects of COVID-19**, and to identify new export markets and operational efficiencies through investment in digitalisation. [medium]

- The European engineering industries are becoming more efficient and more cost-competitive vis-à-vis other world regions, as increasing digitalisation of production processes in engineering will require less input of labour and lower shares of labour costs. [medium]
- The EU engineering industries are able to maintain strategic autonomy in key industrial sectors, through major investment in industrial research and innovation, and closer public private partnership working. [medium]
- The opportunities afforded to, and the competitiveness of European engineering *SMEs* are increasing, as digitalisation allows for cost-efficient production of small lot sizes and customized goods and devices. [high]
- Regulatory changes to core industrial product legislation is expected to be limited, with a continued reliance on technologically-neutral EU legislation, with new technologies being accommodated through harmonised standards, providing industry with regulatory certainty. However, new horizontal legislation on cybersecurity and AI, as well as certain environmental legislation, may be introduced. [medium]
- The EU engineering industries are able to adapt to the need for upskilling and reskilling presented by the trend towards increased digitalisation, and the need for both advanced level and low-level digital skills. [medium]

Conversely, a **negative scenario** of the impact of the key drivers is characterised as follows:

- EU engineering companies are losing access to global sales and input markets (including raw materials), as protectionism and barriers to trade are continuously growing. [high]
- The EU loses its strategic autonomy in key industrial sectors, due to an over-reliance on suppliers in third countries, and a lack of access to rare earths and raw materials needed for the development of critical technologies (e.g. 5G, AI, batteries for electric vehicles). [medium]
- The European engineering industries are losing competitiveness and market shares, as: [medium]
  - digitalisation increases the speed of innovation and change and European companies cannot keep up technologically with competitors in other regions of the world. [high]
  - the EU engineering industries are unable to compete in sectors such as electronic components and semi-conductor manufacturing, other than in specialist areas. [medium]
  - re-shoring of general manufacturing to the EU only takes place to a very limited extent, due to higher labour costs than in low-cost third countries providing the out-shoring of production. [high]
  - skills and labour shortages are increasing in Europe due to adverse demographic changes. [medium]
  - the EU's European Recovery Plan and national programmes are only partially successful in overcoming the economic effects of COVID-19, and other third country competitor countries make further progress in enhancing their competitive position during this period. [medium]
- Increasing dependency and displacement of European engineering companies by major non-EU ICT corporations, as (control over) digital data and data services increasingly become a key resource and factor of economic power. [medium]

- Engineering SMEs in Europe are losing competitiveness and market shares, as digitalisation will increase economies of scale and require very high investments and corresponding volumes of finance, which will lead to increasing market concentration and favour big players. [medium]
- Introduction of significant new environmental legislation, or amendments to existing legislation, that are overly-burdensome due to the introduction of new reporting requirements. [medium]

The remainder of this section presents detailed considerations of future scenarios for the regulatory and digitalisation dimensions, reflecting the detailed analysis presented in sections 3 and 4 of this report, respectively.

### **6.1.2 Regulatory dimension**

In a **positive scenario** seen from an industry perspective, planned regulatory changes in the next 1-2 years would either be slowed down or paused altogether. This would enable the EU engineering industries to focus on COVID-19 mitigation efforts and on accelerating digitalisation in the short-medium term.

At least for some types of EU legislation, such as product legislation, core applicable legislation is viewed by industry stakeholders as already working well, given it is underpinned by key principles, such as keeping EU legislation technology-neutral, with new technologies (and associated risks where applicable) being addressed through harmonised standards, rather than by drafting new legislation. Moreover, there was strong support for retaining the overarching legislative framework provided for through the NLF, which sets out common requirements.

As explained in Section 5.1.4.5 on the *Impacts of COVID-19 on EU legislation*, many industry associations (e.g. Orgalim, the VDMA and manufacturers of testing equipment) have called on the European Commission in position papers on the European Recovery Plan to delay some of the upcoming planned regulatory changes to EU industrial product and environmental legislation. Maintaining a reasonable degree of regulatory certainty would allow industry sufficient time to recover from the economic impacts of COVID-19. If forthcoming regulatory changes are delayed, this would enable both EU and national industry associations and their members to focus on COVID-19 mitigation strategies to ensure their survival during the economic downturn.

However, there are already a number of proposed regulatory changes to different EU industrial product directives and regulations, such as the possible activation of various delegated acts within the Radio Equipment Directive, the alignment of the 2006 Machinery Directive with the NLF, and an ongoing *Evaluation of the Electromagnetic Compatibility (EMC) Directive*, which may (or may not) lead to recommendations regarding the Directive's future evolution. Moreover, new EU environmental legislation has already been proposed prior to COVID-19, as outlined in Section 3.4.2 (Impact of planned and potential new EU environmental legislation on EU engineering industries).

Even if the legislative timetable is slowed, it is not therefore realistic for EU legislative planning processes to be paused completely, other than in the short term. Moreover, some planned EU legislative changes are already overdue, so postponing their implementation beyond 1-2 years would cause prolonged regulatory uncertainty for the EU engineering industries.

Under the positive scenario, notwithstanding the importance of EU regulatory stability, some changes are nonetheless likely to be necessary, to reflect the impact of new technologies on EU industry in areas such as AI and cybersecurity. The fast pace of change in these areas is coming under increasing regulatory scrutiny at the EU and international levels, as well as within Member States. However, if new EU legislation is considered in



these areas in future, a common view among industry associations is that a horizontal approach tackling particular issues would be more effective – and less disruptive or burdensome compliance-wise for industry if horizontal legislation were to be adopted, rather than integrating rules on Artificial Intelligence (AI) and cybersecurity in individual pieces of EU legislation, which could be a difficult process, if different pieces of individual legislation were updated and recast separately and only incrementally, leaving regulatory gaps in the interim period.

For example, delegated acts relating to strengthening the security of internet-connected products under the RED could be activated. There are three Articles that focus specifically on security, Art. 3(3)(d) preventing the equipment to misuse the networks where it operates 3(3)(e) on data protection and privacy and 3(3)(f) on protection from fraud, and IA studies have been undertaken on two of these. Whilst activating the delegated acts would strengthen product security, the regulatory requirements would only be applicable to wireless, but not wired products. This demonstrates that a complementing piece of horizontal legislation may be needed to cover possible risks and products that are currently not addressed by certain sectoral legislation.

A clear message from engineering industry stakeholders was that the NLF works effectively, and ensures strong coherence across the regulatory framework. It continues the tradition of the New Approach in ensuring that harmonised standards play a central role in detailed legal implementation.

Under a positive scenario to 2030, once legislative processes recommence following a pause to allow industry to address the immediate COVID-19 impacts, the EU legislative framework could be modernised in certain areas to ensure coherence and to contribute towards strengthening industrial competitiveness. The Machinery Directive 2006 has still not been aligned with the NLF. Without prejudice to the outcome of the impact assessment of this Directive (2019-2020), the Directive could be aligned. Outstanding questions regarding whether AI and machine learning should be covered within the essential requirements and / or other Articles in the Directive or should be addressed through state of the art updated EN standards should be resolved.

In the case of AI, it is likely that, as the majority of industrial applications of AI do not face the ethical or legal challenges that the Commission aims to tackle through horizontal legislation on AI, the EU engineering industries will not be subject to significant mandatory compliance efforts. The focus on ensuring ethical and trustworthy AI through legislation being proposed by the Commission is also mirrored in policy discussions globally; however, the EU is one of the most advanced actors in this regard and, as such, 'first-mover' advantage could stimulate the competitiveness of the European economy by ensuring it is viewed as trustworthy when considering new technologies and AI in particular.

Evidence on the demand and supply side impacts is provided in Section 5. However, there is also legislation where some EU stakeholders, such as Orgalim, have requested the Commission to take some legislative actions urgently, since this could contribute to the European economic recovery from the COVID-19 crisis. This is primarily the case for the activities related to the green and digital transition agendas and for broader horizontal legislation, such as the Regulation 1025/2012 on European Standardisation or the initiatives towards the European Data strategy, where additional guidance for industry is needed.<sup>500</sup>

Under a positive scenario, periodic reviews of the EU legislative framework – through evaluations and impact assessments – should remain a feature of the policy lifecycle.

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[https://www.ifsa.eu.com/uploads/1/2/0/2/120245019/orgalim\\_letter\\_to\\_ec\\_president\\_covid19\\_impact\\_commission\\_work\\_2020.pdf](https://www.ifsa.eu.com/uploads/1/2/0/2/120245019/orgalim_letter_to_ec_president_covid19_impact_commission_work_2020.pdf)



Regular, evidence-based reviews of the legislation enable the engineering industries – and their representative associations – to provide feedback through such studies, and through public consultation and targeted consultation processes on the legislation's effectiveness, and to flag up any administrative burdens and implementation problems.

Whilst the EU engineering industries' preference was for minimal changes to the legislative environment, there is a pragmatic recognition in the context of the EU's Green Deal and the policy on digital transformation that the industry should play its part in combatting climate change and in ensuring the sustainability of industrial production. Indeed, looking ahead to the coming decade to 2030, there are also opportunities that could stem from regulatory changes. For instance, the growth and development of the European clean-tech industry could be promoted, more energy-efficient and competitive products that are appealing to consumers and businesses could be designed and produced. This would allow Europe to remain competitive, given growing awareness about climate change and broader environmental issues among consumers.

To ensure that by 2030, EU legislation plays a positive role in enhancing industrial competitiveness, a clear preference expressed by industry associations was for careful consultation about forthcoming proposed new environmental legislation, especially the proposed EU Climate Law, which includes the Carbon Border Adjustment Mechanism. Stakeholders noted that even when existing EU legislation remains stable, changes may be made over time to reporting requirements and implementing rules that makes EU legislation more burdensome for industry than had been anticipated. Examples are the introduction of the SCIP database reporting requirements for the Waste Framework Directive. Under a positive scenario, greater attention would be given in drafting EU environmental legislation and in bolting on additional secondary legislation (e.g. through the use of delegated and implementing acts requiring extra or unexpected reporting requirements) to the administrative burdens for industry.

From an SME perspective, under a positive scenario, there would be broad regulatory stability, and EU regulators would give consideration to how a lighter reporting regime could be introduced to comply with EU legislation for SMEs. Whilst this may not be possible for product legislation without undermining the single market, it could be achieved in key areas of environmental legislation, for instance when reporting requirements are devised.

Successful implementation of the new updated EU SME policy, which builds on the Small Business Act 2008, would also contribute to a positive scenario.

Additional positive regulatory developments would include continuing with the adoption of a 'one in one out' approach to ensure that any new legislation does not burden industry without due consideration as to which pieces of legislation might be repealed,<sup>501</sup> making data more SME-friendly (e.g. automotive legislation, legislation affecting white goods and for garden machinery), and resolving the many regulatory challenges related to creating an EU data space (as set out in the Communication on Shaping Europe's digital future). In the area of data protection and privacy, the finalisation of the proposed regulatory proposal on the e-Privacy Regulation to replace the e-Privacy Directive would help to provide regulatory certainty for manufacturers, in that it would update and align the data protection and privacy principles in the GDPR to electronic communications, which impacts industry as producers of consumer IoT equipment, for instance.

Whilst the impacts of COVID-19 are mainly negative, there could also be some positive impacts in the medium-long term. For example, engineering firms are likely to review their value chains to ensure strengthened resilience in future, with diversification expected within the supply chain. This may benefit European components producers and parts

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<sup>501</sup> [https://ec.europa.eu/commission/sites/beta-political/files/working-methods-principles\\_en.pdf](https://ec.europa.eu/commission/sites/beta-political/files/working-methods-principles_en.pdf)  
See Principle 3 – One in, one out

suppliers, and could lead to some limited reshoring of manufacturing activities back to Europe. On the demand side, a likely future scenario is that this unexpected macro-economic crisis impacts the EU engineering industries overall and at the firm level, poses a considerable competitiveness and even an existential challenge. For instance, export markets may be more limited depending how long the crisis persists, meaning that intra-EU trade and more effective implementation of the Single Market in industrial products is likely to be more important than it would otherwise have been. Moreover, the pace of digitalisation in production processes and in work organisation is likely to be accelerated, which may help to offset negative economic impacts.

A **negative scenario** is one in which:

- There are many changes to the body of applicable EU legislation in the short-medium term, despite the fact the EU engineering industries are focusing on COVID-19 economic impact mitigation;
- The pace of changes to existing EU legislation, as well as new EU regulatory proposals imposes disproportionate administrative costs and burdens for industry;
- A loss of competitiveness, especially if other regulatory jurisdictions in major competitor countries adopt either a comparatively 'regulatory light-touch' approach, or at least do not impose as burdensome requirements as the EU.
- Other competitor countries globally commit to lower climate change targets on emissions, and introduce much less stringent legislation than that applicable to the EU engineering industries. Under such a scenario, there could be higher production costs, due to higher input costs (e.g. of raw materials, steel) with a risk of increased production offshoring. This could be especially burdensome and impact on the competitiveness of export-oriented engineering industries.
- Prolonged regulatory uncertainty in some areas of EU legislation, such as the question of how the EU Climate Law is going to be translated into regulatory practice, and how well-equipped industry would be to respond faced with an economic downturn due to the COVID-19 crisis.

A short example in relation to the final point about relating to the EU Climate Law is now highlighted.

Whilst the possibility of putting forward a regulatory proposal for a Carbon Border Adjustment Mechanism (CBMA) aimed at energy-intensive industries in Europe has been raised (for 2021), for industries already subject to the EU's Emissions Trading System ("ETS"), there is uncertainty as to whether this would be sufficient to offset the additional costs for European producers of having to meet more stringent EU climate standards than in other competitor countries. This could put European firms at a competitive disadvantage.

It is too early to assess the impacts as the regulatory for a CMBA proposal is expected only in 2021, although a public consultation was launched in July 2020.<sup>502</sup> It is also as yet unknown what regulatory approaches other jurisdictions will take regarding climate emissions targets and what role their national manufacturing including engineering industries will play in sharing the burden with other sectors. Not all outcomes from this regulatory development process may be negative for industry, as if Europe takes the lead, others may follow. Alternatively, a global agreement in this direction may be reached.

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<sup>502</sup> On 23 July 2020, the Commission launched public consultations on two initiatives to maximise the impact of taxation in meeting the EU's climate goals. The revision of the Energy Tax Directive (ETD) and creation of a Carbon Border Adjustment Mechanism (CBAM) were identified in the European Green Deal as a means to help with the transition towards a greener and more sustainable economy, together with the EGD investment plan.

As explained in Section 5 on the impacts of COVID-19, supply-side shocks experienced in January – May 2020, including supply dislocations in global value chains, national, regionalised and localised lockdowns mean that the EU engineering industries are likely to have had adverse impacts under the negative scenario. The **base case scenario** is that several elements from the positive scenario outlined above are likely to occur over the next decade. There is unlikely to be an appetite for significant changes to the EU regulatory framework at least for the core product legislation applicable to the EU engineering industries. Different pieces of law, such as the LVD, EMC, MD and the RED are seen as broadly working effectively already, albeit with some scope for improvements detailed earlier in the report (see Section 3.2.1 (Key findings – mapping existing EU legislation on European engineering industries)). Moreover, the tolerance threshold in terms of the ability of engineering firms to absorb too many regulatory changes will be limited by the economic impacts of the COVID-19 crisis.

Achieving **positive economic outcomes from increased digitalisation** in the EU engineering industries very much depends on shaping supportive framework conditions, including a clear regulatory framework. However, there are also many factors beyond legislation alone that will influence how engineering firms across the different branches of the engineering industries are likely to perform. Reference should be made here to the next sub-section on the digitalisation dimension.

Regarding the base case for the economic impacts of COVID-19, there is likely to be a slower economic recovery than had originally been forecast by Eurostat and the IMF in the earlier stages of the crisis, meaning that the economic rebound in 2021 and beyond may not be as strong as had been expected. The base case is that overall, the impacts will be negative, even if there are also opportunities for firms in the engineering industries to accelerate digitalisation, and to reduce over-stretched global value chains so as to strengthen their resilience in future.

Regarding the **impacts on SMEs**, under the base case scenario, SMEs will continue to be impacted by the existing and growing body of EU legislation, for example, in the environmental and digital fields. SMEs tend to be disproportionately impacted by such legislation in terms of the compliance costs compared with large firms, as they cannot spread the costs across high unit volume production, unlike large firms and multinationals. New legislation on combating climate change and on achieving carbon neutrality by 2050 will open up some opportunities for SMEs, such as for the cleantech sector, as will continued digitalisation. However, change is a double-edged sword and while there will be winners, there will also be losers. Some new legislation is likely to mainly affect large firms, which would offer some relief to SMEs in the EU engineering industries. Examples of this in the past include, among others, the Non-Financial Reporting Directive, only applicable to firms with >500 employees, the WEEE Directive, where there are lighter reporting requirements for SMEs.

### **6.1.3 Digitalisation dimension**

Regarding the digitalisation dimension of future scenarios modelling, under a positive scenario, by 2030, European engineering firms across the different branches of engineering capitalise on their relative strengths in particular market niches, most notably on the hardware part of digitalisation, B2B, and valorise their relatively strong innovation positions in high-speed networks and mobile wireless communication. Under this scenario the EU engineering industries are in a position to benefit fully from the digitalisation wave not only in the EU but beyond. The leading sectors within the EU engineering sector (NACE 26 - manufacture of computer, electronic and optical products) can provide the solutions to other parts of engineering for increasing digital applications and value added creation and as such would stimulate the catch-up with their Asian and U.S. counterparts in investing in digitalisation in advanced manufacturing facilities and more broadly across all aspects of their operations.

With respect to SMEs and the change in business models propelled by digitalisation, a positive scenario harbours a freely accessible and open source EU digital software (Asset Administration Shell) that can be used by SMEs and large companies alike to share machine and production data (digital twinning, predictive maintenance, etc.) in dedicated platforms. All parties involved do not only have the possibility to share data, irrespective as to whether they use their own proprietary ICT-solutions. They can also benefit from gaining access to a common data repository to increase the effectiveness of their operations, efficiency and value added creation.

A further characteristic of such a scenario is that, as highlighted above, there could be increased re-shoring of higher value added aspects of the manufacturing value chain, especially during the product development phase, through increased take-up of virtual and augmented reality technologies, and more widespread development of digital production hubs in Europe. These may be part of a network of global production facilities. This would strengthen the resilience of EU engineering industry supply chains in light of the COVID-19 pandemic, which were more vulnerable than had been supposed.

This would not only help to strengthen the resilience of EU engineering industry supply chains, which would help in turn to minimise and mitigate the risks of over-dependency of key components from outside Europe, it would also reinforce local value chains and ultimately contribute to the Green Deal policy objectives of increased circularity and carbon neutrality. However, such a transition would avoid recourse to protectionism, as this could damage valuable European export markets, especially of high-end, high-value and specialised machinery, a sub-sector in which Europe excels.

Under a positive scenario, firms in the EU engineering industries would continue to have access to both basic and more advanced digital skills necessary in the connected and smart factories of the future, as the implementation of digitalisation in the production process demands reskilling and upskilling

Under a **negative scenario**, however, the major competitive strengths of the EU engineering industries in digital niche markets would be gradually eroded and the EU engineering industries would gradually start to lose ground. Some EU Member States and SMEs would continue to lag behind their major competitors globally regarding the extent of investment in digitalisation generally, and for the digital transformation of production generally. The research found clear evidence that whilst there are many leading engineering firms in Europe that have invested in Factory 4.0 capabilities, these are concentrated in countries that have strong engineering hubs (e.g. Germany, Austria, Italy, France, the Czech Republic, etc.). In some other EU countries, there is already evidence of lagging behind in the necessary capital investment required for automation and robotisation both in terms of building state of the art smart factories, and in terms of investing in the necessary hardware and software. There are particular challenges for SMEs in investing in digital technologies used in production due to the capital-intensive nature of the scale of investments to upgrade existing, and to build new production facilities. More positively, the costs of automation software for use in factories, previously mainly accessible to large firms due to high costs are likely to continue to be reduced. This, cost barriers for SMEs to adopting factory automation and robotisation are likely to diminish.

Another dimension of the negative scenario is that the R&D&I in digital patents and applications is valorised elsewhere in the world with relatively little return on investment of private and public money. The EU Digital Single Market would in this negative scenario not be a substantial reality and fail to provide a solid 'home market' for the EU engineering industries. The solutions for digital B2B solutions would come mainly from elsewhere.

The **base case** is that due to the EU's major strategic policy and funding focus on supporting firms (especially SMEs) in digital transition that Europe will partially catch up with the US and Asia. For example, investments made through the European Recovery

Plan and the planned European Digitalisation Programme with a planned budget of EUR 9.2 billion, among other programmes that support the modernisation of industry should play a major role in this regard. However, given the scale of disparities with leading global competitors when looking at the EU-27 as a whole (see Section 4.5 on investments in digitalisation), it is unlikely that Europe will be able to catch up fully, as the pace of digitalisation adoption generally, and the implementation of Industry 4.0 practices by European manufacturing firms is some 10-15 percentage points ahead in the US and in many Asian countries, especially China, compared with Europe. Notwithstanding, a smaller group of leading European manufacturing countries are likely to maintain their competitiveness regarding digitalisation and the adoption and deployment of digital technologies, but there is likely to be an uneven picture in this regard across the EU as a whole.

#### **6.1.4 EU and national funding support – a future perspective**

It is worth briefly considering the role of national and EU funding support in helping to maintain and strengthen the competitiveness of the EU engineering industries. Given the challenges posed by the COVID-19 pandemic, it is arguable that the engineering industries will need to be supported more strongly in the coming decade by public sector support. Cross-references to relevant parts of the report are provided, as the funding landscape is complex, and has been rendered more so by the COVID-19 pandemic.

In the immediate term, as detailed in Section 5.2.3 (National measures to mitigate the economic impacts), financial support is urgently needed. At the national level, this includes, for instance, bridging the funding gap by improving access to short-term finance and furlough schemes to subsidise salaries temporarily. SMEs in the EU engineering industries need strengthened access to finance and funding support to help them mitigate the economic impacts of the crisis, and enable them to make investments where appropriate. Access to finance, be this through grants, loan guarantees, or through other financial instruments, including equity capital, is required for different reasons, such as to:

- a. Overcome the impact on cashflow and liquidity of COVID-19, due to supply chain dislocations, delays in firms receiving national funding under furlough schemes for their staff, and the downturn in demand (order cancellations, reduced forward order books);
- b. Support the acceleration of the digital and Green transition in engineering firms, as SMEs lag behind;
- c. Use capital investment to help upgrade production facilities to integrate digital technologies, automation and robotisation and remain efficient and competitive; and
- d. Enable engineering firms to bring new innovations to market more rapidly in order to enable the industry as a whole to mitigate the impacts of COVID-19.

The type of financing that is appropriate will vary depending on the needs of the SMEs concerned. For instance, in the early stages of the pandemic, many SMEs needed short-term liquidity support (combined with national furlough schemes to retain and fund their workforce) to remain in business. Over the medium-term, financing needs are likely to evolve towards different types of investment that will help to ensure that SMEs are sufficiently efficient to remain competitive over the medium and longer-term. In the medium-term, there are already other forms of innovation support schemes funded at national level which pre-exist the pandemic. As detailed in Section 4.9.2 (Specific challenges for SMEs), there are a number of national digitalisation programmes in countries such as Belgium, Denmark and Italy, that support firms in digitalising. Some programmes explicitly include engineering firms as a target. Given the challenges for engineering SMEs in digitalising, these represent an important form of support.

Regarding EU funding support that benefits (though may not explicitly target) the EU engineering industries, again, different forms of support likely to be important in the coming decade are worth mentioning. Again, in the short-term, in Section 5.2.2 (EU approach to mitigating the economic impacts of the COVID-19 crisis: the European Recovery Plan), the investment to be made through the Next Generation EU Programme (NGEU), as set out in the Commission Communication of May 2020 on the European Recovery Plan will help to mitigate the negative economic impacts of COVID-19 on the EU engineering industries. However, the extent to which this makes a difference does depend in turn on the final budgetary agreement between the EU, the European Council and the European Parliament.

The role of existing and new programmes to be funded through the EU budget in the 2021-2027 Multiannual Financial Framework (MFF) are worth mentioning, alongside the NGEU funding package, as often funding will be implemented in parallel. In the new MFF, the following EU programmes have been identified as being among the most relevant to the EU engineering industries:

- **Horizon Europe** – through which industrial research activities crucial to competitiveness are being supported, along with the ECSEL Joint Undertaking on semi-conductors;
- **Co-investment between the EU and Member States through public-private investments.** In addition, there is EU and national public funding support through co-investment in large-scale, strategic PPPs (e.g. the IPCEIs, the Joint Undertakings in Horizon 2020 and through the future thematic partnerships in Horizon Europe) in strategically-important sub-sectors, such as micro-electronics and batteries, which are crucial to the European economy's recovery. Such support should help to strengthen supply chain resilience and strategic autonomy in the medium to longer term.
- **Digital Europe Programme** – engineering firms could benefit from reduced risk of supply-chain dislocations to help maintain the strategic autonomy of EU industries. As detailed in Section 4.9.2, Funding for the Digital Innovation Hubs (DIHs) will be set aside in the Digital Europe Programme in the 2021-2027 period, which should promote broader uptake of digitalisation, AI and Cybersecurity among SMEs, including engineering firms. Moreover, it should allow firms to apply for funding to help them to make use of digital platforms, which could improve their operating efficiencies.
- The **Digitising European Industry initiative** has the potential to ensure more effective coordination and cooperation on industry digitalisation initiatives across Europe, which could be beneficial as there are many diverse national initiatives. The European platform of national initiatives on digitising industry has been set up to ensure greater coherence among Member States digitising industry initiatives. Through the initiative, several Public-Private Partnerships (PPPs) in key digital technologies such as 5G, big data, High Performance Computing, cybersecurity, photonics, robotics and electronic components & systems. These are all sectors where the EU engineering industries are either participating directly as manufacturers, or indirectly, as intermediate producers of components and parts used by other sectors.
- **Cohesion funding through ESIFs and the Cohesion Programme** – these are likely to remain important funding sources for projects designed to enable industry to respond flexibly to industrial change and to adapt to the new normal in the workplace (e.g. ESF funding for worker adaptation). Moreover, the important role of the EU-funded **Smart Specialisation Strategies (RIS3)** funded through ESIFs should also be highlighted (see Section 2.3.2 - SWOT analysis of the competitiveness of the EU Smart Specialisation regions in the field of engineering); and
- **COSME** - Under the EU programme for the Competitiveness of SMEs, non-financial instruments targeted at SMEs will be supported.

- **InvestEU Programme.** Through the SME Window of the InvestEU programme, financial instruments will be supported (previously such instruments were supported mainly under COSME).
- The **Strategic Investment Facility (within the InvestEU Programme)** - will provide grants and loans to finance investment and reform needs. This will mobilise investment to support the recovery and long-term growth, including a proposed new facility to promote investments in strategic European value chains.
- **European Defence Fund (EDF)** – this fund also offers important industrial research funding opportunities in which industry can participate directly. The EDF is aimed at fostering the competitiveness, efficiency and innovation capacity of the European defence technological and industrial base.

There are also a number of proposed dedicated new EU funding instruments under the NGEU that could benefit the EU engineering industries, both directly and indirectly.

- **Recovery and Resilience Facility (RRF)** – the RRF will provide large-scale financial support to reforms and investments undertaken by EU MS, with the aims of mitigating the economic and social impact of the coronavirus pandemic and of making the EU economies more sustainable, resilient and better prepared for the challenges posed by the green and digital transitions. The scheme is meant to be in the form of grants, with large repayable loans also possible.
- **SURE (European instrument for temporary Support to mitigate Unemployment Risks in an Emergency).** SURE will support EU MS that need to mobilise significant financial means to fight the negative economic and social consequences of the coronavirus outbreak on their territory. It can provide financial assistance up to EUR 100 billion in the form of loans from the EU to affected Member States to address sudden increases in public expenditure for the preservation of employment.
- **REACTEU – the Recovery Assistance for Cohesion and the Territories of Europe.** An initiative that continues and extends the crisis response and crisis repair measures delivered through the Coronavirus Response Investment Initiative and the Coronavirus Response Investment Initiative Plus. It will contribute to a green, digital and resilient recovery of the economy. The REACT-EU package includes €55 billion of additional funds that will be made available to the 2014-2020 European Regional Development Fund (ERDF) and the European Social Fund (ESF) as well as the European Fund for Aid to the Most Deprived (FEAD).
- **Just Transition Fund (JTF)** - funding will be available to all Member States, while focusing on regions with the biggest transition challenges. The proposed budget for the Just Transition Fund is to be complemented with resources from cohesion policy funds and national co financing. The Fund will be part of a Just Transition Mechanism, which also includes resources under InvestEU and a public-sector loan facility.

Evidently, the scale of challenges ahead for the European economy generally, and for the EU engineering industries in particular, means that the EU engineering industries (especially industry representative associations) need to closely follow the detailed planning and implementation of EU and national programmes to maximise their potential to strengthen competitiveness, for example, by improving access to finance for engineering SMEs, and accelerating digital transition. Recommendations regarding optimising funding to the benefit of the EU engineering industries are made in Section 7.2.1.

#### **6.1.5 Summary of results from Future Scenario Analysis**

The **positive and negative scenarios** outlined below relate to all three parts of the study, namely competitiveness, the regulatory framework and digitalisation. A summative assessment of the degree of plausibility, and the relative significance of each aspect of the



future scenario is provided in square brackets. Only impacts of at least medium relevance/plausibility are depicted here.

**Table 6-1 – Key drivers of change for the EU engineering industries to 2030 – scenario modelling (competitiveness, digitalisation and EU legislation)**

| Key driver / factor                                                       | Possible positive impacts                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Possible negative impacts                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                           | Positive scenario                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Negative scenario                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Digitalisation and the increased role of Industry 4.0 technologies</b> | <p><b>Demand for European engineering products/services is increasing</b>, as digitalisation raises the need, in all areas of economy and society, for technical devices (e.g. robots) supplied by engineering companies. [high]</p> <p><b>European engineering industries are becoming more efficient and more cost-competitive</b> vis-à-vis other world regions, as increasing digitalisation of production processes in engineering will require less input of labour and lower shares of labour costs, diminishing the cost advantages of the EU's competitors. [medium].</p> <p>Furthermore, increasing deployment of AI and other emerging technologies will drive efficiency and other benefits.</p> <p><b>SMEs: Chances and competitiveness of European engineering SMEs are increasing</b>, as digitalisation allows for cost-efficient production of small lot sizes and customized goods and devices, and new service-oriented business models. [high]</p> | <p><b>European engineering industries are losing competitiveness and market shares</b>, as digitalisation increases the speed of innovation and change and European companies cannot keep up technologically with competitors in other regions globally. Furthermore, the deployment of AI and other emerging technologies may continue to lag behind compared to competitors. [high]</p> <p><b>Increasing dependency and displacement of European engineering companies</b> by major non-EU ICT corporations, as (control over) digital data and data services increasingly become a key resource and factor of economic power. [medium]</p> <p><b>SMEs: Engineering SMEs in Europe are losing competitiveness and market shares</b>, as digitalisation will increase economies of scale and require very high investments and corresponding volumes of finance, which will lead to increasing market concentration and favour big players. [medium]</p> |
| <b>Decarbonisation, circular economy</b>                                  | <p><b>Demand for European engineering products/services is increasing</b>, as decarbonisation and circular economy require extensive investments into clean tech solutions in the entire economy. [medium]</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p><b>Costs of decarbonisation for the EU engineering industry</b> and also the risk that legislation in the EU regarding the costs of production due to carbon emissions increased beyond those in other regulatory jurisdictions. [medium]</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Demographic change</b>                                                 | <p><b>Accelerated investment of digital technologies in factories, automation, robotisation and upskilling of the workforce.</b> [medium]</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <p><b>European engineering industries are losing competitiveness and market shares</b>, as skills and labour shortages are increasing in Europe</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

| Key driver / factor                     | Possible positive impacts<br>Positive scenario                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Possible negative impacts<br>Negative scenario                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | due to demographic developments. [medium]                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>International trade</b>              | EU policy objectives are moving towards <b>encouraging EU firms to maintain strategic independence to improve supply chain resilience</b> for electronic components (whilst avoiding protectionism). For example, presently, many European firms are dependent on Asia, especially China, for crucial components and semi-conductors. Strategic non-dependency could help to reinforce the competitiveness of the EU engineering sector. [medium]                                                                                                                | <b>EU engineering companies are losing access to global sales and input markets</b> (including raw materials), as national protectionism and barriers to trade are continuously growing. [high]                                                                                                                                                                                                                                                                       |
| <b>Degree of re-shoring</b>             | <b>Demand for European engineering products/services is increasing</b> , as re-shoring of general manufacturing to the EU strengthens the engineering sector's local user/customer industry base in Europe. [medium]<br><br><b>Opportunities to strengthen competitiveness by reshoring high-value aspects of production.</b> Examples are using digital technologies such as 3D printing, AI, augmented and virtual reality to help prototype products, thereby accelerating lead times to market. [medium]                                                     | Negative scenario is that only very limited reshoring takes place with offshoring of manufacturing remaining the prevalent model, due to higher labour costs in Europe.                                                                                                                                                                                                                                                                                               |
| <b>Impacts of the Covid-19 pandemic</b> | The impacts of the pandemic have been assessed to be negative. The impact in 2021-2024 will depend on what measures are put in place to support EU engineering firms in Europe, the degree to which firms in the different sub-sectors strengthen the resilience of their supply chains, by diversifying the supply chain and avoiding over-dependence on a single or small number of suppliers for crucial components and parts (especially electronic).<br><br>In the short to medium term, the impacts are assessed as being medium to high, based on ongoing | Positives could also emerge, for instance:<br><br>Faster pace of adoption of digitalisation by EU engineering firms (e.g. in production processes and in patterns of work organisation).<br><br>EU manufacturers may decide to reshore some elements of production to Europe and to rethink strategic value chains, thereby strengthening Europe's strategic autonomy.<br><br>Some electronics-related industries have benefited from the lockdowns through increased |

| Key driver / factor                 | Possible positive impacts                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Possible negative impacts                                                                                                                                                                                                                                                                                                        |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                     | Positive scenario                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Negative scenario                                                                                                                                                                                                                                                                                                                |
|                                     | supply chain disruptions, demand-side challenges. However, over a 5-10-year time period, the impacts are expected to be between low and medium, but this depends on the speed of the economic recovery and the impacts of the EU Recovery Programme, Next Generation EU and of national stimulus programmes.                                                                                                                                                                                                                                                                                             | turnover, e.g. gaming industries, but most have suffered highly adverse effects.                                                                                                                                                                                                                                                 |
| <b>Extent of regulatory changes</b> | <p>The possible <b>introduction of new horizontal legislation on cybersecurity and AI</b> could prevent the need for ongoing revision of individual vertical pieces of legislation, especially product legislation (i.e. by having a single new legislation rather than integrating. [medium])</p> <p>This could also <b>prevent Member States from developing a patchwork of national divergent legislation</b> that could serve to undermine the single market (e.g. testing of autonomous vehicles on national roads in Europe, and civil liability for connected and autonomous driving). [high]</p> | <p>If too many pieces of new environmental legislation are introduced, or existing legislation is made overly-burdensome through the introduction of new reporting requirements, this risks damaging competitiveness, especially when considering the economic recovery stimulus that will be needed post-COVID 19. [medium]</p> |

#### 6.1.6 Conclusions – Future scenario analysis and strategic outlook

Looking forward, there is a need to focus on maximising the opportunities linked to the positive key drivers and minimising the risks linked to the negative drivers. The scenario analysis has sought to shed light on the strategic outlook and has shown that, for most of the future strategic key drivers, the likely direction of travel can already be discerned, as well as the types of impacts on the EU engineering industries, based on big picture trends, some of which are already underway (e.g. digital transition and the digitalisation of manufacturing processes, demographic change, trade wars etc.) However, as with any forward-looking analysis looking ahead over a 10-year period, there are also many uncertainties, especially in light of the COVID-19 pandemic. The general guidance derived from this analysis primarily includes the following.

In order to **foster digitalisation in the EU engineering industries**, a number of steps need to be taken to strengthen the framework conditions.

- Supporting innovation in engineering products with a clear focus on increasing digital content. Engineering products need to become digital in order to profit from increasing digitalisation in all areas of society. Strong client orientation and client cooperation in developing digital products and solutions is required. Especially SMEs are in need of support, including provision of finance, in the field of innovation to market.

- Supporting digitalisation projects in engineering companies with a clear focus on cost reduction and efficiency gains in production processes, including replacement of labour. Comprehensive standardisation and harmonisation as well as clear legislation of cybersecurity are important for actually realising efficiency gains through digitalisation.
- SMEs need strong guidance in implementing new service-oriented business models and with digital technologies to facilitate customised production. SMEs also need assistance with strategic decisions on digital solutions to avoid choosing wrong, unsustainable solutions. Showcasing and demonstrating technologies is important for SMEs.
- In order to cope with and harness the significant economies of scale inherent in digitalisation and digital applications, Europe needs large-scale strategic public-private investments (e.g. IPCEI) as well as standardisation and harmonisation, also in order to avoid world competitors imposing their solutions and services and gaining economic control and monopolies. It also requires effective market surveillance, competition rules and effective protection of intellectual property.
- Research and innovation support systems in Europe also need to become increasingly dynamic and adaptable to keep up with the growing speed of innovation and regulatory impediments to (testing) innovation should be avoided.

On the other drivers / factors, the following issues are important to consider from a policy perspective:

- **Decarbonisation and the circular economy** could work as important positive key drivers for the European engineering industries. Europe should state strong support for climate policies at an international level. Investments in clean tech could boost the competitiveness of the European engineering industries, which are already seen as having a competitive advantage over competitors in other parts of the world in this field. However, to avoid negative impacts, care should be taken to ensure that any new environmental legislation (and / or amendments to existing legislation) needs to carefully consider the impacts on industry.
- **Demographic change, ageing and the question of maintaining the skills base** pose a significant threat to European engineering industries. There is a need to invest in higher-level digital skills and in basic digital skills for the existing workforce. Moreover, Europe therefore needs significant efforts to attract young people into engineering occupations at all educational levels, starting at early education stages. Here, it is particularly important to attract more women into engineering.
- Vocational training courses, university courses and school curricula need to remain flexible and responsive to accommodating new technologies. **Courses need to be adapted to address digitalisation and digital transition related challenges for industry.** Apprenticeship type training systems are successful in meeting employer needs and should be further established and developed in Europe.
- **Continuous investment is needed in upskilling and reskilling the existing workforce.** In particular, digital and electronics skills need to be mainstreamed in all engineering industries workforces. Beyond technical skills, digitalisation also alters the nature of personal and social skills needed. This is particularly key as the employees whose jobs will likely be replaced or amended significantly by AI and other new technologies are not those who currently have the skillset to profit from new roles and job creation derived from these new technologies.
- Current trends in international trade relations, characterised by **increasing protectionism and barriers to trade**, pose another serious challenge to European engineering industries. The EU must therefore continue to push towards free and fair international trade and investment agreements. Within Europe, ensuring a **well-functioning Single Market** – in terms of standards and

legislation – is important to enable sufficiently large markets for emerging technologies in engineering and digitalisation.

Policy actions for the engineering industries in the above-mentioned fields, wherever possible, should take into account two general approaches to be more effective.

- European (mechanical) engineering companies/SMEs have competitive strengths in **niche markets**. These are often narrower and more specific, but diverse. This is important to consider, for example with a view to targeted innovation support. Also, S3 strategies, for example, need to be focused and identify strategic priorities. They must not cover everything in order to be effective.
- Policy approaches should also consider how they could **strengthen the resilience of supply chains in the EU engineering industries**. For example, as is shown in Section 5 on the impacts of COVID-19, some sectors (e.g. automotive supply chain) were adversely affected by supply chain dislocation and the non-availability of specialist electronic components. The EU engineering industries will therefore need to diversify strong upstream and downstream industries to flourish. EU and national policies could facilitate the establishment of entirely new supply chains around new/emerging technologies. Taking an example, in the space sector, EU funding was used in Horizon 2020 to help stimulate the market in specialist areas where key components and hardware were needed through a contract procurement approach.

## 7. OVERALL CONCLUSIONS AND RECOMMENDATIONS

This section sets out the study findings. It takes stock of the evolution in the European engineering industries' competitiveness in the past decade. It also provide a summary of the current and future strengths, weaknesses, opportunities and threats.

The overall conclusions are summarised in Section 7.1. The detailed conclusions from the three study parts (on competitiveness, the impacts of EU and international legislation and on digitalisation) were already outlined in sections 2, 3 and 4 respectively.

Recommendations are then outlined in Section 7.2. These are addressed to the European Commission, Member States and to industry association representing the EU engineering industries are then outlined in Section 7.2. The focus is on how the EU policy and regulatory framework might best support the EU engineering industries in maintaining and strengthening their competitiveness, especially in sub-sectors where they have a competitive advantage over major competitors (e.g. mechanical engineering and the production of machinery), and either regain ground, or at least prevent any further loss of competitiveness in other engineering sub-sectors (e.g. semi-conductors, some other electronic components) where there has been a comparative loss of competitiveness over the past decade.

### 7.1 Overall conclusions

Overall, the study has shown that the different branches of the EU engineering sectors remain crucially important to European manufacturing and to the European economy as a whole based on an assessment of different key metrics, for instance, as a share of turnover, employment, value added and extra-EU exports.

#### ***7.1.1 Competitiveness issues – analysis of strengths, weaknesses, opportunities and threats of the EU engineering industries***

In terms of market performance (real turnover, GVA) in the 2013-2018 period, while all engineering industries have experienced positive annual growth rates, the sub-industries of computer, electronic and optical products, as well as medical and dental instruments and supplies have developed most dynamically in the previous decade. However, these two industries are still relatively small in Europe and the engineering sector is still dominated by the manufacture of fabricated metal products and manufacture of machinery and equipment, together accounting for 60% of the sector's value added and employment.

Key findings from the assessment of market size and structure were that in most Asian countries, value added in the EU engineering industries grew faster than in the EU between 2013 and 2018, but in two of the major competitors – Japan and the U.S. – value added grew at about the same pace. Compared with the competitiveness studies undertaken in 2012-2013 (which covered mechanical engineering and electrical and electronic engineering and components separately), competitiveness at a sub-sector level varies considerably. A finding was that Europe has strengthened its competitiveness in mechanical engineering and in niche sub-sectors, such as semi-conductors and cyber-secure sensors for the automotive industry and medical instruments. However, the EU engineering industries have continued to lose ground to the U.S., China and certain other Asian countries in electronic components and semi-conductors more broadly . Overall, unit labour costs in the EU's engineering industries are far above those in the main competitor countries of the U.S., China, Japan and South Korea.

A comparative assessment was made between the **relative competitive strengths, weaknesses, opportunities and threats** of the EU engineering industries through a SWOT analysis and assessment of those Smart Specialisation regions that focused on different engineering sectors. The findings were that the major **strengths** include factors

related to human resources (working conditions, the availability of industry specific know-how and skills, and the quality and availability of digital skills).

Access to international markets is seen as another strength of the EU engineering industries, especially in the Northern and Western European regions. The high specialisation of many engineering companies in Europe is also viewed as a competitive strength. Innovation and R&D, including the availability of support structures, was assessed as a moderate strength, although there was less stakeholder consensus in this regard. Overall, EU engineering companies have a competitive edge over their international competitors in some areas, such as product quality, reliability and safety.

Major **weaknesses** refer to the lack of easy access to (new forms of) finance, for instance to invest in the digitalisation of production processes, especially by SMEs, the comparatively high (labour) costs of production in comparison with other major competitor countries (especially in East Asia), and the capacity to transfer innovations into marketable products and services. Furthermore, low average enterprise size and a comparatively burdensome regulatory regime at EU level, with comparatively restrictive legislation) were among the main disadvantages the EU engineering sector is facing.

#### **7.1.1.1 Challenges and threats**

The uncertainties with respect to the future **development of international trade relations** is seen as a major threat for the EU engineering industries, which are highly export-oriented and rely on open markets and sales at a global scale. Increased protectionism and trade barriers may increasingly hamper export activities in the future. There is a risk that some countries may pursue economic policies that tend to favour their own national companies over foreign competitors, at least in certain strategic industry sectors (e.g. semi-conductors, electronic components, batteries, space) relevant to the EU's new industrial strategy.

Furthermore, **shortages of skilled engineering workers** are likely to increase further in the near future. Demographic change may widen the gap between the supply of, and demand for labour at all educational levels. Apart from quantitative gaps, the speed of innovation changes skills requirements quickly and poses a challenge of constant up-skilling and re-skilling of the existing workforce, especially with a view to digital skills.

The **Covid-19 pandemic** has resulted in considerable uncertainty regarding the resilience of global supply chains, on which the EU engineering industries depend. It has also disrupted supply chains within the EU and intra-EU trade due to the temporary suspension of the Schengen area and closure of national borders. This may have a sustained impact on international demand, and is expected to adversely impact demand, for instance for machinery across many different industrial sectors. Moreover, there is expected to be an especially significant downturn in demand in the automotive and aviation sectors, to which the EU engineering industries are major suppliers within strategic value chains.

#### **7.1.1.2 The evolution in European exports**

Since 2011, exports of engineering goods have been performing distinctly better than EU exports overall, in particular since 2016. Looking specifically at extra-EU exports, there was an average annual growth for total engineering products of 5.7% in the 2013-2018 period. The (relatively small) medical instruments industry experienced the most dynamic development of exports. Computer, electronic and optical products ranked second in that period. Exports of machinery and equipment, though developing slightly below average, still account for the bulk of extra-EU engineering exports (43% share) and the EU takes an excellent position in terms of global market shares. However, while exports of computer, electronic and optical products experienced a notable growth, this is still the only product category within engineering where the EU shows a negative trade balance and achieves low market shares in comparison to its main competitors in Asia and America.



#### **7.1.1.3 Perspectives for the development of the engineering industry at European level and worldwide**

Beyond innovation and digitalisation (addressed later in the conclusions), among the opportunities for the future development of the European engineering industries include the scope for increased **collaboration** in the value chain. An example is the close ties between the automotive and metal production and processing industries in Europe. As many European engineering companies are small in scale, collaboration is becoming an increasingly important competitiveness factor in helping them to remain competitive, innovate, cope with digitalisation and to develop new business models.

The **Green Deal and the circular economy** are offering another significant perspective for engineering enterprises in Europe. Relevant topics include energy labelling, eco-design, the recycling of materials, 3D printing and the scope to prototype without needing to outsource outside Europe, and the development of green steel etc. The circular economy represents an opportunity to re-shore activities to the EU and to distinguish European players from global competitors. However, whilst industry representative stakeholders foresaw there to be some evidence of increased reshoring, this was not seen as being likely on a significant scale. However, the COVID-19 pandemic may increase the speed of reshoring.

**New business models and a greater service orientation** may bring about new opportunities for EU engineering industry firms in general and SMEs in particular. This refers to the increased scope for the customisation of products and product-related services. Customer-driven and open innovation will be key in this context.

#### **7.1.1.4 Scenarios as to where industry may be heading in future under different circumstances**

Based on the identification of key drivers (digitalisation, decarbonisation, demographic change, international trade regimes, re-shoring, and the Covid-19 pandemic) and their possible impacts on the engineering industries, two scenarios for the next 5-10 years have been developed. The **positive scenario** is characterised by increasing demand for European engineering products/services due to widespread digitalisation in society, extensive investments into clean tech solutions in the entire economy, and re-shoring of general manufacturing to the EU. It is also characterised by European engineering industries becoming cost-competitive through digitalisation of their production processes and by increasing chances of European engineering SMEs based on cost-efficient production of small lot sizes and customized goods and devices.

Conversely, the **negative scenario** is characterised by EU engineering companies losing access to global sales and input markets because of more protectionism and barriers to trade, and by European engineering industries losing competitiveness and market shares, as they cannot keep up technologically with competitors in other regions of the world and because of severe skills and labour shortages. The negative scenario also sees an increasing dependency and displacement of European engineering companies by major non-EU ICT corporations, and engineering SMEs in Europe losing competitiveness and market shares, as digitalisation leads to increasing market concentration and favours big players.

### **7.1.2 Conclusions – the impact of legislation on the EU engineering industries**

#### **7.1.2.1 How has legislation affected the EU engineering industries in the past 10 years?**

- A broad range of different types of legislation are applicable to the EU engineering industries, including core industrial product legislation (e.g. MD, LVD, EMC, RED), environmental legislation and labour market legislation.

- Evidence suggests a broad consensus that the legal framework for core industrial product legislation has remained stable. However, requirements for economic operators concerning environmental and horizontal legislation are constantly evolving in terms of key aspects of their implementation, monitoring and enforcement. This was seen as posing additional administrative burdens on industry.
- In this respect, it was observed that the objectives of environmental and horizontal legislation are primarily concerned with improving the environment and strengthening sustainability in a Circular Economy context. Although industrial competitiveness and innovation are considered, these are secondary considerations.
- However, the level of compliance costs and burdens of EU legislation collectively was viewed by many survey respondents across all stakeholder groups as being between 10% and 20% more burdensome for SMEs than large companies. Primary reasons for this include that SMEs have fewer specialist compliance staff available, have to use external testing laboratories for conformity assessment purposes, produce in comparatively lower volume and cannot therefore offset compliance costs against high unit volume.
- Evidence suggests some concerns that the costs could often outweigh the benefits of the regulatory framework, especially as other jurisdictions globally do not always face as demanding legislation. However, it is difficult to generalise, as the picture is very nuanced.
- Only limited evidence was identified of gold-plating in the field of product legislation. However, some environmental legislation, by way of adopting a minimum harmonisation approach, was found to be at greater risk of national regulatory divergence emerging, with additional costs for those engineering firms doing business cross-border.
- The fact that there are very limited differentiated requirements for economic operators between large firms and SMEs is perhaps understandable, given concerns regarding the imperative of having a level regulatory playing field. However, as stakeholders perceived EU legislation to be burdensome generally (at least environmental and horizontal legislation), with additional burdens of between 10 and 20% for SMEs compared with large firms.

#### **7.1.2.2 *Legislation: How are different types of applicable EU legislation to the EU engineering industries likely to evolve in future?***

- Looking ahead between now and 2030, there are likely to be at least some further regulatory changes that will impact the EU engineering industries. Some of these are reasonably predictable (e.g. aligning the 2006 Machinery Directive with the NLF is already foreseen), but there is also uncertainty, for instance as to whether proposed new environmental legislation will go ahead in a Green Deal context, given the economic challenges posed by COVID-19.
- Considering the rapid development of new technologies in the EU engineering industries, important questions relating to the future direction of the EU regulatory framework exist. These include whether the core product legislation applicable to the EU engineering sectors are adept enough to accommodate scientific and technological progress, or if new legislation is needed (e.g. horizontal legislation AI).
- Cybersecurity is an area that requires specific attention in relation to the engineering industries given: i) growing concerns about cybersecurity; and ii) the growing interrelationship between product safety, covered by Art. 114 of the TFEU and mentioned in individual product legislation, and the security aspects of products, which are not currently covered in primary legislation. Until the practical

implementation and impacts of the 2019 Cybersecurity Act are clear, questions will exist around the potential need for horizontal cybersecurity legislation or integration of cybersecurity separately within existing product legislation. Across industry, the majority supported the former over the latter.

- A strong preference among industry associations and individual manufacturers is to maintain the broad regulatory stability noted in the decade up to the present 2020 baseline. This could help to ensure that the EU legal framework benefits the competitiveness of the EU engineering industries by providing stability and by avoiding imposing additional administration burdens.
- The technology-neutral approach taken through the New Approach and the common requirements implemented through the New Legislative Framework are considered to be positive for the EU engineering industries.
- A strong preference was therefore expressed to continue using harmonised standards as a means of regulating new technological developments.

#### **7.1.2.3 Legislation's role as a driver and inhibitor of industrial competitiveness and innovation**

- Evidence was identified of legislation serving as a driver and inhibitor of industrial competitiveness and innovation. Therefore, the interrelationship between the impact of EU legislation on the sectoral performance of the EU engineering industries is a highly complex one. For example:
  - An analysis of the impact of the REACH Regulation on the EU engineering industries, was inconclusive as to whether the costs of compliance for producers (and intermediate users of chemicals) outweighs the benefits stemming from the promotion of innovation and competitiveness.
  - The RoHS Directive was regarded as quite burdensome by some industry players when first adopted (2002), as there was a need to eliminate certain hazardous substances from the production process and from final end products. However, as more than 40 jurisdictions globally have adopted RoHS and REACH-type regimes, this has helped to reduce compliance costs, and RoHS compliance is sometimes used in product branding, thereby strengthening the value proposition of the product and enhancing competitiveness.
- Some evidence was found that in new and emerging areas of legislation such as AI and cybersecurity in the IoT domain, if the EU decides to take regulatory action early on, this may bring some competitive advantage over the medium to long term, as other regulators globally are already examining these areas, and are also considering the introduction of horizontal legislation. Being the first major global regulatory mover carries some potential benefits.
- However, the degree of competitive advantage (or disadvantage) for the EU engineering industries from regulating these areas is difficult to predict, as firstly, the detailed regulatory proposals have not yet been developed, and secondly, it is not yet therefore known how regulatorily burdensome (or light) new legislation in emerging areas of technology, such as AI and cybersecurity are likely to be.
- Nonetheless, some industry stakeholders viewed there as being strong competitive advantage from having a clear regulatory framework in areas such as in fostering industrial applications of AI and in the use cybersecurity of industrial products, as they perceived Europe to already have some competitive advantages in this domain, such as in producing secure chips and sensors.
- The EU is already globally-leading in terms of the development of standards in some areas of cybersecurity. An example is the development of the ETSI Consumer IoT standard, which was the first such standard globally outlining key principles in respect of embedding security by design and default into product design.

### 7.1.3 Conclusions relating to digitalisation

#### Use of digitalisation in the engineering sector

- Digitalisation has had a significant impact on the EU engineering industries in recent years.
  - *Industry associations think that digital technologies have made their respective industries more competitive and more productive.* Benefits occur for instance due to integrating and embedding AI into industrial products (machine learning), improvements made in process efficiencies (reduction of errors, time savings) and improved logistics and strengthened relationships with suppliers through investments in digitalised supply chains.
  - Digital technologies into which European industries are investing the most are robotics and automation, followed by the industrial internet of things (B2B) and predictive maintenance. Technologies into which European industries invest less include ledger technologies, such as blockchain.
  - Digitalisation affects engineering as well: servicing, fading conventional industry borders, disintermediation, decentralised production systems, increased customisation, moving from proprietary to collaborative solutions.
  - Engineering sectors are more than average users of digital technologies.
  - Although the EU hosts a number of world class companies in the engineering and ICT sector, a large percentage of the production occurs in SMEs, for which digitalisation does present challenges, in terms of technology choice, investment capacity, skills development and adjusting business models.
  - Digital technologies do play an important role in reshoring activities, yet not necessarily in terms of reallocating production back into Europe but rather by setting up new means of production using robotization, AI and IoT technologies where the high capital-intensity is matched by an appropriate 'eco-system' in terms of knowledge centres, access to advanced digital skills and to finance.
- Looking ahead, it is clear that the presence and impact of digitalisation in the EU engineering industries will continue. Not only is facilitating the digital transition one of the EU's primary goals, industry associations and manufacturers have stressed the expectation that investment in digitalisation will increase significantly over the next decade.
- Although investment, and particularly private investment, has decreased significantly as a result of the COVID-19, the pandemic appears to have strengthened the EU's resolve with regard to its digital transition goals, and driven significant developments in the digitalisation of industry, most prominently regarding digital working practices.
- It is expected that the future value-added creation lies especially in software component part of the value chain.

#### Digitalisation and competitiveness

- Engineering is an essential and instrumental sector to deploy and validate digitalisation opportunities in industry and society, thereby driving competitiveness and further digitalisation across the economy.
- Considering the dynamics between digitalisation and competitiveness, there may be some *uncertainty about the ultimate effects of digital technologies* and the mechanisms through which competitiveness and company performance are positively affected, as well as the conditions for their respective members. For instance, there is a risk that companies in the EU engineering industries remain stuck in a paradox of digital transformation while their counterparts in competitor countries make progress. As

such, investment needs to be appropriately targeted and utilised, focusing on overcoming challenges related strategy development, supply chain digitalisation, skills and education and digital innovation.

- EU industry associations consider reliability and trust in final product, degree of innovation embedded in product and quality / cost ratio of manufacturing process to be the main factors giving EU firms a competitive advantage.
- Asia is considerably ahead of Europe in high-technology industries, such as semi-conductors and components production as well as in digitalisation and the adoption of specific technologies, such as the use of robotization and automation in production processes.
  - With regard to the relative global competitive position, the EU engineering industries have a relatively strong position in network equipment technologies, additive manufacturing, use of mobile data, B2B solutions, predictive maintenance, components and modules. Yet the perception is that it is losing ground on semiconductors to Asia, most notably China, and in the area of B2C solutions and services to USA.
  - Specifically focusing on digital goods in NACE 26 Manufacturing of computers, electronic and optical instruments, we found that the EU engineering sector is a niche player meaning that for particular applications it plays a world leading role, e.g. in the area of regulating and controlling instruments with almost 80% of the world trade, but for the large market segments it plays a minor role. For instance, in the case of integrated circuits, the EU engineering industries account for around 10% of world trade.

### **Digitalisation and regulation**

- In order to manage digital transformation, EU-27 industry representatives are expecting appropriate framework conditions ensuring that there is a supportive regulatory framework to facilitate the wider take up of new technologies and to accommodate new technological developments, such as AI. This especially holds for SMEs in the engineering sector.
- The assessment of the impact of regulation on the EU engineering industries found that there are a number of EU regulatory developments, such as the proposed new policy framework and possible future horizontal regulation to ensure ethical use of AI (including in industrial applications), the strengthening of cybersecurity across the body of industrial product legislation, etc. that are relevant in fostering different aspects of digitalisation.
- However, there remains a reluctance among most industry associations to regulate AI and machine learning in individual pieces of industrial product legislation, such as the Machinery Directive, with technical standards the preferred means of ensuring that new technologies are safely integrated into industrial products, such as the use of AI and machine learning technologies within machinery. The central argument is that standards are a means of adapting to new technologies and ensuring that new standards development accommodates state of the art.

## 7.2 Recommendations

### ***7.2.1 Recommendations to improve the strategic outlook for the EU engineering industries and to mitigate the impacts of COVID-19.***

#### **Recommendations to the European Commission**

- 1. The EU policy framework set out in the Commission Communication of May 2020 on the EU's Economic Recovery Plan and the Next Generation EU Programme (NGEU), as well as existing programmes through the MFF,<sup>503</sup> should be fully exploited to mitigate the negative economic impacts of COVID-19 on the EU engineering industries.**
- 2. The EU should increase EU funding support (and joint EU-Member State co-funding support) to large-scale strategic public-private investments (e.g. the IPCEIs, Joint Undertakings) in strategically important sub-sectors crucial to the European economy's recovery to strengthen supply chain resilience and strategic autonomy in the medium to longer term.**

Consideration should be given to increasing the budget for the existing IPCEIs (e.g. electronic components/ semi-conductors and batteries) which require state-of-the-art industrial research. These sub-sectors are key enablers of green growth to provide intermediate inputs to other sectors of the European economy. Moreover, these sectors help to maintain Europe's strategic autonomy in key areas where having an independent research and production capability is essential for industrial competitiveness and geopolitical reasons. For example, ensuring strategic autonomy and improved security of supply of critical raw materials and rare earths will be crucial to future advanced semiconductor production, which in turn is key to new technologies, such as 5G and AI. These technologies are driving innovation across many other European industry sectors (e.g. automotive, transportation, industrial automation in manufacturing).

- 3. Given that private sector industry is likely to experience a significant economic shock due to COVID-19, private sector resources to invest in industrial research are likely to be diminished, risking a loss of competitiveness over the next decade.**

The EU could mitigate this problem by playing a catalytic role and strengthening the emphasis on Public-Private Partnerships (PPPs) in industrial research and in industrial ecosystems in key sectors identified in the European industrial strategy and in the EU's Recovery Plan. A current problem is that, whilst some Member States take part in joint research programmes involving PPPs, many others have insufficient resources to do so. Major industry players could be approached directly to enable industry in more countries to participate in value-adding PPPs conducting industrial research.

- 4. The Commission should work together with national authorities and industry associations at the EU and national levels to help the EU engineering industries strengthen supply chain resilience.**

This could be achieved either through new proposed EU funding programmes, for instance through the Strategic European investment window of InvestEU, or could be achieved by engaging in active social dialogue with relevant engineering industry stakeholders. For instance, industry associations could be encouraged to work together with each other and with their members to rethink their supply chains as part of risk mitigation strategies. This

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<sup>503</sup> European engineering industries will tend to benefit from existing programmes, such as Horizon Europe, and new programmes relevant to them such as the Digital Europe Programme. It is not yet clear how far engineering sector firms will be direct beneficiaries of new programmes linked to NGEU, such as the Recovery and Resilience Facility (RRF).

would avoid repeats of the supply chain dislocations experienced during the pandemic. Good practices could also be shared to strengthen resilience.

5. **Despite the major challenges posed by COVID-19, the Commission should develop measures to ensure the full integrity of the Single Market regarding the free movement of goods. This could be extended to include the free movement of persons directly involved in logistics, maintenance and servicing related to those goods.**

Exceptions could be considered by the Commission to avoid blanket (temporary) national border closures, which have led to major supply chain dislocations and considerably damaged the European economy. For example, the movement of goods in key industrial sectors could be maintained, provided that industry meets certain health and safety standards, to be determined by the appropriate health and safety authorities, and can demonstrate that appropriate risk prevention measures have been taken (e.g. disinfecting lorries). Exemptions for maintenance and servicing personnel linked to the cross-border movement of goods could be considered, provided that industry meets stringent standards to avoid the spread of COVID-19.

6. **Planned EU regulatory changes affecting the EU engineering industries could be paused – or at least their pace of adoption could be slowed – to allow European industry to recover from the economic fall-out of COVID-19 and to adapt to the 'new normal'.**

Many industry associations contributing position papers to the Commission's consultations on the Recovery Plan supported pausing the regulatory timetable to allow time for the EU engineering industries to overcome the adverse supply-side and demand-side impacts of COVID-19. This should not exceed the minimum period necessary for industry to begin their recovery, for example, within 12 months. Otherwise, if delays are extended, this would lead to prolonged regulatory uncertainty for businesses.

7. **When the regulatory timetable is restarted, due consideration should be given to assessing the impacts of COVID-19 on EU manufacturers generally, and engineering manufacturing and services firms in particular.**

This applies to new legislation under development by the Commission, and / or existing regulatory proposals under scrutiny by the Council and the European Parliament, as well as Commission impact assessments, supporting Staff Working Documents, and EP responses to regulatory proposals.

8. **The Commission should request a small Rapid Evidence Assessment study to assess the impacts of COVID-19 on exporters within the EU engineering industries in 2021 (to take advantage of a full year of data).**

Exporters in the EU engineering industries, especially in mechanical engineering / machinery production where there are competitive strengths, are vital players in Europe's industrial ecosystems, and in international trading relationships. Whilst Section 5 of this study has examined the evolution in production and international trade data, a follow-up study could consider the longitudinal impacts of COVID-19 and the challenges and opportunities arising as a result.

9. **EU engineering firms should be supported in their pathways to digitalisation through relevant EU programmes (e.g. ESF or ERDF funding through the ESIFs, and the Digital Europe Programme could be used to foster digitalisation and strengthen digital skills and adaptation to changing workforce skills requirements.**

Accelerated digitalisation and take-up of new technologies should help to mitigate the impacts of COVID-19. European firms (especially SMEs) are behind counterparts in Asia



and the U.S. in adopting digital working practices and digital technologies in production processes (e.g. AI, machine learning, automation and robotisation). the Digitalisation Innovation Hubs could support training, networking and joint investments in shared digital platforms to foster take-up of digitalisation and promote the adaptation of existing business models.

**10. Access to finance for engineering firms should be enhanced that wish to invest in digitalisation and in Industry 4.0 technologies to help them cope with the economic crisis and its aftermath throughout the recovery period.**

11. There are several existing EU financial instruments schemes, ranging from the COSME Programme in 2014-2020 (access to finance for more conventional firms for example through SME guarantees) through to innovation financing through the InnovFin Programme (equity-based). Engineering industry representatives could work together with the Commission to explore whether existing funding schemes are fit for purpose from the point of view of engineering firms accessing these schemes to invest in digitalisation and the adoption of Industry 4.0 technologies (e.g. digital production processes using AI, machine learning, robotics) or whether dedicated thematic financial instruments should be considered. **The Commission should maximise the added value from existing EU-funded business and innovation support services (e.g. through the European Enterprise Network, IPR helpdesk, digital innovation hubs, EIC Accelerators, the EIT's KICs, etc.).**

These support structures could be encouraged to provide practical support to engineering firms to mitigate the economic impacts of COVID-19. Some support may be COVID-specific, such as advising exporters on which national borders are closed (within the EU, and outside), and in which countries supply chain difficulties exist.

**12. The Commission should encourage Eurofound and / or EU-OSHA to produce a study for the EU manufacturing industries – with a focus on engineering – on how to make workplace adaptations in response to COVID-19 to avoid factory lockdowns and ensure adequate risk assessments are conducted.**

This could help to communicate and disseminate good practices and save industry a considerable amount of money, if the ability to implement social distancing measures ensures factories can continue their operations rather than face prolonged closures. Moreover, the study could analyse the medium and longer-term implications on the adoption of new forms of work organisation and on virtual working. For example, a high percentage of the workforce may not wish to return to an office and factory environment, meaning there could be supply-side shortages in the labour force. There is consequently a need to invest in digital communication technologies, and in the development of digital production hubs. The EU-funded Digital Innovation Hubs (DIHs) could play a central role in this regard, as they are already focused on digital transformation.<sup>504</sup>

**13. A simple guide to the new EU funding programmes that will be supported under the NGEU and the MFF should be developed once the EU budgetary negotiations have been completed.**

The EU engineering industries need to be able to understand how they might benefit from different EU programmes, as well as which EU programmes benefit them directly, and which play a strategic role in addressing the structural challenges and economic impacts of COVID-19 on the industry. One option is for a guide to be developed, a second is to provide a clear overview and explanation of these programmes and how industry and

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<sup>504</sup> <https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs>

manufacturers could benefit on a Commission webpage and via the EU business and innovation support networks.

### **Recommendations to the EU engineering industries (and industry associations)**

- 14. The EU engineering industries – and their representative associations (e.g. Orgalim, SMEUnited) – need to engage in the European Recovery Plan and strengthen the resilience of manufacturers’ supply chains, to minimise the risks associated with over-dependence on suppliers in third countries. This is particularly true for electrical parts and electronic components.**

The focus should be on risk minimisation, and on showcasing good practices (for example, in the use of digital twins, in reshoring elements of production), rather than being rooted in economic protectionism.

- 15. Supply chain resilience should be strengthened at the sectoral and firm levels across the EU engineering industries.**

This could be achieved in a number of ways, such as:

- The **identification of alternative suppliers to diversify the supplier base**. This would help to ensure business continuity in case a second wave, or subsequent waves of the pandemic, impact supply chains. In the case of EU manufacturing firms dependent on third countries, this could involve seeking back-up suppliers and / or diversifying the supplier base to include European parts and components suppliers.
  - In the case of firms dependent on intra-EU supply chains, **over-dependence on a single supplier for crucial components in another EU Member State should be avoided**. This is due to the risk of temporary border closures.
  - Ensuring that **digital inventories are prepared, and digital twins made, for key parts and components at firm level**. This would enable EU engineering manufacturers to turn to alternative manufacturers domestically, or in other EU countries to address short-term supply problems if unexpected supply chain dislocations in Asia or other third countries reoccur. This would minimise the risk of a repeat of the dislocations that occurred during the pandemic, and reduce the potential negative economic impacts of further disruptions.
- 16. Industry associations should collect and disseminate good practices regarding different aspects of risk mitigation in a COVID-19 context (e.g. strengthening supply chain resilience, adapting the workforce to the new normal, remaining competitive during the crisis, etc.)**
- 17. Business and innovation support services in Europe – as well as cluster and Industry 4.0 organisations – could make engineering SMEs one of their key target beneficiaries.** SMEs need strong guidance in implementing new service-oriented business models and customized production. SMEs also need assistance with strategic decisions on digital solutions to avoid choosing inappropriate or unsustainable solutions. Showcasing and demonstrating technologies is a recommended method.
- 18. Member States should ensure that national funding support is sufficient to complement and share the burden of supporting national engineering industries with EU funding. There is a need to complement EU funding to address the scale of the problem.** Engineering stakeholders at EU and national level have high expectations regarding the ability of EU funding support through the NGEU and the new MFF to help mitigate the economic impacts COVID-19. However, given the unprecedented scale of the challenges,
- 19. The EU engineering industries need ongoing public funding support from the national level to facilitate their digitalisation.** Although the Digital Europe

Programme will provide a major boost, maintaining and increasing support for national and regional industry digitalisation programmes would provide complementary support to the EU's Recovery Plan. For example, additional top-up funding support could be provided to existing Industry 4.0 and manufacturing-related digitalisation programmes, especially those targeted at SMEs. Other forms of support services might include advisory support to enable firms to adapt to COVID-19 in the workplace.

20. **In order to preserve the Single Market's integrity, national borders should only be closed when absolutely necessary, and should be reopened as soon as it is safe to do so.** Whilst it is understandable that, for public health reasons, Member States may temporarily close national borders to reduce the spread of COVID-19, the impacts on the EU engineering industries of the temporary non-functioning of the Single Market (free movement of persons and goods) should be fully understood. In particular, this adversely impacts exporters, who depend on installation, services and maintenance people being able to cross-borders (e.g. mechanical engineering).
21. **Exceptions to border closures should be considered by national authorities for key industries, such as the EU engineering industries, provided they meet certain health and safety requirements (see earlier recommendation addressed to the Commission).**

#### ***7.2.2 Recommendations on industrial competitiveness and strengthening the business environment***

The previous set of recommendations covered the impacts of COVID-19 and mitigation measures, whereas in this sub-section, we address a broader set of competitiveness challenges and drivers. Notwithstanding, the pandemic will nonetheless impact the general conditions for the future industrial competitiveness of the EU engineering industries. Digitalisation-focused recommendations are summarised in Section 7.2.3, as these impact on competitiveness, but were a separate study focus.

1. **Strengthening transnational public-private sector cooperation and joint investments in industrial research, especially in key sectors vital to Europe's strategic autonomy.** Examples are semi-conductors and electronic components and batteries (and the other sectors mentioned in the European Industrial Strategy and the ERP). Such research is crucial in:
  - a. Ensuring that the private sector is still able to maintain investment in industrial R&D, by leveraging public sector R&D&I spending through joint research activities. Otherwise, there is a risk that private sector industrial R&D activities decline due to a lack of available funding linked to the crisis;
  - b. Contributing to the longer-term competitiveness of engineering-related manufacturing sectors important to the European economy (e.g. automotive, electrical equipment manufacturing);
  - c. Supporting 'state-of-the-art' research in new technologies, such as AI and 5G, on which disruptive innovations across different engineering sectors will depend. This will allow European firms to remain competitive with firms in major competitor countries;
  - d. Nurturing the growth and development of emerging sectors, such as the development of electrical vehicles (EVs), etc. The IPCEIs, the Joint Undertakings in Horizon 2020 and the future thematic European Institutionalised Partnerships in Horizon Europe are useful instruments in this regard.
2. **Policy actions for the EU engineering industries should take into account the fact that European engineering companies/SMEs are strong in niche**

**markets and require targeted approaches to support specific branches of engineering.**

For example, Europe has major competitive strengths in the manufacturing of specialist machinery and in mechanical engineering. This should be kept in mind in designing innovation support services, and in the design and implementation of regional Smart Specialisation (RIS3) strategies. These strategies need to integrate a clear focus on particular sub-sectors to be effective. The same applies to the design of support services offered by sectoral clusters and the new European Digital Innovation Hubs.

- 3. The European Commission should encourage the EU industries to maximise the value of big data from advanced production processes. This will allow industry to harness operating efficiencies, and to remain competitive with other advanced countries globally.**

The EU has already sought to put in place a policy and regulatory framework to ensure the free movement of data within the EU. However, given that production activities and manufacturing value chains are globalised, it is important that data-sharing arrangements with other regulatory jurisdictions are put in place as part of international trade agreements. The European Strategy for Data has an important role to play in this regard as it provides an overarching policy and proposed future regulatory framework.

- 4. More effective market surveillance and enforcement is required to ensure the effective implementation of Single Market legislation on industrial products, to reduce non-compliance on the European market, and to ensure a level playing field.**

The new Market Surveillance Regulation 2019, which comes into force from July 2021, could modernise the EU regulatory framework and ensure fitness for purpose for the digital age. Any steps to strengthen market surveillance will benefit the EU engineering industries by reducing the incidence of non-European producers putting non-compliant, low-quality products on the European market, thereby avoiding market distortions.

- 5. Existing EU support networks, notably the IPR helpdesk, should continue to provide support to EU engineering sector firms in protecting their Intellectual property (IP).<sup>505</sup>**

IP needs to be protected effectively outside the EU, for example considering goods such as pharmaceuticals and smartphones. These face a loss of sales as a result of counterfeiting and IPR infringements.

- 6. Europe should assume a lead role in the development of climate-friendly legislation, whilst taking care that the regulatory approach is not overly-onerous such that it might damage industrial competitiveness.**

Investments into clean tech could boost the European engineering industries, which are already seen as having competitive advantages over competitors in other parts of the world. Decarbonisation and the circular economy could work as important positive key drivers for the European engineering industries. However, industry concerns regarding potential new legislation, such as the proposed Carbon Border Adjustment Mechanism, and the potential for increased production costs should be noted. These concerns should

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<sup>505</sup> Report on the protection and enforcement of intellectual property rights in third countries, DG Trade, SWD, 2019, [https://trade.ec.europa.eu/doclib/docs/2020/january/tradoc\\_158561.pdf](https://trade.ec.europa.eu/doclib/docs/2020/january/tradoc_158561.pdf) SWD(2019) 452 final/2 and See also IPR-intensive Industries and Economic Performance in the European Union, Industry-Level Analysis Report, joint EPO/EUIPO study, 2nd edition, September 2019.

be fully reflected and investigated when the European Commission undertakes an impact assessment of the proposed new mechanism.

7. Current **difficulties in international trade relations** – in particular, the increased frequency of trade disputes between different global players – pose a challenge to the future competitiveness of the European engineering industries. The EU should continue to **push towards free and fair international trade and investment agreements**. There is a need in this regard to ensure that such agreements also maintain a level playing field in terms of regulatory protection, to avoid the engineering industries facing unfair competition from third country jurisdictions with less demanding regulatory requirements.
8. **EU policy approaches need to be based on a better understanding of how entire engineering supply chains might be supported in an integrated way (covering upstream and downstream industries), rather than in isolation.** Further research/consultation on the topic could be undertaken by the Commission.
9. **The EU could play an important role in facilitating the establishment of new supply chains centred around new/emerging technologies, and in key sectors identified as being strategically important. This could be achieved through procurement using tools such as pre-commercial procurement and procurement for innovation.**

For example, in the space sector, pre-commercial procurement was supported using Horizon 2020 funding to foster the development of new commercial markets that did not previously exist. This concept could be applied to other key sectors and industrial ecosystems identified in the European Industrial Strategy and the European Recovery Plan, as a means of strengthening strategic value chains and maintaining Europe's autonomy.

### **7.2.3 Recommendations – the digitalisation of the EU engineering industries**

Whilst digitalisation is among a number of competitiveness drivers under review, it was a central focus of this study. A number of recommendations have been developed to improve the competitiveness of the EU engineering industries through digitalisation. A distinction can be made between two broad strategies of recommendations: those aimed at deepening and those aimed at widening digitalisation. The latter is focused on getting all engineering firms on board to valorise the benefits of digitalisation and the former focuses on value added creation at a more strategic level in terms of the economy, society, environment and climate. Evidently, both dimensions are interrelated.

1. **The opportunities linked to more widespread digitalisation of the EU engineering industries should be fully exploited by engineering firms, especially relating to the transformation of business models.**

There is scope for SMEs and larger firms to offer clients more customised production using additive manufacturing technologies, accelerating the prototyping process, and a transition could also be made to a more integrated manufacturing and services-driven model, with digitalisation facilitating servitization and the development of aftercare services, such as virtual maintenance and servicing/ problem diagnostics.

2. **The European Commission, together with EU and national engineering associations, should promote the accelerated digitalisation of the EU engineering industries by promoting awareness about, and wider uptake of, new and innovative technologies.**

Digitalisation is key to maintaining industrial competitiveness, for instance in optimising operating efficiencies across different production hubs, harnessing the potential of Industry 4.0 technologies to automate production and to identify any production problems

earlier. Collectively, the benefits of digitalisation could help to mitigate the economic impacts of the COVID-19 pandemic.

3. **The European Commission should develop a guidance document targeted at engineering SMEs on the role of digitalisation in strengthening competitiveness.** For example, there are opportunities to transform existing business models, for instance by implementing new service-oriented business models, using digital technologies to facilitate more customised production and to use digital technologies to optimise production processes.
4. **The scope for reshoring some areas of production to Europe should be explored, to strengthen supply chain resilience and maintain Europe's strategic autonomy in key industrial sectors identified in the EU's industrial strategy and European Recovery Plan.**
5. **EU and national innovation support services should be provided to engineering firms to accelerate the use of digitalisation and new technologies, such as 3D printing, virtual and augmented reality to foster innovation in product design and accelerate product development lead times.**

This could help to promote reshoring to Europe of high-value added areas of production, such as new product development and prototyping. This could be cost-effective to carry out in Europe, as it is technologically-driven, but low labour-intensity.

6. **EU funding support for digitalisation (e.g. through the Digital Europe Programme) should prioritise European engineering SMEs, who lag behind their counterparts in major competitor countries as regards the degree of digitalisation and extent of use of Industry 4.0 technologies.**
7. **Supportive (regulatory) framework conditions should be ensured by the European Commission, as this is key to ensuring increasing digitalisation among EU engineering firms and achieving the associated economic benefits.**

Revisions to existing, and the development of new EU legislation over the medium-term could foster digitalisation and the competitiveness of the EU engineering industries in the medium to long-term. For example:

- If EU legislation were to be adopted to strengthen the inter-linkages between product safety and cybersecurity in internet-connected devices and equipment, Europe could harness and further develop existing competitive strengths in cybersecurity.
  - Digitalisation could be supported directly through the introduction of regulatory requirements to ensure that industrial products are designed in a way that could be conducive to carrying out virtual maintenance and servicing in a cybersecure way. Problem definition diagnostics can already be performed virtually. In future, harmonised standards could foresee more digitally-driven, IoT-connected products that add value by allowing digital services to be provided post-market placement. This would serve as a driver of product innovation by increasing the digital content and connectivity of products.
8. **EU legislation could be reviewed to integrate a stronger cybersecurity dimension and/ or, over the medium term, consideration could be given to a horizontal cybersecurity law.** Cybersecurity is important in realising efficiency gains through digitalisation, as it is an enabler of trust and efficiency through digitalisation. The digital elements of industrial products produced by the EU engineering industries need to be cybersecure. The Cybersecurity Act is presently voluntary, and, over the medium term, consideration could be given to making it mandatory through such a horizontal law.

9. **Recognising that global value chains play a crucial role in Europe's industrial competitiveness, the EU should reach international data-sharing agreements to facilitate the sharing of non-personal data between digitalised production hubs located within, and outside the EU-27.** This implies reaching such data-sharing agreements with third countries through trade deals and/ or bi-lateral agreements to enable data-sharing across production hubs for EU manufacturers with production facilities in say the EU and Asia. This could in turn optimise the potential operating efficiencies from big data analytics. As arrangements for the sharing of personal data have been put in place, such as the EU-US data shield, such an approach could be replicated in the sharing of non-personal data.
10. **Further standardisation is needed to harness the significant economies of scale inherent in digitalisation and digital applications.** Standardisation has been identified as being key to support the digitisation of European industry. For example, the EU Digitising European Industry (DEI) package foresees ICT standardisation to support the digitalisation of EU industries. This could, for example, support cost reductions and efficiency gains in production processes through digitalisation, standardisation and harmonisation.
11. **A common platform language with open source properties should be fostered within a well-defined and clear regulatory context that allows existing proprietary solutions to communicate and exchange data.** The idea of an Asset Administration Shell (AAS) where digital twins of machinery can be logged into, communicate and derive useful information from is a potential example. Although large companies can take the forefront in this, policy-making also has a role in setting appropriate regulatory conditions, promoting the open source nature of the solution so that SMEs, in particular can benefit, and fostering R&D and innovative applications (e.g. within existing H2020 programmes or even as part of the NGEU strategy).
12. **New financial instruments should be introduced for engineering SMEs who wish to invest in digitalisation, but whom may struggle to identify suitable alternative financing sources.** For instance, further thematic financial instruments could be included within the successor to the InnovFin Programme (Horizon 2020) in Horizon Europe.<sup>506</sup>
13. **R&D&I for new digitalisation applications and developments, particularly demonstration projects should be fostered using the EIB's €25 billion Pan-European Guarantee Fund.** As investment in such R&D&I is relatively high risk and accessing conventional sources of bank loan finance could be difficult, guarantees could be instrumental in providing coverage for a share of the risks and providing input additionality effects by taking the private sector on board for investments that were put on hold because of COVID-19, or where additional investment is needed to achieve a higher technology readiness level (TRL).
14. **The EU should capitalise on the Digital Innovation Hubs (DIHs) and ensure that their potential to support the accelerated digitalisation of the EU engineering industries is maximised.** Reflecting the strong political priority given to digitalisation and the digital transition by the new Commission in the 2019-2024 period, there will be major EU funding allocation to this topic. For instance, the European Digital Innovation Hubs were initially allocated €9.2 billion in the Digital Europe Programme. Although this appears to have been reduced in the MFF 2021-2027 as a result of COVID-19, it is still a primary focus of the Digital Europe Programme and the European Commission more generally. Therefore, making the link with smart specialisation regions and engineering, an effort could be made to

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<sup>506</sup> The InnovFin Programme is overseen by DG RTD and managed by the EIF and is designed to improve access to finance through the use of venture capital and guarantee schemes.



encourage enterprises (especially SMEs) in the engineering sectors to make use of the DIHs. Moreover, by 2023 at the latest, the EU intends to support a mid-term evaluation of DIHs (including consideration as to how far they have been used by different sectors, including engineering). Lessons learned could then be fed into planning the next generation of support mechanisms to foster digital innovation.

15. **An evaluation or study of national and EU-supported digitalisation programmes that benefit the engineering industries should be requested by the European Commission.** The purpose of such a study would be to identify best practices and review their impacts on digitalisation in the engineering sectors, including on SMEs, as well as the downstream impacts of digitalisation.

#### ***7.2.4 Recommendations related to education, skills development and training needs in the engineering sectors.***

The research found that the engineering industry is changing rapidly, driven by digitalisation and the increased use of new technologies in particular. New skills relevant to digitalisation will need to be mainstreamed across all the EU engineering industries at the workforce level. Digitalisation also alters the nature of necessary personal and social skills. Recommendations are that:

1. **Higher-level digital and technological skills need to be fostered among engineering graduates/ post-graduates and among engineering professionals, such as in AI and machine learning, digitalisation (automation, robotisation) and in data science, in order to strengthen big data analytics capabilities and the use of new technologies.**

Higher-level skills in the EU engineering industries will become increasingly in demand in the context of the transition to smart factories and digital production hubs. For example:

- Demand for AI and machine learning specialists is expected to be significant in the coming decade.
  - Considerably more data scientists will be needed to analyse the big data generated by digital production hubs, and the increased use of Industry 4.0-related technologies.
2. **Educational curricula in higher education systems need to be more responsive and adapt to the evolving skills and training needs of the EU engineering industries.**

Changes to skills needs are increasingly demanded by the ongoing digitalisation of EU industries, as well as the increased adoption of new technologies. Educational curricula at higher education institutions (HEI) need to be adapted to the digital age, for instance by ensuring that engineering graduates develop an understanding of the value of big data, the operating efficiencies derived from robotisation and automation and the transition to digital production hubs, etc. HEI engineering course provision needs to become more adaptable to incorporate digital technologies. More courses in new and emerging fields, such as AI, robotics and big data analysis will be needed to reflect industrial needs.

3. **Vocational education and training systems need to be adapted to address the rapidly evolving nature of skills needs in the EU engineering industries in general, and in manufacturing-oriented engineering firms in particular.**

Digitalisation and digital skills should be a major feature of engineering apprenticeship schemes. Engineering apprenticeship schemes, such as those prevalent in Germany, could be more widely developed elsewhere in Europe, and could place a significant focus on digital skills.

**4. Professional associations of engineers will need to adapt their professional development and training provision.**

Increased demand for digital skills will also have implications for professional development and training. Engineering professionals will need to reskill and upskill and develop a good understanding of how digitalisation is changing the engineering profession, how this might benefit their firm's production processes, approaches to work organisation etc.

**5. Significant investment should be made to upgrade the basic digital skills of the factory workforce to prevent unemployment arising as a result of increased digitalisation of production processes and the replacement of human labour through automation by machines and robots.**

There is an urgent need for basic digital skills training for lower-level and intermediate-level workers to strengthen digital competency. Presently, this is a neglected area in terms of vocational training for young people and workforce-based professional training provision for factory floor workers, who might otherwise face redundancy unless they upgrade their skills. This could also help to strengthen productivity by replacing repetitive manual human labour with automatisation and robotisation, whilst upskilling and shifting activities up the value chain.

**6. As continuous investment in upskilling and reskilling the existing engineering workforce is imperative, the EU should invest in helping EU engineering firms to strengthen basic and advanced digital skills.**

There is an onus on engineering firms themselves to invest in continuous skills development and training, especially in digital skills. Additionally, EU funding support through the ESF and/ or ERDF and national resources should be made available in the new MFF to support engineering firms in digital transformation processes, which imply the workforce learning new digital skills. The proposed increase in the Erasmus+ budget provides an opportunity to strengthen advanced digital skills within higher education institutions as a means of improving digitalisation know-how, competences and skills among the future generation of graduates, Masters' students and researchers. This could potentially be relevant to meeting higher-level skills needs (and some emerging shortages due to ageing demographics) in the EU engineering industries.

**7. Industrial talents need to be fostered within Europe by attracting top European and global talent to work in the EU engineering industries, including in the smart factories of the future.**

In order to tackle demographic ageing and to maintain and upskill the workforce, Europe needs to attract talent to study and base their career in the EU engineering industries. The EU needs to work together with EU and national engineering industry associations to attract more young people into the engineering professions and attract people at all educational levels, starting at early education stages. Whilst nurturing home-grown talent in the EU should be a priority, given demographic changes, there is a need to attract top foreign talent in parallel. This will require a joined-up approach between the European Commission and Member State authorities, as the working visa regime needs to allow scope for highly skilled engineers and researchers with digital skills from third countries to work in the EU.

**8. Achieving a better gender balance in the EU engineering industries should be prioritised to expand and increase the diversity of the existing talent pool.** It is important to attract more women into the EU engineering industries, starting by encouraging more women into science, technology, engineering and mathematics (STEM) subjects at university. This would help to widen the existing talent pool within Europe.

### 7.2.5 Recommendations on the EU regulatory framework

1. **To ensure strong coherence across the whole body of applicable EU product legislation, all remaining Directives not yet aligned with the common requirements in the NLF should be aligned.** This is especially relevant for the Machinery Directive 2006/42/EC, as this is one of the most important pieces of legislation in the mechanical engineering industry. Whilst an evaluation and impact assessment have been conducted, a revised regulatory proposal has not yet been tabled.
2. **The European Commission should ensure that the cumulative body of EU industrial product legislation remains stable overall to support the competitiveness of the EU engineering industries.** Industry stakeholders would appreciate greater regulatory stability, especially in light of the demand-side economic fall-out from the COVID-19 epidemic. An exception is where proposed revisions to existing legislation can demonstrate that there would be significant benefits for industry.
3. **Industrial product legislation should retain its longstanding focus on drawing up technology-neutral legislation.** Industry stakeholders expressed a strong reluctance to move away from the current principles underlying the overarching body of industrial product legislation, as defined in the “New Approach” and underpinned by the New Legislative Framework. Technology-neutral legislation needs to be supported by harmonised standards to accommodate state-of-the-art.
4. **The “Think Small First” and the “one-in, one-out” principle should be given attention in the regulatory development process to reduce the administrative burden on SMEs of proposed new EU legislation applicable to the EU engineering industries.**
5. **Consideration should be given to going beyond applying the SME Test during impact assessments and implementing a differentiated approach to setting requirements for economic operators depending on their size.** This could at least be achieved regarding reporting requirements to comply with EU law (the examples provided for the WEEE producer registration schemes are a good practice example in this regard). It would not be realistic for product legislation, as the essential requirements necessarily apply to all producers, irrespective of their size.
6. **When reviewing the fitness for purpose of existing EU legislation, and in considering new regulatory proposals, the impacts on the value chain as a whole should be considered.**

Since the NLF was adopted in 2008, further consideration has been given to the value chain, as requirements for economic operators were extended beyond manufacturers. Impact assessments should also consider how value chains will be impacted in greater detail. For instance, the GDPR IA does not appear to have considered the specific implications for industrial producers (as data controllers), and other economic operators in the value chain (in their capacity as data processors).<sup>507</sup>

7. **Impact assessments and technical studies relating to revisions of existing, or new, environmental legislation should give greater consideration to assessing the impacts on industry, including differentiating sub-sector level impacts.**

Industry stakeholders commented that Commission impact assessments required insufficient consideration of the compliance costs for industry or whether the impacts were proportionate to the benefits. The impacts on industrial competitiveness and innovation

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<sup>507</sup> Specific examples of Articles from the GDPR with implications for industry are, *inter alia*, Art. 25 data protection by design and default and Art. 24 organisational and technical measures.

should also be given greater attention, as well as a more in-depth assessment of the risks of any unintended consequences on industry.

**8. The EU should capitalise on its leading competitive position in cybersecurity and consider developing harmonised standards and minimum security requirements in this area.**

The EU should encourage the European Standards Organisations (ESOs) to develop the existing portfolio of harmonised standards and the concept of minimum baseline requirements in the cybersecurity domain. Europe has some competitive advantages in this area. If European (EN) standards become a *de facto* global standard, this could be beneficial to industrial competitiveness, as producers would use European standards if these become well-established (e.g. for electrical equipment, domestic appliances, consumer IoT).

**9. EU regulators should support the development of a risk-based approach to legislation on trustworthy AI. It should be ensured that AI applications in the engineering industries not posing any ethical risks are exempt from any requirements in a possible future legislative framework on AI.**

Many industrial AI applications do not pose the ethical challenges highlighted in the White Paper on AI (e.g. related to data protection and privacy, transparency etc.) Furthermore, the European Commission should assess the results of the piloting of the Assessment List of the Ethics Guidelines for Trustworthy AI in the context of the engineering industries. Although many AI industrial applications may not pose ethical challenges, ensuring a strong non-regulatory or voluntary system for assessing and ensuring trustworthy AI could also be beneficial to the EU engineering industries.

## ANNEX 1 – BIBLIOGRAPHY

This Annex presents the bibliography of literature reviewed for this study, by section of the analysis. This has been organised according to the three study parts. In addition, due to the COVID-19 pandemic, position papers, research reports, etc. on the views of EU and national engineering associations on the impacts of the COVID-19 pandemic and possible mitigation measures have also been added.

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## ANNEX 2 – DETAILED TABLES AND FIGURES (SUPPORTING COMPETITIVENESS ANALYSIS)

### LIST OF TOP-SELLING COMPANIES BY SECTOR

**Table 2: Top-selling companies in the EU-27+UK in the sector fabricated metal products (C 25)**

| NACE                                                                                                       | Enterprise                                                                                        | Country     | Turnover in € million |
|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-------------|-----------------------|
| 25.1 Structural metal products (e.g. metal structures and parts of structures; doors and windows of metal) | Aktien-Gesellschaft der Dillinger Hüttenwerke (Société Anonyme des Forges et Aciéries de Dilling) | Netherlands | 2.019                 |
|                                                                                                            | Aubert & Duval                                                                                    | France      | 770                   |
|                                                                                                            | voestalpine Grobblech GmbH                                                                        | Austria     | 744                   |
| 25.2 Tanks, reservoirs and containers of metal                                                             | Vaillant GmbH                                                                                     | Germany     | 2.501                 |
|                                                                                                            | Bosch Thermotechnik GmbH                                                                          | Germany     | 1.608                 |
|                                                                                                            | BOC Limited                                                                                       | Ireland     | 981                   |
| 25.3 Steam generators, except central heating hot water boilers                                            | Rolls-Royce Plc                                                                                   | UK          | 18.081                |
|                                                                                                            | RPC GROUP LIMITED                                                                                 | UK          | 4.353                 |
|                                                                                                            | Vaillant Industrial Slovakia s.r.o.                                                               | Slovakia    | 410                   |
| 25.4 Weapons and ammunition                                                                                | BAE Systems Plc                                                                                   | UK          | 19.336                |
|                                                                                                            | Defence Equipment & Support                                                                       | UK          | 2.038                 |
|                                                                                                            | MBDA France                                                                                       | France      | 1.860                 |
| 25.5 Forging, pressing, stamping and roll-forming of metal; powder metallurgy                              | OTTO FUCHS - KG -                                                                                 | Germany     | 2.811                 |
|                                                                                                            | Ntn-snr Roulements                                                                                | France      | 921                   |
|                                                                                                            | SKF France                                                                                        | France      | 840                   |
| 25.6 Treatment and coating of metals; machining                                                            | ArcelorMittal Commercial Germany GmbH                                                             | Germany     | 1.901                 |
|                                                                                                            | Rolls-Royce Power Engineering Plc                                                                 | UK          | 604                   |
|                                                                                                            | Eaton Limited                                                                                     | UK          | 458                   |
| 25.7 Cutlery, tools and general hardware                                                                   | Julius Blum GmbH                                                                                  | Austria     | 1.580                 |
|                                                                                                            | Häfele GmbH & Co KG                                                                               | Germany     | 1.396                 |
|                                                                                                            | Viega Holding GmbH & Co. KG                                                                       | Germany     | 1.318                 |
| 25.9 Other                                                                                                 | RADIUS PAYMENT SOLUTIONS LIMITED                                                                  | UK          | 2.873                 |
|                                                                                                            | MICRON EUROPE LIMITED                                                                             | UK          | 2.375                 |
|                                                                                                            | Muhr und Bender KG                                                                                | Germany     | 2.176                 |

Source: Bisnode – Dun& Bradstreet, 2020; latest available turnover, Top 3 of each group

**Table 3: Top-selling companies in the EU-27+UK in the computer, electronic and optical sector (C 26)**

| NACE                                                                                      | Enterprise                                                                   | Country        | Turnover in € million |
|-------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|----------------|-----------------------|
| 26.1 Electronic components and boards                                                     | Infineon Technologies AG                                                     | Netherlands    | 8.029                 |
|                                                                                           | Canon Europa NV                                                              | UK             | 7.125                 |
|                                                                                           | TTI, INC.                                                                    | UK             | 4.721                 |
| 26.2 Computers and peripheral equipment                                                   | Microsoft Ireland Operations Limited                                         | Ireland        | 24.648                |
|                                                                                           | Oracle Emea Limited                                                          | Ireland        | 8.273                 |
|                                                                                           | Nokia solutions and networks Oy                                              | Finland        | 8.071                 |
| 26.3 Communication equipment                                                              | Proximus                                                                     | Belgium        | 4.108                 |
|                                                                                           | Leonardo Mw Ltd                                                              | UK             | 2.367                 |
|                                                                                           | Samsung Electronics Magyar Zártkörűen Működő Részvénytársaság                | Hungary        | 2.105                 |
| 26.4 Consumer electronics                                                                 | Samsung Electronics (UK) Limited                                             | UK             | 3.696                 |
|                                                                                           | Flextronics International Termelő és Szolgáltató Vámszabadterületi Korlátolt | Hungary        | 2.691                 |
|                                                                                           | LG Electronics Mława Sp Z O O                                                | Poland         | 2.102                 |
| 26.5 Instruments and appliances for measuring, testing and navigation; watches and clocks | Continental Automotive Czech Republic s.r.o.                                 | Czech Republic | 2.877                 |
|                                                                                           | Rohde & Schwarz GmbH & Co. KG                                                | Germany        | 2.038                 |
|                                                                                           | Daikin Europe N.V.                                                           | Belgium        | 1.920                 |
| 26.6. Irradiation, electromedical and electrotherapeutic equipment                        | Fresenius SE & Co. KGaA                                                      | Germany        | 35.409                |
|                                                                                           | Ge Medical Systems                                                           | France         | 1.549                 |
|                                                                                           | Otto Bock Healthcare Products GmbH                                           | Austria        | 1.038                 |
| 26.7 Optical instruments and photographic equipment                                       | Siemens AG                                                                   | Germany        | 86.849                |
|                                                                                           | Carl Zeiss AG                                                                | Germany        | 6.428                 |
|                                                                                           | Johnson & Johnson vision care (Ireland)                                      | Ireland        | 1.079                 |
| 26.8. Magnetic and optical media.                                                         | Arcadia Digital SA                                                           | Greece         | 19                    |
|                                                                                           | Infinera Limited                                                             | UK             | 19                    |
|                                                                                           | XDISC S A                                                                    | Poland         | 8                     |

Source: Bisnode – Dun&Bradstreet, 2020; latest available turnover, Top 3 of each group

**Table 4: Top-selling companies in the EU-27+UK in the sector electrical equipment (C 27)**

| NACE                                                                                              | Enterprise                                          | Country     | Turnover in € million |
|---------------------------------------------------------------------------------------------------|-----------------------------------------------------|-------------|-----------------------|
| 27.1 Electric motors, generators, transformers and electricity distribution and control apparatus | Bussmann International Inc. U.S.A. Filial I Danmark | Denmark     | 19.567                |
|                                                                                                   | BRITISH GAS TRADING LIMITED                         | UK          | 10.077                |
|                                                                                                   | Vestas Manufacturing A/s                            | Denmark     | 5.030                 |
| 27.2 Batteries and accumulators                                                                   | Clarios Iberia P&D Sl.                              | Spain       | 580                   |
|                                                                                                   | LG Chem Wroclaw Energy Sp Z O                       | Poland      | 482                   |
|                                                                                                   | Exide Technologies Slu                              | Spain       | 480                   |
| 27.3 Wiring and wiring devices                                                                    | LEONI AG                                            | Germany     | 4.846                 |
|                                                                                                   | Prysmian Cables & Systems Limited                   | UK          | 588                   |
|                                                                                                   | Aptiv Services Austria GPD. GmbH & Co KG            | Austria     | 81                    |
| 27.4 Electric lighting equipment                                                                  | LEDVANCE GmbH                                       | UK          | 1.753                 |
|                                                                                                   | Signify Poland Sp Z O O                             | Poland      | 1.603                 |
|                                                                                                   | Signify Netherlands B.V.                            | Netherlands | 680                   |
| 27.5 Domestic appliances                                                                          | BSH Hausgeräte GmbH                                 | Germany     | 11.389                |
|                                                                                                   | LIEBHERR-HAUSGERÄTE LIENZ GMBH                      | Austria     | 10.551                |
|                                                                                                   | Dyson James Group Limited                           | UK          | 5.059                 |
| 27.9 Manufacture of other electrical equipment                                                    | Analog devices International Unlimited company      | Ireland     | 3.610                 |
|                                                                                                   | Mitsubishi Electric Europe B.v.                     | UK          | 3.448                 |
|                                                                                                   | Tew Holdings (2012) Limited                         | UK          | 2                     |

Source: Bisnode – Dun& Bradstreet, 2020; latest available turnover, Top 3 of each group



**Table 5: Top-selling companies in the EU-27+UK in the sector machinery and equipment (C 28)**

| NACE                                                                                                                                                                                                                       | Enterprise                     | Country     | Turnover in € million |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|-------------|-----------------------|
| 28.1 General purpose machinery (engines and turbines, except aircraft, vehicle and cycle engines; fluid power equipment; pumps and compressors; taps and valves; bearings, gears, gearing and driving elements)            | ZF Friedrichshafen AG          | Netherlands | 36.518                |
|                                                                                                                                                                                                                            | Wärtsilä Oyj Abp               | Finland     | 5.170                 |
|                                                                                                                                                                                                                            | Rolls-Royce Power Systems AG   | Germany     | 3.785                 |
| 28.2 Other general-purpose machinery (ovens, furnaces and furnace burners; lifting and handling equipment; office machinery and equipment; power-driven hand tools; non-domestic cooling and ventilation equipment; other) | thyssenkrupp Elevator AG       | Germany     | 7.960                 |
|                                                                                                                                                                                                                            | Knorr-Bremse AG                | Germany     | 6.937                 |
|                                                                                                                                                                                                                            | Danfoss A/S                    | Denmark     | 6.268                 |
| 28.3 Agricultural and forestry machinery                                                                                                                                                                                   | KONE Oyj                       | Finland     | 9.982                 |
|                                                                                                                                                                                                                            | John Deere GmbH & Co. KG       | Germany     | 6.032                 |
|                                                                                                                                                                                                                            | Claas KG auf Aktien mbH        | Germany     | 3.898                 |
| 28.4 Metal forming machinery and machine tools                                                                                                                                                                             | Dürr AG                        | Germany     | 3.922                 |
|                                                                                                                                                                                                                            | TRUMPF GmbH + Co. KG           | Germany     | 3.784                 |
|                                                                                                                                                                                                                            | Heidelberger Druckmaschinen AG | Germany     | 2.490                 |
| 28.9 Other special-purpose machinery (e.g. for metallurgy; for mining, quarrying and construction)                                                                                                                         | LIEBHERR-WERK TELFS GMBH       | Austria     | 10.551                |
|                                                                                                                                                                                                                            | Vodafone Limited               | UK          | 6.347                 |
|                                                                                                                                                                                                                            | J.C.B. SERVICE                 | UK          | 4.735                 |

Source: Bisnode – Dun&Bradstreet, 2020; latest available turnover, Top 3 of each group

**Table 6: Top-selling companies in the EU-27+UK in the medical and dental instruments sector (C 32.5)**

| NACE | Enterprise                             | Country     | Turnover in € million |
|------|----------------------------------------|-------------|-----------------------|
| 32.5 | Siemens Healthineers AG                | Netherlands | 14.518                |
| 32.5 | B. Braun Melsungen AG                  | Germany     | 7.471                 |
| 32.5 | Abbvie Ireland Unlimited company       | Ireland     | 4.889                 |
| 32.5 | Shire Pharmaceuticals Ireland Limited  | Ireland     | 1.842                 |
| 32.5 | Philips Medical Systems Nederland B.V. | Netherlands | 1.342                 |

Source: Bisnode – Dun& Bradstreet, 2020; latest available turnover, Top 3 of each group

**Table 7: Top-selling companies in the EU-27+UK in the repair and installation of machinery and equipment sector (C 33)**

| NACE                                                                                                                                                                                                                                                                    | Enterprise                          | Country     | Turnover in € million |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-------------|-----------------------|
| 33.1 Repair of fabricated metal products, machinery and equipment (of fabricated metal products; of machinery, electronic and optical equipment; of electrical equipment; ships and boats; of aircraft and spacecraft; of other transport equipment; of other equipment | Tupi B.V.                           | Netherlands | 1.872                 |
|                                                                                                                                                                                                                                                                         | Navantia Sa Sme.                    | Spain       | 1.109                 |
|                                                                                                                                                                                                                                                                         | Damen Shipyards Gorinchem B.V.      | Netherlands | 1.058                 |
| 33.2 Installation of industrial machinery and equipment                                                                                                                                                                                                                 | GE AIRCRAFT ENGINE SERVICES LIMITED | UK          | 2.556                 |
|                                                                                                                                                                                                                                                                         | Deutsche Telekom Außendienst GmbH   | Germany     | 2.000                 |
|                                                                                                                                                                                                                                                                         | MINMETALS (U.K) LIMITED             | UK          | 726                   |

Source: Bisnode – Dun& Bradstreet, 2020; latest available turnover, Top 3 of each group

## PRODUCTION

**Table 8: Development<sup>1</sup> of production in the engineering industries and manufacturing in the EU-27 (excl. UK), January – July, change 2018/19 and 2019/20**

|                           | Engineering industries |                                                           |                                           |                      |                                |                                             |                                                    | Manufacturing total |
|---------------------------|------------------------|-----------------------------------------------------------|-------------------------------------------|----------------------|--------------------------------|---------------------------------------------|----------------------------------------------------|---------------------|
|                           | Total                  | Fabricated metal products, except machinery and equipment | Computer, electronic and optical products | Electrical equipment | Machinery and equipment n.e.c. | Medical and dental instruments and supplies | Repair and installation of machinery and equipment |                     |
| Percentage change 2018/19 |                        |                                                           |                                           |                      |                                |                                             |                                                    |                     |
| Jan                       | -0.2                   | -0.6                                                      | -8.3                                      | -0.7                 | 1.7                            | 4.6                                         | 6.5                                                | -0.4                |
| Feb                       | 1.0                    | 0.6                                                       | -4.2                                      | -0.9                 | 2.3                            | 6.3                                         | 5.7                                                | 1.4                 |
| Mar                       | 2.3                    | 1.4                                                       | 9.8                                       | 0.2                  | 1.4                            | 5.9                                         | 3.4                                                | 1.1                 |
| Apr                       | 0.7                    | 0.0                                                       | 2.9                                       | -1.1                 | 0.0                            | 4.5                                         | 3.8                                                | 0.3                 |
| May                       | -1.1                   | -1.1                                                      | -8.5                                      | -1.3                 | -0.5                           | 4.0                                         | 5.0                                                | -0.3                |
| Jun                       | -2.1                   | -2.0                                                      | -6.3                                      | -4.4                 | -1.6                           | -0.4                                        | 3.9                                                | -2.0                |
| Jul                       | -0.8                   | -1.3                                                      | 0.5                                       | -2.3                 | -2.2                           | 6.7                                         | 4.0                                                | -0.7                |
| Percentage change 2019/20 |                        |                                                           |                                           |                      |                                |                                             |                                                    |                     |
| Jan                       | -1.2                   | -2.8                                                      | -0.4                                      | -0.4                 | -2.6                           | 1.3                                         | 3.4                                                | -1.0                |
| Feb                       | -2.0                   | -2.4                                                      | -5.7                                      | 1.9                  | -3.7                           | 1.1                                         | 2.1                                                | -1.4                |
| Mar                       | -14.9                  | -18.1                                                     | -3.2                                      | -12.7                | -18.7                          | -10.2                                       | -11.3                                              | -13.0               |
| Apr                       | -28.1                  | -35.8                                                     | -8.8                                      | -25.9                | -32.5                          | -19.5                                       | -25.5                                              | -29.5               |
| May                       | -19.7                  | -24.5                                                     | -11.5                                     | -15.1                | -20.5                          | -18.6                                       | -20.7                                              | -21.4               |
| Jun                       | -12.2                  | -15.9                                                     | -2.0                                      | -10.2                | -13.2                          | -9.0                                        | -13.4                                              | -11.8               |
| Jul                       | -9.0                   | -12.9                                                     | 5.8                                       | -7.3                 | -12.6                          | -5.2                                        | -9.0                                               | -7.7                |

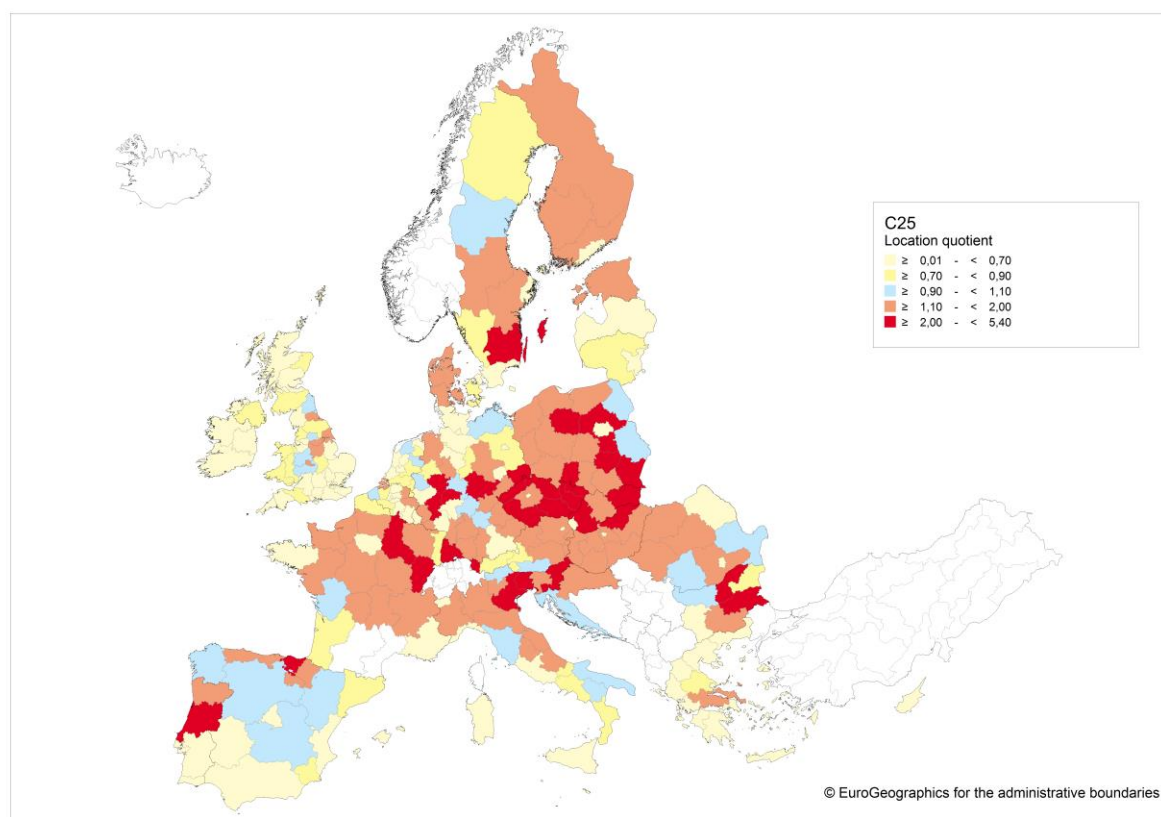
<sup>1</sup> Development is in 2015 prices, calendar adjusted data: Volume index of production (Short-term business statistics for industry)

Source: Eurostat, Short-term business statistics for industry; own calculations; September 2020

## INDUSTRIAL SPECIALISATION IN SUBSECTORS OF THE ENGINEERING INDUSTRIES

In the sector **manufacture of fabricated metal products** (C25), in particular in Germany, Poland and the Czech Republic there are a number of regions with a high LQ > 2. Furthermore, some regions in France and Northern Italy, Bulgaria and Slovakia are specialised in metal product manufacturing. The highest LQ of 5.4 is observed in the French region Franche-Comté (components suppliers for the automotive industry), followed by Vorarlberg (Austria, 3.7), Strední Morava (Czech Republic, 3.6), Vzhodna Slovenija (Slovenia, 3.1) and Arnsberg (Germany, 3.0).

**Figure 8: Industrial specialisation<sup>1</sup> in manufacture of fabricated metal products (C25) in the EU by NUTS 2 regions, 2017<sup>2</sup>**



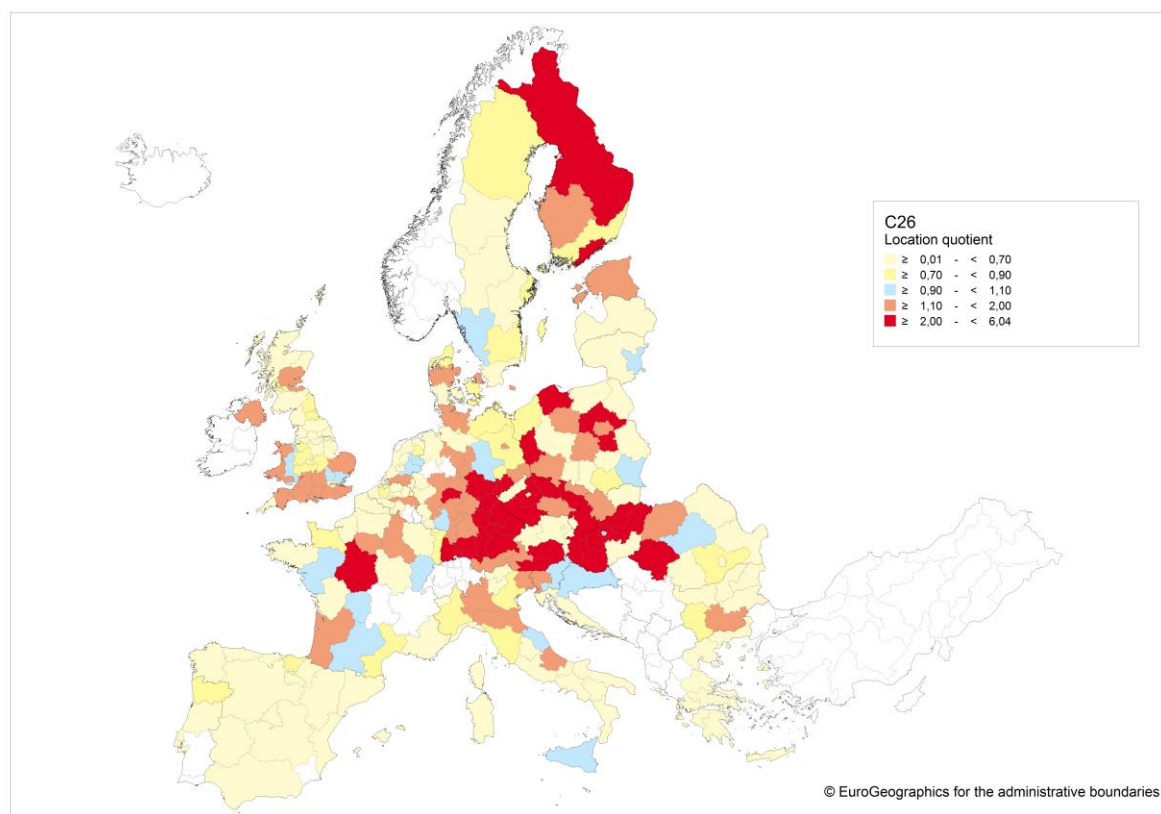
<sup>1</sup> Industrial specialisation: the location quotient measures a region's industrial specialisation relative to the EU (incl. UK) as a whole. Values below 1 (0-0.7; 0.7-0.9) show an underrepresentation of the industry's employment in the region as compared to the EU, values around 1 (0.9-1.1) show an equal specialisation and values above 1 show a spatial concentration of the industry's employment in the region compared to the EU. Values above 2 show a specialisation of the region in the industry.

<sup>2</sup> latest available year

Source: Regional Structural Business Statistics; SBS data by NUTS 2 regions and NACE Rev. 2 [sbs\_r\_nuts06\_r2]; Status: August 2020

In the sector **manufacture of computer, electronic and optical products (C26)**, especially in Germany, Hungary, Czech Republic and Poland there are numerous regions that are highly specialised in this field, as well as regions in Austria (Steiermark, Kärnten), Finland (Pohjois- ja Itä-Suomi, Helsinki-Uusimaa), France (Centre - Val de Loire), Romania (Vest) and Slovakia (Západné Slovensko). The highest LQ of 6.0 has the Hungarian region Észak-Magyarország, followed by Chemnitz (Germany, 5.5), Vest (Romania, 4.4), Közép-Dunántúl (Hungary, 4.2) and the Czech region Severovýchod (4.1).

**Figure 9: Industrial specialisation<sup>1</sup> in manufacture of computer, electronic and optical products (C26) in the EU by NUTS 2 regions, 2017<sup>2</sup>**



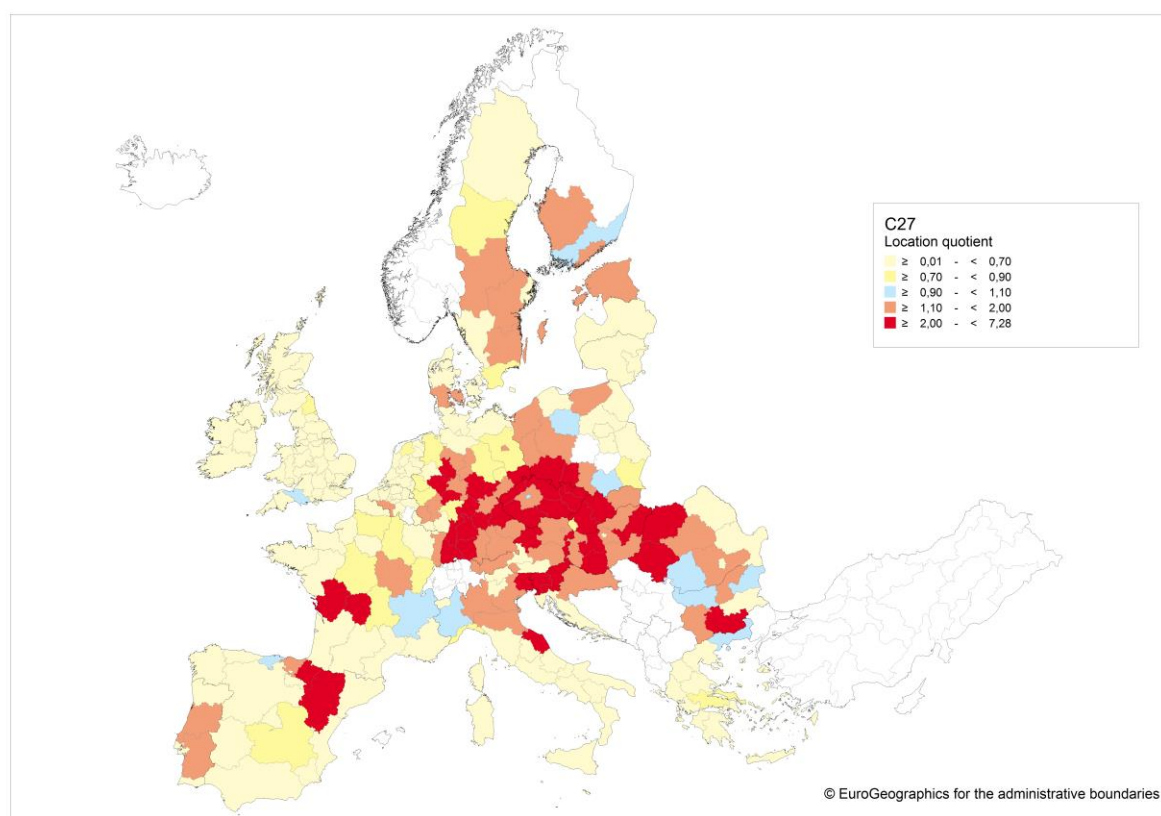
<sup>1</sup> Industrial specialisation: the location quotient measures a region's industrial specialisation relative to the EU (incl. UK) as a whole. Values below 1 (0-0.7; 0.7-0.9) show an underrepresentation of the industry's employment in the region as compared to the EU, values around 1 (0.9-1.1) show an equal specialisation and values above 1 show a spatial concentration of the industry's employment in the region compared to the EU. Values above 2 show a specialisation of the region in the industry.

<sup>2</sup> latest available year

Source: Regional Structural Business Statistics; SBS data by NUTS 2 regions and NACE Rev. 2 [sbs\_r\_nuts06\_r2]; Status: August 2020

In the sector **manufacture of electrical equipment** (C27), the regions specialised in this economic activity are distributed over more countries than in the previous sectors. Again, in particular in Germany and the Czech Republic, there are numerous regions specialised in electrical equipment. In other countries, such as France, Slovakia, Slovenia, Hungary, Poland, Italy, Spain, Bulgaria, Austria and Romania, there are also regions that concentrate on this sector. Oberpfalz in Germany is mostly specialised in electrical equipment with an LQ of nearly 7.3. A region with a longstanding tradition, it is active in environmental, automotive and communication technology as well as in the field of sensors, consumer and industrial electronics. Very high LQ are also observed in Limousin (France, 6.7), Mittelfranken (Deutschland, 5.1), Střední Morava (Czech Republic, 4.7) as well as Detmold (Germany) and Západoé Slovensko (Slovakia) with an LQ of 4.2 each.

**Figure 10: Industrial specialisation<sup>1</sup> in manufacture of electrical equipment (C27) in the EU by NUTS 2 regions, 2017<sup>2</sup>**



<sup>1</sup> Industrial specialisation: the location quotient measures a region's industrial specialisation relative to the EU (incl. UK) as a whole. Values below 1 (0-0.7; 0.7-0.9) show an underrepresentation of the industry's employment in the region as compared to the EU, values around 1 (0.9-1.1) show an equal specialisation and values above 1 show a spatial concentration of the industry's employment in the region compared to the EU. Values above 2 show a specialisation of the region in the industry.

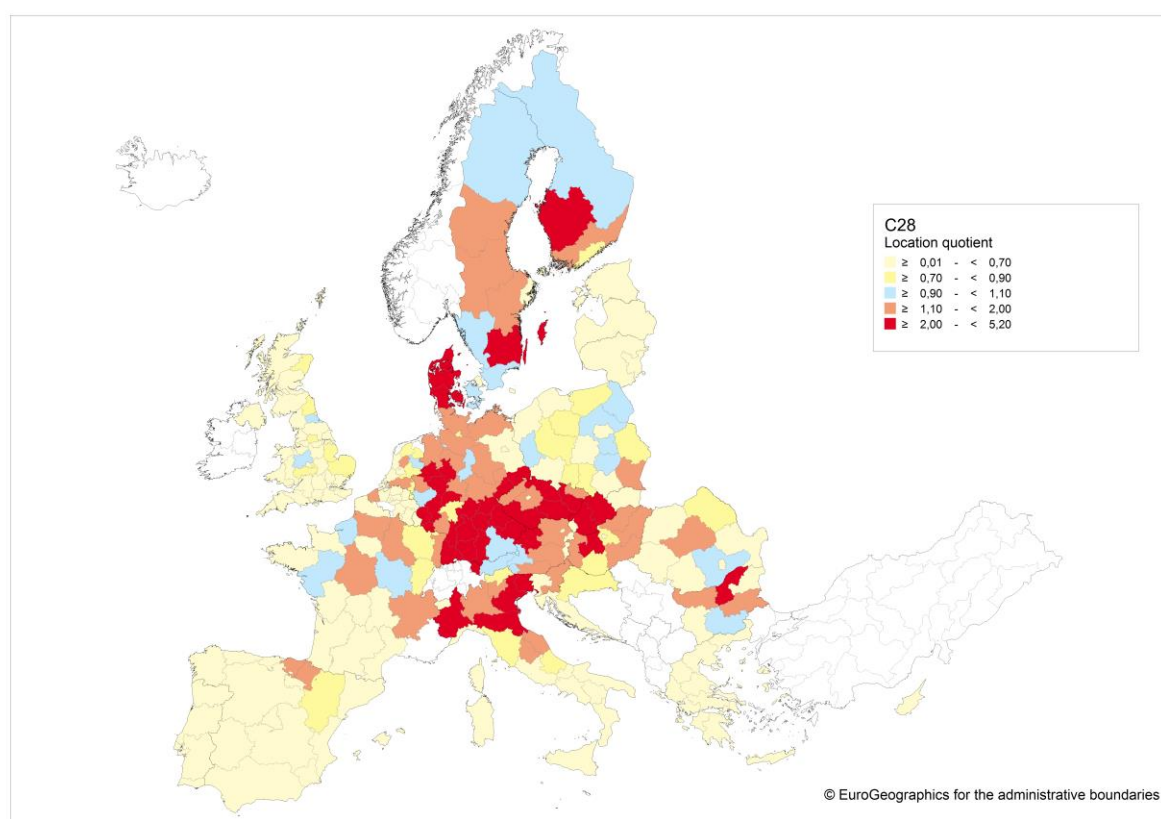
<sup>2</sup> latest available year

Source: Regional Structural Business Statistics; SBS data by NUTS 2 regions and NACE Rev. 2 [sbs\_r\_nuts06\_r2]; Status: August 2020

The **manufacture of machinery and equipment** (C28) is characterised by a great presence of German regions in terms of regional specialisation. Out of the 10 regions with the highest LQ (2.9 to 5.2) in the production of machinery and equipment throughout the EU-28, nine regions are German while one region is Italian (Emilia-Romagna, 3.5). Particularly the regions in the Southern/Western part of Germany are highly specialised in this sector, i.e. Tübingen (5.2), Stuttgart (4.3), Unterfranken (4.1), Oberfranken (3.8), Schwaben (3.6), Freiburg (3.5), Koblenz (3.2), Oberpfalz and Saarland (2.9 each). These regions – located mostly in Baden-Württemberg and Bayern – are among the most competitive regions in Europe.

Besides Germany and Italy, also some regions in Finland (Länsi-Suomi), Denmark (Midtjylland, Syddanmark, Nordjylland), Sweden (Småland med öarna), Austria (Oberösterreich, Vorarlberg), Slovakia (Stredné Slovensko, Západné Slovensko), Czech Republic, Bulgaria (Severen tsentralen) and Hungary (Közép-Dunántúl) have an LQ above 2.

**Figure 11: Industrial specialisation<sup>1</sup> in manufacture of machinery and equipment (C28) in the EU by NUTS 2 regions, 2017<sup>2</sup>**



<sup>1</sup> Industrial specialisation: the location quotient measures a region's industrial specialisation relative to the EU (incl. UK) as a whole. Values below 1 (0-0.7; 0.7-0.9) show an underrepresentation of the industry's employment in the region as compared to the EU, values around 1 (0.9-1.1) show an equal specialisation and values above 1 show a spatial concentration of the industry's employment in the region compared to the EU. Values above 2 show a specialisation of the region in the industry.

<sup>2</sup> latest available year

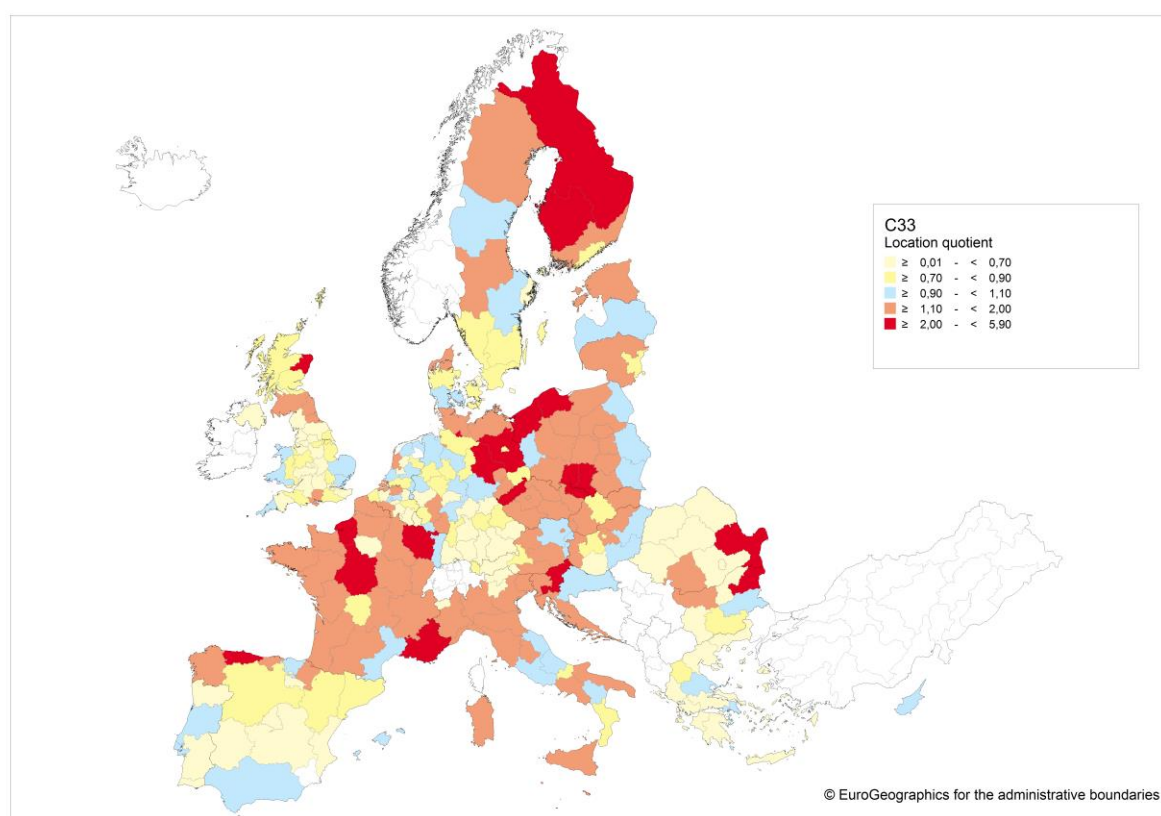
Source: Regional Structural Business Statistics; SBS data by NUTS 2 regions and NACE Rev. 2 [sbs\_r\_nuts06\_r2]; Status: August 2020



The sector **repair and installation of machinery and equipment** (C33) shows a different regional specialisation throughout the EU regions (incl. UK) as compared to the other engineering sectors. The Western part of Germany does not display a high regional concentration, while in Poland, France, Czech Republic, Romania, Bulgaria, Slovenia, Eastern Germany, North Eastern Scotland, Northern Spain (Principado de Asturias) and Finland in some regions the concentration is high (LQ > 2).

Regions with a high specialisation in repair and installation of machinery and equipment include Pomorskie (Poland, 3.4), Haute-Normandie (France, 3.0), Severozápad (Czech Republic, 2.8), Sud-Est (Romania, 2.7) and Severoiztochen (Bulgaria, 2.5).

**Figure 12: Industrial specialisation<sup>1</sup> in repair and installation of machinery and equipment (C33) in the EU by NUTS 2 regions, 2017<sup>2</sup>**



<sup>1</sup> Industrial specialisation: the location quotient measures a region's industrial specialisation relative to the EU (incl. UK) as a whole. Values below 1 (0-0.7; 0.7-0.9) show an underrepresentation of the industry's employment in the region as compared to the EU, values around 1 (0.9-1.1) show an equal specialisation and values above 1 show a spatial concentration of the industry's employment in the region compared to the EU. Values above 2 show a specialisation of the region in the industry.

<sup>2</sup> latest available year

Source: Regional Structural Business Statistics; SBS data by NUTS 2 regions and NACE Rev. 2 [sbs\_r\_nuts06\_r2]; Status: August 2020

## INTERNATIONAL TRADE

**Table 9: AUSTRIA's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| <b>AT</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| BE                                    | 6.1                                    | 1.6                                     | 0.8                                                      | 1.5                                           | 2.0                                              | 8.3                                                         | 653                            | 1.8                |
| BG                                    | 0.3                                    | 0.5                                     | 1.2                                                      | 0.6                                           | 0.7                                              | 0.4                                                         | 276                            | 0.7                |
| CY                                    | 0.0                                    | 0.0                                     | 0.2                                                      | 0.1                                           | 0.0                                              | 0.0                                                         | 31                             | 0.1                |
| CZ                                    | 5.6                                    | 4.7                                     | 2.1                                                      | 6.6                                           | 4.5                                              | 6.6                                                         | 1,650                          | 4.5                |
| DE                                    | 37.5                                   | 46.3                                    | 26.5                                                     | 42.2                                          | 44.6                                             | 41.0                                                        | 14,796                         | 40.1               |
| DK                                    | 3.1                                    | 0.8                                     | 0.4                                                      | 1.0                                           | 1.1                                              | 1.1                                                         | 321                            | 0.9                |
| EE                                    | 0.3                                    | 0.2                                     | 0.2                                                      | 0.2                                           | 0.2                                              | 0.2                                                         | 77                             | 0.2                |
| ES                                    | 2.6                                    | 2.0                                     | 1.4                                                      | 2.5                                           | 2.7                                              | 2.8                                                         | 833                            | 2.3                |
| FI                                    | 2.5                                    | 0.7                                     | 0.3                                                      | 0.9                                           | 1.2                                              | 0.7                                                         | 313                            | 0.8                |
| FR                                    | 4.5                                    | 5.8                                     | 3.1                                                      | 5.2                                           | 9.5                                              | 5.1                                                         | 2,339                          | 6.3                |
| GB                                    | 6.4                                    | 3.6                                     | 2.4                                                      | 3.9                                           | 4.5                                              | 5.3                                                         | 1,393                          | 3.8                |
| GR                                    | 0.2                                    | 0.3                                     | 0.3                                                      | 0.5                                           | 0.4                                              | 0.6                                                         | 157                            | 0.4                |
| HR                                    | 0.5                                    | 1.0                                     | 0.8                                                      | 1.3                                           | 0.8                                              | 0.8                                                         | 340                            | 0.9                |
| HU                                    | 2.3                                    | 4.1                                     | 3.4                                                      | 7.2                                           | 3.6                                              | 6.8                                                         | 1,647                          | 4.5                |
| IE                                    | 0.1                                    | 0.3                                     | 0.4                                                      | 0.2                                           | 0.4                                              | 2.3                                                         | 148                            | 0.4                |
| IT                                    | 10.4                                   | 6.8                                     | 3.7                                                      | 5.6                                           | 6.2                                              | 4.4                                                         | 2,061                          | 5.6                |
| LT                                    | 0.3                                    | 0.3                                     | 0.1                                                      | 0.2                                           | 0.4                                              | 0.2                                                         | 95                             | 0.3                |
| LU                                    | 0.1                                    | 0.3                                     | 0.2                                                      | 0.2                                           | 0.2                                              | 0.0                                                         | 81                             | 0.2                |
| LV                                    | 0.1                                    | 0.2                                     | 0.2                                                      | 0.2                                           | 0.2                                              | 0.1                                                         | 71                             | 0.2                |
| MT                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 20                             | 0.1                |
| NL                                    | 6.4                                    | 1.9                                     | 2.1                                                      | 2.5                                           | 2.9                                              | 4.2                                                         | 921                            | 2.5                |
| PL                                    | 1.4                                    | 8.4                                     | 4.1                                                      | 4.4                                           | 5.0                                              | 3.4                                                         | 1,921                          | 5.2                |
| PT                                    | 0.2                                    | 0.3                                     | 0.4                                                      | 0.3                                           | 0.6                                              | 0.5                                                         | 156                            | 0.4                |
| RO                                    | 3.1                                    | 2.2                                     | 2.5                                                      | 3.9                                           | 1.9                                              | 1.7                                                         | 920                            | 2.5                |
| SE                                    | 2.3                                    | 2.3                                     | 1.1                                                      | 2.1                                           | 2.4                                              | 1.4                                                         | 732                            | 2.0                |
| SI                                    | 2.6                                    | 2.1                                     | 0.7                                                      | 1.6                                           | 1.6                                              | 0.7                                                         | 542                            | 1.5                |
| SK                                    | 1.1                                    | 3.4                                     | 41.2                                                     | 4.9                                           | 2.3                                              | 1.4                                                         | 4,363                          | 11.8               |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>194</b>                             | <b>6,520</b>                            | <b>8,376</b>                                             | <b>7,732</b>                                  | <b>13,094</b>                                    | <b>1,010</b>                                                | <b>36,926</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 10: BELGIUM's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|-------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                             | %                  |
| AT                                    | 0.8                                    | 1.1                                     | 1.7                                                      | 1.5                                           | 2.4                                              | 2.3                                                         | 825                           | 1.9                |
| <b>BE</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                             | -                  |
| BG                                    | 0.1                                    | 0.2                                     | 0.4                                                      | 0.5                                           | 0.9                                              | 0.2                                                         | 237                           | 0.6                |
| CY                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.1                                              | 0.1                                                         | 36                            | 0.1                |
| CZ                                    | 1.8                                    | 1.4                                     | 2.4                                                      | 1.4                                           | 1.9                                              | 1.2                                                         | 755                           | 1.8                |
| DE                                    | 20.4                                   | 19.7                                    | 22.4                                                     | 20.3                                          | 18.7                                             | 18.1                                                        | 8,444                         | 19.8               |
| DK                                    | 1.4                                    | 1.3                                     | 1.4                                                      | 1.5                                           | 2.3                                              | 1.8                                                         | 766                           | 1.8                |
| EE                                    | 0.5                                    | 0.1                                     | 0.3                                                      | 0.2                                           | 0.3                                              | 0.2                                                         | 100                           | 0.2                |
| ES                                    | 3.1                                    | 3.4                                     | 4.6                                                      | 4.3                                           | 4.8                                              | 9.0                                                         | 2,160                         | 5.1                |
| FI                                    | 1.8                                    | 0.6                                     | 0.9                                                      | 0.8                                           | 1.3                                              | 1.2                                                         | 447                           | 1.0                |
| FR                                    | 26.1                                   | 25.2                                    | 14.5                                                     | 24.8                                          | 21.7                                             | 17.3                                                        | 8,703                         | 20.4               |
| GB                                    | 5.6                                    | 7.3                                     | 9.8                                                      | 8.7                                           | 8.8                                              | 13.4                                                        | 4,026                         | 9.4                |
| GR                                    | 0.4                                    | 0.4                                     | 0.5                                                      | 0.4                                           | 0.7                                              | 1.2                                                         | 277                           | 0.6                |
| HR                                    | 0.1                                    | 0.3                                     | 0.1                                                      | 0.2                                           | 0.3                                              | 0.4                                                         | 113                           | 0.3                |
| HU                                    | 0.6                                    | 1.0                                     | 1.5                                                      | 1.5                                           | 1.7                                              | 0.5                                                         | 589                           | 1.4                |
| IE                                    | 0.9                                    | 0.6                                     | 0.7                                                      | 0.6                                           | 0.6                                              | 1.1                                                         | 297                           | 0.7                |
| IT                                    | 5.3                                    | 4.9                                     | 6.3                                                      | 5.6                                           | 8.5                                              | 12.2                                                        | 3,260                         | 7.6                |
| LT                                    | 0.5                                    | 0.2                                     | 0.3                                                      | 0.3                                           | 0.4                                              | 0.4                                                         | 152                           | 0.4                |
| LU                                    | 2.9                                    | 2.8                                     | 2.2                                                      | 1.6                                           | 1.3                                              | 0.6                                                         | 702                           | 1.6                |
| LV                                    | 0.2                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.4                                              | 0.2                                                         | 107                           | 0.3                |
| MT                                    | 0.1                                    | 0.0                                     | 0.1                                                      | 0.1                                           | 0.0                                              | 0.0                                                         | 22                            | 0.1                |
| NL                                    | 15.1                                   | 20.4                                    | 21.9                                                     | 15.7                                          | 12.0                                             | 8.8                                                         | 6,530                         | 15.3               |
| PL                                    | 6.3                                    | 3.5                                     | 2.6                                                      | 3.4                                           | 4.5                                              | 3.2                                                         | 1,555                         | 3.6                |
| PT                                    | 1.0                                    | 1.1                                     | 0.7                                                      | 1.2                                           | 1.0                                              | 0.8                                                         | 403                           | 0.9                |
| RO                                    | 0.6                                    | 0.8                                     | 1.0                                                      | 1.5                                           | 1.1                                              | 0.5                                                         | 432                           | 1.0                |
| SE                                    | 3.7                                    | 2.3                                     | 2.8                                                      | 2.2                                           | 3.3                                              | 4.3                                                         | 1,305                         | 3.1                |
| SI                                    | 0.1                                    | 0.4                                     | 0.2                                                      | 0.3                                           | 0.4                                              | 0.6                                                         | 163                           | 0.4                |
| SK                                    | 0.5                                    | 0.5                                     | 0.6                                                      | 1.0                                           | 0.6                                              | 0.3                                                         | 261                           | 0.6                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>171.2</b>                           | <b>5,273.1</b>                          | <b>9,329.7</b>                                           | <b>5,760.0</b>                                | <b>16,361.8</b>                                  | <b>5,773.9</b>                                              | <b>42,670</b>                 | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 11: BULGARIA's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 1.0                                    | 3.4                                     | 11.4                                                     | 1.4                                           | 7.1                                              | 0.5                                                         | 265                            | 5.2                |
| BE                                    | 0.4                                    | 4.1                                     | 2.0                                                      | 1.9                                           | 1.6                                              | 1.1                                                         | 103                            | 2.0                |
| <b>BG</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| CY                                    | 0.0                                    | 0.2                                     | 0.6                                                      | 0.2                                           | 0.2                                              | 0.7                                                         | 15                             | 0.3                |
| CZ                                    | 0.1                                    | 4.1                                     | 3.2                                                      | 10.7                                          | 1.3                                              | 4.6                                                         | 282                            | 5.5                |
| DE                                    | 19.8                                   | 26.7                                    | 31.6                                                     | 31.2                                          | 24.8                                             | 13.3                                                        | 1,448                          | 28.5               |
| DK                                    | 0.3                                    | 0.4                                     | 0.4                                                      | 0.9                                           | 1.1                                              | 0.6                                                         | 43                             | 0.8                |
| EE                                    | -                                      | 0.1                                     | 0.5                                                      | 0.3                                           | 0.2                                              | 0.2                                                         | 14                             | 0.3                |
| ES                                    | 13.5                                   | 1.9                                     | 4.3                                                      | 6.0                                           | 0.8                                              | 9.4                                                         | 189                            | 3.7                |
| FI                                    | 1.7                                    | 0.8                                     | 0.1                                                      | 0.7                                           | 0.5                                              | 0.2                                                         | 28                             | 0.6                |
| FR                                    | 0.3                                    | 8.2                                     | 4.1                                                      | 8.5                                           | 7.8                                              | 9.3                                                         | 378                            | 7.4                |
| GB                                    | 0.0                                    | 3.1                                     | 5.0                                                      | 3.2                                           | 1.7                                              | 5.8                                                         | 156                            | 3.1                |
| GR                                    | 12.2                                   | 6.8                                     | 4.9                                                      | 3.0                                           | 4.2                                              | 23.1                                                        | 225                            | 4.4                |
| HR                                    | 2.1                                    | 0.7                                     | 1.2                                                      | 0.7                                           | 0.2                                              | 0.3                                                         | 32                             | 0.6                |
| HU                                    | 1.3                                    | 3.6                                     | 4.3                                                      | 3.3                                           | 2.7                                              | 1.2                                                         | 169                            | 3.3                |
| IE                                    | 0.8                                    | 0.6                                     | 0.2                                                      | 0.2                                           | 0.3                                              | 0.1                                                         | 14                             | 0.3                |
| IT                                    | 21.6                                   | 14.1                                    | 8.1                                                      | 9.7                                           | 9.9                                              | 5.7                                                         | 505                            | 9.9                |
| LT                                    | 2.1                                    | 0.3                                     | 0.3                                                      | 0.4                                           | 0.2                                              | 0.3                                                         | 15                             | 0.3                |
| LU                                    | -                                      | 0.2                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 3                              | 0.0                |
| LV                                    | -                                      | 0.1                                     | 0.4                                                      | 0.3                                           | 0.1                                              | 0.3                                                         | 12                             | 0.2                |
| MT                                    | 0.0                                    | 0.0                                     | 0.1                                                      | 0.1                                           | 0.1                                              | -                                                           | 5                              | 0.1                |
| NL                                    | 0.0                                    | 2.5                                     | 2.9                                                      | 2.3                                           | 1.5                                              | 2.2                                                         | 111                            | 2.2                |
| PL                                    | 15.7                                   | 3.9                                     | 3.9                                                      | 2.8                                           | 3.2                                              | 7.8                                                         | 173                            | 3.4                |
| PT                                    | -                                      | 0.2                                     | 0.4                                                      | 1.2                                           | 0.1                                              | 2.1                                                         | 31                             | 0.6                |
| RO                                    | 6.7                                    | 11.2                                    | 6.6                                                      | 3.4                                           | 23.2                                             | 9.3                                                         | 571                            | 11.2               |
| SE                                    | 0.1                                    | 1.4                                     | 1.6                                                      | 2.2                                           | 2.9                                              | 0.5                                                         | 112                            | 2.2                |
| SI                                    | -                                      | 0.5                                     | 0.3                                                      | 0.9                                           | 1.2                                              | 0.3                                                         | 44                             | 0.9                |
| SK                                    | 0.1                                    | 0.7                                     | 1.1                                                      | 4.3                                           | 2.9                                              | 1.2                                                         | 145                            | 2.9                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>25</b>                              | <b>514</b>                              | <b>912</b>                                               | <b>1,941</b>                                  | <b>1,627</b>                                     | <b>70</b>                                                   | <b>5,088</b>                   | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 12: CYPRUS's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | -                                      | -                                       | 2.4                                                      | 5.2                                           | 0.1                                              | 0.0                                                         | 3                              | 2.4                |
| BE                                    | -                                      | -                                       | 0.3                                                      | 0.2                                           | 0.9                                              | 0.1                                                         | 0                              | 0.3                |
| BG                                    | -                                      | 7.1                                     | 5.2                                                      | 0.5                                           | 1.9                                              | 0.0                                                         | 3                              | 2.7                |
| <b>CY</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| CZ                                    | -                                      | 1.6                                     | 0.7                                                      | 0.4                                           | 0.1                                              | 0.0                                                         | 0                              | 0.4                |
| DE                                    | -                                      | 0.1                                     | 16.3                                                     | 1.8                                           | 20.9                                             | 2.1                                                         | 12                             | 10.6               |
| DK                                    | -                                      | -                                       | 1.1                                                      | 0.4                                           | 0.6                                              | -                                                           | 1                              | 0.6                |
| EE                                    | -                                      | -                                       | 5.2                                                      | 0.0                                           | 0.0                                              | -                                                           | 2                              | 2.1                |
| ES                                    | -                                      | 1.2                                     | 0.5                                                      | 2.1                                           | 1.2                                              | 0.0                                                         | 1                              | 1.0                |
| FI                                    | -                                      | 3.0                                     | 0.1                                                      | 0.1                                           | 1.1                                              | -                                                           | 0                              | 0.3                |
| FR                                    | -                                      | 5.7                                     | 18.1                                                     | 6.4                                           | 0.2                                              | 0.2                                                         | 11                             | 9.1                |
| GB                                    | -                                      | 24.9                                    | 4.8                                                      | 8.1                                           | 8.5                                              | 6.6                                                         | 8                              | 7.1                |
| GR                                    | 100.0                                  | 41.5                                    | 26.5                                                     | 67.7                                          | 43.3                                             | 84.6                                                        | 57                             | 49.0               |
| HR                                    | -                                      | 0.0                                     | 0.5                                                      | 1.1                                           | 0.5                                              | -                                                           | 1                              | 0.6                |
| HU                                    | -                                      | 0.4                                     | 0.6                                                      | 0.4                                           | 1.2                                              | 0.3                                                         | 1                              | 0.6                |
| IE                                    | -                                      | 2.0                                     | 0.9                                                      | 0.1                                           | 0.0                                              | -                                                           | 0                              | 0.4                |
| IT                                    | -                                      | 0.2                                     | 11.1                                                     | 0.5                                           | 1.5                                              | 1.4                                                         | 6                              | 5.0                |
| LT                                    | -                                      | 0.0                                     | 0.1                                                      | 0.1                                           | 0.2                                              | 0.1                                                         | 0                              | 0.1                |
| LU                                    | -                                      | -                                       | 0.2                                                      | -                                             | -                                                | -                                                           | 0                              | 0.1                |
| LV                                    | -                                      | -                                       | 0.3                                                      | 0.1                                           | 0.1                                              | -                                                           | 0                              | 0.1                |
| MT                                    | -                                      | 0.5                                     | 0.3                                                      | 0.8                                           | 0.1                                              | 2.4                                                         | 1                              | 0.7                |
| NL                                    | -                                      | 5.4                                     | 1.4                                                      | 0.5                                           | 2.7                                              | 2.0                                                         | 2                              | 1.5                |
| PL                                    | -                                      | 1.3                                     | 0.8                                                      | 0.2                                           | 1.4                                              | 0.1                                                         | 1                              | 0.6                |
| PT                                    | -                                      | 0.0                                     | 0.1                                                      | 0.6                                           | 1.6                                              | -                                                           | 1                              | 0.5                |
| RO                                    | -                                      | 5.2                                     | 2.3                                                      | 1.0                                           | 2.4                                              | 0.1                                                         | 2                              | 1.8                |
| SE                                    | -                                      | -                                       | 0.4                                                      | 1.4                                           | 9.5                                              | 0.1                                                         | 2                              | 2.1                |
| SI                                    | -                                      | -                                       | 0.0                                                      | 0.4                                           | -                                                | -                                                           | 0                              | 0.1                |
| SK                                    | -                                      | -                                       | 0.1                                                      | 0.0                                           | -                                                | -                                                           | 0                              | 0.0                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>0</b>                               | <b>3</b>                                | <b>45</b>                                                | <b>33</b>                                     | <b>19</b>                                        | <b>15</b>                                                   | <b>116</b>                     | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 13: CZECH REPUBLIC's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 6.3                                    | 6.6                                     | 3.5                                                      | 5.1                                           | 4.8                                              | 10.5                                                        | 3,029                          | 4.6                |
| BE                                    | 6.0                                    | 3.4                                     | 1.5                                                      | 1.8                                           | 3.8                                              | 3.4                                                         | 1,564                          | 2.4                |
| BG                                    | 0.2                                    | 0.5                                     | 0.6                                                      | 1.3                                           | 0.6                                              | 1.8                                                         | 476                            | 0.7                |
| CY                                    | 0.0                                    | 0.0                                     | 0.1                                                      | 0.0                                           | 0.0                                              | 0.1                                                         | 29                             | 0.0                |
| <b>CZ</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| DE                                    | 28.0                                   | 43.4                                    | 38.9                                                     | 48.1                                          | 41.7                                             | 36.3                                                        | 27,479                         | 41.9               |
| DK                                    | 5.7                                    | 0.7                                     | 1.6                                                      | 0.7                                           | 0.7                                              | 0.3                                                         | 705                            | 1.1                |
| EE                                    | 0.4                                    | 0.2                                     | 0.2                                                      | 0.2                                           | 0.1                                              | 0.2                                                         | 124                            | 0.2                |
| ES                                    | 1.5                                    | 1.8                                     | 2.9                                                      | 2.6                                           | 3.7                                              | 3.1                                                         | 1,925                          | 2.9                |
| FI                                    | 1.0                                    | 0.6                                     | 0.6                                                      | 0.6                                           | 0.8                                              | 0.3                                                         | 412                            | 0.6                |
| FR                                    | 7.2                                    | 4.9                                     | 6.2                                                      | 6.2                                           | 7.5                                              | 5.8                                                         | 4,181                          | 6.4                |
| GB                                    | 6.8                                    | 4.6                                     | 6.8                                                      | 5.1                                           | 5.5                                              | 3.5                                                         | 3,834                          | 5.8                |
| GR                                    | 0.0                                    | 0.1                                     | 0.4                                                      | 0.1                                           | 0.2                                              | 0.4                                                         | 172                            | 0.3                |
| HR                                    | 0.2                                    | 0.3                                     | 0.4                                                      | 0.2                                           | 0.2                                              | 0.4                                                         | 186                            | 0.3                |
| HU                                    | 2.4                                    | 3.3                                     | 3.9                                                      | 3.9                                           | 3.6                                              | 1.2                                                         | 2,440                          | 3.7                |
| IE                                    | 0.5                                    | 0.2                                     | 1.5                                                      | 0.2                                           | 0.4                                              | 0.3                                                         | 527                            | 0.8                |
| IT                                    | 8.7                                    | 3.1                                     | 3.5                                                      | 3.6                                           | 5.1                                              | 4.5                                                         | 2,563                          | 3.9                |
| LT                                    | 0.2                                    | 0.2                                     | 0.7                                                      | 0.5                                           | 0.4                                              | 0.3                                                         | 342                            | 0.5                |
| LU                                    | 0.2                                    | 0.2                                     | 0.1                                                      | 0.1                                           | 0.2                                              | 0.0                                                         | 79                             | 0.1                |
| LV                                    | 0.1                                    | 0.2                                     | 0.3                                                      | 0.2                                           | 0.1                                              | 0.3                                                         | 135                            | 0.2                |
| MT                                    | 0.0                                    | 0.0                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 12                             | 0.0                |
| NL                                    | 2.5                                    | 4.9                                     | 12.3                                                     | 2.8                                           | 3.1                                              | 5.1                                                         | 4,656                          | 7.1                |
| PL                                    | 9.4                                    | 7.2                                     | 5.3                                                      | 5.4                                           | 5.7                                              | 3.4                                                         | 3,670                          | 5.6                |
| PT                                    | 0.1                                    | 0.6                                     | 0.4                                                      | 0.4                                           | 0.6                                              | 0.5                                                         | 296                            | 0.5                |
| RO                                    | 1.3                                    | 1.8                                     | 1.1                                                      | 2.8                                           | 1.7                                              | 1.4                                                         | 1,111                          | 1.7                |
| SE                                    | 3.7                                    | 2.3                                     | 2.3                                                      | 1.1                                           | 2.3                                              | 3.1                                                         | 1,377                          | 2.1                |
| SI                                    | 0.2                                    | 0.6                                     | 0.3                                                      | 0.4                                           | 0.4                                              | 2.4                                                         | 257                            | 0.4                |
| SK                                    | 7.5                                    | 8.5                                     | 4.5                                                      | 6.8                                           | 6.6                                              | 11.3                                                        | 3,993                          | 6.1                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>162</b>                             | <b>7,811</b>                            | <b>27,285</b>                                            | <b>13,099</b>                                 | <b>16,280</b>                                    | <b>949</b>                                                  | <b>65,585</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 14: GERMANY'S intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 15.3                                   | 10.9                                    | 6.8                                                      | 9.0                                           | 8.7                                              | 8.4                                                         | 21,437                         | 8.5                |
| BE                                    | 5.5                                    | 5.1                                     | 3.9                                                      | 4.3                                           | 4.6                                              | 7.4                                                         | 11,437                         | 4.5                |
| BG                                    | 0.4                                    | 0.6                                     | 0.6                                                      | 0.7                                           | 0.7                                              | 0.4                                                         | 1,612                          | 0.6                |
| CY                                    | 0.0                                    | 0.0                                     | 0.1                                                      | 0.1                                           | 0.1                                              | 0.3                                                         | 204                            | 0.1                |
| CZ                                    | 6.1                                    | 8.1                                     | 8.4                                                      | 8.5                                           | 6.5                                              | 3.7                                                         | 18,793                         | 7.5                |
| <b>DE</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| DK                                    | 3.4                                    | 2.6                                     | 2.5                                                      | 2.5                                           | 2.8                                              | 2.3                                                         | 6,563                          | 2.6                |
| EE                                    | 0.3                                    | 0.2                                     | 0.3                                                      | 0.4                                           | 0.3                                              | 0.3                                                         | 766                            | 0.3                |
| ES                                    | 3.4                                    | 4.9                                     | 5.3                                                      | 6.3                                           | 5.9                                              | 7.5                                                         | 14,503                         | 5.8                |
| FI                                    | 4.7                                    | 1.5                                     | 1.5                                                      | 1.5                                           | 1.8                                              | 1.7                                                         | 4,205                          | 1.7                |
| FR                                    | 9.5                                    | 13.0                                    | 11.4                                                     | 11.2                                          | 14.5                                             | 14.6                                                        | 32,305                         | 12.8               |
| GB                                    | 6.3                                    | 7.9                                     | 8.7                                                      | 7.4                                           | 9.4                                              | 9.7                                                         | 21,831                         | 8.7                |
| GR                                    | 0.4                                    | 0.5                                     | 0.7                                                      | 0.5                                           | 0.7                                              | 1.1                                                         | 1,665                          | 0.7                |
| HR                                    | 0.7                                    | 0.5                                     | 0.4                                                      | 0.4                                           | 0.5                                              | 0.6                                                         | 1,083                          | 0.4                |
| HU                                    | 3.0                                    | 4.4                                     | 5.6                                                      | 6.6                                           | 4.6                                              | 1.5                                                         | 12,805                         | 5.1                |
| IE                                    | 0.4                                    | 0.6                                     | 2.3                                                      | 0.7                                           | 0.8                                              | 2.4                                                         | 3,086                          | 1.2                |
| IT                                    | 7.4                                    | 6.6                                     | 8.3                                                      | 9.0                                           | 9.2                                              | 10.9                                                        | 21,919                         | 8.7                |
| LT                                    | 0.3                                    | 0.5                                     | 0.5                                                      | 0.5                                           | 0.5                                              | 0.4                                                         | 1,258                          | 0.5                |
| LU                                    | 1.0                                    | 1.0                                     | 0.4                                                      | 0.6                                           | 0.5                                              | 0.4                                                         | 1,300                          | 0.5                |
| LV                                    | 0.3                                    | 0.2                                     | 0.2                                                      | 0.2                                           | 0.3                                              | 0.4                                                         | 638                            | 0.3                |
| MT                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.1                                              | 0.1                                                         | 265                            | 0.1                |
| NL                                    | 11.1                                   | 9.8                                     | 11.9                                                     | 8.2                                           | 8.8                                              | 12.8                                                        | 24,735                         | 9.8                |
| PL                                    | 11.8                                   | 10.2                                    | 9.0                                                      | 8.2                                           | 8.4                                              | 5.4                                                         | 21,750                         | 8.6                |
| PT                                    | 0.5                                    | 1.0                                     | 2.0                                                      | 1.6                                           | 1.2                                              | 1.1                                                         | 3,668                          | 1.5                |
| RO                                    | 1.6                                    | 2.9                                     | 3.0                                                      | 4.5                                           | 2.3                                              | 1.4                                                         | 7,430                          | 2.9                |
| SE                                    | 4.3                                    | 3.4                                     | 3.6                                                      | 3.7                                           | 4.4                                              | 3.8                                                         | 9,822                          | 3.9                |
| SI                                    | 0.9                                    | 0.9                                     | 0.5                                                      | 0.9                                           | 0.7                                              | 0.7                                                         | 1,756                          | 0.7                |
| SK                                    | 1.3                                    | 2.9                                     | 1.8                                                      | 2.7                                           | 1.7                                              | 0.9                                                         | 5,121                          | 2.0                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>943</b>                             | <b>28,369</b>                           | <b>67,564</b>                                            | <b>49,044</b>                                 | <b>96,634</b>                                    | <b>9,423</b>                                                | <b>251,978</b>                 | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations



**Table 15: DENMARK's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 1.4                                    | 1.4                                     | 1.5                                                      | 1.2                                           | 1.6                                              | 1.6                                                         | 268                            | 1.5                |
| BE                                    | 1.1                                    | 2.6                                     | 1.8                                                      | 3.8                                           | 2.1                                              | 7.7                                                         | 449                            | 2.5                |
| BG                                    | 0.1                                    | 0.1                                     | 0.3                                                      | 0.2                                           | 0.2                                              | 0.2                                                         | 34                             | 0.2                |
| CY                                    | 0.0                                    | 0.0                                     | 0.1                                                      | 0.0                                           | 0.1                                              | 0.0                                                         | 16                             | 0.1                |
| CZ                                    | 3.4                                    | 1.1                                     | 1.7                                                      | 2.1                                           | 0.9                                              | 0.7                                                         | 227                            | 1.3                |
| DE                                    | 30.8                                   | 25.4                                    | 20.5                                                     | 23.6                                          | 29.2                                             | 32.2                                                        | 4,694                          | 26.4               |
| <b>DK</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| EE                                    | 0.4                                    | 0.5                                     | 0.6                                                      | 0.4                                           | 0.4                                              | 0.2                                                         | 76                             | 0.4                |
| ES                                    | 2.7                                    | 2.9                                     | 3.1                                                      | 3.9                                           | 3.1                                              | 2.6                                                         | 567                            | 3.2                |
| FI                                    | 12.5                                   | 2.7                                     | 4.4                                                      | 3.4                                           | 2.6                                              | 3.8                                                         | 567                            | 3.2                |
| FR                                    | 6.2                                    | 4.7                                     | 7.6                                                      | 6.8                                           | 6.9                                              | 6.0                                                         | 1,202                          | 6.8                |
| GB                                    | 5.5                                    | 14.8                                    | 8.2                                                      | 13.2                                          | 15.2                                             | 5.8                                                         | 2,333                          | 13.1               |
| GR                                    | 0.2                                    | 0.2                                     | 0.5                                                      | 0.5                                           | 1.1                                              | 0.7                                                         | 136                            | 0.8                |
| HR                                    | 0.1                                    | 0.3                                     | 0.2                                                      | 0.2                                           | 0.2                                              | 0.3                                                         | 39                             | 0.2                |
| HU                                    | 1.3                                    | 1.2                                     | 1.5                                                      | 1.0                                           | 1.2                                              | 1.4                                                         | 217                            | 1.2                |
| IE                                    | 0.4                                    | 0.8                                     | 1.0                                                      | 1.4                                           | 2.3                                              | 1.1                                                         | 302                            | 1.7                |
| IT                                    | 3.1                                    | 2.0                                     | 3.9                                                      | 4.0                                           | 3.4                                              | 3.1                                                         | 602                            | 3.4                |
| LT                                    | 1.9                                    | 0.7                                     | 0.6                                                      | 0.4                                           | 0.9                                              | 0.1                                                         | 129                            | 0.7                |
| LU                                    | 0.0                                    | 0.1                                     | 0.3                                                      | 0.2                                           | 0.1                                              | 0.1                                                         | 26                             | 0.1                |
| LV                                    | 0.1                                    | 0.5                                     | 0.3                                                      | 0.6                                           | 0.4                                              | 0.2                                                         | 69                             | 0.4                |
| MT                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 9                              | 0.0                |
| NL                                    | 7.4                                    | 11.7                                    | 8.6                                                      | 6.0                                           | 11.2                                             | 14.8                                                        | 1,802                          | 10.1               |
| PL                                    | 4.0                                    | 4.7                                     | 6.5                                                      | 6.0                                           | 3.7                                              | 3.5                                                         | 831                            | 4.7                |
| PT                                    | 0.4                                    | 0.5                                     | 0.4                                                      | 0.5                                           | 0.8                                              | 0.6                                                         | 112                            | 0.6                |
| RO                                    | 1.4                                    | 0.4                                     | 0.4                                                      | 0.5                                           | 0.5                                              | 0.3                                                         | 85                             | 0.5                |
| SE                                    | 15.0                                   | 19.6                                    | 25.4                                                     | 19.5                                          | 11.1                                             | 12.2                                                        | 2,882                          | 16.2               |
| SI                                    | 0.1                                    | 0.2                                     | 0.3                                                      | 0.2                                           | 0.2                                              | 0.3                                                         | 41                             | 0.2                |
| SK                                    | 0.4                                    | 0.8                                     | 0.4                                                      | 0.5                                           | 0.5                                              | 0.4                                                         | 87                             | 0.5                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>115</b>                             | <b>2,098</b>                            | <b>3,508</b>                                             | <b>2,534</b>                                  | <b>8,972</b>                                     | <b>573</b>                                                  | <b>17,800</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 16: ESTONIA's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 0.0                                    | 0.7                                     | 0.6                                                      | 0.2                                           | 2.0                                              | 0.6                                                         | 23                             | 0.8                |
| BE                                    | 0.0                                    | 1.0                                     | 1.8                                                      | 1.0                                           | 0.8                                              | 0.2                                                         | 32                             | 1.1                |
| BG                                    | 0.0                                    | 0.1                                     | 1.6                                                      | 0.2                                           | 0.4                                              | 0.0                                                         | 17                             | 0.6                |
| CY                                    | 0.0                                    | 0.0                                     | 0.7                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 6                              | 0.2                |
| CZ                                    | 0.0                                    | 0.8                                     | 0.4                                                      | 0.2                                           | 1.5                                              | 1.0                                                         | 19                             | 0.7                |
| DE                                    | 0.0                                    | 7.8                                     | 22.0                                                     | 7.4                                           | 11.5                                             | 41.5                                                        | 380                            | 13.4               |
| DK                                    | 2.3                                    | 3.3                                     | 3.0                                                      | 2.1                                           | 1.9                                              | 0.7                                                         | 70                             | 2.5                |
| <b>EE</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| ES                                    | 0.0                                    | 0.5                                     | 1.3                                                      | 1.2                                           | 1.5                                              | 0.1                                                         | 31                             | 1.1                |
| FI                                    | 68.3                                   | 40.4                                    | 12.0                                                     | 51.0                                          | 35.2                                             | 35.8                                                        | 989                            | 34.8               |
| FR                                    | 0.0                                    | 1.3                                     | 5.4                                                      | 2.6                                           | 1.8                                              | 0.1                                                         | 79                             | 2.8                |
| GB                                    | 0.0                                    | 1.1                                     | 2.0                                                      | 2.1                                           | 1.0                                              | 3.1                                                         | 48                             | 1.7                |
| GR                                    | 0.0                                    | 0.0                                     | 0.2                                                      | 0.0                                           | 0.0                                              | 0.1                                                         | 2                              | 0.1                |
| HR                                    | 0.0                                    | 0.0                                     | 0.0                                                      | 0.1                                           | 0.0                                              | -                                                           | 1                              | 0.1                |
| HU                                    | 0.0                                    | 1.1                                     | 0.6                                                      | 0.5                                           | 0.3                                              | -                                                           | 16                             | 0.6                |
| IE                                    | 0.1                                    | 0.2                                     | 0.3                                                      | 0.2                                           | 0.1                                              | 0.2                                                         | 5                              | 0.2                |
| IT                                    | 0.0                                    | 0.4                                     | 5.0                                                      | 1.8                                           | 1.9                                              | 0.2                                                         | 66                             | 2.3                |
| LT                                    | 7.1                                    | 6.3                                     | 2.3                                                      | 2.8                                           | 7.9                                              | 5.8                                                         | 129                            | 4.6                |
| LU                                    | 0.0                                    | 0.0                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 0                              | 0.0                |
| LV                                    | 2.6                                    | 6.0                                     | 5.4                                                      | 5.3                                           | 9.3                                              | 3.0                                                         | 177                            | 6.2                |
| MT                                    | 0.0                                    | 0.0                                     | 0.4                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 4                              | 0.1                |
| NL                                    | 0.0                                    | 2.7                                     | 4.2                                                      | 1.6                                           | 1.0                                              | 1.2                                                         | 66                             | 2.3                |
| PL                                    | 0.5                                    | 3.2                                     | 2.2                                                      | 3.6                                           | 6.5                                              | 2.4                                                         | 106                            | 3.7                |
| PT                                    | 0.0                                    | 0.2                                     | 0.2                                                      | 0.1                                           | 0.1                                              | -                                                           | 4                              | 0.1                |
| RO                                    | 0.0                                    | 1.3                                     | 2.6                                                      | 0.4                                           | 0.3                                              | 0.0                                                         | 31                             | 1.1                |
| SE                                    | 19.0                                   | 21.5                                    | 25.2                                                     | 15.4                                          | 14.1                                             | 4.0                                                         | 523                            | 18.4               |
| SI                                    | 0.0                                    | 0.0                                     | 0.1                                                      | 0.0                                           | 0.4                                              | 0.0                                                         | 4                              | 0.1                |
| SK                                    | 0.0                                    | 0.1                                     | 0.7                                                      | 0.1                                           | 0.3                                              | -                                                           | 8                              | 0.3                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>17</b>                              | <b>504</b>                              | <b>753</b>                                               | <b>833</b>                                    | <b>631</b>                                       | <b>100</b>                                                  | <b>2,838</b>                   | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 17: SPAIN'S intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 0.5                                    | 1.8                                     | 0.9                                                      | 1.0                                           | 1.6                                              | 0.9                                                         | 365                            | 1.3                |
| BE                                    | 1.6                                    | 2.1                                     | 1.8                                                      | 2.0                                           | 3.0                                              | 14.7                                                        | 750                            | 2.7                |
| BG                                    | 1.3                                    | 0.4                                     | 0.4                                                      | 0.3                                           | 0.5                                              | 0.2                                                         | 111                            | 0.4                |
| CY                                    | 0.1                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.2                                              | 0.1                                                         | 31                             | 0.1                |
| CZ                                    | 1.1                                    | 2.5                                     | 1.2                                                      | 1.5                                           | 2.6                                              | 0.6                                                         | 529                            | 1.9                |
| DE                                    | 35.3                                   | 18.5                                    | 12.8                                                     | 20.9                                          | 17.4                                             | 8.4                                                         | 4,835                          | 17.5               |
| DK                                    | 5.4                                    | 1.7                                     | 0.6                                                      | 1.3                                           | 1.9                                              | 0.6                                                         | 397                            | 1.4                |
| EE                                    | 0.1                                    | 0.1                                     | 0.2                                                      | 0.1                                           | 0.2                                              | 0.1                                                         | 34                             | 0.1                |
| <b>ES</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| FI                                    | 0.6                                    | 0.6                                     | 0.2                                                      | 0.5                                           | 1.4                                              | 0.4                                                         | 205                            | 0.7                |
| FR                                    | 17.0                                   | 28.4                                    | 24.0                                                     | 25.5                                          | 22.0                                             | 15.8                                                        | 6,734                          | 24.4               |
| GB                                    | 7.3                                    | 7.2                                     | 7.5                                                      | 7.8                                           | 7.8                                              | 4.4                                                         | 2,076                          | 7.5                |
| GR                                    | 0.3                                    | 0.9                                     | 0.4                                                      | 0.5                                           | 0.9                                              | 1.0                                                         | 202                            | 0.7                |
| HR                                    | 0.0                                    | 0.2                                     | 0.1                                                      | 0.1                                           | 0.2                                              | 0.4                                                         | 41                             | 0.1                |
| HU                                    | 0.5                                    | 2.0                                     | 1.0                                                      | 1.4                                           | 1.2                                              | 0.6                                                         | 373                            | 1.4                |
| IE                                    | 0.6                                    | 0.7                                     | 0.3                                                      | 0.5                                           | 0.6                                              | 0.4                                                         | 147                            | 0.5                |
| IT                                    | 10.0                                   | 6.1                                     | 11.0                                                     | 9.5                                           | 9.3                                              | 9.5                                                         | 2,485                          | 9.0                |
| LT                                    | 0.2                                    | 0.2                                     | 0.1                                                      | 0.4                                           | 0.4                                              | 0.3                                                         | 86                             | 0.3                |
| LU                                    | 0.1                                    | 0.4                                     | 0.3                                                      | 0.2                                           | 0.2                                              | 0.1                                                         | 70                             | 0.3                |
| LV                                    | 0.0                                    | 0.1                                     | 0.6                                                      | 0.1                                           | 0.1                                              | 0.1                                                         | 53                             | 0.2                |
| MT                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.2                                              | 0.1                                                         | 31                             | 0.1                |
| NL                                    | 3.4                                    | 4.5                                     | 5.5                                                      | 3.6                                           | 3.3                                              | 9.9                                                         | 1,176                          | 4.3                |
| PL                                    | 2.0                                    | 4.1                                     | 3.2                                                      | 4.8                                           | 4.4                                              | 2.3                                                         | 1,141                          | 4.1                |
| PT                                    | 10.2                                   | 11.8                                    | 22.2                                                     | 13.5                                          | 15.4                                             | 27.0                                                        | 4,344                          | 15.7               |
| RO                                    | 1.1                                    | 1.5                                     | 1.0                                                      | 1.5                                           | 2.1                                              | 0.6                                                         | 429                            | 1.6                |
| SE                                    | 1.1                                    | 2.5                                     | 3.6                                                      | 1.3                                           | 1.8                                              | 1.0                                                         | 582                            | 2.1                |
| SI                                    | 0.1                                    | 0.2                                     | 0.2                                                      | 0.6                                           | 0.3                                              | 0.2                                                         | 88                             | 0.3                |
| SK                                    | 0.1                                    | 1.6                                     | 0.5                                                      | 1.0                                           | 1.0                                              | 0.2                                                         | 274                            | 1.0                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>198</b>                             | <b>5,843</b>                            | <b>5,073</b>                                             | <b>7,309</b>                                  | <b>8,293</b>                                     | <b>931</b>                                                  | <b>27,646</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 18: FINLAND's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 0.5                                    | 1.8                                     | 0.9                                                      | 1.0                                           | 1.6                                              | 0.9                                                         | 365                            | 1.3                |
| BE                                    | 1.6                                    | 2.1                                     | 1.8                                                      | 2.0                                           | 3.0                                              | 14.7                                                        | 750                            | 2.7                |
| BG                                    | 1.3                                    | 0.4                                     | 0.4                                                      | 0.3                                           | 0.5                                              | 0.2                                                         | 111                            | 0.4                |
| CY                                    | 0.1                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.2                                              | 0.1                                                         | 31                             | 0.1                |
| CZ                                    | 1.1                                    | 2.5                                     | 1.2                                                      | 1.5                                           | 2.6                                              | 0.6                                                         | 529                            | 1.9                |
| DE                                    | 35.3                                   | 18.5                                    | 12.8                                                     | 20.9                                          | 17.4                                             | 8.4                                                         | 4,835                          | 17.5               |
| DK                                    | 5.4                                    | 1.7                                     | 0.6                                                      | 1.3                                           | 1.9                                              | 0.6                                                         | 397                            | 1.4                |
| EE                                    | 0.1                                    | 0.1                                     | 0.2                                                      | 0.1                                           | 0.2                                              | 0.1                                                         | 34                             | 0.1                |
| ES                                    | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| <b>FI</b>                             | 0.6                                    | 0.6                                     | 0.2                                                      | 0.5                                           | 1.4                                              | 0.4                                                         | 205                            | 0.7                |
| FR                                    | 17.0                                   | 28.4                                    | 24.0                                                     | 25.5                                          | 22.0                                             | 15.8                                                        | 6,734                          | 24.4               |
| GB                                    | 7.3                                    | 7.2                                     | 7.5                                                      | 7.8                                           | 7.8                                              | 4.4                                                         | 2,076                          | 7.5                |
| GR                                    | 0.3                                    | 0.9                                     | 0.4                                                      | 0.5                                           | 0.9                                              | 1.0                                                         | 202                            | 0.7                |
| HR                                    | 0.0                                    | 0.2                                     | 0.1                                                      | 0.1                                           | 0.2                                              | 0.4                                                         | 41                             | 0.1                |
| HU                                    | 0.5                                    | 2.0                                     | 1.0                                                      | 1.4                                           | 1.2                                              | 0.6                                                         | 373                            | 1.4                |
| IE                                    | 0.6                                    | 0.7                                     | 0.3                                                      | 0.5                                           | 0.6                                              | 0.4                                                         | 147                            | 0.5                |
| IT                                    | 10.0                                   | 6.1                                     | 11.0                                                     | 9.5                                           | 9.3                                              | 9.5                                                         | 2,485                          | 9.0                |
| LT                                    | 0.2                                    | 0.2                                     | 0.1                                                      | 0.4                                           | 0.4                                              | 0.3                                                         | 86                             | 0.3                |
| LU                                    | 0.1                                    | 0.4                                     | 0.3                                                      | 0.2                                           | 0.2                                              | 0.1                                                         | 70                             | 0.3                |
| LV                                    | 0.0                                    | 0.1                                     | 0.6                                                      | 0.1                                           | 0.1                                              | 0.1                                                         | 53                             | 0.2                |
| MT                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.2                                              | 0.1                                                         | 31                             | 0.1                |
| NL                                    | 3.4                                    | 4.5                                     | 5.5                                                      | 3.6                                           | 3.3                                              | 9.9                                                         | 1,176                          | 4.3                |
| PL                                    | 2.0                                    | 4.1                                     | 3.2                                                      | 4.8                                           | 4.4                                              | 2.3                                                         | 1,141                          | 4.1                |
| PT                                    | 10.2                                   | 11.8                                    | 22.2                                                     | 13.5                                          | 15.4                                             | 27.0                                                        | 4,344                          | 15.7               |
| RO                                    | 1.1                                    | 1.5                                     | 1.0                                                      | 1.5                                           | 2.1                                              | 0.6                                                         | 429                            | 1.6                |
| SE                                    | 1.1                                    | 2.5                                     | 3.6                                                      | 1.3                                           | 1.8                                              | 1.0                                                         | 582                            | 2.1                |
| SI                                    | 0.1                                    | 0.2                                     | 0.2                                                      | 0.6                                           | 0.3                                              | 0.2                                                         | 88                             | 0.3                |
| SK                                    | 0.1                                    | 1.6                                     | 0.5                                                      | 1.0                                           | 1.0                                              | 0.2                                                         | 274                            | 1.0                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>198</b>                             | <b>5,843</b>                            | <b>5,073</b>                                             | <b>7,309</b>                                  | <b>8,293</b>                                     | <b>931</b>                                                  | <b>27,646</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 19: FRANCE's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 1.9                                    | 2.1                                     | 1.1                                                      | 1.2                                           | 2.2                                              | 2.6                                                         | 1,069                          | 1.7                |
| BE                                    | 7.2                                    | 10.3                                    | 9.5                                                      | 7.3                                           | 8.2                                              | 9.3                                                         | 5,435                          | 8.7                |
| BG                                    | 0.4                                    | 0.4                                     | 0.4                                                      | 0.5                                           | 0.6                                              | 0.2                                                         | 292                            | 0.5                |
| CY                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.1                                              | 0.1                                                         | 55                             | 0.1                |
| CZ                                    | 2.6                                    | 3.0                                     | 2.6                                                      | 2.7                                           | 2.2                                              | 1.1                                                         | 1,519                          | 2.4                |
| DE                                    | 30.5                                   | 22.9                                    | 27.7                                                     | 27.6                                          | 28.0                                             | 20.5                                                        | 16,821                         | 26.9               |
| DK                                    | 0.9                                    | 1.0                                     | 0.7                                                      | 1.0                                           | 1.4                                              | 0.5                                                         | 653                            | 1.0                |
| EE                                    | 0.0                                    | 0.1                                     | 0.2                                                      | 0.2                                           | 0.2                                              | 0.1                                                         | 109                            | 0.2                |
| ES                                    | 6.9                                    | 13.2                                    | 8.5                                                      | 13.6                                          | 10.6                                             | 11.2                                                        | 6,782                          | 10.9               |
| FI                                    | 1.1                                    | 0.6                                     | 0.7                                                      | 0.6                                           | 1.1                                              | 0.4                                                         | 490                            | 0.8                |
| <b>FR</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| GB                                    | 11.5                                   | 10.6                                    | 11.1                                                     | 8.7                                           | 10.6                                             | 8.6                                                         | 6,421                          | 10.3               |
| GR                                    | 0.4                                    | 0.5                                     | 0.5                                                      | 0.6                                           | 0.5                                              | 0.6                                                         | 336                            | 0.5                |
| HR                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.3                                              | 0.2                                                         | 119                            | 0.2                |
| HU                                    | 1.5                                    | 2.1                                     | 2.7                                                      | 3.5                                           | 1.7                                              | 1.2                                                         | 1,463                          | 2.3                |
| IE                                    | 0.3                                    | 0.5                                     | 1.6                                                      | 0.5                                           | 1.0                                              | 3.9                                                         | 742                            | 1.2                |
| IT                                    | 12.1                                   | 8.8                                     | 9.0                                                      | 11.5                                          | 10.7                                             | 14.4                                                        | 6,480                          | 10.4               |
| LT                                    | 0.1                                    | 0.1                                     | 0.2                                                      | 0.5                                           | 0.3                                              | 0.2                                                         | 182                            | 0.3                |
| LU                                    | 1.3                                    | 1.0                                     | 0.4                                                      | 0.6                                           | 0.5                                              | 0.4                                                         | 358                            | 0.6                |
| LV                                    | 0.1                                    | 0.1                                     | 0.1                                                      | 0.2                                           | 0.2                                              | 0.1                                                         | 116                            | 0.2                |
| MT                                    | 0.0                                    | 0.0                                     | 0.8                                                      | 0.1                                           | 0.0                                              | 0.0                                                         | 172                            | 0.3                |
| NL                                    | 7.0                                    | 4.6                                     | 10.2                                                     | 6.1                                           | 5.6                                              | 15.7                                                        | 4,689                          | 7.5                |
| PL                                    | 8.9                                    | 4.3                                     | 4.1                                                      | 4.0                                           | 5.0                                              | 4.4                                                         | 2,762                          | 4.4                |
| PT                                    | 1.5                                    | 3.4                                     | 2.0                                                      | 1.4                                           | 1.5                                              | 1.5                                                         | 1,143                          | 1.8                |
| RO                                    | 0.9                                    | 3.3                                     | 2.0                                                      | 2.2                                           | 3.1                                              | 0.6                                                         | 1,551                          | 2.5                |
| SE                                    | 1.8                                    | 1.8                                     | 1.8                                                      | 3.2                                           | 2.8                                              | 1.6                                                         | 1,502                          | 2.4                |
| SI                                    | 0.3                                    | 0.6                                     | 0.4                                                      | 0.4                                           | 0.6                                              | 0.1                                                         | 284                            | 0.5                |
| SK                                    | 0.7                                    | 4.4                                     | 1.1                                                      | 1.8                                           | 1.2                                              | 0.3                                                         | 962                            | 1.5                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>196</b>                             | <b>6,337</b>                            | <b>18,321</b>                                            | <b>12,016</b>                                 | <b>22,140</b>                                    | <b>3,498</b>                                                | <b>62,508</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 20: UNITED KINGDOM's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 0.7                                    | 1.4                                     | 1.2                                                      | 2.0                                           | 1.7                                              | 0.9                                                         | 654                            | 1.5                |
| BE                                    | 2.3                                    | 5.5                                     | 3.0                                                      | 4.2                                           | 7.2                                              | 15.5                                                        | 2,394                          | 5.5                |
| BG                                    | 0.2                                    | 0.2                                     | 0.4                                                      | 0.2                                           | 0.4                                              | 0.3                                                         | 142                            | 0.3                |
| CY                                    | 0.1                                    | 0.2                                     | 0.2                                                      | 0.3                                           | 0.1                                              | 0.1                                                         | 80                             | 0.2                |
| CZ                                    | 2.1                                    | 2.0                                     | 2.9                                                      | 2.9                                           | 2.3                                              | 0.8                                                         | 1,081                          | 2.5                |
| DE                                    | 26.8                                   | 19.8                                    | 23.0                                                     | 21.6                                          | 21.0                                             | 15.1                                                        | 9,238                          | 21.4               |
| DK                                    | 3.8                                    | 2.3                                     | 2.4                                                      | 2.0                                           | 2.9                                              | 2.8                                                         | 1,095                          | 2.5                |
| EE                                    | 0.2                                    | 0.1                                     | 0.2                                                      | 0.3                                           | 0.3                                              | 0.1                                                         | 105                            | 0.2                |
| ES                                    | 4.2                                    | 7.0                                     | 5.4                                                      | 6.7                                           | 5.5                                              | 4.7                                                         | 2,459                          | 5.7                |
| FI                                    | 1.5                                    | 1.1                                     | 1.0                                                      | 1.1                                           | 1.4                                              | 0.4                                                         | 486                            | 1.1                |
| FR                                    | 13.1                                   | 13.8                                    | 13.0                                                     | 14.5                                          | 15.3                                             | 13.0                                                        | 6,088                          | 14.1               |
| <b>GB</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| GR                                    | 0.4                                    | 0.5                                     | 0.8                                                      | 0.7                                           | 0.5                                              | 0.6                                                         | 284                            | 0.7                |
| HR                                    | 0.1                                    | 0.3                                     | 0.2                                                      | 0.2                                           | 0.2                                              | 0.2                                                         | 82                             | 0.2                |
| HU                                    | 1.6                                    | 0.7                                     | 1.3                                                      | 1.2                                           | 1.5                                              | 1.4                                                         | 565                            | 1.3                |
| IE                                    | 11.7                                   | 18.5                                    | 16.7                                                     | 14.1                                          | 9.5                                              | 13.1                                                        | 5,919                          | 13.7               |
| IT                                    | 10.3                                   | 6.3                                     | 6.6                                                      | 7.8                                           | 7.4                                              | 6.6                                                         | 3,053                          | 7.1                |
| LT                                    | 0.3                                    | 0.2                                     | 0.4                                                      | 0.4                                           | 0.3                                              | 0.9                                                         | 166                            | 0.4                |
| LU                                    | 0.1                                    | 0.1                                     | 0.3                                                      | 0.2                                           | 0.1                                              | 0.1                                                         | 74                             | 0.2                |
| LV                                    | 0.1                                    | 0.1                                     | 0.3                                                      | 0.2                                           | 0.2                                              | 0.1                                                         | 83                             | 0.2                |
| MT                                    | 0.1                                    | 0.2                                     | 0.3                                                      | 0.3                                           | 0.2                                              | 0.2                                                         | 100                            | 0.2                |
| NL                                    | 10.9                                   | 9.8                                     | 11.1                                                     | 9.1                                           | 10.0                                             | 17.2                                                        | 4,593                          | 10.6               |
| PL                                    | 3.5                                    | 4.3                                     | 3.4                                                      | 3.2                                           | 4.6                                              | 2.1                                                         | 1,646                          | 3.8                |
| PT                                    | 1.0                                    | 0.7                                     | 1.0                                                      | 1.0                                           | 1.0                                              | 0.5                                                         | 404                            | 0.9                |
| RO                                    | 1.5                                    | 0.9                                     | 1.1                                                      | 1.6                                           | 1.4                                              | 0.4                                                         | 529                            | 1.2                |
| SE                                    | 2.7                                    | 3.0                                     | 2.8                                                      | 3.5                                           | 4.2                                              | 2.5                                                         | 1,473                          | 3.4                |
| SI                                    | 0.2                                    | 0.1                                     | 0.2                                                      | 0.3                                           | 0.3                                              | 0.1                                                         | 111                            | 0.3                |
| SK                                    | 0.4                                    | 0.8                                     | 0.6                                                      | 0.7                                           | 0.5                                              | 0.2                                                         | 244                            | 0.6                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>189</b>                             | <b>3,765</b>                            | <b>15,289</b>                                            | <b>6,337</b>                                  | <b>15,326</b>                                    | <b>2,384</b>                                                | <b>43,289</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 21: GREECE's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 0.0                                    | 0.8                                     | 1.5                                                      | 0.8                                           | 1.1                                              | 1.9                                                         | 29                             | 1.2                |
| BE                                    | 2.6                                    | 2.6                                     | 2.1                                                      | 9.5                                           | 2.7                                              | 1.2                                                         | 103                            | 4.1                |
| BG                                    | 17.8                                   | 9.0                                     | 7.1                                                      | 5.4                                           | 13.7                                             | 2.8                                                         | 196                            | 7.8                |
| CY                                    | 29.7                                   | 20.6                                    | 14.6                                                     | 14.9                                          | 15.8                                             | 21.4                                                        | 397                            | 15.9               |
| CZ                                    | 0.0                                    | 0.5                                     | 0.2                                                      | 2.9                                           | 1.6                                              | 0.6                                                         | 29                             | 1.2                |
| DE                                    | 27.0                                   | 13.6                                    | 8.7                                                      | 23.6                                          | 10.8                                             | 10.2                                                        | 339                            | 13.5               |
| DK                                    | 0.2                                    | 0.3                                     | 0.9                                                      | 0.7                                           | 1.2                                              | 1.8                                                         | 21                             | 0.8                |
| EE                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.4                                              | 0.2                                                         | 4                              | 0.1                |
| ES                                    | 1.8                                    | 4.3                                     | 20.4                                                     | 1.8                                           | 3.2                                              | 2.3                                                         | 262                            | 10.5               |
| FI                                    | 0.0                                    | 0.4                                     | 0.5                                                      | 1.1                                           | 0.3                                              | 0.7                                                         | 15                             | 0.6                |
| FR                                    | 7.1                                    | 7.0                                     | 0.8                                                      | 2.4                                           | 6.1                                              | 13.8                                                        | 79                             | 3.2                |
| GB                                    | 2.9                                    | 7.2                                     | 0.9                                                      | 10.1                                          | 5.9                                              | 11.3                                                        | 127                            | 5.1                |
| <b>GR</b>                             | 0.0                                    | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| HR                                    | 0.0                                    | 0.6                                     | 0.3                                                      | 0.5                                           | 0.9                                              | 0.4                                                         | 12                             | 0.5                |
| HU                                    | 1.1                                    | 0.7                                     | 1.7                                                      | 1.1                                           | 2.1                                              | 2.3                                                         | 37                             | 1.5                |
| IE                                    | 1.1                                    | 0.4                                     | 0.1                                                      | 0.1                                           | 0.7                                              | 0.1                                                         | 5                              | 0.2                |
| IT                                    | 0.8                                    | 13.6                                    | 25.1                                                     | 9.8                                           | 9.2                                              | 10.4                                                        | 423                            | 16.9               |
| LT                                    | 0.0                                    | 0.2                                     | 0.0                                                      | 0.1                                           | 0.3                                              | 0.2                                                         | 3                              | 0.1                |
| LU                                    | 0.5                                    | 0.0                                     | 0.5                                                      | 0.5                                           | 0.2                                              | 0.0                                                         | 9                              | 0.3                |
| LV                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.1                                              | 0.0                                                         | 2                              | 0.1                |
| MT                                    | 1.4                                    | 1.9                                     | 0.5                                                      | 0.7                                           | 3.9                                              | 1.2                                                         | 32                             | 1.3                |
| NL                                    | 2.4                                    | 2.2                                     | 4.0                                                      | 4.3                                           | 3.2                                              | 7.4                                                         | 95                             | 3.8                |
| PL                                    | 0.1                                    | 1.0                                     | 1.4                                                      | 1.9                                           | 2.8                                              | 2.2                                                         | 43                             | 1.7                |
| PT                                    | 1.8                                    | 0.4                                     | 2.4                                                      | 0.9                                           | 1.3                                              | 1.0                                                         | 39                             | 1.6                |
| RO                                    | 1.2                                    | 8.6                                     | 3.6                                                      | 3.9                                           | 8.4                                              | 3.9                                                         | 126                            | 5.0                |
| SE                                    | -                                      | 0.8                                     | 0.6                                                      | 2.5                                           | 2.7                                              | 2.6                                                         | 37                             | 1.5                |
| SI                                    | 0.2                                    | 0.1                                     | 1.1                                                      | 0.1                                           | 0.5                                              | 0.2                                                         | 15                             | 0.6                |
| SK                                    | 0.3                                    | 2.8                                     | 0.9                                                      | 0.4                                           | 1.1                                              | 0.0                                                         | 25                             | 1.0                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>6</b>                               | <b>316</b>                              | <b>1,094</b>                                             | <b>639</b>                                    | <b>387</b>                                       | <b>63</b>                                                   | <b>2,505</b>                   | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations



**Table 22: CROATIA's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 14.7                                   | 11.9                                    | 8.7                                                      | 16.3                                          | 12.0                                             | 6.7                                                         | 327                            | 12.7               |
| BE                                    | 0.4                                    | 3.5                                     | 1.2                                                      | 0.6                                           | 2.0                                              | 2.3                                                         | 48                             | 1.9                |
| BG                                    | 0.2                                    | 0.4                                     | 1.0                                                      | 1.0                                           | 1.2                                              | 0.4                                                         | 22                             | 0.9                |
| CY                                    | -                                      | 0.1                                     | 0.2                                                      | 0.5                                           | 0.0                                              | 0.1                                                         | 5                              | 0.2                |
| CZ                                    | 1.5                                    | 1.4                                     | 2.3                                                      | 2.8                                           | 2.4                                              | 1.2                                                         | 56                             | 2.2                |
| DE                                    | 51.5                                   | 28.2                                    | 20.3                                                     | 26.5                                          | 27.7                                             | 13.7                                                        | 680                            | 26.5               |
| DK                                    | 0.2                                    | 1.0                                     | 0.8                                                      | 1.2                                           | 0.4                                              | 1.8                                                         | 22                             | 0.9                |
| EE                                    | 0.2                                    | 0.2                                     | 0.1                                                      | 0.3                                           | 0.0                                              | 0.2                                                         | 4                              | 0.2                |
| ES                                    | 0.0                                    | 0.6                                     | 2.4                                                      | 1.7                                           | 1.4                                              | 6.4                                                         | 38                             | 1.5                |
| FI                                    | 0.1                                    | 0.3                                     | 0.3                                                      | 1.3                                           | 0.3                                              | 0.1                                                         | 15                             | 0.6                |
| FR                                    | 1.8                                    | 4.9                                     | 4.1                                                      | 2.7                                           | 5.6                                              | 8.6                                                         | 111                            | 4.3                |
| GB                                    | 4.4                                    | 4.9                                     | 3.2                                                      | 2.4                                           | 2.0                                              | 6.0                                                         | 82                             | 3.2                |
| GR                                    | 0.0                                    | 0.3                                     | 0.9                                                      | 0.6                                           | 0.5                                              | 1.7                                                         | 13                             | 0.5                |
| <b>HR</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| HU                                    | 0.4                                    | 2.5                                     | 1.8                                                      | 3.5                                           | 6.0                                              | 6.0                                                         | 93                             | 3.6                |
| IE                                    | 0.0                                    | 1.0                                     | 0.2                                                      | 0.2                                           | 0.3                                              | 0.0                                                         | 11                             | 0.4                |
| IT                                    | 13.8                                   | 14.1                                    | 19.6                                                     | 15.4                                          | 11.4                                             | 12.1                                                        | 373                            | 14.5               |
| LT                                    | 0.1                                    | 0.3                                     | 0.8                                                      | 0.6                                           | 0.3                                              | 0.5                                                         | 12                             | 0.5                |
| LU                                    | -                                      | 0.6                                     | 0.2                                                      | 0.0                                           | 0.1                                              | -                                                           | 6                              | 0.2                |
| LV                                    | 0.0                                    | 0.2                                     | 0.1                                                      | 0.2                                           | 0.1                                              | 0.1                                                         | 5                              | 0.2                |
| MT                                    | 0.0                                    | 0.0                                     | 0.2                                                      | 0.2                                           | 0.1                                              | 0.0                                                         | 3                              | 0.1                |
| NL                                    | 2.1                                    | 2.6                                     | 5.7                                                      | 3.7                                           | 1.6                                              | 4.6                                                         | 81                             | 3.1                |
| PL                                    | 1.0                                    | 4.5                                     | 8.1                                                      | 2.2                                           | 2.4                                              | 2.3                                                         | 96                             | 3.7                |
| PT                                    | -                                      | 1.3                                     | 0.1                                                      | 0.4                                           | 0.3                                              | 0.6                                                         | 15                             | 0.6                |
| RO                                    | 0.3                                    | 1.8                                     | 1.1                                                      | 0.7                                           | 3.4                                              | 0.3                                                         | 45                             | 1.7                |
| SE                                    | 1.7                                    | 1.5                                     | 0.6                                                      | 3.9                                           | 0.9                                              | 2.4                                                         | 50                             | 2.0                |
| SI                                    | 4.7                                    | 9.0                                     | 12.1                                                     | 10.1                                          | 15.7                                             | 21.4                                                        | 298                            | 11.6               |
| SK                                    | 0.9                                    | 3.0                                     | 4.3                                                      | 0.9                                           | 2.0                                              | 0.5                                                         | 57                             | 2.2                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>29</b>                              | <b>715</b>                              | <b>368</b>                                               | <b>762</b>                                    | <b>658</b>                                       | <b>34</b>                                                   | <b>2,565</b>                   | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 23: HUNGARY's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 2.5                                    | 12.4                                    | 2.3                                                      | 5.4                                           | 7.0                                              | 5.7                                                         | 1,738                          | 4.9                |
| BE                                    | 0.2                                    | 1.4                                     | 2.5                                                      | 4.7                                           | 1.9                                              | 4.3                                                         | 1,075                          | 3.0                |
| BG                                    | 2.4                                    | 1.1                                     | 1.3                                                      | 1.3                                           | 0.7                                              | 0.3                                                         | 405                            | 1.1                |
| CY                                    | -                                      | 0.0                                     | 0.1                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 18                             | 0.0                |
| CZ                                    | 2.0                                    | 5.4                                     | 2.9                                                      | 6.3                                           | 3.5                                              | 2.0                                                         | 1,488                          | 4.2                |
| DE                                    | 54.3                                   | 42.1                                    | 37.2                                                     | 42.8                                          | 39.6                                             | 23.6                                                        | 13,920                         | 39.3               |
| DK                                    | 6.2                                    | 0.6                                     | 0.9                                                      | 1.0                                           | 1.5                                              | 4.4                                                         | 412                            | 1.2                |
| EE                                    | 0.0                                    | 0.1                                     | 0.2                                                      | 0.1                                           | 0.0                                              | 0.1                                                         | 50                             | 0.1                |
| ES                                    | 0.1                                    | 2.0                                     | 4.3                                                      | 2.4                                           | 3.6                                              | 2.6                                                         | 1,198                          | 3.4                |
| FI                                    | 0.0                                    | 0.4                                     | 0.8                                                      | 0.5                                           | 0.2                                              | 0.7                                                         | 203                            | 0.6                |
| FR                                    | 0.8                                    | 4.6                                     | 5.9                                                      | 5.4                                           | 6.4                                              | 16.6                                                        | 2,164                          | 6.1                |
| GB                                    | 3.7                                    | 3.1                                     | 6.1                                                      | 2.9                                           | 4.5                                              | 24.4                                                        | 1,825                          | 5.2                |
| GR                                    | 0.1                                    | 0.2                                     | 0.6                                                      | 0.5                                           | 0.4                                              | 1.5                                                         | 190                            | 0.5                |
| HR                                    | 4.3                                    | 1.0                                     | 0.9                                                      | 0.5                                           | 1.0                                              | 0.5                                                         | 287                            | 0.8                |
| <b>HU</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| IE                                    | 0.0                                    | 0.1                                     | 1.2                                                      | 0.2                                           | 0.3                                              | 0.3                                                         | 209                            | 0.6                |
| IT                                    | 2.1                                    | 2.5                                     | 5.4                                                      | 4.4                                           | 4.8                                              | 5.5                                                         | 1,703                          | 4.8                |
| LT                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.1                                              | 0.1                                                         | 41                             | 0.1                |
| LU                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 13                             | 0.0                |
| LV                                    | 0.0                                    | 0.5                                     | 0.4                                                      | 0.4                                           | 0.1                                              | 0.1                                                         | 116                            | 0.3                |
| MT                                    | -                                      | 0.0                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 5                              | 0.0                |
| NL                                    | 0.8                                    | 2.9                                     | 9.1                                                      | 3.9                                           | 5.9                                              | 1.9                                                         | 2,217                          | 6.3                |
| PL                                    | 1.4                                    | 6.8                                     | 2.9                                                      | 5.2                                           | 4.0                                              | 1.3                                                         | 1,429                          | 4.0                |
| PT                                    | 0.0                                    | 0.5                                     | 0.6                                                      | 0.5                                           | 0.2                                              | 0.6                                                         | 169                            | 0.5                |
| RO                                    | 9.0                                    | 5.4                                     | 3.7                                                      | 4.5                                           | 6.1                                              | 1.3                                                         | 1,581                          | 4.5                |
| SE                                    | 0.2                                    | 1.7                                     | 3.1                                                      | 2.5                                           | 4.6                                              | 0.4                                                         | 1,079                          | 3.0                |
| SI                                    | 1.9                                    | 0.9                                     | 1.3                                                      | 0.9                                           | 0.8                                              | 0.4                                                         | 355                            | 1.0                |
| SK                                    | 8.0                                    | 4.4                                     | 6.0                                                      | 3.5                                           | 2.5                                              | 1.3                                                         | 1,509                          | 4.3                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>25</b>                              | <b>2,017</b>                            | <b>13,977</b>                                            | <b>10,944</b>                                 | <b>7,339</b>                                     | <b>1,098</b>                                                | <b>35,400</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 24: IRELAND's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 0.4                                    | 1.3                                     | 0.9                                                      | 0.5                                           | 1.1                                              | 0.1                                                         | 83                             | 0.6                |
| BE                                    | 0.9                                    | 0.8                                     | 2.9                                                      | 4.9                                           | 1.2                                              | 7.0                                                         | 550                            | 4.2                |
| BG                                    | -                                      | 1.6                                     | 0.2                                                      | 1.8                                           | 0.1                                              | 0.0                                                         | 41                             | 0.3                |
| CY                                    | 0.0                                    | 0.0                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 3                              | 0.0                |
| CZ                                    | 0.3                                    | 0.9                                     | 4.8                                                      | 3.8                                           | 1.0                                              | 0.1                                                         | 306                            | 2.3                |
| DE                                    | 21.8                                   | 17.9                                    | 23.0                                                     | 20.9                                          | 19.5                                             | 7.2                                                         | 2,185                          | 16.5               |
| DK                                    | 2.2                                    | 1.7                                     | 0.7                                                      | 4.4                                           | 1.1                                              | 0.2                                                         | 129                            | 1.0                |
| EE                                    | -                                      | 0.1                                     | 0.0                                                      | 0.1                                           | 0.1                                              | 0.0                                                         | 7                              | 0.0                |
| ES                                    | 0.7                                    | 2.8                                     | 2.7                                                      | 2.6                                           | 3.6                                              | 0.8                                                         | 286                            | 2.2                |
| FI                                    | 0.1                                    | 0.1                                     | 0.6                                                      | 0.6                                           | 0.9                                              | 0.0                                                         | 56                             | 0.4                |
| FR                                    | 1.6                                    | 3.2                                     | 7.8                                                      | 3.2                                           | 11.7                                             | 2.5                                                         | 785                            | 5.9                |
| GB                                    | 63.2                                   | 50.9                                    | 23.7                                                     | 33.2                                          | 26.2                                             | 7.3                                                         | 2,707                          | 20.4               |
| GR                                    | 0.0                                    | 0.1                                     | 0.2                                                      | 0.0                                           | 0.3                                              | 0.1                                                         | 23                             | 0.2                |
| HR                                    | 0.1                                    | 0.0                                     | 0.1                                                      | 0.0                                           | 0.1                                              | 0.0                                                         | 7                              | 0.1                |
| HU                                    | 0.1                                    | 0.3                                     | 1.2                                                      | 0.3                                           | 2.5                                              | 0.2                                                         | 124                            | 0.9                |
| <b>IE</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| IT                                    | 1.2                                    | 5.8                                     | 4.4                                                      | 2.8                                           | 2.6                                              | 1.9                                                         | 419                            | 3.2                |
| LT                                    | -                                      | 0.1                                     | 0.1                                                      | 0.1                                           | 0.6                                              | 0.0                                                         | 19                             | 0.1                |
| LU                                    | -                                      | 0.2                                     | 0.3                                                      | 0.1                                           | 2.2                                              | 0.0                                                         | 62                             | 0.5                |
| LV                                    | 0.0                                    | 0.0                                     | 0.0                                                      | 0.0                                           | 0.1                                              | 0.0                                                         | 3                              | 0.0                |
| MT                                    | -                                      | 0.0                                     | 0.0                                                      | 0.0                                           | 0.1                                              | 0.0                                                         | 3                              | 0.0                |
| NL                                    | 6.6                                    | 3.0                                     | 13.5                                                     | 13.0                                          | 10.0                                             | 71.1                                                        | 4,327                          | 32.6               |
| PL                                    | 0.4                                    | 2.7                                     | 8.5                                                      | 1.1                                           | 3.3                                              | 0.7                                                         | 532                            | 4.0                |
| PT                                    | 0.0                                    | 0.2                                     | 0.5                                                      | 0.1                                           | 0.3                                              | 0.1                                                         | 38                             | 0.3                |
| RO                                    | 0.1                                    | 0.1                                     | 0.5                                                      | 0.6                                           | 0.7                                              | 0.1                                                         | 49                             | 0.4                |
| SE                                    | 0.3                                    | 5.1                                     | 3.1                                                      | 4.3                                           | 9.5                                              | 0.4                                                         | 444                            | 3.4                |
| SI                                    | 0.0                                    | 0.0                                     | 0.1                                                      | 0.1                                           | 0.1                                              | 0.0                                                         | 9                              | 0.1                |
| SK                                    | 0.0                                    | 1.0                                     | 0.2                                                      | 1.5                                           | 1.0                                              | 0.0                                                         | 53                             | 0.4                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>10</b>                              | <b>603</b>                              | <b>4,765</b>                                             | <b>1,150</b>                                  | <b>2,069</b>                                     | <b>4,656</b>                                                | <b>13,253</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 25: ITALY's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 3.6                                    | 4.1                                     | 2.2                                                      | 3.0                                           | 4.2                                              | 2.0                                                         | 2,919                          | 3.6                |
| BE                                    | 3.6                                    | 2.9                                     | 1.8                                                      | 3.2                                           | 4.3                                              | 5.0                                                         | 2,903                          | 3.6                |
| BG                                    | 0.8                                    | 1.0                                     | 0.7                                                      | 0.9                                           | 1.1                                              | 0.5                                                         | 776                            | 1.0                |
| CY                                    | 0.1                                    | 0.2                                     | 0.4                                                      | 0.2                                           | 0.2                                              | 0.4                                                         | 167                            | 0.2                |
| CZ                                    | 3.5                                    | 3.3                                     | 3.1                                                      | 3.5                                           | 2.8                                              | 1.0                                                         | 2,422                          | 3.0                |
| DE                                    | 25.0                                   | 27.9                                    | 16.6                                                     | 23.0                                          | 22.2                                             | 18.5                                                        | 18,105                         | 22.5               |
| DK                                    | 2.3                                    | 0.8                                     | 0.8                                                      | 1.3                                           | 1.5                                              | 1.1                                                         | 1,011                          | 1.3                |
| EE                                    | 0.6                                    | 0.1                                     | 0.2                                                      | 0.3                                           | 0.2                                              | 0.4                                                         | 176                            | 0.2                |
| ES                                    | 5.7                                    | 7.5                                     | 19.7                                                     | 8.3                                           | 9.3                                              | 12.0                                                        | 8,071                          | 10.0               |
| FI                                    | 3.3                                    | 0.7                                     | 0.5                                                      | 0.9                                           | 1.2                                              | 0.6                                                         | 785                            | 1.0                |
| FR                                    | 13.3                                   | 19.2                                    | 15.0                                                     | 18.4                                          | 17.1                                             | 21.8                                                        | 14,146                         | 17.6               |
| GB                                    | 12.8                                   | 6.6                                     | 7.8                                                      | 7.9                                           | 8.1                                              | 11.6                                                        | 6,404                          | 8.0                |
| GR                                    | 1.1                                    | 1.6                                     | 1.0                                                      | 1.7                                           | 1.6                                              | 2.0                                                         | 1,245                          | 1.5                |
| HR                                    | 0.5                                    | 1.1                                     | 0.5                                                      | 1.1                                           | 0.8                                              | 1.5                                                         | 733                            | 0.9                |
| HU                                    | 1.3                                    | 2.6                                     | 1.6                                                      | 2.2                                           | 2.2                                              | 1.1                                                         | 1,725                          | 2.1                |
| IE                                    | 0.4                                    | 0.4                                     | 0.4                                                      | 0.6                                           | 0.9                                              | 0.7                                                         | 542                            | 0.7                |
| <b>IT</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| LT                                    | 0.2                                    | 0.3                                     | 0.3                                                      | 0.4                                           | 0.5                                              | 0.4                                                         | 332                            | 0.4                |
| LU                                    | 0.1                                    | 0.3                                     | 0.3                                                      | 0.2                                           | 0.2                                              | 0.1                                                         | 191                            | 0.2                |
| LV                                    | 0.2                                    | 0.1                                     | 0.4                                                      | 0.1                                           | 0.3                                              | 0.3                                                         | 193                            | 0.2                |
| MT                                    | 0.1                                    | 0.3                                     | 1.9                                                      | 0.3                                           | 0.2                                              | 0.4                                                         | 350                            | 0.4                |
| NL                                    | 8.0                                    | 2.8                                     | 11.9                                                     | 4.4                                           | 4.5                                              | 7.7                                                         | 4,175                          | 5.2                |
| PL                                    | 4.9                                    | 5.7                                     | 4.1                                                      | 6.6                                           | 6.7                                              | 3.2                                                         | 4,868                          | 6.1                |
| PT                                    | 1.0                                    | 1.3                                     | 1.5                                                      | 1.3                                           | 2.0                                              | 2.2                                                         | 1,358                          | 1.7                |
| RO                                    | 2.6                                    | 4.5                                     | 2.5                                                      | 3.9                                           | 2.8                                              | 1.1                                                         | 2,545                          | 3.2                |
| SE                                    | 3.7                                    | 1.5                                     | 2.2                                                      | 2.6                                           | 2.7                                              | 2.4                                                         | 1,955                          | 2.4                |
| SI                                    | 0.6                                    | 1.2                                     | 0.6                                                      | 1.5                                           | 1.2                                              | 1.4                                                         | 946                            | 1.2                |
| SK                                    | 0.8                                    | 2.1                                     | 2.0                                                      | 2.1                                           | 1.4                                              | 0.4                                                         | 1,342                          | 1.7                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>795</b>                             | <b>13,398</b>                           | <b>8,996</b>                                             | <b>14,834</b>                                 | <b>39,210</b>                                    | <b>3,225</b>                                                | <b>80,458</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 26: LITHUANIA's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 0.4                                    | 1.5                                     | 1.7                                                      | 1.6                                           | 1.7                                              | 0.6                                                         | 44                             | 1.6                |
| BE                                    | 14.7                                   | 1.4                                     | 0.5                                                      | 0.7                                           | 2.2                                              | 0.4                                                         | 33                             | 1.2                |
| BG                                    | 5.0                                    | 0.4                                     | 0.5                                                      | 0.8                                           | 1.0                                              | 0.1                                                         | 18                             | 0.7                |
| CY                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.2                                           | 0.1                                              | 0.2                                                         | 3                              | 0.1                |
| CZ                                    | 0.8                                    | 0.5                                     | 1.6                                                      | 2.1                                           | 3.1                                              | 5.8                                                         | 55                             | 2.0                |
| DE                                    | 9.9                                    | 17.5                                    | 15.7                                                     | 22.8                                          | 13.7                                             | 10.3                                                        | 469                            | 16.8               |
| DK                                    | 9.3                                    | 7.5                                     | 1.7                                                      | 3.6                                           | 3.6                                              | 0.9                                                         | 105                            | 3.8                |
| EE                                    | 9.6                                    | 6.0                                     | 16.3                                                     | 6.9                                           | 8.8                                              | 5.5                                                         | 278                            | 10.0               |
| ES                                    | 2.1                                    | 0.7                                     | 1.6                                                      | 1.9                                           | 2.4                                              | 6.0                                                         | 51                             | 1.8                |
| FI                                    | 5.2                                    | 9.5                                     | 1.8                                                      | 6.6                                           | 5.0                                              | 1.5                                                         | 144                            | 5.2                |
| FR                                    | 2.6                                    | 3.4                                     | 2.8                                                      | 2.3                                           | 3.5                                              | 15.6                                                        | 99                             | 3.5                |
| GB                                    | 4.8                                    | 8.9                                     | 5.5                                                      | 5.1                                           | 4.6                                              | 16.6                                                        | 179                            | 6.4                |
| GR                                    | 0.1                                    | 0.2                                     | 0.5                                                      | 0.2                                           | 0.4                                              | 0.4                                                         | 9                              | 0.3                |
| HR                                    | 0.5                                    | 0.3                                     | 0.3                                                      | 0.3                                           | 1.8                                              | 0.3                                                         | 17                             | 0.6                |
| HU                                    | 0.6                                    | 0.5                                     | 0.8                                                      | 7.2                                           | 1.2                                              | 0.3                                                         | 59                             | 2.1                |
| IE                                    | 0.1                                    | 0.5                                     | 0.2                                                      | 0.1                                           | 0.3                                              | 1.5                                                         | 9                              | 0.3                |
| IT                                    | 0.2                                    | 1.5                                     | 3.9                                                      | 3.7                                           | 1.7                                              | 3.2                                                         | 78                             | 2.8                |
| <b>LT</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| LU                                    | 0.0                                    | 0.0                                     | 0.1                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 2                              | 0.1                |
| LV                                    | 16.0                                   | 11.5                                    | 22.9                                                     | 13.1                                          | 20.8                                             | 8.7                                                         | 483                            | 17.3               |
| MT                                    | 0.0                                    | 0.0                                     | 0.1                                                      | 0.0                                           | 0.2                                              | 0.0                                                         | 2                              | 0.1                |
| NL                                    | 2.5                                    | 3.0                                     | 4.7                                                      | 4.3                                           | 4.6                                              | 10.6                                                        | 124                            | 4.4                |
| PL                                    | 6.2                                    | 7.5                                     | 12.0                                                     | 5.8                                           | 9.2                                              | 2.9                                                         | 245                            | 8.8                |
| PT                                    | 3.9                                    | 0.2                                     | 0.5                                                      | 0.2                                           | 0.6                                              | 2.8                                                         | 14                             | 0.5                |
| RO                                    | 0.8                                    | 1.0                                     | 0.7                                                      | 2.1                                           | 1.1                                              | 0.3                                                         | 31                             | 1.1                |
| SE                                    | 3.9                                    | 15.7                                    | 2.4                                                      | 7.7                                           | 7.4                                              | 2.9                                                         | 210                            | 7.5                |
| SI                                    | 0.1                                    | 0.2                                     | 0.6                                                      | 0.2                                           | 0.4                                              | 0.7                                                         | 11                             | 0.4                |
| SK                                    | 0.6                                    | 0.4                                     | 0.5                                                      | 0.4                                           | 0.8                                              | 1.9                                                         | 16                             | 0.6                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>9</b>                               | <b>618</b>                              | <b>868</b>                                               | <b>558</b>                                    | <b>616</b>                                       | <b>120</b>                                                  | <b>2,789</b>                   | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 27: LUXEMBOURG's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 1.4                                    | 1.2                                     | 1.3                                                      | 2.7                                           | 2.9                                              | 4.7                                                         | 76                             | 2.0                |
| BE                                    | 21.3                                   | 10.3                                    | 5.7                                                      | 11.1                                          | 8.8                                              | 37.9                                                        | 315                            | 8.2                |
| BG                                    | 0.0                                    | 0.4                                     | 0.1                                                      | 1.0                                           | 0.4                                              | 0.1                                                         | 13                             | 0.3                |
| CY                                    | 0.0                                    | 0.0                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 1                              | 0.0                |
| CZ                                    | 0.4                                    | 1.0                                     | 12.8                                                     | 4.2                                           | 2.8                                              | 0.1                                                         | 276                            | 7.2                |
| DE                                    | 9.1                                    | 39.2                                    | 11.9                                                     | 26.2                                          | 25.7                                             | 10.2                                                        | 798                            | 20.8               |
| DK                                    | 0.4                                    | 0.6                                     | 0.7                                                      | 0.2                                           | 1.1                                              | 1.8                                                         | 30                             | 0.8                |
| EE                                    | 0.0                                    | 0.0                                     | 0.1                                                      | 0.0                                           | 0.3                                              | 0.0                                                         | 6                              | 0.2                |
| ES                                    | 4.1                                    | 1.1                                     | 3.5                                                      | 5.7                                           | 4.8                                              | 4.3                                                         | 151                            | 3.9                |
| FI                                    | 0.8                                    | 0.5                                     | 1.5                                                      | 0.2                                           | 0.8                                              | 0.2                                                         | 38                             | 1.0                |
| FR                                    | 22.4                                   | 26.2                                    | 10.9                                                     | 19.1                                          | 21.0                                             | 34.0                                                        | 649                            | 17.0               |
| GB                                    | 10.4                                   | 1.2                                     | 11.0                                                     | 3.4                                           | 4.4                                              | 0.6                                                         | 262                            | 6.8                |
| GR                                    | 0.2                                    | 0.1                                     | 0.6                                                      | 0.1                                           | 0.4                                              | 0.1                                                         | 15                             | 0.4                |
| HR                                    | 0.0                                    | 0.1                                     | 0.2                                                      | 0.1                                           | 0.3                                              | 0.1                                                         | 8                              | 0.2                |
| HU                                    | 0.3                                    | 0.6                                     | 1.9                                                      | 1.2                                           | 1.4                                              | 0.1                                                         | 57                             | 1.5                |
| IE                                    | 0.3                                    | 0.3                                     | 4.2                                                      | 0.1                                           | 0.8                                              | 0.0                                                         | 83                             | 2.2                |
| IT                                    | 6.1                                    | 2.7                                     | 8.8                                                      | 9.9                                           | 10.0                                             | 2.2                                                         | 327                            | 8.6                |
| LT                                    | 1.0                                    | 1.0                                     | 0.9                                                      | 0.2                                           | 0.3                                              | 0.0                                                         | 24                             | 0.6                |
| <b>LU</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| LV                                    | 0.0                                    | 0.2                                     | 0.2                                                      | 0.0                                           | 0.0                                              | 0.1                                                         | 5                              | 0.1                |
| MT                                    | 0.0                                    | 0.0                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 1                              | 0.0                |
| NL                                    | 9.5                                    | 3.4                                     | 4.6                                                      | 3.4                                           | 3.8                                              | 2.7                                                         | 155                            | 4.1                |
| PL                                    | 3.1                                    | 6.0                                     | 5.0                                                      | 3.4                                           | 4.1                                              | 0.3                                                         | 175                            | 4.6                |
| PT                                    | 0.2                                    | 1.5                                     | 0.6                                                      | 0.4                                           | 1.5                                              | 0.1                                                         | 35                             | 0.9                |
| RO                                    | 7.6                                    | 0.7                                     | 0.4                                                      | 2.9                                           | 0.9                                              | 0.2                                                         | 34                             | 0.9                |
| SE                                    | 0.6                                    | 0.5                                     | 11.5                                                     | 0.9                                           | 2.2                                              | 0.2                                                         | 230                            | 6.0                |
| SI                                    | 0.1                                    | 0.8                                     | 0.2                                                      | 0.9                                           | 0.5                                              | 0.0                                                         | 16                             | 0.4                |
| SK                                    | 0.6                                    | 0.3                                     | 1.5                                                      | 2.4                                           | 0.8                                              | 0.0                                                         | 48                             | 1.2                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>7</b>                               | <b>413</b>                              | <b>1,754</b>                                             | <b>452</b>                                    | <b>1,195</b>                                     | <b>47</b>                                                   | <b>3,869</b>                   | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 28: LATVIA's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 0.0                                    | 2.6                                     | 1.7                                                      | 0.6                                           | 1.3                                              | 1.8                                                         | 32                             | 1.7                |
| BE                                    | 0.0                                    | 3.8                                     | 0.4                                                      | 0.4                                           | 0.8                                              | 1.3                                                         | 24                             | 1.2                |
| BG                                    | 0.0                                    | 0.0                                     | 0.5                                                      | 0.0                                           | 0.3                                              | 0.4                                                         | 6                              | 0.3                |
| CY                                    | -                                      | 0.0                                     | 0.4                                                      | 0.0                                           | 0.1                                              | 0.5                                                         | 5                              | 0.2                |
| CZ                                    | 1.6                                    | 0.2                                     | 5.2                                                      | 0.7                                           | 0.9                                              | 0.8                                                         | 52                             | 2.7                |
| DE                                    | 22.3                                   | 3.9                                     | 10.4                                                     | 11.7                                          | 12.1                                             | 4.0                                                         | 180                            | 9.3                |
| DK                                    | 2.4                                    | 17.5                                    | 0.4                                                      | 13.6                                          | 8.7                                              | 0.3                                                         | 142                            | 7.4                |
| EE                                    | 11.3                                   | 8.3                                     | 14.1                                                     | 16.5                                          | 17.9                                             | 15.0                                                        | 264                            | 13.7               |
| ES                                    | 0.0                                    | 0.7                                     | 4.0                                                      | 1.0                                           | 1.7                                              | 1.4                                                         | 47                             | 2.4                |
| FI                                    | 2.6                                    | 5.8                                     | 0.8                                                      | 1.5                                           | 3.9                                              | 0.6                                                         | 48                             | 2.5                |
| FR                                    | 0.1                                    | 1.2                                     | 1.9                                                      | 11.2                                          | 1.9                                              | 7.1                                                         | 61                             | 3.2                |
| GB                                    | 0.0                                    | 13.4                                    | 3.1                                                      | 3.3                                           | 2.6                                              | 3.9                                                         | 103                            | 5.3                |
| GR                                    | 0.0                                    | 0.1                                     | 0.6                                                      | 0.1                                           | 0.2                                              | 1.3                                                         | 7                              | 0.4                |
| HR                                    | 0.0                                    | 0.0                                     | 0.2                                                      | 0.1                                           | 0.4                                              | 0.6                                                         | 3                              | 0.2                |
| HU                                    | 0.4                                    | 0.2                                     | 2.3                                                      | 0.6                                           | 1.2                                              | 0.5                                                         | 27                             | 1.4                |
| IE                                    | 0.0                                    | 1.8                                     | 0.1                                                      | 0.9                                           | 0.2                                              | 0.3                                                         | 12                             | 0.6                |
| IT                                    | 0.0                                    | 0.5                                     | 4.8                                                      | 1.1                                           | 1.7                                              | 12.7                                                        | 57                             | 3.0                |
| LT                                    | 23.7                                   | 11.0                                    | 33.0                                                     | 25.8                                          | 22.9                                             | 28.5                                                        | 491                            | 25.5               |
| LU                                    | -                                      | 0.1                                     | 0.6                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 6                              | 0.3                |
| <b>LV</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| MT                                    | 0.0                                    | 0.0                                     | 0.1                                                      | 0.0                                           | 0.1                                              | 0.0                                                         | 2                              | 0.1                |
| NL                                    | 2.9                                    | 4.4                                     | 2.9                                                      | 2.7                                           | 4.7                                              | 7.3                                                         | 68                             | 3.5                |
| PL                                    | 0.2                                    | 2.7                                     | 6.5                                                      | 2.6                                           | 4.4                                              | 3.2                                                         | 91                             | 4.7                |
| PT                                    | 0.0                                    | 0.1                                     | 0.6                                                      | 0.4                                           | 0.1                                              | 0.1                                                         | 7                              | 0.4                |
| RO                                    | -                                      | 0.2                                     | 0.3                                                      | 0.1                                           | 0.4                                              | 0.6                                                         | 5                              | 0.3                |
| SE                                    | 32.4                                   | 21.4                                    | 1.8                                                      | 4.1                                           | 9.6                                              | 6.6                                                         | 150                            | 7.8                |
| SI                                    | 0.0                                    | 0.0                                     | 0.8                                                      | 0.5                                           | 0.3                                              | 0.1                                                         | 10                             | 0.5                |
| SK                                    | 0.0                                    | 0.1                                     | 2.4                                                      | 0.3                                           | 1.4                                              | 1.1                                                         | 27                             | 1.4                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>7</b>                               | <b>424</b>                              | <b>897</b>                                               | <b>281</b>                                    | <b>285</b>                                       | <b>32</b>                                                   | <b>1,925</b>                   | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations



**Table 29: MALTA's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | -                                      | 0.0                                     | 0.1                                                      | 1.1                                           | 2.0                                              | -                                                           | 3                              | 0.6                |
| BE                                    | -                                      | 16.2                                    | 0.2                                                      | 0.7                                           | 0.1                                              | 1.7                                                         | 2                              | 0.6                |
| BG                                    | -                                      | 0.1                                     | 0.0                                                      | 0.0                                           | 0.2                                              | 0.0                                                         | 0                              | 0.0                |
| CY                                    | -                                      | 0.0                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 0                              | 0.0                |
| CZ                                    | -                                      | 0.6                                     | 0.1                                                      | 0.9                                           | 1.3                                              | 0.0                                                         | 2                              | 0.5                |
| DE                                    | -                                      | 34.1                                    | 7.7                                                      | 33.9                                          | 55.9                                             | 40.0                                                        | 100                            | 25.1               |
| DK                                    | -                                      | 0.0                                     | 0.0                                                      | 0.1                                           | 0.8                                              | -                                                           | 1                              | 0.2                |
| EE                                    | -                                      | -                                       | 0.0                                                      | 0.0                                           | 0.0                                              | -                                                           | 0                              | 0.0                |
| ES                                    | -                                      | 4.8                                     | 0.2                                                      | 2.4                                           | 2.4                                              | 0.0                                                         | 5                              | 1.2                |
| FI                                    | -                                      | 0.0                                     | 0.1                                                      | 0.1                                           | 1.0                                              | -                                                           | 1                              | 0.2                |
| FR                                    | -                                      | 2.4                                     | 77.3                                                     | 11.4                                          | 6.7                                              | 6.4                                                         | 165                            | 41.7               |
| GB                                    | -                                      | 2.2                                     | 1.7                                                      | 7.1                                           | 2.5                                              | 2.9                                                         | 14                             | 3.5                |
| GR                                    | -                                      | 14.9                                    | 0.0                                                      | 0.0                                           | 0.5                                              | 0.5                                                         | 1                              | 0.3                |
| HR                                    | -                                      | 0.0                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.2                                                         | 0                              | 0.0                |
| HU                                    | -                                      | 1.2                                     | 0.2                                                      | 14.0                                          | 0.2                                              | -                                                           | 16                             | 4.1                |
| IE                                    | -                                      | -                                       | 0.1                                                      | 1.4                                           | -                                                | 0.1                                                         | 2                              | 0.4                |
| IT                                    | 28,3                                   | 16.9                                    | 5.8                                                      | 14.1                                          | 22.8                                             | 36.9                                                        | 53                             | 13.3               |
| LT                                    | -                                      | -                                       | -                                                        | 0.0                                           | 0.1                                              | -                                                           | 0                              | 0.0                |
| LU                                    | -                                      | -                                       | 0.0                                                      | -                                             | -                                                | -                                                           | 0                              | 0.0                |
| LV                                    | -                                      | 0.0                                     | 0.2                                                      | 0.0                                           | 0.1                                              | 0.0                                                         | 0                              | 0.1                |
| <b>MT</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| NL                                    | 71,7                                   | 6.3                                     | 3.2                                                      | 9.2                                           | 1.6                                              | 9.5                                                         | 21                             | 5.2                |
| PL                                    | -                                      | 0.3                                     | 0.1                                                      | 0.3                                           | 0.8                                              | 0.0                                                         | 1                              | 0.2                |
| PT                                    | -                                      | 0.0                                     | 0.0                                                      | 1.8                                           | 0.0                                              | -                                                           | 2                              | 0.5                |
| RO                                    | -                                      | 0.0                                     | 1.2                                                      | 0.4                                           | 0.0                                              | -                                                           | 3                              | 0.7                |
| SE                                    | -                                      | 0.1                                     | 1.9                                                      | 0.6                                           | 0.1                                              | 0.5                                                         | 5                              | 1.1                |
| SI                                    | -                                      | -                                       | 0.0                                                      | 0.1                                           | 0.7                                              | 1.2                                                         | 1                              | 0.2                |
| SK                                    | -                                      | -                                       | 0.0                                                      | 0.5                                           | 0.1                                              | -                                                           | 1                              | 0.2                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>0</b>                               | <b>4</b>                                | <b>189</b>                                               | <b>112</b>                                    | <b>58</b>                                        | <b>32</b>                                                   | <b>396</b>                     | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 30: NETHERLAND's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 2.2                                    | 2.2                                     | 1.3                                                      | 1.6                                           | 2.1                                              | 2.4                                                         | 2,575                          | 1.6                |
| BE                                    | 9.9                                    | 14.8                                    | 6.6                                                      | 11.3                                          | 12.8                                             | 6.7                                                         | 13,595                         | 8.7                |
| BG                                    | 0.1                                    | 0.2                                     | 0.3                                                      | 0.3                                           | 0.3                                              | 0.2                                                         | 471                            | 0.3                |
| CY                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.2                                              | 0.1                                                         | 191                            | 0.1                |
| CZ                                    | 1.9                                    | 2.2                                     | 6.1                                                      | 2.3                                           | 1.9                                              | 1.6                                                         | 6,819                          | 4.3                |
| DE                                    | 31.7                                   | 37.3                                    | 25.7                                                     | 36.9                                          | 30.3                                             | 24.6                                                        | 44,300                         | 28.2               |
| DK                                    | 6.3                                    | 2.6                                     | 1.9                                                      | 1.8                                           | 2.1                                              | 1.6                                                         | 3,024                          | 1.9                |
| EE                                    | 0.3                                    | 0.2                                     | 0.3                                                      | 0.4                                           | 0.2                                              | 0.1                                                         | 443                            | 0.3                |
| ES                                    | 2.7                                    | 2.8                                     | 5.0                                                      | 3.5                                           | 4.5                                              | 8.7                                                         | 7,778                          | 5.0                |
| FI                                    | 3.6                                    | 1.1                                     | 1.7                                                      | 1.0                                           | 1.4                                              | 1.3                                                         | 2,362                          | 1.5                |
| FR                                    | 8.6                                    | 10.2                                    | 14.6                                                     | 10.8                                          | 13.3                                             | 15.5                                                        | 21,671                         | 13.8               |
| GB                                    | 8.8                                    | 8.6                                     | 11.8                                                     | 8.4                                           | 10.6                                             | 13.3                                                        | 17,532                         | 11.2               |
| GR                                    | 0.3                                    | 0.3                                     | 0.7                                                      | 0.4                                           | 0.9                                              | 0.8                                                         | 1,074                          | 0.7                |
| HR                                    | 0.2                                    | 0.2                                     | 0.2                                                      | 0.2                                           | 0.2                                              | 0.1                                                         | 314                            | 0.2                |
| HU                                    | 1.8                                    | 1.6                                     | 2.4                                                      | 1.6                                           | 1.8                                              | 0.5                                                         | 3,173                          | 2.0                |
| IE                                    | 1.0                                    | 1.1                                     | 1.7                                                      | 1.1                                           | 1.2                                              | 1.4                                                         | 2,307                          | 1.5                |
| IT                                    | 5.6                                    | 4.3                                     | 5.8                                                      | 5.7                                           | 6.0                                              | 11.2                                                        | 9,683                          | 6.2                |
| LT                                    | 0.3                                    | 0.3                                     | 0.3                                                      | 0.3                                           | 0.3                                              | 0.2                                                         | 415                            | 0.3                |
| LU                                    | 0.2                                    | 0.5                                     | 0.4                                                      | 0.6                                           | 0.6                                              | 0.2                                                         | 683                            | 0.4                |
| LV                                    | 0.3                                    | 0.2                                     | 0.1                                                      | 0.2                                           | 0.2                                              | 0.1                                                         | 260                            | 0.2                |
| MT                                    | 0.1                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.1                                              | 0.1                                                         | 112                            | 0.1                |
| <b>NL</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| PL                                    | 7.5                                    | 3.5                                     | 4.7                                                      | 4.7                                           | 3.6                                              | 2.9                                                         | 6,776                          | 4.3                |
| PT                                    | 0.8                                    | 1.0                                     | 1.2                                                      | 1.3                                           | 1.1                                              | 1.5                                                         | 1,878                          | 1.2                |
| RO                                    | 1.0                                    | 0.9                                     | 0.9                                                      | 1.1                                           | 1.0                                              | 0.5                                                         | 1,395                          | 0.9                |
| SE                                    | 4.2                                    | 3.0                                     | 5.4                                                      | 3.0                                           | 2.4                                              | 3.9                                                         | 6,863                          | 4.4                |
| SI                                    | 0.2                                    | 0.2                                     | 0.2                                                      | 0.3                                           | 0.3                                              | 0.2                                                         | 334                            | 0.2                |
| SK                                    | 0.2                                    | 0.7                                     | 0.6                                                      | 0.9                                           | 0.4                                              | 0.2                                                         | 865                            | 0.6                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>361</b>                             | <b>8,882</b>                            | <b>90,865</b>                                            | <b>15,776</b>                                 | <b>28,270</b>                                    | <b>12,875</b>                                               | <b>157,028</b>                 | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 31: POLAND's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 3.6                                    | 2.9                                     | 2.0                                                      | 3.9                                           | 3.1                                              | 1.7                                                         | 1,637                          | 2.9                |
| BE                                    | 4.8                                    | 3.7                                     | 1.2                                                      | 4.3                                           | 3.3                                              | 1.8                                                         | 1,687                          | 3.0                |
| BG                                    | 0.2                                    | 0.4                                     | 0.3                                                      | 0.4                                           | 0.7                                              | 0.5                                                         | 251                            | 0.4                |
| CY                                    | 0.0                                    | 0.0                                     | 0.1                                                      | 0.0                                           | 0.0                                              | 0.5                                                         | 32                             | 0.1                |
| CZ                                    | 5.0                                    | 5.7                                     | 6.1                                                      | 3.9                                           | 5.6                                              | 4.0                                                         | 2,962                          | 5.3                |
| DE                                    | 43.3                                   | 38.9                                    | 29.6                                                     | 33.7                                          | 38.1                                             | 42.8                                                        | 19,393                         | 34.5               |
| DK                                    | 4.2                                    | 2.6                                     | 2.0                                                      | 2.6                                           | 1.8                                              | 3.8                                                         | 1,283                          | 2.3                |
| EE                                    | 1.1                                    | 0.5                                     | 0.3                                                      | 0.5                                           | 0.5                                              | 1.4                                                         | 262                            | 0.5                |
| ES                                    | 1.5                                    | 2.5                                     | 4.2                                                      | 3.1                                           | 2.6                                              | 2.9                                                         | 1,815                          | 3.2                |
| FI                                    | 1.6                                    | 1.8                                     | 0.7                                                      | 1.2                                           | 1.5                                              | 0.9                                                         | 693                            | 1.2                |
| FR                                    | 4.0                                    | 6.5                                     | 8.2                                                      | 11.3                                          | 8.2                                              | 7.1                                                         | 4,927                          | 8.8                |
| GB                                    | 4.4                                    | 5.0                                     | 12.0                                                     | 6.6                                           | 6.7                                              | 8.8                                                         | 4,524                          | 8.0                |
| GR                                    | 0.2                                    | 0.4                                     | 0.9                                                      | 0.5                                           | 0.2                                              | 0.3                                                         | 310                            | 0.6                |
| HR                                    | 0.4                                    | 0.5                                     | 0.2                                                      | 0.5                                           | 0.4                                              | 0.8                                                         | 214                            | 0.4                |
| HU                                    | 2.5                                    | 3.3                                     | 2.9                                                      | 3.8                                           | 4.1                                              | 1.4                                                         | 1,935                          | 3.4                |
| IE                                    | 0.4                                    | 0.2                                     | 1.6                                                      | 0.3                                           | 0.4                                              | 0.3                                                         | 405                            | 0.7                |
| IT                                    | 2.9                                    | 4.4                                     | 5.4                                                      | 5.9                                           | 5.2                                              | 6.7                                                         | 2,999                          | 5.3                |
| LT                                    | 2.4                                    | 1.8                                     | 0.9                                                      | 1.2                                           | 1.6                                              | 1.2                                                         | 737                            | 1.3                |
| LU                                    | 0.0                                    | 0.3                                     | 0.1                                                      | 0.1                                           | 0.1                                              | 0.0                                                         | 72                             | 0.1                |
| LV                                    | 1.0                                    | 0.6                                     | 0.6                                                      | 0.8                                           | 0.6                                              | 0.5                                                         | 372                            | 0.7                |
| MT                                    | 0.0                                    | 0.0                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 14                             | 0.0                |
| NL                                    | 7.1                                    | 6.1                                     | 12.2                                                     | 5.1                                           | 4.3                                              | 5.1                                                         | 4,106                          | 7.3                |
| <b>PL</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| PT                                    | 0.1                                    | 0.7                                     | 0.9                                                      | 0.5                                           | 0.4                                              | 0.5                                                         | 369                            | 0.7                |
| RO                                    | 1.9                                    | 2.6                                     | 1.7                                                      | 2.0                                           | 2.5                                              | 2.4                                                         | 1,204                          | 2.1                |
| SE                                    | 4.9                                    | 5.1                                     | 4.0                                                      | 5.2                                           | 5.5                                              | 2.5                                                         | 2,710                          | 4.8                |
| SI                                    | 0.7                                    | 0.3                                     | 0.2                                                      | 0.5                                           | 0.4                                              | 0.5                                                         | 193                            | 0.3                |
| SK                                    | 1.4                                    | 3.1                                     | 1.5                                                      | 2.0                                           | 2.2                                              | 1.4                                                         | 1,151                          | 2.0                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>345</b>                             | <b>9,532</b>                            | <b>17,259</b>                                            | <b>16,117</b>                                 | <b>11,924</b>                                    | <b>1,081</b>                                                | <b>56,258</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 32: PORTUGAL's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 0.1                                    | 1.5                                     | 0.9                                                      | 4.2                                           | 0.5                                              | 0.4                                                         | 156                            | 1.6                |
| BE                                    | 1.0                                    | 3.9                                     | 1.2                                                      | 3.8                                           | 2.2                                              | 4.5                                                         | 261                            | 2.7                |
| BG                                    | 0.6                                    | 0.2                                     | 0.5                                                      | 0.4                                           | 0.5                                              | 0.0                                                         | 40                             | 0.4                |
| CY                                    | 0.0                                    | 0.0                                     | 0.0                                                      | 0.0                                           | 0.1                                              | 0.2                                                         | 6                              | 0.1                |
| CZ                                    | 0.3                                    | 2.2                                     | 0.3                                                      | 1.0                                           | 0.5                                              | 0.3                                                         | 93                             | 1.0                |
| DE                                    | 2.2                                    | 13.6                                    | 41.3                                                     | 33.1                                          | 28.3                                             | 8.0                                                         | 2,767                          | 28.8               |
| DK                                    | 0.1                                    | 0.6                                     | 0.1                                                      | 0.2                                           | 0.3                                              | 1.9                                                         | 31                             | 0.3                |
| EE                                    | 0.1                                    | 0.1                                     | 0.0                                                      | 0.1                                           | 0.0                                              | 0.1                                                         | 6                              | 0.1                |
| ES                                    | 32.1                                   | 28.2                                    | 18.5                                                     | 17.0                                          | 28.3                                             | 23.8                                                        | 2,194                          | 22.9               |
| FI                                    | 0.2                                    | 0.5                                     | 0.4                                                      | 0.3                                           | 0.2                                              | 0.1                                                         | 33                             | 0.3                |
| FR                                    | 48.6                                   | 29.6                                    | 9.6                                                      | 13.1                                          | 14.8                                             | 18.8                                                        | 1,618                          | 16.9               |
| GB                                    | 2.4                                    | 6.1                                     | 11.5                                                     | 7.0                                           | 9.6                                              | 11.2                                                        | 843                            | 8.8                |
| GR                                    | 0.3                                    | 0.5                                     | 0.1                                                      | 1.3                                           | 0.2                                              | 0.1                                                         | 45                             | 0.5                |
| HR                                    | -                                      | 0.4                                     | 0.0                                                      | 0.1                                           | 0.1                                              | 0.0                                                         | 13                             | 0.1                |
| HU                                    | 0.0                                    | 0.8                                     | 2.6                                                      | 1.7                                           | 0.8                                              | 0.2                                                         | 148                            | 1.5                |
| IE                                    | 0.5                                    | 0.8                                     | 0.0                                                      | 1.6                                           | 0.3                                              | 0.5                                                         | 59                             | 0.6                |
| IT                                    | 1.9                                    | 2.2                                     | 1.8                                                      | 3.1                                           | 4.8                                              | 6.8                                                         | 278                            | 2.9                |
| LT                                    | 0.0                                    | 0.1                                     | 0.0                                                      | 0.2                                           | 0.1                                              | 0.3                                                         | 10                             | 0.1                |
| LU                                    | 0.0                                    | 0.2                                     | 0.0                                                      | 0.1                                           | 0.3                                              | 0.1                                                         | 13                             | 0.1                |
| LV                                    | 0.0                                    | 0.0                                     | 0.4                                                      | 0.0                                           | 0.0                                              | 0.1                                                         | 13                             | 0.1                |
| MT                                    | 0.4                                    | 0.0                                     | 0.0                                                      | 0.1                                           | 0.1                                              | 0.0                                                         | 4                              | 0.0                |
| NL                                    | 0.4                                    | 2.5                                     | 2.3                                                      | 2.8                                           | 2.4                                              | 16.6                                                        | 276                            | 2.9                |
| PL                                    | 1.8                                    | 2.2                                     | 1.1                                                      | 2.6                                           | 2.4                                              | 3.1                                                         | 192                            | 2.0                |
| <b>PT</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| RO                                    | 1.2                                    | 0.7                                     | 0.7                                                      | 4.1                                           | 1.3                                              | 0.2                                                         | 144                            | 1.5                |
| SE                                    | 1.6                                    | 1.6                                     | 1.9                                                      | 1.3                                           | 1.4                                              | 2.4                                                         | 154                            | 1.6                |
| SI                                    | 0.5                                    | 0.2                                     | 0.4                                                      | 0.1                                           | 0.0                                              | 0.0                                                         | 21                             | 0.2                |
| SK                                    | 3.6                                    | 1.1                                     | 4.2                                                      | 1.0                                           | 0.4                                              | 0.1                                                         | 177                            | 1.8                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>8</b>                               | <b>2,498</b>                            | <b>2,939</b>                                             | <b>1,921</b>                                  | <b>1,970</b>                                     | <b>259</b>                                                  | <b>9,596</b>                   | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 33: ROMANIA's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 1.3                                    | 2.0                                     | 2.7                                                      | 3.6                                           | 3.8                                              | 4.5                                                         | 599                            | 3.3                |
| BE                                    | 1.1                                    | 1.9                                     | 2.5                                                      | 2.8                                           | 2.4                                              | 9.7                                                         | 470                            | 2.6                |
| BG                                    | 0.8                                    | 2.3                                     | 1.6                                                      | 1.7                                           | 2.1                                              | 7.9                                                         | 347                            | 1.9                |
| CY                                    | 0.0                                    | 0.2                                     | 0.1                                                      | 0.1                                           | 0.0                                              | 0.2                                                         | 12                             | 0.1                |
| CZ                                    | 1.2                                    | 3.5                                     | 1.9                                                      | 6.6                                           | 2.9                                              | 1.7                                                         | 743                            | 4.1                |
| DE                                    | 27.9                                   | 26.6                                    | 35.3                                                     | 41.5                                          | 39.1                                             | 23.7                                                        | 6,857                          | 37.7               |
| DK                                    | 0.7                                    | 0.7                                     | 0.4                                                      | 0.4                                           | 1.3                                              | 0.1                                                         | 118                            | 0.6                |
| EE                                    | 0.4                                    | 0.1                                     | 0.6                                                      | 0.0                                           | 0.4                                              | 0.0                                                         | 50                             | 0.3                |
| ES                                    | 2.8                                    | 5.1                                     | 2.7                                                      | 2.4                                           | 2.8                                              | 1.5                                                         | 516                            | 2.8                |
| FI                                    | 0.4                                    | 1.2                                     | 0.8                                                      | 0.6                                           | 0.5                                              | 0.5                                                         | 123                            | 0.7                |
| FR                                    | 8.7                                    | 10.7                                    | 6.2                                                      | 6.6                                           | 12.4                                             | 10.7                                                        | 1,548                          | 8.5                |
| GB                                    | 10.3                                   | 3.3                                     | 6.0                                                      | 3.6                                           | 6.7                                              | 7.5                                                         | 921                            | 5.1                |
| GR                                    | 0.2                                    | 0.5                                     | 1.1                                                      | 0.6                                           | 0.3                                              | 7.1                                                         | 120                            | 0.7                |
| HR                                    | 0.5                                    | 0.3                                     | 0.0                                                      | 0.1                                           | 0.3                                              | 0.6                                                         | 33                             | 0.2                |
| HU                                    | 4.1                                    | 7.1                                     | 5.1                                                      | 6.0                                           | 6.2                                              | 4.4                                                         | 1,074                          | 5.9                |
| IE                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.1                                           | 0.1                                              | 1.1                                                         | 14                             | 0.1                |
| IT                                    | 28.8                                   | 21.0                                    | 22.0                                                     | 10.5                                          | 7.9                                              | 10.3                                                        | 2,487                          | 13.7               |
| LT                                    | 0.1                                    | 0.1                                     | 0.2                                                      | 0.2                                           | 0.1                                              | 0.3                                                         | 27                             | 0.1                |
| LU                                    | 0.1                                    | 0.0                                     | 0.0                                                      | 0.1                                           | 0.0                                              | 0.0                                                         | 9                              | 0.0                |
| LV                                    | 0.0                                    | 0.0                                     | 0.2                                                      | 0.0                                           | 0.0                                              | 0.0                                                         | 11                             | 0.1                |
| MT                                    | 0.0                                    | 0.0                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.1                                                         | 4                              | 0.0                |
| NL                                    | 4.6                                    | 3.4                                     | 3.1                                                      | 3.7                                           | 2.6                                              | 4.4                                                         | 589                            | 3.2                |
| PL                                    | 4.8                                    | 3.1                                     | 3.8                                                      | 4.2                                           | 4.2                                              | 1.8                                                         | 727                            | 4.0                |
| PT                                    | 0.1                                    | 0.2                                     | 0.3                                                      | 0.3                                           | 0.3                                              | 0.0                                                         | 49                             | 0.3                |
| <b>RO</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| SE                                    | 0.1                                    | 3.4                                     | 0.6                                                      | 1.0                                           | 1.1                                              | 1.5                                                         | 208                            | 1.1                |
| SI                                    | 0.1                                    | 0.4                                     | 0.7                                                      | 0.5                                           | 0.3                                              | 0.2                                                         | 85                             | 0.5                |
| SK                                    | 1.0                                    | 2.9                                     | 1.7                                                      | 2.9                                           | 2.4                                              | 0.2                                                         | 444                            | 2.4                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>64</b>                              | <b>1,749</b>                            | <b>4,425</b>                                             | <b>6,835</b>                                  | <b>4,955</b>                                     | <b>155</b>                                                  | <b>18,183</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 34: SWEDEN's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 2.7                                    | 0.7                                     | 1.4                                                      | 1.2                                           | 2.2                                              | 0.5                                                         | 313                            | 1.6                |
| BE                                    | 4.2                                    | 8.7                                     | 1.9                                                      | 2.5                                           | 10.4                                             | 3.2                                                         | 1,200                          | 6.0                |
| BG                                    | 0.1                                    | 0.2                                     | 0.2                                                      | 0.4                                           | 0.6                                              | 0.1                                                         | 73                             | 0.4                |
| CY                                    | 0.0                                    | 0.0                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.1                                                         | 6                              | 0.0                |
| CZ                                    | 9.8                                    | 3.4                                     | 1.0                                                      | 2.2                                           | 2.0                                              | 0.4                                                         | 378                            | 1.9                |
| DE                                    | 8.6                                    | 12.8                                    | 13.2                                                     | 17.1                                          | 18.9                                             | 16.1                                                        | 3,216                          | 16.1               |
| DK                                    | 18.2                                   | 14.5                                    | 33.1                                                     | 19.1                                          | 8.0                                              | 16.2                                                        | 3,747                          | 18.7               |
| EE                                    | 2.5                                    | 2.1                                     | 1.8                                                      | 2.0                                           | 1.1                                              | 0.5                                                         | 314                            | 1.6                |
| ES                                    | 2.1                                    | 2.1                                     | 2.1                                                      | 2.5                                           | 4.6                                              | 1.5                                                         | 619                            | 3.1                |
| FI                                    | 13.5                                   | 12.0                                    | 18.0                                                     | 19.7                                          | 10.0                                             | 15.9                                                        | 2,904                          | 14.5               |
| FR                                    | 8.2                                    | 4.6                                     | 3.3                                                      | 5.9                                           | 9.2                                              | 7.5                                                         | 1,259                          | 6.3                |
| GB                                    | 8.1                                    | 5.9                                     | 5.1                                                      | 7.5                                           | 7.8                                              | 9.4                                                         | 1,352                          | 6.7                |
| GR                                    | 0.1                                    | 0.4                                     | 0.3                                                      | 0.4                                           | 0.9                                              | 0.5                                                         | 109                            | 0.5                |
| HR                                    | 0.2                                    | 0.2                                     | 0.3                                                      | 0.3                                           | 0.2                                              | 0.2                                                         | 52                             | 0.3                |
| HU                                    | 0.7                                    | 1.3                                     | 1.2                                                      | 0.9                                           | 1.1                                              | 0.3                                                         | 220                            | 1.1                |
| IE                                    | 0.3                                    | 0.4                                     | 0.6                                                      | 0.4                                           | 1.0                                              | 0.7                                                         | 140                            | 0.7                |
| IT                                    | 4.5                                    | 1.8                                     | 2.7                                                      | 5.0                                           | 6.2                                              | 3.6                                                         | 866                            | 4.3                |
| LT                                    | 0.4                                    | 1.5                                     | 0.8                                                      | 1.2                                           | 0.7                                              | 0.3                                                         | 181                            | 0.9                |
| LU                                    | 0.1                                    | 0.1                                     | 0.0                                                      | 0.1                                           | 0.4                                              | 0.0                                                         | 38                             | 0.2                |
| LV                                    | 0.7                                    | 0.9                                     | 1.6                                                      | 0.4                                           | 0.7                                              | 0.2                                                         | 185                            | 0.9                |
| MT                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.0                                           | 0.1                                              | 0.0                                                         | 12                             | 0.1                |
| NL                                    | 3.4                                    | 17.8                                    | 7.5                                                      | 3.4                                           | 6.4                                              | 21.0                                                        | 1,588                          | 7.9                |
| PL                                    | 9.1                                    | 6.2                                     | 2.6                                                      | 5.9                                           | 4.9                                              | 0.9                                                         | 876                            | 4.4                |
| PT                                    | 0.8                                    | 0.5                                     | 0.2                                                      | 0.4                                           | 0.7                                              | 0.2                                                         | 89                             | 0.4                |
| RO                                    | 0.4                                    | 0.6                                     | 0.3                                                      | 0.5                                           | 0.7                                              | 0.3                                                         | 106                            | 0.5                |
| <b>SE</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| SI                                    | 0.2                                    | 0.3                                     | 0.1                                                      | 0.4                                           | 0.6                                              | 0.1                                                         | 73                             | 0.4                |
| SK                                    | 1.0                                    | 1.0                                     | 0.5                                                      | 0.6                                           | 0.6                                              | 0.3                                                         | 121                            | 0.6                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>97</b>                              | <b>2,121</b>                            | <b>6,286</b>                                             | <b>3,305</b>                                  | <b>7,588</b>                                     | <b>638</b>                                                  | <b>20,036</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Table 35: SLOVENIA's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 17.2                                   | 17.5                                    | 3.2                                                      | 4.9                                           | 15.2                                             | 1.8                                                         | 813                            | 10.0               |
| BE                                    | 2.1                                    | 1.5                                     | 1.2                                                      | 1.0                                           | 1.3                                              | 1.1                                                         | 100                            | 1.2                |
| BG                                    | 0.1                                    | 1.5                                     | 1.8                                                      | 0.7                                           | 0.6                                              | 0.2                                                         | 77                             | 0.9                |
| CY                                    | 0.0                                    | 0.0                                     | 0.4                                                      | 0.1                                           | 0.0                                              | 0.1                                                         | 9                              | 0.1                |
| CZ                                    | 2.1                                    | 2.6                                     | 1.8                                                      | 3.5                                           | 2.8                                              | 1.5                                                         | 231                            | 2.8                |
| DE                                    | 21.6                                   | 34.5                                    | 14.8                                                     | 38.8                                          | 30.4                                             | 28.6                                                        | 2,615                          | 32.0               |
| DK                                    | 0.9                                    | 0.3                                     | 2.9                                                      | 1.6                                           | 2.4                                              | 0.3                                                         | 142                            | 1.7                |
| EE                                    | 0.2                                    | 0.1                                     | 0.3                                                      | 0.2                                           | 0.2                                              | 0.2                                                         | 14                             | 0.2                |
| ES                                    | 1.6                                    | 0.7                                     | 1.2                                                      | 4.4                                           | 1.3                                              | 3.2                                                         | 193                            | 2.4                |
| FI                                    | 0.2                                    | 0.3                                     | 0.5                                                      | 0.5                                           | 0.5                                              | 0.3                                                         | 38                             | 0.5                |
| FR                                    | 2.3                                    | 4.6                                     | 2.6                                                      | 5.7                                           | 4.6                                              | 3.7                                                         | 383                            | 4.7                |
| GB                                    | 0.1                                    | 3.8                                     | 2.6                                                      | 2.8                                           | 2.1                                              | 0.6                                                         | 217                            | 2.7                |
| GR                                    | 0.1                                    | 0.1                                     | 1.1                                                      | 0.3                                           | 0.2                                              | 0.2                                                         | 30                             | 0.4                |
| HR                                    | 11.2                                   | 8.0                                     | 11.1                                                     | 4.4                                           | 9.3                                              | 9.1                                                         | 619                            | 7.6                |
| HU                                    | 1.8                                    | 3.8                                     | 11.6                                                     | 6.4                                           | 6.4                                              | 1.9                                                         | 525                            | 6.4                |
| IE                                    | 0.1                                    | 0.5                                     | 0.2                                                      | 0.2                                           | 0.4                                              | 0.0                                                         | 24                             | 0.3                |
| IT                                    | 21.9                                   | 8.1                                     | 8.5                                                      | 7.1                                           | 6.9                                              | 38.1                                                        | 701                            | 8.6                |
| LT                                    | 0.4                                    | 0.2                                     | 0.4                                                      | 0.2                                           | 0.1                                              | 0.2                                                         | 16                             | 0.2                |
| LU                                    | -                                      | 0.2                                     | 0.0                                                      | 0.0                                           | 0.1                                              | 0.0                                                         | 7                              | 0.1                |
| LV                                    | 0.2                                    | 0.0                                     | 0.3                                                      | 0.1                                           | 0.1                                              | 0.2                                                         | 7                              | 0.1                |
| MT                                    | 0.0                                    | 0.0                                     | 0.1                                                      | 0.0                                           | 0.1                                              | 0.1                                                         | 5                              | 0.1                |
| NL                                    | 0.3                                    | 1.1                                     | 5.0                                                      | 3.3                                           | 1.5                                              | 0.6                                                         | 201                            | 2.5                |
| PL                                    | 3.1                                    | 3.0                                     | 4.9                                                      | 4.5                                           | 3.3                                              | 1.4                                                         | 312                            | 3.8                |
| PT                                    | 0.7                                    | 0.1                                     | 0.3                                                      | 0.3                                           | 0.2                                              | 1.6                                                         | 23                             | 0.3                |
| RO                                    | 4.8                                    | 1.7                                     | 10.0                                                     | 2.5                                           | 3.8                                              | 2.1                                                         | 300                            | 3.7                |
| SE                                    | 5.3                                    | 1.0                                     | 0.6                                                      | 3.6                                           | 1.4                                              | 0.4                                                         | 162                            | 2.0                |
| <b>SI</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| SK                                    | 1.6                                    | 4.6                                     | 12.6                                                     | 2.8                                           | 4.7                                              | 2.7                                                         | 402                            | 4.9                |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>24</b>                              | <b>1,457</b>                            | <b>1,053</b>                                             | <b>2,888</b>                                  | <b>2,453</b>                                     | <b>293</b>                                                  | <b>8,168</b>                   | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations



**Table 36: SLOVAKIA's intra EU-exports of engineering goods by engineering sector and country of destination, 2019**

|                                       | Tube or pipe fittings of iron or steel | Manufacture of metal products (NACE 25) | Manufacture of electronic and optical products (NACE 26) | Manufacture of electrical equipment (NACE 27) | Manufacture of machinery and equipment (NACE 28) | Manufacture of medical instruments and supplies (NACE 32.5) | EEI total (Value in Mio. Euro) | share of total EEI |
|---------------------------------------|----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|--------------------------------------------------|-------------------------------------------------------------|--------------------------------|--------------------|
|                                       | Share within category (column %)       |                                         |                                                          |                                               |                                                  |                                                             | €                              | %                  |
| AT                                    | 3.9                                    | 7.3                                     | 4.0                                                      | 3.9                                           | 5.9                                              | 3.2                                                         | 1,181                          | 4.9                |
| BE                                    | 1.7                                    | 1.5                                     | 0.4                                                      | 2.3                                           | 2.6                                              | 0.9                                                         | 353                            | 1.5                |
| BG                                    | 0.1                                    | 0.8                                     | 2.4                                                      | 0.8                                           | 0.6                                              | 0.7                                                         | 349                            | 1.4                |
| CY                                    | -                                      | 0.0                                     | 0.1                                                      | 0.0                                           | 0.0                                              | 0.1                                                         | 14                             | 0.1                |
| CZ                                    | 19.9                                   | 12.4                                    | 11.1                                                     | 10.3                                          | 9.3                                              | 19.6                                                        | 2,606                          | 10.7               |
| DE                                    | 46.6                                   | 29.7                                    | 20.1                                                     | 35.2                                          | 36.2                                             | 7.0                                                         | 6,816                          | 28.1               |
| DK                                    | 0.3                                    | 1.3                                     | 0.3                                                      | 1.6                                           | 0.9                                              | 0.5                                                         | 195                            | 0.8                |
| EE                                    | 0.1                                    | 0.1                                     | 0.2                                                      | 0.2                                           | 0.1                                              | 0.1                                                         | 31                             | 0.1                |
| ES                                    | 1.0                                    | 2.2                                     | 2.8                                                      | 4.9                                           | 4.4                                              | 1.1                                                         | 842                            | 3.5                |
| FI                                    | 0.1                                    | 0.5                                     | 0.2                                                      | 0.7                                           | 0.6                                              | 0.1                                                         | 100                            | 0.4                |
| FR                                    | 3.0                                    | 8.8                                     | 4.2                                                      | 6.4                                           | 7.1                                              | 3.0                                                         | 1,441                          | 5.9                |
| GB                                    | 2.1                                    | 4.5                                     | 6.2                                                      | 3.8                                           | 4.5                                              | 3.5                                                         | 1,240                          | 5.1                |
| GR                                    | -                                      | 0.1                                     | 0.6                                                      | 0.2                                           | 0.1                                              | 0.3                                                         | 86                             | 0.4                |
| HR                                    | 0.0                                    | 0.8                                     | 1.6                                                      | 0.6                                           | 0.3                                              | 0.6                                                         | 239                            | 1.0                |
| HU                                    | 5.8                                    | 6.8                                     | 7.3                                                      | 6.3                                           | 4.7                                              | 3.0                                                         | 1,552                          | 6.4                |
| IE                                    | 0.0                                    | 0.1                                     | 0.1                                                      | 0.2                                           | 0.3                                              | 0.0                                                         | 37                             | 0.2                |
| IT                                    | 1.2                                    | 4.0                                     | 6.0                                                      | 5.0                                           | 8.6                                              | 4.4                                                         | 1,500                          | 6.2                |
| LT                                    | 0.5                                    | 1.7                                     | 0.4                                                      | 0.3                                           | 0.3                                              | 0.3                                                         | 121                            | 0.5                |
| LU                                    | 0.0                                    | 0.2                                     | 0.0                                                      | 0.3                                           | 0.0                                              | 0.0                                                         | 23                             | 0.1                |
| LV                                    | 0.5                                    | 0.1                                     | 0.7                                                      | 0.1                                           | 0.1                                              | 0.3                                                         | 90                             | 0.4                |
| MT                                    | -                                      | 0.0                                     | 0.0                                                      | 0.0                                           | 0.0                                              | 0.1                                                         | 4                              | 0.0                |
| NL                                    | 1.6                                    | 2.0                                     | 5.8                                                      | 3.0                                           | 2.6                                              | 37.4                                                        | 1,018                          | 4.2                |
| PL                                    | 9.8                                    | 10.0                                    | 15.0                                                     | 7.8                                           | 5.0                                              | 4.6                                                         | 2,542                          | 10.5               |
| PT                                    | 0.2                                    | 0.4                                     | 0.4                                                      | 0.3                                           | 0.2                                              | 0.3                                                         | 78                             | 0.3                |
| RO                                    | 0.7                                    | 3.1                                     | 6.4                                                      | 2.3                                           | 3.1                                              | 1.0                                                         | 1,055                          | 4.3                |
| SE                                    | 0.7                                    | 1.0                                     | 3.0                                                      | 2.5                                           | 1.8                                              | 7.4                                                         | 582                            | 2.4                |
| SI                                    | 0.1                                    | 0.6                                     | 0.9                                                      | 1.2                                           | 0.6                                              | 0.3                                                         | 202                            | 0.8                |
| <b>SK</b>                             | -                                      | -                                       | -                                                        | -                                             | -                                                | -                                                           | -                              | -                  |
| <b>EU27 + UK (in Mio. Euro =100%)</b> | <b>29</b>                              | <b>3,190</b>                            | <b>10,475</b>                                            | <b>4,365</b>                                  | <b>6,083</b>                                     | <b>154</b>                                                  | <b>24,296</b>                  | <b>100</b>         |

Note: Data are based on the CN-classification and engineering goods as defined in the frame of the present study.

Source: Eurostat, International trade in goods; own calculations

**Evolution in EU export data in the machinery and transport equipment sectors (SITC 7) December 2019 – June 2020 (supporting COVID-19 impacts analysis – see Section 5.1.4).**

An overview of export data in the machinery and transport equipment sectors (SITC 7) is provided below. This is again at a higher level of aggregation, where the impacts on exports by sub-sector within engineering were presented:

**Table 37: Overview of EU and global level export data on machinery and transport equipment sectors in selected competitor countries.**

| PARTNER/TIME                                                                 | 2019M12  | 2020M01  | 2020M02  | 2020M03  | 2020M04  | 2020M05  | 2020M06  |
|------------------------------------------------------------------------------|----------|----------|----------|----------|----------|----------|----------|
| EU-27 countries (from 2020)                                                  | 86,920.6 | 92,624.4 | 94,478.5 | 84,575.4 | 49,537.1 | 65,681.6 | :        |
| UK                                                                           | 8,990.2  | 9,733.1  | 10,435.7 | 11,551.6 | 4,044.5  | 4,918.1  | 7,764.5  |
| EFTA                                                                         | 4,510.0  | 4,718.5  | 4,824.0  | 4,637.3  | 3,268.9  | 3,973.5  | 5,073.0  |
| Norway                                                                       | 1,702.4  | 1,677.7  | 1,628.9  | 1,669.1  | 1,190.6  | 1,386.8  | 1,874.0  |
| Switzerland                                                                  | 2,698.0  | 2,918.7  | 3,066.7  | 2,838.7  | 1,983.7  | 2,482.2  | 3,087.6  |
| Candidate countries from 2015 (5 countries)                                  | 3,030.2  | 2,744.2  | 3,113.8  | 2,899.2  | 1,856.5  | 2,066.8  | 3,191.6  |
| Turkey                                                                       | 2,466.7  | 2,152.5  | 2,467.0  | 2,369.2  | 1,558.0  | 1,629.3  | 2,567.5  |
| WBC - Western Balkan Countries (aggregate changing according to the context) | 708.4    | 718.7    | 799.9    | 653.5    | 375.6    | 545.5    | 774.2    |
| Russia                                                                       | 2,957.4  | 2,774.3  | 3,273.3  | 3,044.4  | 2,142.2  | 2,293.8  | 2,935.3  |
| Extra-EU27 (from 2020)                                                       | 74,080.9 | 63,416.3 | 68,558.2 | 67,797.8 | 40,668.2 | 46,534.3 | 61,158.3 |
| European non-EU27 countries (from 2020)                                      | 20,750.6 | 21,036.3 | 22,841.9 | 23,245.4 | 12,052.9 | 14,185.7 | 20,201.3 |
| Africa                                                                       | 4,797.0  | 3,687.2  | 4,192.6  | 3,766.4  | 2,056.2  | 2,431.4  | 3,357.9  |
| America                                                                      | 17,767.5 | 16,388.9 | 18,495.4 | 17,483.4 | 9,562.3  | 10,606.9 | 13,707.0 |
| Canada                                                                       | 1,056.9  | 1,061.1  | 1,402.8  | 1,148.8  | 627.1    | 652.2    | 1,055.1  |
| United States                                                                | 11,440.2 | 11,620.3 | 12,880.8 | 12,601.4 | 6,816.1  | 7,728.5  | 9,997.5  |
| Latin American countries                                                     | 4,708.7  | 3,545.4  | 3,631.1  | 3,575.0  | 1,946.5  | 1,992.7  | 2,485.7  |
| Brazil                                                                       | 1,468.3  | 934.7    | 1,036.1  | 1,042.3  | 543.8    | 572.2    | 701.7    |
| Asia                                                                         | 28,723.7 | 20,571.6 | 21,461.7 | 21,575.4 | 16,045.9 | 17,490.8 | 21,716.0 |
| China except Hong Kong                                                       | 9,948.1  | 7,672.6  | 7,069.3  | 7,942.2  | 7,336.7  | 7,411.4  | 9,365.1  |
| Hong Kong                                                                    | 637.8    | 501.4    | 556.8    | 609.3    | 497.1    | 489.5    | 553.6    |
| Japan                                                                        | 1,753.4  | 1,723.4  | 1,739.7  | 1,759.2  | 952.2    | 1,274.8  | 1,409.4  |
| South Korea                                                                  | 1,805.5  | 1,804.9  | 2,390.4  | 2,404.6  | 1,203.3  | 1,876.8  | 2,145.9  |
| Taiwan                                                                       | 2,084.9  | 1,150.8  | 998.7    | 926.3    | 901.6    | 831.1    | 1,181.3  |
| India                                                                        | 1,972.2  | 958.0    | 1,329.8  | 1,259.9  | 441.9    | 592.2    | 1,148.4  |
| Singapore                                                                    | 1,008.3  | 1,179.9  | 1,202.1  | 861.3    | 713.0    | 666.4    | 732.9    |
| Thailand                                                                     | 595.2    | 449.7    | 389.5    | 440.4    | 331.1    | 341.9    | 378.0    |
| Australia                                                                    | 1,061.7  | 915.1    | 1,042.4  | 992.4    | 636.8    | 851.3    | 1,091.1  |

Source: - Eurostat, International trade in goods data, EU27 (from 2020) trade by SITC product group [ext\_st\_eu27\_2020sitc], Trade value in million EURO, SITC7, Machinery and transport equipment

The previous table shows a broadly similar position in terms of exports compared with the situation in Europe. Depending when the pandemic hit different economic regions globally, there was a significant decline in exports for a three - four month period, followed by a partial recovery. The data shows that the fall in exports hit Asia one-two months earlier than Europe, but that the severity of the decline in exports was broadly similar between Europe and major competitor countries.

Specifically regarding EU trade with China, exports were a major area of focus, as some sub-sectors within the EU engineering industries are strongly export-oriented. The data on machinery and transport equipment is provided month by month in the table below.

**Table 38: Data on EU exports to China in machinery and transport equipment sectors in selected competitor countries.**

| Country                                                                                                                | Dec. 2019     | Jan. 2020     | Feb. 2020     | Mar. 2020     | Apr. 2020     | May. 2020     | Jun. 2020     |
|------------------------------------------------------------------------------------------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| EU27_2020 (AT, BE, BG, CY, CZ, DE, DK, EE, ES, FI, FR, GR, HR, HU, IE, IT, LT, LU, LV, MT, NL, PL, PT, RO, SE, SI, SK) | 9,948,075,758 | 7,672,638,509 | 7,069,251,022 | 7,942,194,874 | 7,336,675,769 | 7,411,438,495 | 9,365,137,043 |
| <b>Percentage change month on month</b>                                                                                | <b>NA</b>     | <b>-22.9%</b> | <b>-28.9%</b> | <b>-20.2%</b> | <b>-26.3%</b> | <b>-25.5%</b> | <b>-5.9%</b>  |
| BELGIUM (and LUXBG -> 1998)                                                                                            | 113,200,373   | 104,753,228   | 108,257,235   | 122,267,746   | 114,846,537   | 113,030,137   | 119,845,753   |
| BULGARIA                                                                                                               | 10,540,824    | 5,779,030     | 5,562,870     | 5,426,893     | 7,538,124     | 10,783,535    | 6,131,639     |
| CZECHIA (CS->1992)                                                                                                     | 100,380,417   | 92,821,632    | 89,626,099    | 104,844,314   | 104,515,190   | 99,832,781    | 114,353,747   |
| DENMARK                                                                                                                | 88,906,151    | 78,110,500    | 58,447,963    | 93,275,674    | 91,725,508    | 83,790,608    | 101,048,575   |
| GERMANY (incl DD from 1991)                                                                                            | 5,843,878,162 | 4,868,420,673 | 4,404,968,994 | 4,981,597,128 | 4,600,656,275 | 4,632,763,656 | 5,846,050,677 |
| ESTONIA                                                                                                                | 4,524,723     | 3,069,288     | 2,501,859     | 4,876,409     | 7,175,771     | 3,981,818     | 7,823,336     |
| IRELAND                                                                                                                | 604,349,851   | 592,818,396   | 562,540,294   | 560,028,520   | 532,608,770   | 591,934,270   | 475,197,239   |
| SPAIN                                                                                                                  | 83,888,252    | 68,317,531    | 74,485,522    | 77,829,440    | 62,532,898    | 71,673,444    | 82,110,607    |
| FRANCE                                                                                                                 | 1,157,401,436 | 390,355,106   | 292,168,685   | 427,223,048   | 341,563,652   | 280,960,060   | 439,841,562   |
| CROATIA                                                                                                                | 6,024,984     | 2,470,819     | 2,263,787     | 3,844,368     | 6,459,546     | 2,169,343     | 1,413,178     |
| ITALY                                                                                                                  | 496,448,945   | 325,588,388   | 311,570,018   | 396,206,426   | 270,829,462   | 349,500,827   | 453,288,477   |
| CYPRUS                                                                                                                 | 137,074       | 190,323       | 6,786         | 142,918       | 62,473,612    | 24,965        | 17,463        |
| LATVIA                                                                                                                 | 1,871,677     | 1,062,461     | 874,839       | 3,289,094     | 1,328,391     | 1,648,713     | 3,778,741     |
| LITHUANIA                                                                                                              | 2,161,592     | 2,425,677     | 1,970,660     | 2,130,597     | 2,443,150     | 2,116,615     | 4,508,192     |
| LUXEMBOURG                                                                                                             | 5,496,691     | 2,751,320     | 3,299,656     | 4,905,785     | 4,074,471     | 5,651,478     | 5,756,309     |
| HUNGARY                                                                                                                | 69,543,919    | 63,278,617    | 49,265,341    | 56,982,911    | 64,150,351    | 63,701,239    | 69,504,599    |
| MALTA                                                                                                                  | 1,326,139     | 1,023,277     | 422,397       | 525,464       | 637,613       | 538,086       | 422,284       |
| NETHERLANDS                                                                                                            | 528,730,458   | 368,845,064   | 473,975,479   | 343,626,805   | 453,237,688   | 423,100,092   | 617,299,278   |
| AUSTRIA                                                                                                                | 202,794,024   | 130,230,528   | 116,835,856   | 170,297,019   | 134,404,265   | 188,081,920   | 188,896,613   |
| POLAND                                                                                                                 | 116,928,857   | 70,731,734    | 67,873,122    | 89,406,179    | 98,994,747    | 108,277,959   | 126,066,286   |
| PORTUGAL                                                                                                               | 8,116,109     | 5,003,587     | 3,725,862     | 5,696,849     | 6,510,558     | 3,056,948     | 5,588,170     |
| ROMANIA                                                                                                                | 24,394,795    | 17,147,392    | 16,322,000    | 21,586,708    | 25,395,204    | 21,431,944    | 22,768,353    |
| SLOVENIA                                                                                                               | 13,966,173    | 8,491,958     | 12,770,497    | 18,279,290    | 16,912,855    | 15,869,666    | 17,818,381    |
| SLOVAKIA                                                                                                               | 81,610,832    | 98,704,431    | 89,293,149    | 63,656,794    | 36,049,800    | 65,699,862    | 260,862,292   |
| FINLAND                                                                                                                | 93,452,270    | 87,561,783    | 87,841,612    | 77,297,111    | 83,097,046    | 69,762,245    | 88,697,620    |
| SWEDEN                                                                                                                 | 279,247,139   | 276,991,029   | 226,591,271   | 303,228,929   | 195,589,605   | 180,797,927   | 294,521,490   |
| EUROZONE (Evol.)                                                                                                       | 9,252,108,672 | 7,065,307,756 | 6,553,298,569 | 7,263,598,898 | 6,742,307,494 | 6,840,653,159 | 8,629,329,176 |

Source: Eurostat -, International trade in goods, data on exports

The above table covers the EU-27 as a whole, and also provides disaggregated data on exports by EU Member State between December 2019 and June 2020. The data shows that compared with December 2019 as a baseline for the pre-COVID situation, exports of machinery declined significantly, with a significant drop in the period January – May 2020, with the low-point being February 2020, where the reduction in exports was 28.9% compared with December 2019, whereas the percentage decline in June 2020 had declined to 5.9%. This data corresponds to the timing of the pandemic being at its worst in China in January and February 2020, but trade being curtailed in Europe later in the March to May 2020 period, with a recovery in the volume of exports by June 2020.

## TECHNOLOGICAL COMPETITION

Table 39: Comparison of ICB and NACE classifications

| ICB Industry         | ICB Supersector                  | ICB3 Sector                              | ICB4 Subsector                     | ICB Definition                                                                                                                                                                                                                                                                                                                                                                                                                    | NACE engineering industries correspondence                                                                        |
|----------------------|----------------------------------|------------------------------------------|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| 0001 Oil & Gas       |                                  |                                          |                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                   | none                                                                                                              |
| 1000 Basic Materials |                                  |                                          |                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                   | none                                                                                                              |
| 2000 Industrials     | 2300 Construction & Materials    | <b>2350 Construction &amp; Materials</b> | 2353 Building Materials & Fixtures | Producers of materials used in the construction and refurbishment of buildings and structures, including cement and other aggregates, wooden beams and frames, paint, glass, roofing and flooring materials other than carpets. Includes producers of bathroom and kitchen fixtures, plumbing supplies and central air-conditioning and heating equipment. Excludes producers of raw lumber, which are classified under Forestry. | 25 a lot of headings<br>25.21 central heating radiators & boilers<br>28.25 air conditioning, ventilating, heating |
|                      |                                  |                                          | 2357 Heavy Construction            |                                                                                                                                                                                                                                                                                                                                                                                                                                   | none                                                                                                              |
|                      | 2700 Industrial Goods & Services | <b>2710 Aerospace &amp; Defence</b>      | 2713 Aerospace                     |                                                                                                                                                                                                                                                                                                                                                                                                                                   | none                                                                                                              |
|                      |                                  |                                          | 2717 Defence                       | Producers of components and equipment for the defence industry, including military aircraft, radar equipment and weapons.                                                                                                                                                                                                                                                                                                         | 26.51 radar, navigation, instruments                                                                              |
|                      |                                  | <b>2720 General Industrials</b>          | 2723 Containers & Packaging        | Makers and distributors of cardboard, bags, boxes, cans, drums, bottles and jars and glass used for packaging.                                                                                                                                                                                                                                                                                                                    | none                                                                                                              |
|                      |                                  |                                          | 2727 Diversified Industrials       | Industrial companies engaged in three or more classes of business within the Industrial industry that differ substantially from each other.                                                                                                                                                                                                                                                                                       | Some, depends on companies                                                                                        |

| ICB Industry        | ICB Supersector          | ICB3 Sector                                       | ICB4 Subsector                                              | ICB Definition                                                                                                                                                                                                                                                                                                                             | NACE engineering industries correspondence                                                                         |
|---------------------|--------------------------|---------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
|                     |                          | <b>2730 Electronic &amp; Electrical Equipment</b> | 2733 Electrical Components & Equipment                      | Makers and distributors of electrical parts for finished products, such as printed circuit boards for radios, televisions and other consumer electronics. Includes makers of cables, wires, ceramics, transistors (???), electric adapters and security cameras.                                                                           | 26.11.50 Printed circuit boards<br>26.11.21.50 Transistors (should be with semiconductors)<br>27 a lot of headings |
|                     |                          |                                                   | 2737 Electronic Equipment                                   | Manufacturers and distributors of electronic products used in different industries. Includes makers of lasers, smart cards, bar scanners, fingerprinting equipment and other electronic factory equipment.                                                                                                                                 | 26.12.30 smart cards<br>26.51 measuring and control equipment<br>27 some headings<br>28 some headings              |
|                     |                          | <b>2750 Industrial Engineering</b>                | 2753 Commercial Vehicles & Trucks, Ships, Railway equipment |                                                                                                                                                                                                                                                                                                                                            | none                                                                                                               |
|                     |                          |                                                   | 2757 Industrial Machinery                                   | Designers, manufacturers, distributors and installers of industrial machinery and factory equipment, such as machine tools, lathes, presses and assembly line equipment. Includes makers of pollution control equipment, castings, pressings, welded shapes, structural steelwork, compressors, pumps, bearings, elevators and escalators. | 25 many headings<br>27.12 switching and control equipment<br>28 many headings                                      |
|                     |                          | <b>2770 Industrial Transportation</b>             |                                                             |                                                                                                                                                                                                                                                                                                                                            | none                                                                                                               |
|                     |                          | <b>2790 Support Services</b>                      |                                                             |                                                                                                                                                                                                                                                                                                                                            | none                                                                                                               |
| 3000 Consumer Goods | 3300 Automobiles & Parts | <b>3350 Automobiles &amp; Parts</b>               | 3353 Automobiles                                            |                                                                                                                                                                                                                                                                                                                                            |                                                                                                                    |

| ICB Industry | ICB Supersector                 | ICB3 Sector                                         | ICB4 Subsector                     | ICB Definition                                                                                                                                                                                                  | NACE engineering industries correspondence                                                                                      |
|--------------|---------------------------------|-----------------------------------------------------|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
|              |                                 |                                                     | 3355 Auto Parts                    | Manufacturers and distributors of new and replacement parts for motorcycles and automobiles, such as engines, carburetors and batteries. Excludes producers of tires, which are classified under Tires.         | 27.2 batteries                                                                                                                  |
|              |                                 |                                                     | 3357 Tires                         |                                                                                                                                                                                                                 | none                                                                                                                            |
|              | 3500 Food & Beverage            |                                                     |                                    |                                                                                                                                                                                                                 |                                                                                                                                 |
|              | 3700 Personal & Household Goods | <b>3720 Household Goods &amp; Home Construction</b> | 3722 Durable Household Products    | Manufacturers and distributors of domestic appliances, lighting, hand tools and power tools, hardware, cutlery, tableware, garden equipment, luggage, towels and linens                                         | 25.7 cutlery, tools, general hardware<br>27.4 electric lighting equipment<br>27.5 domestic appliances<br>28.24 power hand tools |
|              |                                 |                                                     | 3724 Nondurable Household Products | Producers and distributors of pens, paper goods, batteries, light bulbs, tissues, toilet paper and cleaning products such as soaps and polishes                                                                 | 27.2 batteries<br>27.4 electric lighting equipment                                                                              |
|              |                                 |                                                     | 3726 Furnishings                   |                                                                                                                                                                                                                 | none                                                                                                                            |
|              |                                 |                                                     | 3728 Home Construction             |                                                                                                                                                                                                                 | none                                                                                                                            |
|              |                                 | <b>3740 Leisure Goods</b>                           | 3743 Consumer Electronics          | Manufacturers and distributors of consumer electronics, such as TVs, VCRs, DVD players, audio equipment, cable boxes, calculators and camcorders                                                                | 26.4 consumer electronics                                                                                                       |
|              |                                 |                                                     | 3745 Recreational Products         | Manufacturers and distributors of recreational equipment. Includes musical instruments, photographic equipment and supplies, RVs, ATVs and marine recreational vehicles such as yachts, dinghies and speedboats | 26.7 optical instruments, photographic equipment                                                                                |
|              |                                 |                                                     | 3747 Toys                          | Manufacturers and distributors of toys and video/computer games, including such toys and games as playing cards, board games, stuffed animals and dolls                                                         | 26.4 consumer electronics                                                                                                       |



| ICB Industry           | ICB Supersector  | ICB3 Sector                                      | ICB4 Subsector              | ICB Definition                                                                                                                                                                                                                                                                                                    | NACE engineering industries correspondence |
|------------------------|------------------|--------------------------------------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
|                        |                  | <b>3760 Personal Goods</b>                       | 3763 Clothing & Accessories | Manufacturers and distributors of all types of clothing, jewellery, watches or textiles. Includes sportswear, sunglasses, eyeglass frames, leather clothing and goods, and processors of hides and skins                                                                                                          | 26.52 watches and clocks                   |
|                        |                  |                                                  | 3765 Footwear               |                                                                                                                                                                                                                                                                                                                   | <i>none</i>                                |
|                        |                  |                                                  | 3767 Personal Products      | Makers and distributors of cosmetics, toiletries and personal-care and hygiene products, including deodorants, soaps, toothpaste, perfumes, diapers, shampoos, razors and feminine-hygiene products. Includes makers of contraceptives other than oral contraceptives, which are classified under Pharmaceuticals | 27.5 domestic appliances                   |
|                        |                  |                                                  | 3785 Tobacco                |                                                                                                                                                                                                                                                                                                                   | <i>none</i>                                |
| 4000 Health Care       | 4500 Health Care | <b>4530 Health Care Equipment &amp; Services</b> | 4533 Health Care Providers  |                                                                                                                                                                                                                                                                                                                   |                                            |
|                        |                  |                                                  | 4535 Medical Equipment      | Manufacturers and distributors of medical devices such as MRI scanners, prosthetics, pacemakers, X-ray machines and other non-disposable medical devices.                                                                                                                                                         | 26.6 electromedical equipment              |
|                        |                  |                                                  | 4537 Medical Supplies       | Manufacturers and distributors of medical supplies used by health care providers and the general public. Includes makers of contact lenses, eyeglass lenses, bandages and other disposable medical supplies.                                                                                                      | 32.5 medical instruments & supplies        |
|                        |                  | <b>4570 Pharmaceuticals &amp; Biotechnology</b>  |                             |                                                                                                                                                                                                                                                                                                                   | <i>none</i>                                |
| 5000 Consumer Services |                  |                                                  |                             |                                                                                                                                                                                                                                                                                                                   | <i>none</i>                                |

| ICB Industry                     | ICB Supersector | ICB3 Sector                                     | ICB4 Subsector                    | ICB Definition                                                                                                                                                                                                                                                                                              | NACE engineering industries correspondence                                                                                                |
|----------------------------------|-----------------|-------------------------------------------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| 6000 Telecommunications Services |                 |                                                 |                                   |                                                                                                                                                                                                                                                                                                             | none                                                                                                                                      |
| 7000 Utilities                   |                 |                                                 |                                   |                                                                                                                                                                                                                                                                                                             | none                                                                                                                                      |
| 8000 Financials                  |                 |                                                 |                                   |                                                                                                                                                                                                                                                                                                             | none                                                                                                                                      |
| 9000 Technology                  | 9500 Technology | <b>9530 Software &amp; Computer Services</b>    |                                   |                                                                                                                                                                                                                                                                                                             | none                                                                                                                                      |
|                                  |                 | <b>9570 Technology Hardware &amp; Equipment</b> | 9572 Computer Hardware            | Manufacturers and distributors of computers, servers, mainframes, workstations and other computer hardware and subsystems, such as mass-storage drives, mice, keyboards and printers.                                                                                                                       | 26.2 computers and peripheral equipment<br>26.99.00.Z0 other data processing equipment                                                    |
|                                  |                 |                                                 | 9574 Electronic Office Equipment  | Manufacturers and distributors of electronic office equipment, including photocopiers and fax machines.                                                                                                                                                                                                     | 28.23 office equipment and machinery                                                                                                      |
|                                  |                 |                                                 | 9576 Semiconductors               | Producers and distributors of semiconductors and other integrated chips, including other products related to the semiconductor industry, such as semiconductor capital equipment and motherboards. Excludes makers of printed circuit boards, which are classified under Electrical Components & Equipment. | 26.11.21 discrete semiconductors<br>26.11.22 photo and other discrete semiconductors<br>26.11.30 integrated circuit chips                 |
|                                  |                 |                                                 | 9578 Telecommunications Equipment | Makers and distributors of high-technology communication products, including satellites, mobile telephones, fiber optics, switching devices, local and wide-area networks, teleconferencing equipment and connectivity devices for computers, including hubs and routers.                                   | 26.12.22 hubs, routers<br>26.30 communications equipment<br>26.99.00.Z4 radio telephony reception equipment<br>27.31 optical fibre cables |

Source DECISION, FTSE Russell, Eurostat

**Table 40: PCT patent publications in engineering industries<sup>1</sup> by country of origin<sup>2</sup> and field of technology, 2018**

| Rank 2018 | Country of origin | Electrical engineering |             | Instruments (optics, medical technology) |             | Mechanical engineering |             | Engineering industries total |
|-----------|-------------------|------------------------|-------------|------------------------------------------|-------------|------------------------|-------------|------------------------------|
|           |                   | Number                 | Share in %  | Number                                   | Share in %  | Number                 | Share in %  | Number                       |
| 1         | United States     | 20,135                 | 57.7        | 7,002                                    | 20.1        | 7,736                  | 22.2        | 34,873                       |
| 2         | China             | 24,677                 | 72.9        | 3,338                                    | 9.9         | 5,857                  | 17.3        | 33,872                       |
| 3         | Japan             | 16,531                 | 50.2        | 5,088                                    | 15.5        | 11,287                 | 34.3        | 32,906                       |
| <b>4</b>  | <b>EU-28</b>      | <b>12,252</b>          | <b>38.0</b> | <b>4,666</b>                             | <b>14.5</b> | <b>15,332</b>          | <b>47.5</b> | <b>32,250</b>                |
| 5         | Germany           | 4,031                  | 33.3        | 1,304                                    | 10.8        | 6,785                  | 56.0        | 12,120                       |
| 6         | South Korea       | 6,768                  | 67.0        | 1,338                                    | 13.2        | 1,993                  | 19.7        | 10,099                       |
| 7         | France            | 1,743                  | 37.9        | 560                                      | 12.2        | 2,291                  | 49.9        | 4,594                        |
| 8         | Sweden            | 1,910                  | 65.1        | 191                                      | 6.5         | 834                    | 28.4        | 2,935                        |
| 9         | United Kingdom    | 1,319                  | 45.4        | 539                                      | 18.6        | 1,045                  | 36.0        | 2,903                        |
| 10        | Netherlands       | 845                    | 35.3        | 896                                      | 37.5        | 651                    | 27.2        | 2,392                        |
| 11        | Switzerland       | 729                    | 35.4        | 459                                      | 22.3        | 874                    | 42.4        | 2,062                        |
| 12        | Italy             | 347                    | 20.0        | 228                                      | 13.1        | 1,159                  | 66.8        | 1,734                        |
| 13        | Canada            | 523                    | 40.2        | 245                                      | 18.8        | 534                    | 41.0        | 1,302                        |
| 14        | Finland           | 838                    | 65.2        | 129                                      | 10.0        | 319                    | 24.8        | 1,286                        |
| 15        | Israel            | 460                    | 41.6        | 383                                      | 34.7        | 262                    | 23.7        | 1,105                        |
| 16        | Australia         | 352                    | 38.8        | 201                                      | 22.1        | 355                    | 39.1        | 908                          |
| 17        | Austria           | 282                    | 32.9        | 88                                       | 10.3        | 486                    | 56.8        | 856                          |
| 18        | Denmark           | 150                    | 19.9        | 127                                      | 16.8        | 478                    | 63.3        | 755                          |
| 19        | India             | 319                    | 42.6        | 121                                      | 16.2        | 309                    | 41.3        | 749                          |
| 20        | Belgium           | 178                    | 28.2        | 139                                      | 22.0        | 315                    | 49.8        | 632                          |
| 21        | Spain             | 160                    | 25.4        | 144                                      | 22.9        | 326                    | 51.7        | 630                          |
| 22        | Turkey            | 193                    | 34.5        | 81                                       | 14.5        | 285                    | 51.0        | 559                          |
| 23        | Russia            | 192                    | 36.5        | 83                                       | 15.8        | 251                    | 47.7        | 526                          |
| 24        | Singapore         | 315                    | 67.6        | 53                                       | 11.4        | 98                     | 21.0        | 466                          |
| 25        | Norway            | 112                    | 29.2        | 39                                       | 10.2        | 233                    | 60.7        | 384                          |
| 26        | Ireland           | 144                    | 42.4        | 109                                      | 32.1        | 87                     | 25.6        | 340                          |
| 27        | Brazil            | 60                     | 20.5        | 66                                       | 22.5        | 167                    | 57.0        | 293                          |

Note: Countries of origin with more than 200 patent publications in 2018

Indicator 5a: PCT publications by technology and origin

<sup>1</sup> Engineering industries: Electrical engineering, Instruments - optics, medical technology, Mechanical engineering; the definition of the fields is based on the WIPO IPC technology concordance.

<sup>2</sup> Origin: For statistical purposes, the origin of an application means the country or territory of residence (or nationality, in the absence of a valid residence) of the first named applicant in the application.

Source: WIPO statistics database. Last updated: September 2020

## FINANCIAL PERFORMANCE

### Equity

#### **Note on accounting regulations**

Local accounting regulations differ across countries with regard to the valuation of or the approach to the asset / liability items as well as the timing of the realisation of profits. While the **prudence principle** and creditor protection dominate in Germany, Austria and France (despite the partial implementation of IFRS – International Financial Reporting Standards – in France), other countries have partially or fully implemented the IFRS regulations, which are dominated by the **accrual principle**.

As a result, the IFRS-inspired annual financial statements tend to have higher assets and higher equity (due to earlier realisation of profits) as compared to the annual financial statements according to the principle of prudence. This results, for example, from the obligation to recognise development costs (under certain conditions), the possibility of fair value valuation beyond acquisition costs, the reporting of partial profits from long-term construction contracts during the construction phase etc. The revaluation does not have to be carried out via the income statement. In some cases, the unrealised profit from the evaluation is recognised in other comprehensive income (OCI) and therefore directly in equity. For this purpose, a separate item “revaluation reserve” or “fair value reserve” is provided in equity.

It should be noted that annual financial statements prepared according to IFRS or inspired by IFRS can differ from one another, since IFRS also provides for some options, but above all allows many discretions based on subjective assessment.

#### **Data analysis**

**Table 41: Average equity ratio of companies in computer, electronic and optical products, 2008-2017, in %**

|                | Computer, electronic and optical products (C 26) |       |       |                                    |                                    |
|----------------|--------------------------------------------------|-------|-------|------------------------------------|------------------------------------|
|                | 2008                                             | 2013  | 2017  | Change<br>2008/2013<br>in %-points | Change<br>2013/2017<br>in %-points |
| Germany        | 29.40                                            | 29.43 | 34.22 | 0.03                               | 4.79                               |
| Italy          | 35.06                                            | 38.18 | 41.58 | 3.12                               | 3.40                               |
| France         | 29.12                                            | 36.12 | 30.87 | 7.00                               | -5.25                              |
| Spain          | 37.11                                            | 53.09 | 49.73 | 15.98                              | -3.36                              |
| Austria        | 47.42                                            | 45.35 | 37.20 | -2.07                              | -8.15                              |
| Poland         | 34.69                                            | 50.40 | 51.28 | 15.71                              | 0.88                               |
| Czech Republic | 26.10                                            | 35.90 | 52.00 | 9.80                               | 16.10                              |

Source: Bank for the Accounts of Companies Harmonized (BACH), May 2020

**Table 42: Average equity ratio of companies in electrical equipment, 2008-2017, in %**

|                | Electrical equipment (C 27) |       |       |                              |                              |
|----------------|-----------------------------|-------|-------|------------------------------|------------------------------|
|                | 2008                        | 2013  | 2017  | Change 2008/2013 in %-points | Change 2013/2017 in %-points |
| Germany        | 31.29                       | 33.23 | 34.70 | 1.94                         | 1.47                         |
| Italy          | 30.86                       | 35.31 | 40.33 | 4.45                         | 5.02                         |
| France         | 30.72                       | 37.80 | 42.40 | 7.08                         | 4.60                         |
| Spain          | 37.89                       | 39.30 | 40.27 | 1.41                         | 0.97                         |
| Austria        | 29.68                       | 31.34 | 32.10 | 1.66                         | 0.76                         |
| Poland         | 40.27                       | 45.31 | 45.19 | 5.04                         | -0.12                        |
| Czech Republic | 46.90                       | 47.00 | 54.90 | 0.10                         | 7.90                         |

Source: Bank for the Accounts of Companies Harmonized (BACH), May 2020

**Table 43: Average equity ratio of companies in repair and installation of machinery and equipment, 2008-2017, in %**

|                | Repair and installation of machinery and equipment (C 33) |       |       |                              |                              |
|----------------|-----------------------------------------------------------|-------|-------|------------------------------|------------------------------|
|                | 2008                                                      | 2013  | 2017  | Change 2008/2013 in %-points | Change 2013/2017 in %-points |
| Germany        | 18.04                                                     | 16.12 | 29.16 | -1.92                        | 13.04                        |
| Italy          | 20.47                                                     | 23.89 | 30.86 | 3.42                         | 6.97                         |
| France         | 28.61                                                     | 32.57 | 30.06 | 3.96                         | -2.51                        |
| Spain          | 39.16                                                     | 42.38 | 35.16 | 3.22                         | -7.22                        |
| Austria        | 28.45                                                     | 23.05 | 25.15 | -5.40                        | 2.10                         |
| Poland         | 47.71                                                     | 41.22 | 44.59 | -6.49                        | 3.37                         |
| Czech Republic | 48.90                                                     | 51.60 | 58.50 | 2.70                         | 6.90                         |

Source: Bank for the Accounts of Companies Harmonized (BACH), May 2020

**Table 44: Average equity ratio of companies in manufacturing, 2008-2017, in %**

|                | Manufacturing (C) |       |       |                              |                              |
|----------------|-------------------|-------|-------|------------------------------|------------------------------|
|                | 2008              | 2013  | 2017  | Change 2008/2013 in %-points | Change 2013/2017 in %-points |
| Germany        | 29.74             | 33.14 | 33.57 | 3.40                         | 0.43                         |
| Italy          | 31.25             | 34.22 | 39.38 | 2.97                         | 5.16                         |
| France         | 33.67             | 37.73 | 38.89 | 4.06                         | 1.16                         |
| Spain          | 39.55             | 41.74 | 44.15 | 2.19                         | 2.41                         |
| Austria        | 34.23             | 38.79 | 39.66 | 4.56                         | 0.87                         |
| Poland         | 46.43             | 51.73 | 52.90 | 5.30                         | 1.17                         |
| Czech Republic | 48.50             | 49.70 | 55.10 | 1.20                         | 5.40                         |

Source: Bank for the Accounts of Companies Harmonized (BACH), May 2020

### **EBT – Earnings before taxes**

#### ***Note on accounting regulations***

The EBT definition is important and useful for the comparison of the profitability of a company with its international competition, especially for companies operating worldwide.

The EBT is a key figure from business management and describes the profit that is made in a company before the deduction of income taxes. In addition, the EBT is independent of special tax effects and therefore free of tax reductions through losses carried forward or additional tax payments. In this way, the pre-tax profit is more suitable for comparing different financial years.

Considering different countries it should be noted that local accounting regulations may differ with regard to the timing of the profit recognition. In the case of local accounting regulations with a stronger implementation of IFRS, the accrual principle dominates. This means that the liquidability on the balance sheet date is a prerequisite for the recognition in the income statement.

In countries such as Germany and Austria, the prudence principle and the imparity realisation principle are decisive. This means that in case of profits, only realised profits (realisation = completion of a sales transaction) are allowed to be recorded in the income statement, but the recognisable risks and impending losses are to recognise as soon as they become known.

The accrual principle may have the consequence that in certain cases profits can be brought forward in time not affecting net income, because of the recognition in the revaluation reserve in the balance sheet and in other comprehensive income (OCI) in the income statement (e.g. revaluation of property, plant and equipment), which is not the part of EBT.

## Data analysis

**Table 45: Average EBT margin of companies in computer, electronic and optical products, 2008-2017, in %**

|                | Computer, electronic and optical products (C 26) |      |      |                              |                              |
|----------------|--------------------------------------------------|------|------|------------------------------|------------------------------|
|                | 2008                                             | 2013 | 2017 | Change 2008/2013 in %-points | Change 2013/2017 in %-points |
| Germany        | -5.00                                            | 7.10 | 7.00 | 12.10                        | -0.10                        |
| Italy          | 3.12                                             | 3.96 | 5.98 | 0.84                         | 2.02                         |
| France         | 0.96                                             | 0.56 | 5.44 | -0.40                        | 4.88                         |
| Spain          | 0.98                                             | 0.40 | 4.61 | -0.58                        | 4.21                         |
| Austria        | 4.66                                             | 5.93 | 7.84 | 1.27                         | 1.91                         |
| Poland         | 0.56                                             | 3.86 | 2.58 | 3.30                         | -1.28                        |
| Czech Republic | -2.10                                            | 1.40 | 5.70 | 3.50                         | 4.30                         |

Source: Bank for the Accounts of Companies Harmonized (BACH), May 2020

**Table 46: Average EBT margin of companies in electrical equipment, 2008-2017, in %**

|                | Electrical equipment (C 27) |       |      |                              |                              |
|----------------|-----------------------------|-------|------|------------------------------|------------------------------|
|                | 2008                        | 2013  | 2017 | Change 2008/2013 in %-points | Change 2013/2017 in %-points |
| Germany        | 5.12                        | 3.37  | 4.42 | -1.75                        | 1.05                         |
| Italy          | 3.55                        | 2.95  | 4.94 | -0.60                        | 1.99                         |
| France         | 5.94                        | 7.41  | 7.33 | 1.47                         | -0.08                        |
| Spain          | 4.48                        | 1.20  | 2.19 | -3.28                        | 0.99                         |
| Austria        | 7.25                        | 10.77 | 8.62 | 3.52                         | -2.15                        |
| Poland         | 4.68                        | 4.25  | 2.89 | -0.43                        | -1.36                        |
| Czech Republic | 2.90                        | 6.00  | 6.30 | 3.10                         | 0.30                         |

Source: Bank for the Accounts of Companies Harmonized (BACH), May 2020



**Table 47: Average EBT margin in repair and installation of machinery and equipment, 2008-2017, in %**

|                | Repair and installation of machinery and equipment (C 33) |      |      |                              |                              |
|----------------|-----------------------------------------------------------|------|------|------------------------------|------------------------------|
|                | 2008                                                      | 2013 | 2017 | Change 2008/2013 in %-points | Change 2013/2017 in %-points |
| Germany        | 4.83                                                      | 0.30 | 3.54 | -4.53                        | 3.24                         |
| Italy          | 5.02                                                      | 3.48 | 5.84 | -1.54                        | 2.36                         |
| France         | 5.91                                                      | 4.29 | 5.78 | -1.62                        | 1.49                         |
| Spain          | 4.95                                                      | 2.48 | 5.86 | -2.47                        | 3.38                         |
| Austria        | 5.77                                                      | 4.50 | 4.71 | -1.27                        | 0.21                         |
| Poland         | 7.34                                                      | 6.70 | 5.50 | -0.64                        | -1.20                        |
| Czech Republic | 7.70                                                      | 7.60 | 7.00 | -0.10                        | -0.60                        |

Source: Bank for the Accounts of Companies Harmonized (BACH), May 2020

**Table 48: Average EBT margin in manufacturing, 2008-2017, in %**

|                | Manufacturing (C) |      |      |                              |                              |
|----------------|-------------------|------|------|------------------------------|------------------------------|
|                | 2008              | 2013 | 2017 | Change 2008/2013 in %-points | Change 2013/2017 in %-points |
| Germany        | 1.65              | 3.76 | 4.95 | 2.11                         | 1.19                         |
| Italy          | 2.72              | 2.27 | 5.04 | -0.45                        | 2.77                         |
| France         | 3.04              | 3.41 | 5.63 | 0.37                         | 2.22                         |
| Spain          | 1.75              | 2.02 | 5.67 | 0.27                         | 3.65                         |
| Austria        | 5.40              | 5.51 | 7.16 | 0.11                         | 1.65                         |
| Poland         | 3.46              | 4.81 | 5.76 | 1.35                         | 0.95                         |
| Czech Republic | 4.00              | 5.10 | 6.80 | 1.10                         | 1.70                         |

Source: Bank for the Accounts of Companies Harmonized (BACH), May 2020

## QUESTIONNAIRE OF THE REGIONAL SWOT ANALYSIS

### BACKGROUND

1. Which **country / region** is your Smart Specialisation Strategy covering or relating to? (- please tick one)

*Drop down list with countries / regions*

2. What **type of organisation** are you representing?  
Governmental organisation / public body

- Regional Development Agency
- Industry Associations / Chamber of Commerce
- Other, please specify: \_\_\_\_\_

3. On which of the following engineering industries does your **Regional Smart Specialisation Strategy focus** on?

- Mechanical engineering (incl. metal products, machinery, equipment)
- Electronic engineering (incl. computer, electronics, optical products)
- Electrical engineering (incl. electrical equipment)
- No specific focus on one of the above mentioned sectors - covering wider engineering industry area

4. Are engineering industry companies in your region primarily...

- supplying companies (supplying other companies with products that are further processed by them)
- final manufacturers (producing final products for clients/users)
- both

5. How do you assess the overall competitiveness of your regional engineering industry in comparison to other regions within the European Union?

- strong
- rather strong
- average
- rather weak
- weak

6. How do you assess the overall competitiveness of your regional engineering industry compared to countries outside the European Union (such as the US, Japan, South Korea, BRIC countries)?

- strong
- rather strong
- average

- rather weak
  - weak
7. What are the competitive advantages of the engineering industry in your region?
- 
8. What are competitive disadvantages of the engineering industry in your region?
- 
9. Is **digitalisation / digital transformation** an explicit policy objective of the Smart Specialisation Strategy (S3) of your region?
- Yes
  - No
10. (*If yes in previous question*) Which **application domains** does **your Regional Smart Specialisation Strategy** mainly focus on? (multiple choice)
- Health care
  - Mobility
  - Retail & (smart) logistics
  - Renewable energy
  - Circular economy
  - Advanced manufacturing
  - Others:.....
11. (*If yes in previous question*): Which **digital technologies** are most important for the **main application domains** in your Regional Smart Specialisation Strategy? (multiple choice)
- Artificial intelligence (AI)
  - Augmented/virtual/extended reality
  - Big data and analytics
  - Cloud-based services
  - Distributed ledger technologies (DLT) and Blockchain
  - Internet of Things (IoT)
  - Cyber security
  - Smart and enhanced mobility
  - Robotics
  - Digital twinning
  - Others: ...
12. Is there one or more Digital Innovation Hub(s) (DIH) in your region? (*Digital Innovation Hubs act as one-stop-shops where SMEs and mid-caps can test the latest digital*

*technologies and get e.g. training, financing advice, as well as market intelligence and networking opportunities to improve their business through digital innovation.)*

- Yes
- No

## ASSESSMENT OF STRENGTHS AND WEAKNESSES OF THE ENGINEERING INDUSTRY IN YOUR REGION (INTERNAL FACTORS)

13. Please assess whether the following factors represent a **strength / favourable condition**, a **neutral condition** or a **weakness / unfavourable condition** of the engineering industry in your region:

|                                                                                                                                                                                      | (Rather) favourable condition for the engineering industry in your region | Neutral condition for the engineering industry in your region | (Rather) unfavourable condition for the engineering industry in your region |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------|-----------------------------------------------------------------------------|
| <b>Please evaluate the factors concerning business structure / networks:</b>                                                                                                         |                                                                           |                                                               |                                                                             |
| <b>Degree of specialisation</b><br>of the engineering industry in your region                                                                                                        | o                                                                         | o                                                             | o                                                                           |
| <b>Degree of diversification</b><br>of the engineering industry in your region                                                                                                       | o                                                                         | o                                                             | o                                                                           |
| <b>Sustainable newcomers / start-ups</b><br>(e.g. number of new innovative firms; enterprise births surviving 5 years and longer) within the engineering industry in your region     | o                                                                         | o                                                             | o                                                                           |
| <b>Cooperation and networks</b><br>(e.g. regional industry clusters, platforms, sector initiatives)<br>that enterprises in the engineering industry in your region are integrated in | o                                                                         | o                                                             | o                                                                           |
| <b>Financial viability of enterprises</b><br>(capital and financing structure, profitability / performance) of engineering industry companies in your region                         | o                                                                         | o                                                             | o                                                                           |
| <b>Access to international markets</b><br>for your regional engineering industry                                                                                                     | o                                                                         | o                                                             | o                                                                           |
| <b>Access to international supply markets incl. access to raw materials</b><br>for your regional engineering industry                                                                | o                                                                         | o                                                             | o                                                                           |
| <b>Production costs</b><br>Development of local production costs (incl. labour costs) for your regional engineering industry compared to countries outside the EU                    | o                                                                         | o                                                             | o                                                                           |
| <b>Please evaluate the factors concerning human resources</b>                                                                                                                        |                                                                           |                                                               |                                                                             |
| <b>Availability of industry-specific know-how and skills</b><br>for the engineering industry in your region                                                                          | o                                                                         | o                                                             | o                                                                           |
| <b>Quality and availability of digital skills</b><br>in the engineering industry in your region                                                                                      | o                                                                         | o                                                             | o                                                                           |
| <b>Working Conditions</b><br>within the engineering industry in your region                                                                                                          | o                                                                         | o                                                             | o                                                                           |
| <b>Please evaluate the factors concerning access to finance</b>                                                                                                                      |                                                                           |                                                               |                                                                             |

# Study on the Competitiveness of the EU Engineering Industries and the Impact of Digitalisation

|                                                                                                                                                                                                                                                                                                                                                        | (Rather) favourable condition for the engineering industry in your region | Neutral condition for the engineering industry in your region | (Rather) unfavourable condition for the engineering industry in your region |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------|-----------------------------------------------------------------------------|
| <b>Access to traditional forms of financing</b><br>(such as bank financing)<br>for the engineering industry in your region                                                                                                                                                                                                                             | o                                                                         | o                                                             | o                                                                           |
| <b>Access to new forms of financing</b><br>(such as venture capital, business angels, crowdfunding)<br>for the engineering industry in your region                                                                                                                                                                                                     | o                                                                         | o                                                             | o                                                                           |
| <b>Access to public funding instruments / subsidies</b><br>(such as grants, subsidized loans, bank guarantees)<br>for the engineering industry in your region                                                                                                                                                                                          | o                                                                         | o                                                             | o                                                                           |
| <b>Please evaluate the factors concerning products and services offered</b>                                                                                                                                                                                                                                                                            |                                                                           |                                                               |                                                                             |
| <b>Focus on high tech products</b><br>Share of enterprises that focus on high tech products (products with a high level of technological intensity / R&D-intensity) within your regional engineering industry                                                                                                                                          | o                                                                         | o                                                             | o                                                                           |
| <b>Product innovation</b><br>Degree of innovation embedded in products offered by the engineering industry in your region                                                                                                                                                                                                                              | o                                                                         | o                                                             | o                                                                           |
| <b>Service innovation</b><br>Degree of innovation embedded in services offered by the engineering industry in your region                                                                                                                                                                                                                              | o                                                                         | o                                                             | o                                                                           |
| <b>Please evaluate the factors concerning innovation and digitalisation</b>                                                                                                                                                                                                                                                                            |                                                                           |                                                               |                                                                             |
| <b>(Pace of) adoption of new digital technologies</b><br>(such as AI / machine learning, robotics and automation, internet of things, 3D printing, big data analytics)<br>in the engineering industry in your region                                                                                                                                   | o                                                                         | o                                                             | o                                                                           |
| <b>R&amp;D capabilities and intensity</b><br>(business expenditure on R&D) of enterprises in the engineering industry in your region                                                                                                                                                                                                                   | o                                                                         | o                                                             | o                                                                           |
| <b>Access to research infrastructures</b><br>(access to facilities including universities and extramural research institutions that provide resources such as major scientific equipment or sets of instruments, collections, archives or scientific data, computing systems and communication networks)<br>of the engineering industry in your region | o                                                                         | o                                                             | o                                                                           |
| <b>Access to R&amp;D support and subsidies</b><br>(including e.g. consulting, grants, loans)<br>of the engineering industry in your region                                                                                                                                                                                                             | o                                                                         | o                                                             | o                                                                           |
| <b>Capacity to transfer innovations into marketable products and services</b><br>(industrial property rights, patents, patterns) of enterprises in the engineering industry in your region                                                                                                                                                             | o                                                                         | o                                                             | o                                                                           |

14. Do you want to add anything concerning internal factors (strengths or weaknesses) of the engineering industry in your region?

### ASSESSMENT OF OPPORTUNITIES AND THREATS FOR THE ENGINEERING INDUSTRY IN YOUR REGION (EXTERNAL FACTORS)

15. Please assess whether the following factors represent an **opportunity / favourable condition**, a **neutral condition** or a **threat / unfavourable condition** for the engineering industry in your region:

|                                                                                                                                                                                                                    | (Rather) favourable condition for the engineering industry in your region | Neutral condition for the engineering industry in your region | (Rather) unfavourable condition for the engineering industry in your region |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------|-----------------------------------------------------------------------------|
| <b>Please evaluate the factors concerning Economic, political, legal, social and ecological factors</b>                                                                                                            |                                                                           |                                                               |                                                                             |
| <b>Demographic change</b><br>(in terms of age and development of the population)<br>within your region / country                                                                                                   | <input type="radio"/>                                                     | <input type="radio"/>                                         | <input type="radio"/>                                                       |
| <b>Climate change</b><br>(incl. decarbonisation of industrial processes, circular economy)                                                                                                                         | <input type="radio"/>                                                     | <input type="radio"/>                                         | <input type="radio"/>                                                       |
| <b>Structural changes in economic sectors</b><br>such as de- or re-industrialisation processes                                                                                                                     | <input type="radio"/>                                                     | <input type="radio"/>                                         | <input type="radio"/>                                                       |
| <b>Digital transformation</b><br>affecting the engineering industry in your region                                                                                                                                 | <input type="radio"/>                                                     | <input type="radio"/>                                         | <input type="radio"/>                                                       |
| <b>Increased technological competition</b><br>(e.g. R&D expenditure of South Korea, Japan and the US are considerably higher than the EU-28 average)                                                               | <input type="radio"/>                                                     | <input type="radio"/>                                         | <input type="radio"/>                                                       |
| <b>Regulation</b><br>legal obligations / bureaucracy for enterprises in the<br>engineering industry within your region                                                                                             | <input type="radio"/>                                                     | <input type="radio"/>                                         | <input type="radio"/>                                                       |
| <b>Increasing protectionism</b><br>(trade regulations and barriers / tariffs with third countries) affecting exporting engineering industry companies in your region                                               | <input type="radio"/>                                                     | <input type="radio"/>                                         | <input type="radio"/>                                                       |
| <b>Increasing proliferation of new forms of financing</b><br>(such as venture capital, business angels, crowdfunding)                                                                                              | <input type="radio"/>                                                     | <input type="radio"/>                                         | <input type="radio"/>                                                       |
| <b>Increasing international competition</b><br>(increased intensity of extra-EU competition by other market participants incl. extra- and intra-industry competitors) affecting your regional engineering industry | <input type="radio"/>                                                     | <input type="radio"/>                                         | <input type="radio"/>                                                       |

16. Do you want to add anything concerning **external factors (opportunities or threats)** of the engineering industry in your region?

## FINAL EVALUATION

17. In your view, to which extent has the development and the implementation of your **Regional Smart Specialisation Strategy (S3)** contributed to improving the competitiveness of your regional engineering industry?

- Strong contribution
- Rather strong contribution
- Medium contribution
- Rather weak contribution
- Weak contribution

18. (*In case of rather strong contribution*): Please describe shortly **how** the development and implementation of your regional Smart Specialisation Strategy (S3) contributed to improving the engineering industry sector's competitiveness. Which aspects were most helpful?

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19. (*In case of rather weak contribution*): Please describe shortly **why** the development and implementation of your regional Smart Specialisation Strategy (S3) did not contribute to improving the engineering industry sector's competitiveness.

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20. Which framework conditions do you consider most important for a positive development of the engineering industry in your region? (Please name 3 to 5 most important factors)

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21. Do you have remarks, observations, messages or views that you would like to highlight and share with us?

If yes, please provide these here:

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22. May we contact you for further questions concerning engineering industries / Smart Specialisation in your region?

If yes, please provide your contact details: \_\_\_\_\_

Thank you very much for participating in the survey!



## ANNEX 3 – NACE CODES WITHIN STUDY SCOPE AND STATISTICAL SOURCES

### Definition of engineering industries according to the NACE Rev. 2 classifications

| Division<br>(2-digit level) | Group<br>(3-digit level) | Description                                                                                                                                                                                                                 |
|-----------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>25</b>                   |                          | <b>Fabricated metal products, except machinery and equipment</b>                                                                                                                                                            |
|                             | 25.1                     | Structural metal products (e.g. metal structures and parts of structures; doors and windows of metal)                                                                                                                       |
|                             | 25.2                     | Tanks, reservoirs and containers of metal                                                                                                                                                                                   |
|                             | 25.3                     | Steam generators, except central heating hot water boilers                                                                                                                                                                  |
|                             | 25.4                     | Weapons and ammunition                                                                                                                                                                                                      |
|                             | 25.5                     | Forging, pressing, stamping and roll-forming of metal; powder metallurgy                                                                                                                                                    |
|                             | 25.6                     | Treatment and coating of metals; machining                                                                                                                                                                                  |
|                             | 25.7                     | Cutlery, tools and general hardware                                                                                                                                                                                         |
|                             | 25.9                     | Other fabricated metal products (e.g. steel drums and similar containers, light metal packaging, wire products, chain and springs, etc.)                                                                                    |
| <b>26</b>                   |                          | <b>Computer, electronic and optical products</b>                                                                                                                                                                            |
|                             | 26.1                     | Electronic components and boards                                                                                                                                                                                            |
|                             | 26.2                     | Computers and peripheral equipment                                                                                                                                                                                          |
|                             | 26.3                     | Communication equipment                                                                                                                                                                                                     |
|                             | 26.4                     | Consumer electronics                                                                                                                                                                                                        |
|                             | 26.5                     | Instruments and appliances for measuring, testing and navigation; watches and clocks                                                                                                                                        |
|                             | 26.6                     | Irradiation, electromedical and electrotherapeutic equipment                                                                                                                                                                |
|                             | 26.7                     | Optical instruments and photographic equipment                                                                                                                                                                              |
|                             | 26.8                     | Magnetic and optical media                                                                                                                                                                                                  |
| <b>27</b>                   |                          | <b>Electrical equipment</b>                                                                                                                                                                                                 |
|                             | 27.1                     | Electric motors, generators, transformers and electricity distribution and control apparatus                                                                                                                                |
|                             | 27.2                     | Batteries and accumulators                                                                                                                                                                                                  |
|                             | 27.3                     | Wiring and wiring devices                                                                                                                                                                                                   |
|                             | 27.4                     | Electric lighting equipment                                                                                                                                                                                                 |
|                             | 27.5                     | Domestic appliances                                                                                                                                                                                                         |
|                             | 27.9                     | Manufacture of other electrical equipment                                                                                                                                                                                   |
| <b>28</b>                   |                          | <b>Machinery and equipment n.e.c.</b>                                                                                                                                                                                       |
|                             | 28.1                     | General-purpose machinery (e.g. engines and turbines, except aircraft, vehicle and cycle engines; fluid power equipment; other pumps and compressors; other taps and valves; bearings, gears, gearing and driving elements) |

| Division<br>(2-digit level) | Group<br>(3-digit level) | Description                                                                                                                                                                                                                                                                                           |
|-----------------------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                             | 28.2                     | Other general-purpose machinery (e.g. ovens, furnaces and furnace burners; lifting and handling equipment; office machinery and equipment, except computers and peripheral equipment; power-driven hand tools; non-domestic cooling and ventilation equipment; other general-purpose machinery n.e.c. |
|                             | 28.3                     | Agricultural and forestry machinery                                                                                                                                                                                                                                                                   |
|                             | 28.4                     | Metal forming machinery and machine tools                                                                                                                                                                                                                                                             |
|                             | 28.9                     | Other special-purpose machinery (e.g. for metallurgy; for mining, quarrying and construction; for food, beverage and tobacco processing; for textile, apparel and leather production; for paper and paperboard production; plastic and rubber machinery; other special-purpose machinery n.e.c.:      |
| <b>32</b>                   |                          | <b>Other manufacturing<br/>(only the following 3-digit code is included in the scope of the study)</b>                                                                                                                                                                                                |
|                             | 32.5                     | Medical and dental instruments and supplies                                                                                                                                                                                                                                                           |
| <b>33</b>                   |                          | <b>Repair and installation of machinery and equipment</b>                                                                                                                                                                                                                                             |
|                             | 33.1                     | Repair of fabricated metal products, machinery and equipment (e.g. fabricated metal products; machinery, electronic and optical equipment; electrical equipment; ships and boats; aircraft and spacecraft; other transport equipment; other equipment                                                 |
|                             | 33.2                     | Installation of industrial machinery and equipment                                                                                                                                                                                                                                                    |

Source: NACE Rev. 2 classification, <https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF>

## Data availability of structural business data

| Data source                                                                               | Latest available year                   |
|-------------------------------------------------------------------------------------------|-----------------------------------------|
| <b>Structural Business Statistics:</b><br>Number of enterprises<br>Employment<br>Turnover | 2018                                    |
| <b>Structural Business Statistics:</b><br>Data by enterprise size                         | 2017                                    |
| <b>Short-term Business Statistics:</b>                                                    | 2018                                    |
| <b>National accounts:</b><br>Value added                                                  | 2017                                    |
| <b>PRODCOM:</b><br>Production                                                             | 2020 (annual and monthly data analysed) |
| <b>Business Demography:</b><br>Enterprise births                                          | 2017                                    |
| <b>International trade in goods</b><br>Exports<br>Imports                                 | 2020 (annual and monthly data analysed) |
| <b>OECD Balanced International Merchandise Trade Statistics</b>                           | 2016                                    |
| <b>World Input-Output Database</b>                                                        | 2014                                    |
| <b>Statistics on research and development</b>                                             | GERD: 2018<br>BERD: 2017                |

## **ANNEX 4 – DEFINITION OF ADVANCED (DIGITAL) TECHNOLOGIES<sup>508</sup>**

### ***Robotics***

Robotics is technology that encompasses the design, building, implementation, and operation of robots. Robotics is often organised into three categories: 1) Application specific. This includes robotics designed to conduct a specific task or series of tasks for commercial purposes. These robots may be stationary or mobile but are limited in function as defined by the intended application. 2) Multipurpose. Multipurpose robots are capable of performing a variety of functions and movements determined by a user that programs the robot for tasks, movement, range, and other functions and that may change the effector based on the required task. These robots function autonomously within the parameters of their programming to conduct tasks for commercial applications and may be fixed, "moveable," or mobile. 3) Cognitive. Cognitive robots are capable of decision making and reason, which allows them to function within a complex environment. These robots can learn and make decisions to support optimal function and performance and are designed for commercial applications. When measuring production and uptake of robotics, industrial applications will be taken into account.

### ***Internet of Things (IoT)***

The Internet of Things (IoT) refers to the network of smart, interconnected devices and services that are capable of sensing or even listening to requests. IoT is an aggregation of endpoints that are uniquely identifiable and that communicate bi-directionally over a network using some form of automated connectivity. Objects become interconnected, make themselves recognizable, and acquire intelligence in the sense that they can communicate information about themselves and access information that has been provided by another source. The Internet of Things relies on networked sensors to remotely connect, track and manage products, systems and grids. The Industrial Internet of Things (IIoT) – a subset of the larger Internet of Things – focuses on the specialized requirements of industrial applications, such as manufacturing, oil and gas, and utilities. IIoT systems connect non-consumer devices, used by companies, governments and utility providers in their service delivery. The IIoT is enabled by technologies such as cybersecurity, cloud computing, edge computing, mobile technologies, machine-to-machine, 3D printing, advanced robotics, big data, Internet of Things, RFID technology, and cognitive computing.

### ***Artificial Intelligence***

Artificial Intelligence is a heterogenous field/area in terms of its technology base. While some aspects like sensors, chips, robots as well as certain applications like autonomous driving, logistics or medical instruments refer to hardware components, a relevant part of AI is rooted in algorithms and software. This latter dimension is hardly identifiable in patent data and also in other classifications it will be almost impossible to identify it directly as AI is 'hidden' in software categories in general. For example, the software industry as such might be identifiable, but the share of AI next to operating systems or PC applications/software can hardly be identified. This holds for NACE (employment, production), but also for PRODCOM (trade). In sum, this means for AI that we will include it in the list of new technologies and mainly focus on the hardware part. The software components of AI will be covered by the applications that we include and the so-called embedded software as well as computer-implemented inventions (software patents). The (more or less solely) software-based components of AI will be hard to tackle and might only be included via estimates. In so far, we expect the indicators to reflect lower

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<sup>508</sup> Monitoring Digital Transformation and Key Enabling Technologies Advanced Technologies for Industry, Methodological Report, IDC, September 2019

boundaries of data coverage in this respect, but we will be able to provide data for AI in all dimensions (patents, employment, production, trade).

### ***Security***

Security products are tools designed using a wide variety of technologies to enhance the security of an organization's networking infrastructure — including computers, information systems, internet communications, networks, transactions, personal devices, mainframe, and the cloud — as well as help provide advanced value-added services and capabilities.

Cybersecurity products are utilized to provide confidentiality, integrity, privacy, and assurance. Through the use of security applications, organizations are able to provide security management, access control, authentication, malware protection, encryption, data loss prevention (DLP), intrusion detection and prevention (IDP), vulnerability assessment (VA), and perimeter defense, among other capabilities. All these tools are designed to enhance the security of an organization's computing infrastructure as well as help provide advanced value-added services and capabilities.

It is possible to file patents for these applications and for the processes and based on this in conjunction with our empirical approach, we will be able to identify relevant sectors (NACE) or products (PRODCOM) and be able to estimate the share of 'security and connectivity' within these classes.

### ***Connectivity***

Connectivity refers to all those technologies and services that allow end-users to connect to a communication network. It encompasses an increasing volume of data, wireless and wired protocols and standards, and combinations within a single use case or location.

It includes Fixed Voice and Mobile Voice telecom services to allow fixed or mobile voice communications, but also Fixed Data and Mobile Data services to have access and transfer data via a network. More recently, also thanks to the rise of Internet of Things scenarios, connectivity technologies boundaries expand beyond wired and cellular (e.g. 3G, 4G, 5G...) services to Low Power Wide Area Network (LPWAN), Satellite, and Short Range Wireless technologies (e.g. Bluetooth, zigbee).

### ***Cloud computing***

Public cloud services are available on public networks and open to a largely unrestricted universe of potential users. Public clouds are designed for a market, not a single enterprise. Public cloud has all or most of the following characteristics.

### ***Blockchain***

Blockchain is a digital, distributed ledger of transactions or records, in which the ledger stores the information or data and exists across multiple participants in a peer-to-peer network. Distributed ledgers technology (DLT) allows new transactions to be added to an existing chain of transactions using a secure, digital or cryptographic signature. Blockchain protocols aggregate, validate, and relay transactions within the blockchain network. New blocks of transactions can be added to existing blockchains and dispersed to other parts of the blockchain network. Blockchain technology allows the data to exist on a network of instances or "nodes," allowing for copies of the ledger to exist rather than being managed in one centralized instance. Nodes within the network contain a complete copy of the entire ledger, making it available to those that can access the network. There is no single central repository that stores the ledger.

### ***Big Data***

Big Data is a term describing the continuous increase in data, and the technologies needed to collect, store, manage, and analyze it. It is a complex and multidimensional phenomenon, impacting people, processes and technology. From a technology point of view, Big Data encompasses hardware and software that integrate, organize, manage, analyze, and present data which is characterized by "four Vs": IDC describes Big Data technologies as a new generation of technologies and architectures, designed to economically extract value from very large volumes of a wide variety of data, by enabling high-velocity capture, discovery, and/or analysis.

- Volume: massive volume of data
- Variety: breadth of data sources and formats
- Velocity: speed at which information arrives, is analyzed and delivered
- Value: referring to both the cost of technology and the value derived from its use
- The Big Data technology stack includes:
  - Infrastructure, such as storage systems, servers, and datacenter networking infrastructure
  - Data organisation and management software
  - Analytics and discovery software
  - Decision support and automation software
  - Services including business consulting, business process outsourcing, IT outsourcing, IT project-based services, and IT support and training related to Big Data implementations.

### ***Augmented/Virtual Reality***

Augmented reality devices look to overlay digital information or objects with a person's current view of reality. As such, the user is able to see his/her surroundings while also seeing the AR content – Virtual reality devices place end users into a completely new reality, obscuring the view of their existing reality.

### ***Mobility technologies and enterprise mobility***

Mobility covers a large number of different technology areas and markets, which does not only encompass vehicles that take people from point A to point B, but also includes all kinds of technologies that make people more mobile (like for example mobile phones etc.). In this project, first of all a sub-section of mobility is captured, which is related to vehicles only, e.g. satellite navigation and radio-location, which are also the core technologies that are necessary to make autonomous driving work. Secondly, we capture enterprise mobility, which is made up of mobile solutions and technologies, empowering a borderless workforce to securely work anywhere, at any time and from any device. It does not include only the provision of smartphones or tablets to the workforce but also all the tools and applications for transforming key processes, from internal operations to operations with customers and suppliers, all the way from the shop floor to the top floor and from the back office to the end customers.

## ANNEX 5 – THE AVAILABILITY OF PUBLIC DATA FOR ASSESSING THE EFFECT OF DIGITALISATION ON THE EU ENGINEERING SECTOR’S COMPETITIVENESS

An assessment has been made on the relevance of each of the sets of indicators for answering the research questions of Part 3, covered by Section 4 of the main report (Impacts, challenges and opportunities of digitalisation of the EU’s electronic, electrical and mechanical engineering industries). The various data sets identified were ordered in the table below based on descending overall relevance. In case data sources had the same score, they were ranked based on the highest score on the engineering industry relevance.

The main conclusion from the public data analysis is that there is no dataset that gets the maximum overall score, as it always scores low on one of the dimensions.

- Some indicator sets (mainly from the EU-institutions) combine digitalisation concepts with sector classifications (although not perfectly fitting with the NACE delimitation used for the engineering industry), but they are lacking data on the main competitors.
- Some indicator sets (mainly from international institutions or private research organisations) combine digitalisation concepts with data for the EU’s main competitors, but they are lacking data on economic activities since the assessments are made at economy-wide level.
- Other conclusions and observations that can be made based on the assessment of the data availability are the following:
- Many of the indicators focus on citizens or the society as a whole (e.g. penetration of broadband internet access, internet use, skills levels of citizens, ...) while only a limited number of them focus on the use of digitalisation in businesses.
- Almost all international studies compare the performance of individual countries, not aggregates of countries (like the EU27/28). In order to overcome this issue, the share of EU28-countries in the top 10-countries can be calculated, which makes it possible to get insights in how the best performing EU countries are evolving compared to the main competitors.
- In the different indicator sets, the same general indicators are used (mostly dealing with citizens and ICT infrastructure). Only a limited number of business specific indicators, focussing on the internal vertical or external horizontal value chain, are available, which is important in view of the competitiveness assessment.

**Table 49: Overview of data sources and relevance in answering research questions**

| Data source and short description                                                                                                                                                                                                                                                         | Organisation | Relevance                             |                                       |                                       |                                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
|                                                                                                                                                                                                                                                                                           |              | Digitalisation conceptual             | Data on engineering industry          | Data of main competitors              | Overall                               |
| <b>ISOC Database on digital economy and Society</b>                                                                                                                                                                                                                                       | Eurostat     | 3                                     | 3                                     | 1                                     | 2,3                                   |
| General digitisation statistics EU Economy, covering a wide array of indicators on 8 dimensions: ICT-usage by households and by individuals, ICT-usage in Enterprises, digital skills and ICT-sector. The most relevant indicators are on ICT-usage in enterprises covering the following |              | (section on ICT-usage by enterprises) | (section on ICT-usage by enterprises) | (section on ICT-usage by enterprises) | (section on ICT-usage by enterprises) |



| Data source and short description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Organisation         | Relevance                 |                              |                          |         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---------------------------|------------------------------|--------------------------|---------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                      | Digitalisation conceptual | Data on engineering industry | Data of main competitors | Overall |
| subthemes: e-commerce; connection to the internet; websites and use of social media; e-business (integration of internal processes, integration with customers/suppliers and supply chain management, cloud computing services, big data analysis, 3D-printing and robotics) and ICT-security.                                                                                                                                                                                                                                                                                   |                      |                           |                              |                          |         |
| <b>IMD World Digital Competitiveness Ranking (WDCR) 2019</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | IMD                  | 3                         | 1                            | 3                        | 2,3     |
| IMD World Digital Competitiveness Ranking measures (by calculating a composite index) the capacity and readiness of 63 economies to adopt and explore digital technologies as a key driver for economic transformation in business, government and wider society. The rankings are calculated on the basis of the 51 ranked criteria: 31 hard and 20 survey data. The countries are ranked from the most to the least digital competitive.                                                                                                                                       |                      |                           |                              |                          |         |
| To evaluate an economy, WDCR examines three digital competitiveness factors: <i>knowledge</i> (which measures the know-how necessary to discover, understand and build new technologies), <i>technology</i> (which evaluates the overall context that enables the development of digital technologies) and <i>future readiness</i> (which assesses the level of preparedness to exploit digital transformations. In turn, each of these factors is divided into 3 sub-factors which highlight every facet of the areas analysed. Altogether, the WDC features 9 such sub-factors |                      |                           |                              |                          |         |
| <b>Readiness for the Future of Production 2018</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | World Economic Forum | 3                         | 1                            | 3                        | 2,3     |
| 2 dimensions plot where the assessment is made up of two main components: 'Structure of Production' (complexity and scale score from 0 to 10) or a country's current baseline of production, and Drivers of Production (Technology & Innovation, Human capital, Global trade & Investment, Institutional framework, Sustainable resources, Demand Environment                                                                                                                                                                                                                    |                      |                           |                              |                          |         |

| Data source and short description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Organisation | Relevance                 |                              |                          |         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------------------|------------------------------|--------------------------|---------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              | Digitalisation conceptual | Data on engineering industry | Data of main competitors | Overall |
| score from 0-10) or the key enablers that position a country to capitalize on the Fourth Industrial Revolution to transform production systems. in total 59 indicators are used to calculate the composite indicator                                                                                                                                                                                                                                                                                                                                                                                              |              |                           |                              |                          |         |
| <b>Accenture Digital Density Index (DDI)</b><br><br>The Digital Density Index, produced by Accenture Strategy in partnership with Oxford Economics, confirms the link between increased use of digital technologies and greater productivity, and quantifies the resulting impact on competitiveness and economic growth. To accomplish this, they used +50 digital technology indicators, from both private and public sources, across 33 major economies. The indicators are equally weighted across 4 areas of economic activity: making markets, running enterprises, sourcing inputs and fostering enablers. | Accenture    | 3                         | 1                            | 3                        | 2,3     |
| <b>Accenture Digital Performance Index (DPI)</b><br><br>The Digital Performance Index (DPI) was created to quantitatively assess the level of digital investment and progress across four business functions (plan, make, sell, manage), each broken down to three key action points along the value chain. Forty-two further business activities and 117 detailed behaviour metrics are also evaluated to support the DPI framework. This multi-pillared structure enables a comprehensive view of companies' digital integration across the full breadth of business activities.                                | Accenture    | 3                         | 1                            | 3                        | 2,3     |
| <b>International Digital Economy and Society Index 2018 (I-DESI)</b><br><br>The International Digital Economy and Society Index (I-DESI) provides an overall assessment of where the EU stands, compared to non-EU economies, in its progress towards a digital society and economy. First created in 2013, I-DESI compares the average                                                                                                                                                                                                                                                                           | DG Connect   | 3                         | 1                            | 3                        | 2,3     |

# Study on the Competitiveness of the EU Engineering Industries and the Impact of Digitalisation

| Data source and short description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Organisation          | Relevance                 |                              |                          |         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------------|------------------------------|--------------------------|---------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | Digitalisation conceptual | Data on engineering industry | Data of main competitors | Overall |
| performance of EU member States with 17 non-EU countries, using a similar methodology to the EU DESI index.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       |                           |                              |                          |         |
| <b>UN Comtrade database</b><br><br>This trade database can give insight in the relative trade performance in engineering related products and services at a very detailed level (both at product/service level as at country level.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | United Nations        | 1                         | 3                            | 3                        | 2,3     |
| <b>Comext database</b><br><br>This trade database can give insight in the relative trade performance in engineering related products and services at a very detailed level (both at product/service level as at country level.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Eurostat              | 1                         | 3                            | 3                        | 2,3     |
| <b>Digital Economy and Society Index 2019 (DESI)</b><br><br>DESI is a composite index that summarises relevant indicators on Europe's digital performance and tracks the progress of EU Member States in digital competitiveness. It is integrating the following 5 principal dimensions (weight of each of the dimensions): connectivity (25%), human capital (25%), use of internet services (15%), integration of digital technology (20%) and digital public services (15%). In total more than 30 indicators are used to calculate the composite DESI-index, Dimension 4 is of particular interest as it measures the digitisation of businesses and the development of the online sales channel. | DG Connect - Eurostat | 3                         | 2                            | 1                        | 2,0     |
| <b>ICT access and use by businesses</b><br><br>Statistics on connectivity (11), Website (3), Information management tool (5), Electronic Commerce (10), Security and Privacy (2), E-government (2), Use of cloud computing (12), CT-skills (6), Use of social media (1)                                                                                                                                                                                                                                                                                                                                                                                                                                | OECD                  | 3                         | 1                            | 2                        | 2,0     |
| <b>Going Digital Toolkit</b><br><br>The Going Digital Toolkit includes indicators on the relative performance of OECD countries to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | OECD                  | 2                         | 1                            | 3                        | 2,0     |

| Data source and short description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Organisation | Relevance                 |                              |                          |         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------------------|------------------------------|--------------------------|---------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |              | Digitalisation conceptual | Data on engineering industry | Data of main competitors | Overall |
| OECD average for various digital performance indicators. The Toolkit is structured along the lines of the Going Digital Integrated Policy Framework, which includes seven policy dimensions that need to be co-ordinated to shape a common digital future that improves the lives of all people. Most of the indicators are focussing on citizens, not on businesses. This toolkit contains indicators on 7 dimensions (Access to communications infrastructures, services and data; Effective use of digital technologies and data; Data-driven and digital innovation; Good jobs for all; Social prosperity and inclusion; Trust in the digital age; Market openness in digital business environments)                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |                           |                              |                          |         |
| <b>Digital Transformation scoreboard</b><br><br>the DTS monitor the digital transformation of existing industry and enterprises. It is composed of 2 composite indices: the DTEI and the DTII. The DTEI provides a ranking for Member States based on a 5-category typology of 'enablers' (digital infrastructures, investment and access to finance, demand and supply of digital skills, e-leadership, entrepreneurial culture) who are drivers of digital transformation.<br><br>The DTII measures the effects of digital transformation and is captured by 2 'output' categories (increase of ICT start-ups and integration of digital technology).<br><br>Chapter 6 on adoption of digital technologies (9 categories: social media; big data and data analytics; cloud technology; IoT; mobile services; robotics and automated machinery; cybersecurity; 3D printing; AI) in businesses is of particular interest (based on survey data). It provides insights on which technologies being adoption, the purpose, the business functions affected and the associated impacts in terms of turnover, productivity, job creation and cost reduction | DG Grow      | 3                         | 1                            | 1                        | 1,7     |

| Data source and short description                                                                                                                                                             | Organisation | Relevance                 |                              |                          |         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------------------|------------------------------|--------------------------|---------|
|                                                                                                                                                                                               |              | Digitalisation conceptual | Data on engineering industry | Data of main competitors | Overall |
| <b>OECD Telecommunications and Internet Statistics</b><br><br>Statistics on broadband subscriptions (different types) per 100 inhabitants, total number of broadband subscriptions (per type) | OECD         | 2                         | 1                            | 2                        | 1,7     |

*Relevance scores: 1 = low, 2 = medium, 3 = high*

## **ANNEX 6 – MONITORING DIGITALISATION BY THE OECD, UN, WTO AND BEA**

In view of the absence of an overall accepted definition, view and approach to monitoring digitalisation at sectoral level, the analysis of the public data focussed on the assessment of the most feasible and relevant ways to analyse the EU engineering sector's competitiveness in a digitalized business environment. In this section we document the work done by international organisations with regard to monitoring digitalisation, the underlying conceptualisation and the work done by the BEA in the USA.

### **THE RESEARCH PRIORITIES OF THE OECD, UNSTATS AND THE WTO REGARDING THE DIGITAL ECONOMY**

The goal of this study is to identify the role of digitalisation for the competitiveness of the European engineering sector in comparison to other parts of the world, such as China or the United States. Against this background, the work of the OECD is worth mentioning. Already in 2005, the OECD acknowledged the developments of digitalisation by capturing the definition of the digitised products as *"those which are able to be digitally delivered via the Internet"*<sup>509</sup>. Since then, UNSTATS<sup>510</sup>, the OECD and the WTO<sup>511</sup> joined forces to apprehend digitalisation by focussing on the following topics:

- Developing a framework for a satellite account on the digital economy
- Valuation of free assets and free services
- Recording of data in the national accounts
- Cryptocurrencies
- Price and volume measurement of goods and services affected by digitalization<sup>512</sup>

These topics have been chosen because the digital transformation is still largely invisible in core economic accounts. Also, production chains between producer and consumer are changing while the current frameworks struggle to show the winners and the losers. Therefore, these topics attempt to grasp the development of intermediary platforms (Amazon), "free" assets (Wikipedia) and services (Facebook) and to account for the role of data<sup>513</sup>.

### **THE CREATION OF DIGITAL SATELLITE ACCOUNTS BY CREATING DIGITAL SUPPLY-AND-USE TABLES**

Given that the study is especially interested in assessing the competitiveness of the EU engineering sector in regard to digitalisation, the satellite accounts are of particular interest: with standardized satellite accounts it is possible to assess various aspects of the digital economy of different countries or regions with a standardized, and therefore comparable, method<sup>514</sup>.

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<sup>509</sup> <http://www.oecd.org/internet/ieconomy/35937246.pdf>

<sup>510</sup> <https://unstats.un.org/unsd/trade/events/2018/Beijing/presentations/Schreyer1.pdf>

<sup>511</sup> [http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=SDD/CSSP/WPTGS\(2019\)4&docLanguage=En](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=SDD/CSSP/WPTGS(2019)4&docLanguage=En)

<sup>512</sup> [https://unstats.un.org/unsd/trade/events/2019/Shanghai/China\\_HL\\_Seminar\\_3a\\_UNSD\\_international\\_statistical\\_development.pdf](https://unstats.un.org/unsd/trade/events/2019/Shanghai/China_HL_Seminar_3a_UNSD_international_statistical_development.pdf)

<sup>513</sup> [https://unstats.un.org/unsd/trade/events/2019/Shanghai/China\\_HL\\_Seminar\\_3a\\_UNSD\\_international\\_statistical\\_development.pdf](https://unstats.un.org/unsd/trade/events/2019/Shanghai/China_HL_Seminar_3a_UNSD_international_statistical_development.pdf)

<sup>514</sup> Measuring the Digital Transformation: A Roadmap for the future" (2019)

The first step in creating a digital satellite account is to create a digital supply and use table (S-U table). Developments within these satellite documents have been thoroughly monitored by the OECD in close collaboration with UNSTAT and the WTO. The main objective consisted of measuring GDP in a digitalised economy which is described in detail in the paper "A Proposed framework for Digital Supply-Use Tables"<sup>515</sup>.

For the creation of these tables, the OECD is primarily focussed on the integration of the nature of transactions, products and digital industries / activities, so that the supply and use table can inform on the following:

- The total value of all transactions in goods and services that meet the digital transaction definition, both from a final demand and an output point of view.
- The total output of the digitally enabling industries<sup>516</sup>.
- The level of investment in digitally related capital goods split by the various sub-groups undertaking production using digital means.
- The total value of e-commerce (i.e. digitally ordered goods and services).
- The total value of services provided by intermediary platforms as a separate proportion of the overall value of the goods and services being provided by the producer.
- The imputed value of free services provided and used by households and enterprises.
- The digital margin that exists on top of the standard trade margin for digitally enabled retailers and other resellers.

From a researcher's point of view, it is worth noting that the OECD provides in their paper a conceptual framework regardless of practical issues, such as the conversion between two different coding schemes (e.g. North American Industry Classification System (NAICS) and Prodcom). Latest insights are shared during informal meetings, workshops or on seminars like the High Level Seminar on the Digital Economy (2018)<sup>517</sup> or the High Level Seminar on the Future of Economic Statistics (2019)<sup>518</sup> organised by UNSTATS.

## DIGITAL GOODS

To establish the digital S-U tables the OECD focusses primarily on the nature of the transaction, the nature of the goods and the nature of the industries. Both industries and transaction are currently not part of our scope. Therefore, we will discuss the developments regarding the defining of goods and services.

As for regular or non-digital S-U tables, the same CPA-division level applies, but for products presented at a lower level than the CPA-division classification a clear definition is needed. This relates directly to our research as we are working with the 8-digit level ProdCom classification.

However, the OECD argues that the current product classification systems are sufficient to capture the trends of digitalisation, because those products can be seen as "enablers" rather than "digital goods" and therefore "the Advisory Group still recommended that, (...) digital goods can be considered interchangeable with ICT goods". Next to this definition of

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<sup>515</sup> [https://unstats.un.org/unsd/nationalaccount/aeg/2018/M12\\_3a\\_Digital\\_Economy\\_OECD.pdf](https://unstats.un.org/unsd/nationalaccount/aeg/2018/M12_3a_Digital_Economy_OECD.pdf)

<sup>516</sup> This includes units within various ISIC groupings that make up the ICT sector as defined in ISIC Rev 4: "The production (goods and services) of a candidate industry must primarily be intended to fulfil or enable the function of information processing and communication by electronic means, including transmission and display."

<sup>517</sup> <https://unstats.un.org/unsd/trade/events/2018/Beijing/default.asp>

<sup>518</sup> <https://unstats.un.org/unsd/trade/events/2019/Shanghai/>



digital products, fourteen different digital services have been distinguished, such as retail trade or cloud computing services.<sup>519</sup>

In other words: to measure the role of the engineering sector – or for that matter any sector – regarding digitalisation, we must identify a list of existing goods and services that are indicators for enabling digitalisation and are relevant for the sector.

## DEFINING AND MEASURING THE DIGITAL ECONOMY IN THE USA

To measure the role of the engineering we must identify a list of existing goods and services that are indicators for enabling digitalisation. Therefore, we looked at specific examples of measuring the digital economy to identify a list of goods and services that function as indicators for digitalisation.

The oldest relevant example has been executed by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce.<sup>520</sup> In their paper *"Defining and measuring the Digital Economy"* (2018) the BEA elaborated a conceptual definition of the Digital Economy, identified specific goods and services categories within the use-supply framework and used this framework to identify the relevant industries and their estimated output. Their methodology is in line with the OECD methodology described above.

Given that the study is especially interested in assessing the competitiveness of the EU engineering sector regarding digitalisation, the list of selected goods and services is of interest. Using the NAICS economic activity classification, consisting of over 5000 products, the BEA selected more than 200 goods and services in the category's hardware, software, support services and telecommunications goods and services.

Following the OECD, the BEA did not include the goods and services that are "partially digital", because this would have required additional sources and data. This means that both structures and IoT infrastructure are not part of the scope (see NOTE above). Moreover, for both it is currently impossible to separate their different activities: digital and non-digital. Especially for IoT infrastructure further challenges arise:

*"For example, the connectivity of an internet-enabled refrigerator may allow the owner to track and purchase food items when they are running low or record usage of the appliance. However, the primary function of the refrigerator is to keep food cold, output which BEA would not classify as being part of the digital economy"*<sup>521</sup>

Still, the BEA is expanding their understanding of the nature of (non-)digital goods to further enhance their current estimates.

Last but not least, and specifically important for the purpose of this study, the BEA uses a type of the NAICS, which is according to the official NAICS Census Bureau *"not truly NAICS codes, (...) and should not be assumed to be consistent or comparable across agencies"* left aside across different coding schemes. Therefore, and as expected, conversion tables between these classification system and any, more familiar, system (ProdCom, NACE and/or others) were not found. Moreover, we have reached out to the BEA itself, which

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<sup>519</sup> NOTE: These 14 services together with digital goods are (for now) the only goods and services part of the scope. The main reason is that the OECD uses the transactional split (digitally ordered, ... ) as the guiding principle (see above) and most business are currently not willing or able to share this information. This is particularly important for the example of the BEA as presented below.

<sup>520</sup> NOTE: Studying the impact of digitization on the economy is not a new idea. The Bureau of Economic Analysis (BEA) , other agencies in the Department of Commerce , and other organizations have been researching and publishing reports measuring the impact of the "digital economy," the "internet economy," or the "new economy" for nearly two decades. (...) But "this report offers BEA's first digital economy estimates within the framework of the national accounts.

<sup>521</sup> <https://www.bea.gov/system/files/papers/WP2018-4.pdf>

replied that they have *"not made any concordances between our digital economy items list in NAICS and other classification systems"*.

In regard to the challenges described by the BEA and the fact that conversion between their NAICS list of goods and services and a European one, it is currently impossible to use these approaches to assess the competitiveness of the European engineering sector. Moreover, as we have turned the page into 2020 the *"digital transformation is [still] largely invisible in the core economic accounts and challenges our conceptual frameworks and measurement approaches"*<sup>522</sup>.

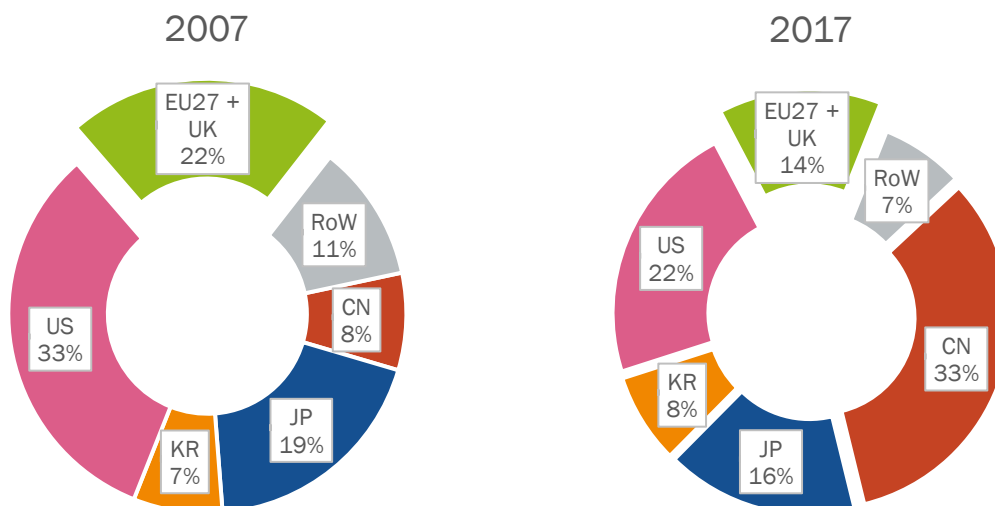
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[https://unstats.un.org/unsd/trade/events/2019/Shanghai/China\\_HL\\_Seminar\\_3a\\_UNSD\\_international\\_statistical\\_development.pdf](https://unstats.un.org/unsd/trade/events/2019/Shanghai/China_HL_Seminar_3a_UNSD_international_statistical_development.pdf)

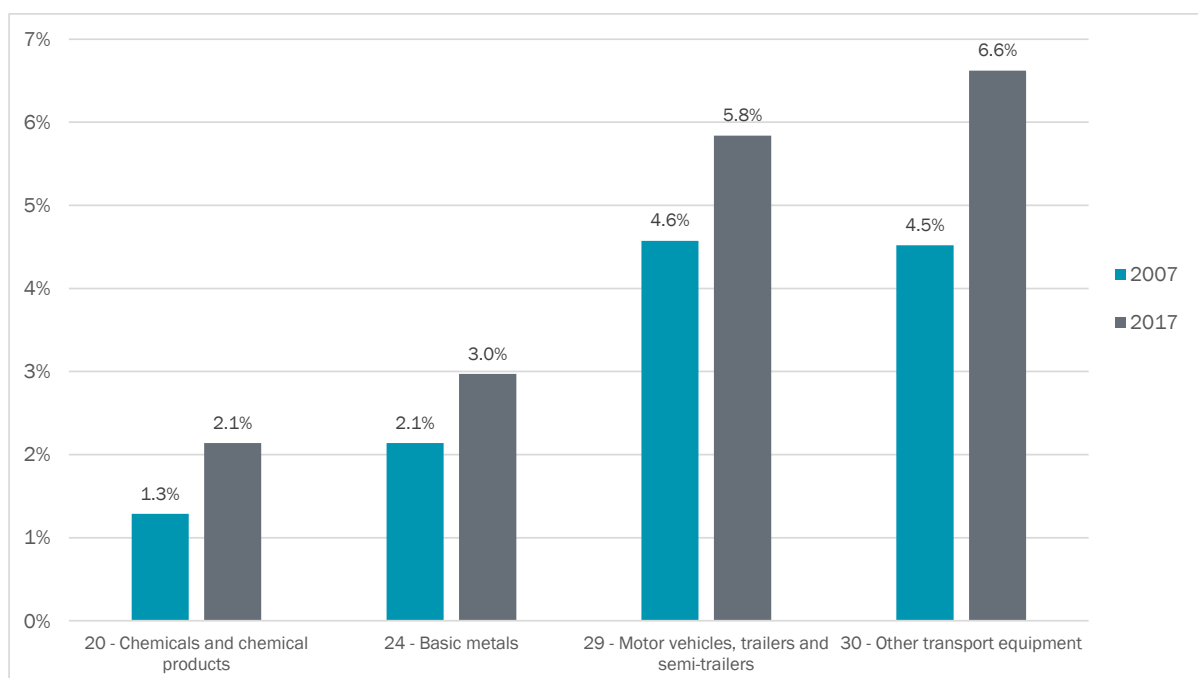
## ANNEX 7 – ADDITIONAL FIGURES ON THE ENDOGENOUS DIGITAL INNOVATION POTENTIAL

**Figure 13: Global “market shares” of digital patents in the engineering industry, 2007 vs. 2017**



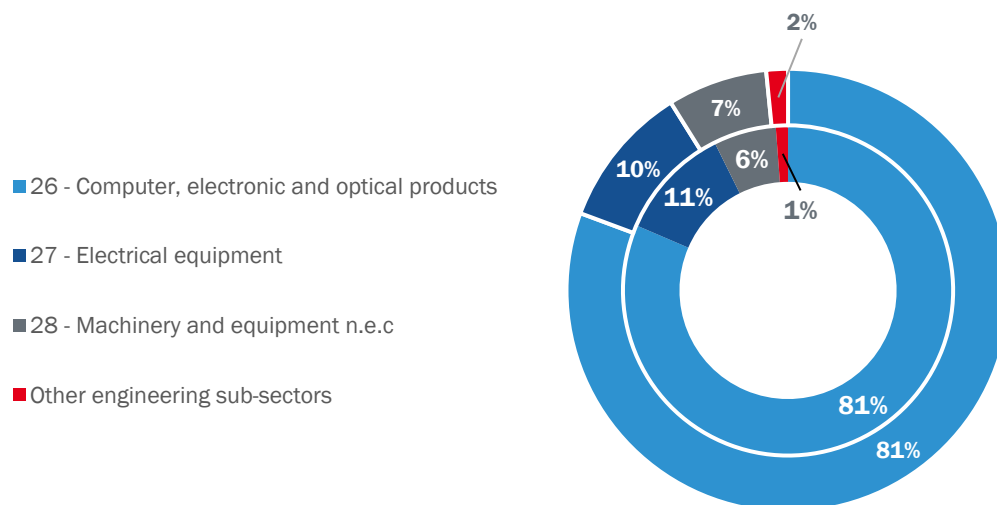
Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014)

**Figure 14: Estimated share of digital patents in all patents in the EU27 + UK of selected manufacturing sectors, 2007 – 2017**



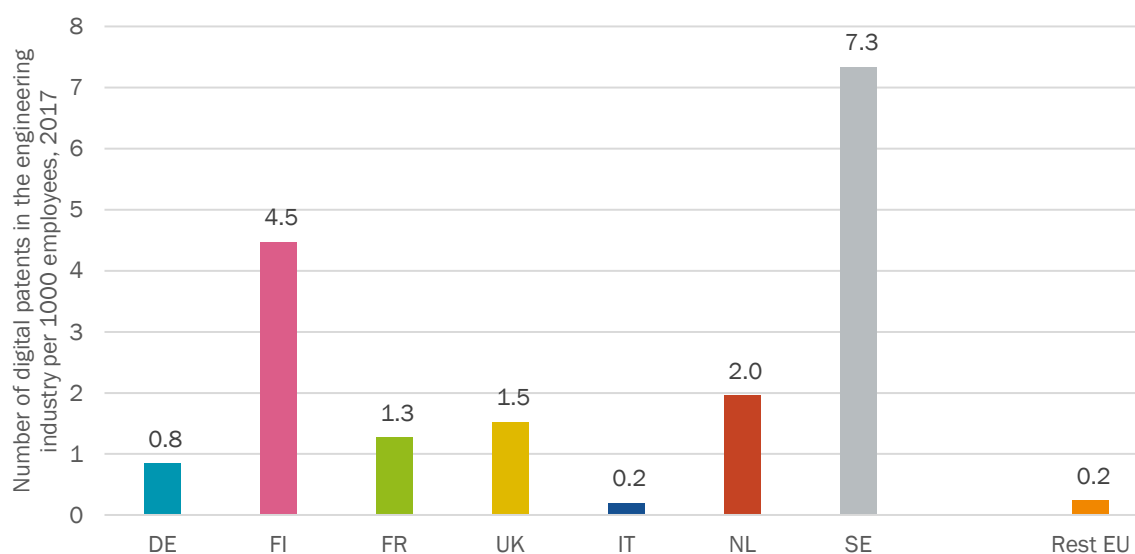
Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014)

**Figure 15: Share of sub-sectors in all digital patents of the EU engineering industry, 2007 (inner circle) vs 2017 (external circle)**



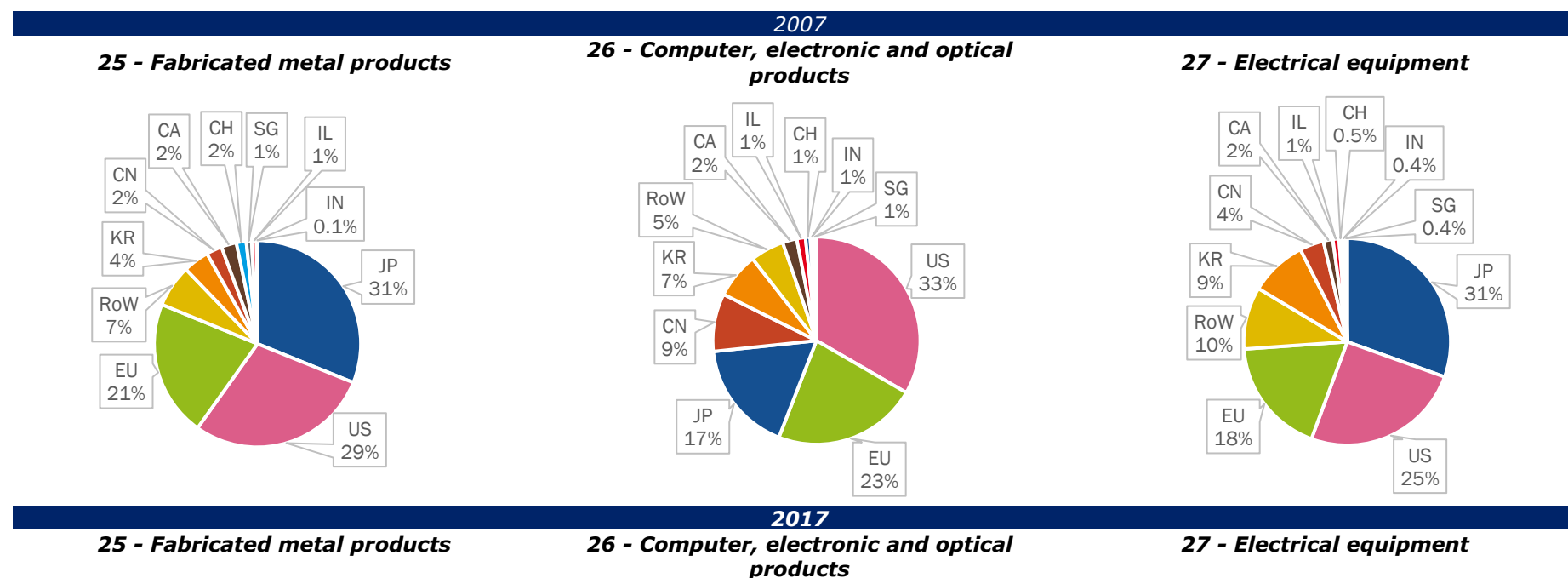
Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014)

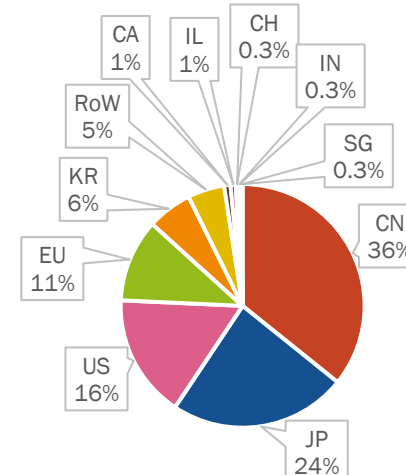
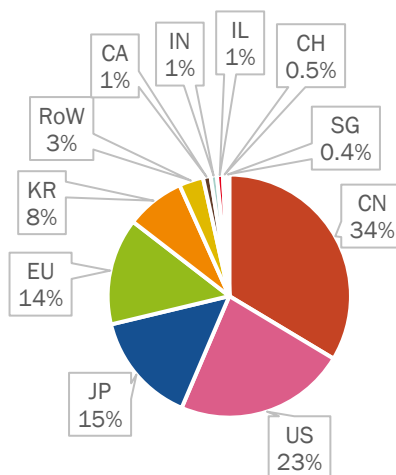
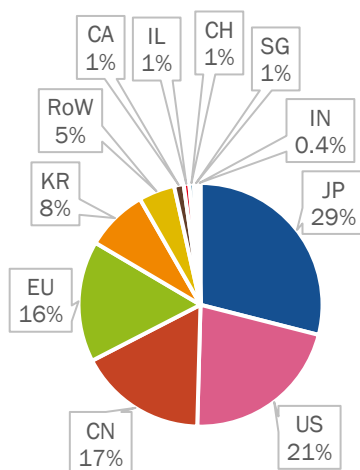
**Figure 16: Digital patents per 1,000 employees in the EU engineering industry**



Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017), Lybbert & Zolas (2014) and Eurostat (SBS statistics).

**Figure 17: Global “market shares” of digital patents in the sub-sectors of the engineering industry, 2007 vs. 2017**



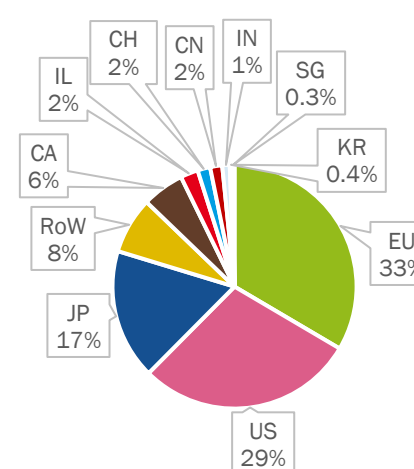
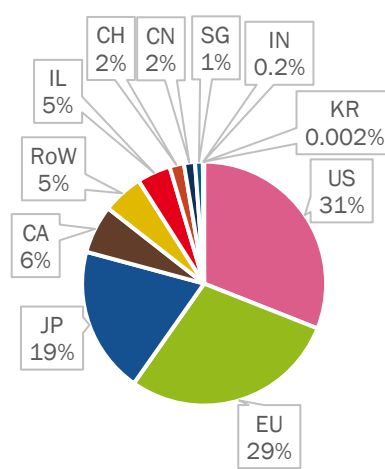
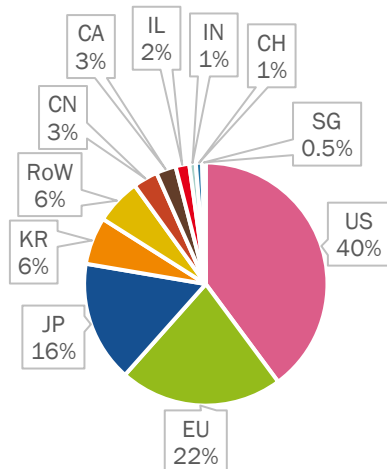


2007

**28 - Machinery and equipment n.e.c**

**32.5 - Medical and dental instruments and supplies**

**33 - Repair and installation of machinery and equipment\***

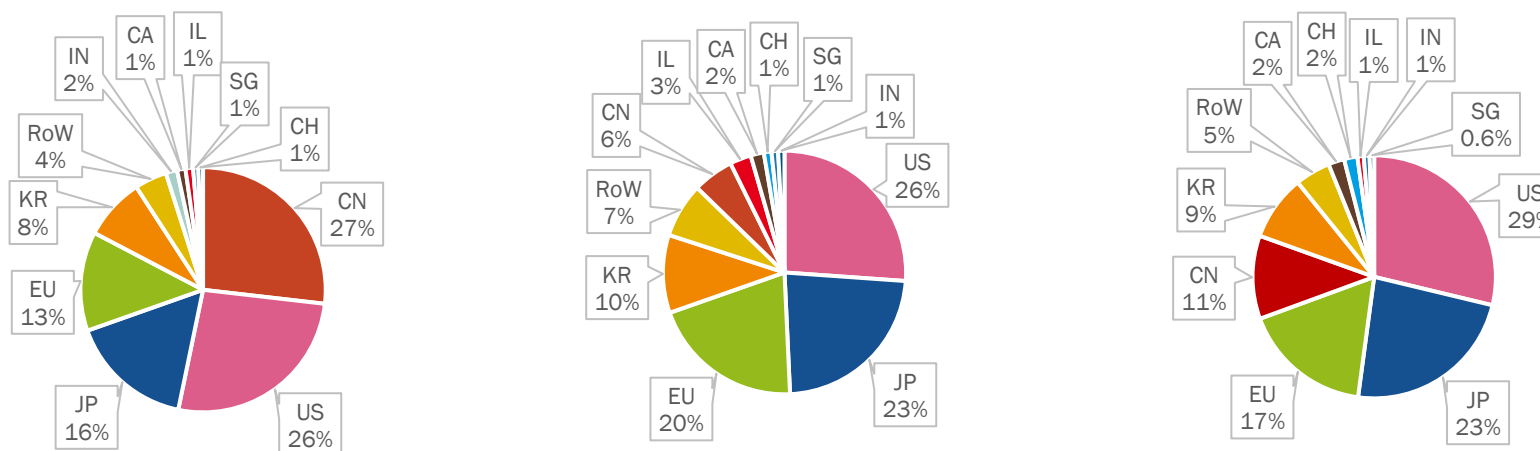


2017

**28 - Machinery and equipment n.e.c**

**32.5 - Medical and dental instruments and supplies**

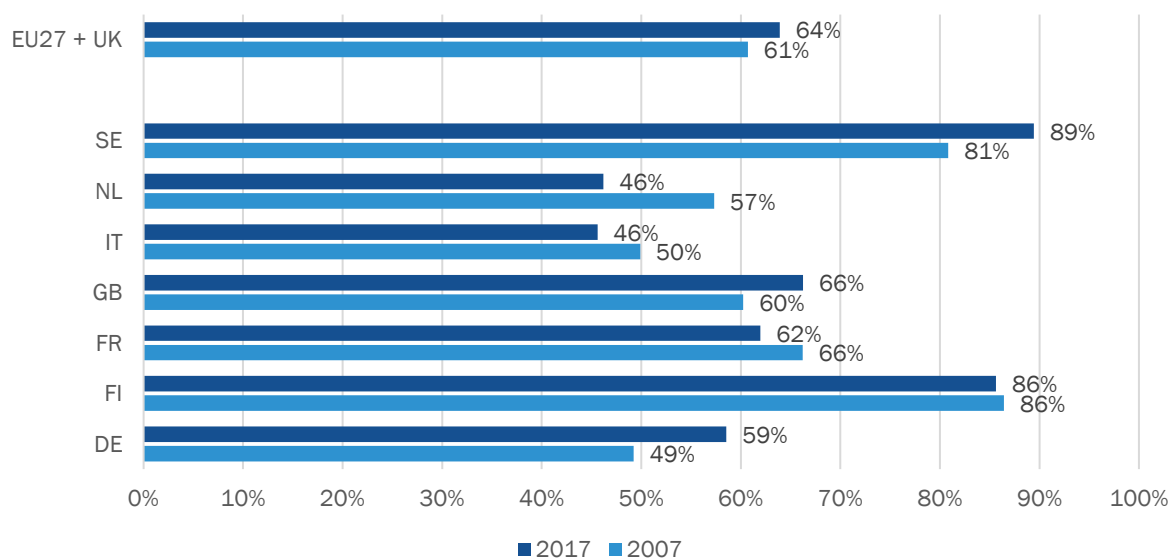
**33 - Repair and installation of machinery and equipment\***



Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014). \*For sub-sector 33 a different approach was used for the computation of the digitalisation share (see Section 1.4.4.3).

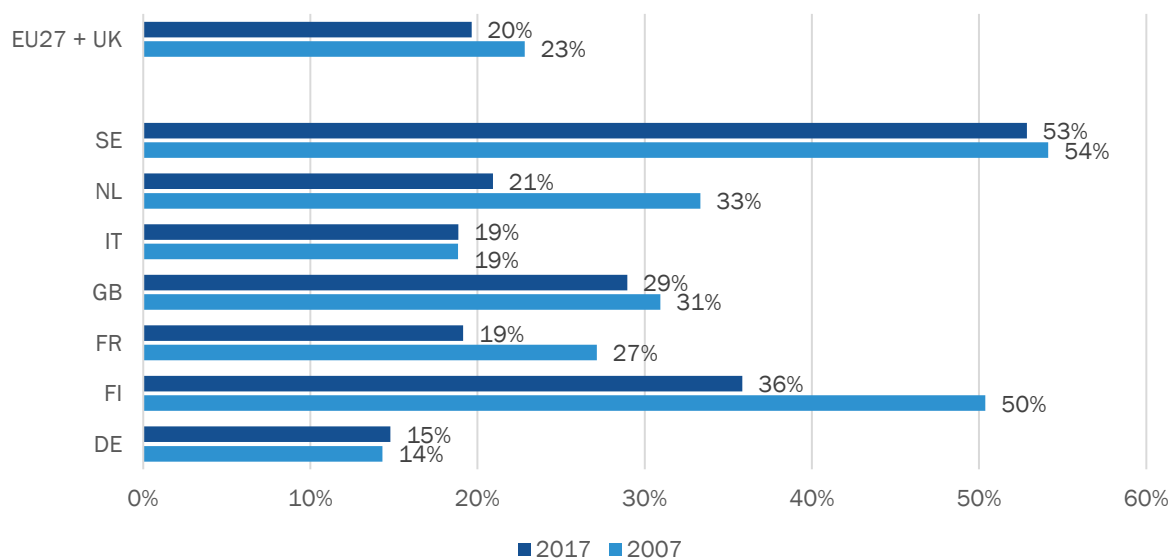


**Figure 18: Estimated share of digital patents in all patents for computer, electronic and optical products (NACE 26) in the EU member states, 2007 vs. 2017**



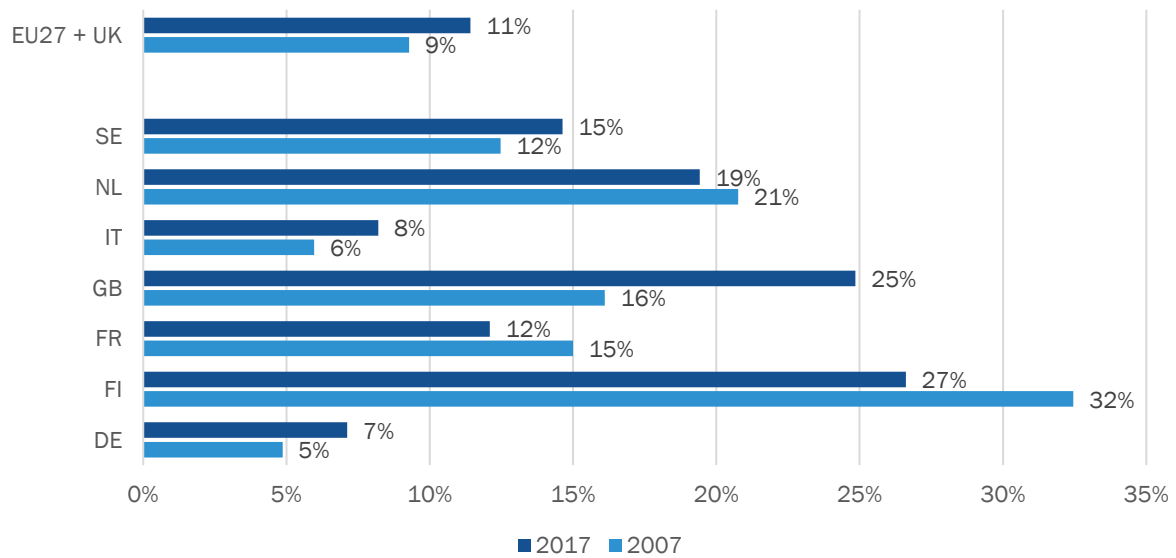
Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014).

**Figure 19: Estimated share of digital patents in all patents for electrical equipment (NACE 27) in the EU member states, 2007 vs. 2017**



Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014).

**Figure 20: Estimated share of digital patents in all patents for machinery and equipment n.e.c (NACE 28) in the EU member states, 2007 vs. 2017**



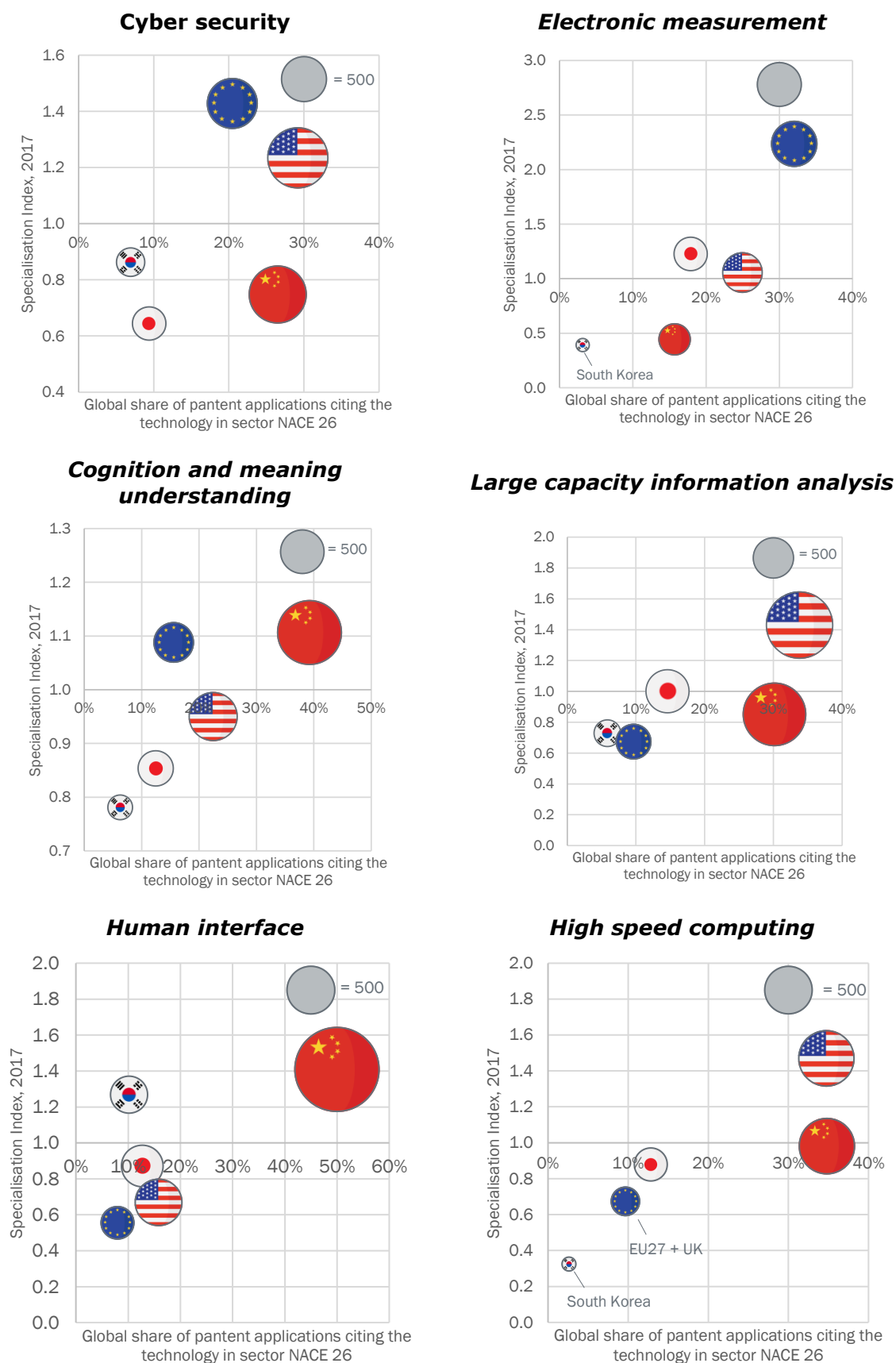
Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014).

**Table 50: ICT technology areas as defined by Inaba, T. & Squicciarini, M. (2017)**

| Technology area                       | Enables                                                                                                                | Encompasses                                                                                                                                                                                                                        |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| High speed network                    | High speed communication through networks. Enhances communication ability.                                             | Digital transmission, network (protocols, architecture, etc.), telephone communication, broadcasting, and transmission, reception, channels (see e.g. Haykin, 2001; ATIS, 2001). Wireless network technologies are not included.   |
| Mobile communication                  | Wireless communication by portable devices.                                                                            | Cellular systems, wireless Local Area Networks (LAN) and Personal Area Networks (PAN). (see e.g. Stüber, 2011).                                                                                                                    |
| Security                              | Security in information processing and communication                                                                   | Secret-coding, authentication, and electronic payment (see e.g. ATIS, 2001).                                                                                                                                                       |
| Sensor and device network             | Communication among sensors and devices.                                                                               | 'Ubiquitous Sensor Networks', i.e. networks of intelligent sensors (see e.g. ITU, 2008).                                                                                                                                           |
| High speed computing                  | High speed data processing. Enhances data processing ability of computers.                                             | Computer architecture, composition of hardware (arithmetic, logic, control, input/output, and storage units), computer programs, and operating systems (see e.g. Hennessy et al., 2012; ATIS, 2001).                               |
| Large-capacity and high speed storage | Storage of large-capacity data and high speed storage.                                                                 | Various storage device-related technologies (e.g. semiconductor memory, magnetic storage, optical storage, etc.); network (e.g. network attached storage, NAS; storage area network, SAN); and file systems (see e.g. ATIS, 2001). |
| Large-capacity information analysis   | Dealing with large amounts of data for analysis.                                                                       | Database and numerical analysis, computational science, and computer aided engineering (see Date, 2005; Teorey et al., 2011; Strang, 2007).                                                                                        |
| Cognition and meaning understanding   | High-level concept understanding.                                                                                      | Cognitive computing (see Wang et al., 2010).                                                                                                                                                                                       |
| Human-interface                       | Operability by human beings.                                                                                           | Human-interface technologies (see e.g. Raskin, 2000).                                                                                                                                                                              |
| Imaging and sound technology          | Processing and transmission of images and sound data.                                                                  | Video equipment, television, image processing, acoustic equipment, and audio signal processing-related technologies (see e.g. Rosenfeld et al., 2014; Bovik, 2010; Spanias et al., 2006; ATIS, 2001).                              |
| Information communication device      | Electronic components (both active and passive devices) realising function of information processing or communication. | Electronic circuits, communication cables, semiconductor lasers, etc. (see e.g. ATIS, 2001).                                                                                                                                       |
| Electronic measurement                | Electronic measurement technologies utilising information processing and communication.                                | Radio navigation, radio direction-finding, etc. (see e.g. Klaassen, 1996).                                                                                                                                                         |
| Others                                | Residual category. ICT related technologies not belonging to any of above categories.                                  | Data input and output, hybrid computer, etc. (see e.g. ATIS, 2001)                                                                                                                                                                 |

Source: Inaba, T. & Squicciarini, M. (2017): *ICT: A new taxonomy based on the international patent classification*, OECD Science, Technology and Industry Working Papers, 2017/01, OECD Publishing, Paris, p.11.

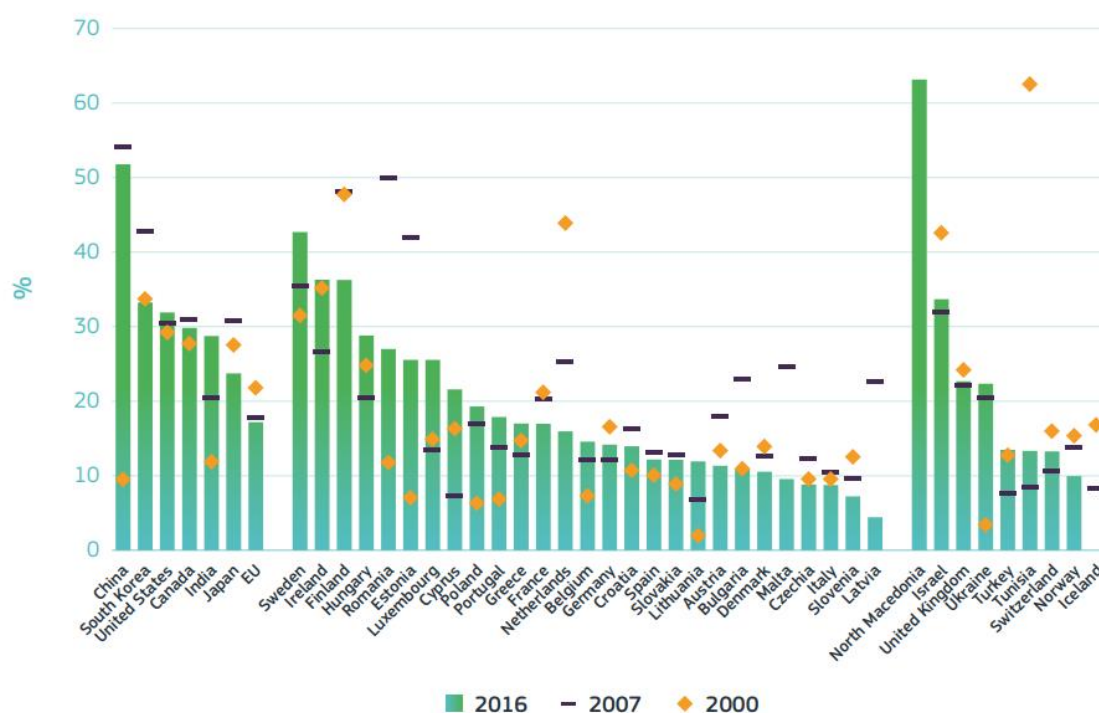
**Figure 21: Specialisation index and global share of digital patent applications in selected technology fields (focus on NACE 26)**



*Note:* The figure shows on the Y-axis the technology specialisation index (SI) for the computer and electronics industry (NACE 26). The specialisation index shows the country's concentration on a specific digital technology field in comparison to the global average. On the X-axis the global share of digital patent applications from the computer and electronics sector citing the technology is shown. The higher the share, the higher is the country's number of patent applications citing the specific technology. The number of patent applications citing the technology is represented by the size of the bubble.

*Source:* Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014).

**Figure 22: ICT-related<sup>(1)</sup> PCT patent applications as % of total PCT patent applications<sup>(2)</sup>, 2000, 2007 and 2016**



Science, research and innovation performance of the EU 2020

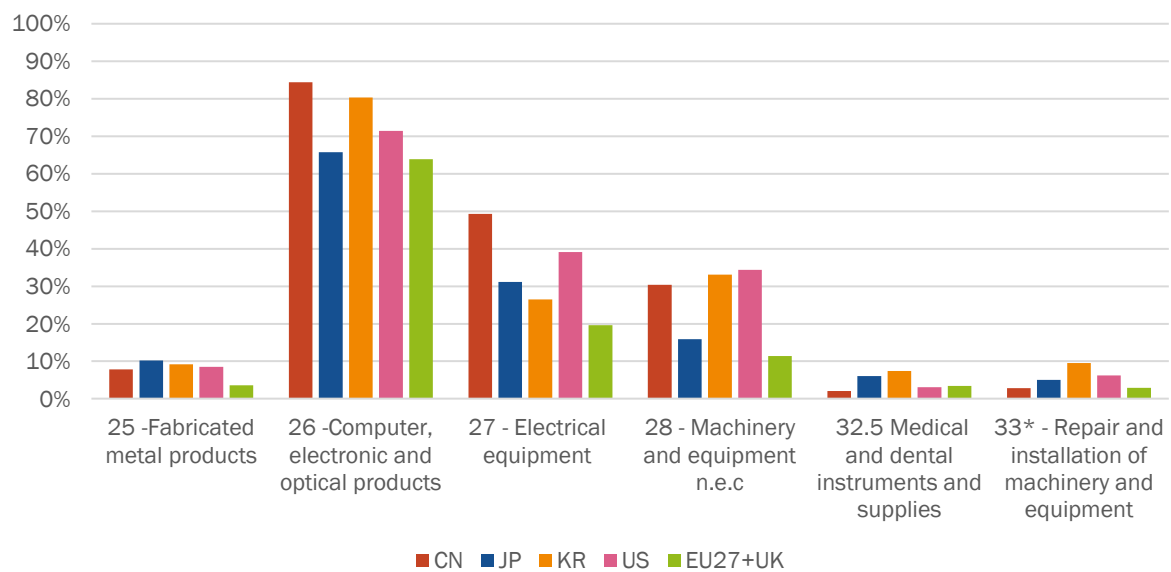
Source: OECD (Patents by technology)

Notes: <sup>(1)</sup>Domains covered are: telecommunications, consumer electronics, computers, office machinery, and other ICT. <sup>(2)</sup>Patent applications filed under the PCT, at international phase, designating the European Patent Office (EPO). Patent counts are based on the priority data and the inventor's country of residence.

Stat. link: <https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter54/figure-54-11.xlsx>

Source: European Commission (2020): Science, Research, and innovation performance of the EU 2020 – A fair, green and digital Europe. p.349.

**Figure 23: Share of digital patents in all patents in the subs-sectors of the engineering industry across EU's main competitors, 2017**



Source: Prognos AG (2020) based on PATSTAT, Inaba, T. & Squicciarini, M. (2017) and Lybbert & Zolas (2014).

\*For sub-sector 33 a different approach was used for the computation of the digitalisation share (see Annex 9: Technical Methodological Note

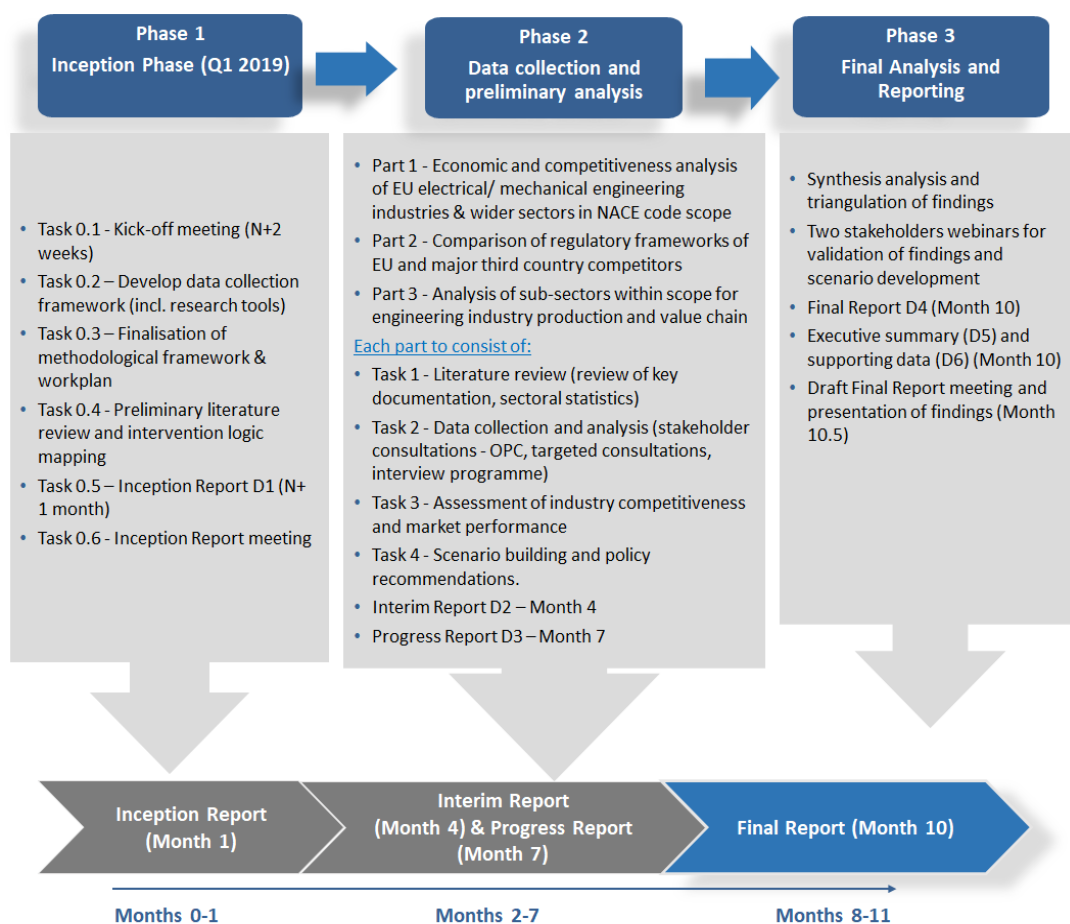
## ANNEX 8 – METHODOLOGICAL ANNEX

### 1. INTRODUCTION

This section contains the standalone supporting Annex 8, which provides a Technical Methodological Note. Whereas in the main report, an overview of the methodology is provided. This is supported by basic information about the level of stakeholder engagement in the interview programme, online surveys and the webinars. However, it is important that this is supported by a more technical explanation of the methodology applied, and the data collection and analysis techniques deployed during the study assignment.

As noted in section 1.3 - Methodological approach of the study report, this study assignment was carried out over three phases, as per the workplan provided in the following Figure:

**Figure 1.1: Methodology overview**



In order to make the study more manageable, there were three different study parts in the Tender Specifications, as below:

- **Part 1 - Economic and competitiveness analysis of the EU electronic, electrical and mechanical engineering industries.**
- **Part 2 - Regulatory analysis between the EU and its key competitors.**
- **Part 3 – Analysis of the extent, impacts, challenges and opportunities of digitalisation.**



The methodological approach reflected the division into the three parts of the study, each with a tailored methodology. However, whilst there were differences specific to each part, a common framework was adopted to conducting the data collection, research and analysis related tasks, namely:

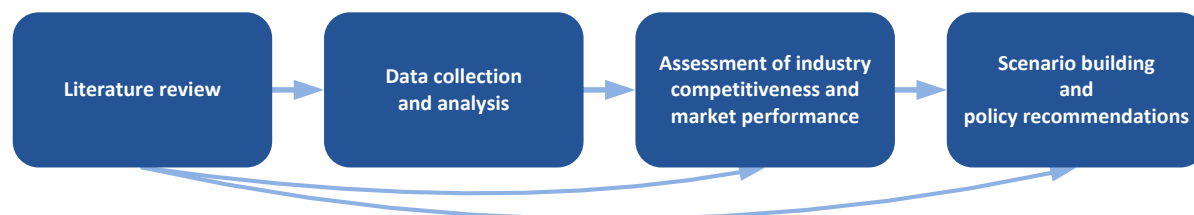
- **Task 1 – Literature review (desk research of key documentation, sectoral statistics);**
- **Task 2 – Data collection and analysis (stakeholder consultations - OPC, targeted consultations, and an interview programme);**
- **Task 3 – Assessment of industry competitiveness and market performance; and**
- **Task 4 – Scenario building and policy recommendations.**

In the following sections, the methodology adopted for each part is summarised.

### **1.1 METHODOLOGY - PART 1 - ECONOMIC AND COMPETITIVENESS ANALYSIS OF THE EU ENGINEERING INDUSTRIES**

The methodological approach for part 1 was comprised of the following steps: a comprehensive literature review, a systematic data analysis (including firm-level data to the extent possible), a regional SWOT of the smart specialisation regions in the field of engineering, as well as desk research and interviews to capture relevant qualitative feedback on key competitiveness drivers as well as strengths, weaknesses, opportunities and threats.

**Figure 1.2: Structure of Part 1 – Economic and competitiveness analysis**



#### **1.1.1 Literature review**

The aim of the literature review was to identify the most crucial and relevant competitiveness factors and obtain an understanding of the issues, factors and developments being discussed among policy makers, the research community and sectoral representatives in relation to the engineering industries.

The literature review was based on a review and assessment of relevant policy documents on EU industrial policy, studies on the competitiveness of the European engineering sectors and on developments in Industry 4.0 and advanced manufacturing, as well as various internet-based grey literature sources (such as articles and blogs on Industry 4.0, the IoT and the implications for the engineering sector and firms). The documents identified and reviewed are detailed in Annex 1 – Bibliography. It covered the engineering industries in their entirety as well as each of the subsectors.

#### **1.1.2 Data collection and analysis**

The aim of the data collection and analysis was to collect and analyse (preferably comparable) statistical data on the engineering industries and its subsectors at a European (including national) and international level. The intention was to cover – as far as possible – the previous 10 years starting from 2008 to the most recent year available. This section

first details the relevant indicators covered by the data collection and analysis, before detailing the public and private data sources used.

### **Indicators**

The following list of target indicators was developed on the basis of the Tender Specifications, as well as the two predecessor studies on the electrical and electronic engineering industry<sup>523</sup> and the mechanical engineering industry<sup>524</sup>:

- Indicators related to growth, such as the number and size of enterprises, employment, turnover and value added;
- Production: production / output, market coverage by production;
- Labour force and skills: share of engineers and researchers, skills, skills needs, vacancies and vocational training;
- Trade: exports, imports, balance; trade with key competitors (US, China, Russia, Japan, South Korea and India); import of raw materials; data on global value chains
- Foreign Direct Investment (FDI); merger and acquisitions
- Price and cost competitiveness, productivity (including labour costs and Unit Labour Costs as well as productivity);
- Investment (gross and net) and investment patterns;
- Investment/expenditure in R&D and uptake of new technologies;
- Patents and
- Financial strength indicators: equity / equity ratio and EBT – Earnings before taxes / EBT margin.

### **Use of price indices**

In order to present developments in the engineering industries in real terms, both for 2008 and 2013 as well as 2013 up to the most recent available year, the following existing price indices have been used:

- Eurostat, National accounts: Price index value added in 2015 prices – this price index was used for calculating changes in real terms for the indicators “turnover”, “value added” and “investments”.
- Eurostat, Short terms business statistics for industry: Total output price index in 2015 prices – this price index was used for calculating changes in real terms for the indicator “production value”.
- Eurostat, Trade data base: Import and export volume indices in 2015 prices for the product group related to “machinery”.

### **Key data sources**

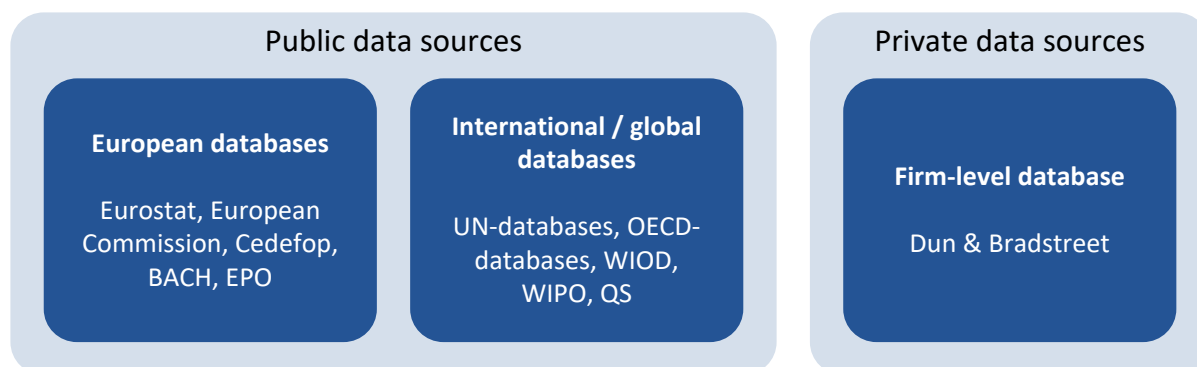
The following public and private databases have been used in order to gather relevant and comparable data of the engineering industries in the EU and globally.

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<sup>523</sup> ECSIP Consortium (2013): Study on the Competitiveness of the Electrical and Electronic Engineering Industry - Final Report. Brussels: European Commission.

<sup>524</sup> Vieweg, H.G. et al. (2012): An introduction to Mechanical Engineering: Study on the Competitiveness of the EU Mechanical Engineering Industry. Final Report. Study on behalf of the European Commission, DG Enterprise and Industry. Available at <https://ec.europa.eu/docsroom/documents/12329/attachments/1/translations/en/renditions/native>, 11 July 2019

**Figure 1.3: Public and private data sources used**



**Eurostat:**

- Structural Business Statistics (enterprises, persons employed, turnover, investments etc.)
- National accounts (gross value added)
- Statistics on the production of manufactured goods (PRODCOM)
- Business Demography
- International trade in goods (COMEXT)
- Statistics on research and development (GERD, BERD)
- ICT statistics

**European Commission:**

- EU Industrial R&D Investment Scoreboard
- Raw Materials Scoreboard
- Research and Innovation Observatory (RIO)
- SME Performance Review
- Survey on Access to Finance for Enterprises
- Merger Cases database
- Smart Specialisation Platform (S3)

**Cedefop:**

- Skills-OVATE

**Other European databases:**

- Bank for the Accounts of Companies Harmonized (BACH)
- European Patent Office (EPO)

**OECD:**

- OECD Balanced International Merchandise Trade Statistics
- OECD International Direct Investment database

#### **UN-databases:**

- UNIDO INDSTAT 2 Database
- UNCTAD, FDI/MNE database

#### **International databases:**

- World Intellectual Property Organization
- World Input-Output Database (WIOD)
- Institute for Mergers, Acquisitions and Alliances (IMAA) research
- QS World University Rankings

#### **1.1.3 Assessment of industry competitiveness and market performance**

Next to the literature, statistical data and indicators listed above, further methodological instruments have been used to assess the competitiveness of the engineering industries.

- **Global value chain analysis:** Global value chains are the macroeconomic conceptual basis for analysing the global distribution of production and work. Multi-regional Input-Output Tables (MRIO), such as the World Input-Output Database (WIOD), allow identification of the global value-added network. Specifically, the value-added contribution of the European engineering industries to global production (forward integration), as well as the value-added contribution of other countries to production in the European engineering industries has been determined. In doing so, the developments of global distribution of production until production of final goods has been traced and related changes in international competitiveness as well as winners and losers of these changes have been identified. The benefits and disadvantages of globalisation in the European engineering industries in comparison to the major competitors has also been assessed, both in relation to the baseline and over time. Based on this assessment, potential opportunities and/ or threats for the European engineering industry caused by the reorganisation of value chain networks have been examined.
- An **interview programme** with key **stakeholders from industry associations, relevant public authorities and policy makers, relevant researchers, and large firms and SMEs** to collect their assessment of the competitive position of the EU's engineering industries and their strengths and weaknesses.
- **Targeted stakeholder consultation** through an online survey-based questionnaire covering the aspects listed above.

#### **SWOT ANALYSIS OF THE COMPETITIVENESS OF THE EU SMART SPECIALISATION REGIONS**

The aim of the SWOT analysis was to summarise the key strengths, weaknesses, opportunities and threats of the EU Smart Specialisation Regions and develop favourable framework conditions for their further development. The assessment also demonstrated the extent to which (and how) the development and implementation of Smart Specialisation Strategies has been contributing to improving the competitiveness of the EU engineering industries.

The SWOT analysis of the EU Smart Specialisation regions was conducted through the following six steps:

- 1) **Specification of the aims:** In the first step, **the aim of the analysis was specified as follows:** assessing the competitiveness of EU Smart Specialisation regions in the field of engineering industries and identification of favourable framework conditions for their further development.

- 2) **Identification of internal factors**, i.e. strengths and weaknesses. Based on a literature review and data analyses, **22 internal factors were identified**. These factors refer to the intra-industry situation of the engineering industries and can represent either **strengths or weaknesses**.
- 3) **Identification of external factors**, i.e. opportunities and threats. Based on a literature review and data analyses, **10 external factors were identified** allowing for a description of the wider socio-economic environment and the extra-industry situation of the engineering industries. These external factors represent changes in the market and in the technological, social or ecological environment and, thus, reflect realistic **chances or opportunities as well as possible threats**.
- 4) **Assessment of key competitiveness factors**. In the next step, the **internal and external factors were assessed** by relevant industry experts and representatives of the Smart Specialisation regions focusing on engineering industries. Smart specialisation is an approach that enables European regions to identify and develop their own competitive advantages and implement according strategies supported by the European Structural and Investment Funds. The S3 online Platform<sup>525</sup> provides an overview of all regions that have implemented Smart Specialisation Strategies. For the assessment of the SWOT factors, all regions that had included engineering industry sectors in their Smart Specialisation Strategies (S3) – e.g. as priority economic or priority scientific domain – were identified on the S3 online Platform;<sup>526</sup>
- 5) **Creation of a SWOT matrix**; and
- 6) **Derivation of favourable framework conditions**.

The assessment was based on an online survey carried out in March and April 2020 (see questionnaire in the Annex). The contact data of the smart specialisation regions was drawn from the S3 online Platform. Altogether, 280 regional representatives were invited to participate in the survey. In total, 34 valid responses from 31 different regions could be included in the analysis. Participating regions included: Anatoliki Makedonia / Thraki, Aragón, Calabria, Centro Region of Portugal, Comunidad Valenciana, Dolnoslaskie, Etelä-Pohjanmaa, Etelä-Savo, Flemish Region, Kentriki Makedonia, Lithuania, Malopolskie, Malta, Nord – Pas-de-Calais, Nordjylland, Nord-Vest, Opolskie, Östergötlands, Pirkanmaa, Podlaskie, Pohjois-Karjala, Salzburg, Satakunta, Skåne län, Steiermark, Sud-Vest Oltenia, Varsinais-Suomi, Veneto, Warminsko-Mazurskie, Western Netherlands and Zachodniopomorskie.

From the above mentioned data and sources (literature, statistics, consultations, SWOT), a synoptic overview on the competitive position of the EU engineering industry has been developed.

#### **1.1.4 Scenario building and policy recommendations**

**Step 1:** The stakeholder consultations and the SWOT analysis of Smart Specialisation Regions have also been used to develop a limited set of potential key drivers – in other words, future opportunities and threats – and how positively or negatively they are potentially influencing the EU engineering industries over the next 10 years.

**Step 2:** The preliminary hypotheses about key drivers and their impacts have then been validated and prioritized in the framework of a stakeholder workshop, which was held through a webinar on May 20th, 2020.

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<sup>525</sup> <https://s3platform.jrc.ec.europa.eu/de/what-is-smart-specialisation->

<sup>526</sup> For a detailed description of the methodological approach, please see the Annex.

**Step 3:** Based on the validated and prioritized hypotheses, i.e. those with significant and likely future impact, a positive development scenario and a negative development scenario have been constructed.

**Step 4:** Recommendations have then been derived from both scenarios, i.e. recommendations on how to support the positive scenario to materialise as well as 'defensive' recommendations on how to prevent the negative scenario from materialising.

## 1.2 Methodology - Part –on Regulatory analysis of legislation applicable to the EU engineering industries.

### 1.2.1 Introduction to Part 2

Part 2 also followed the four common steps outlined in Part 1. The specific steps involved in undertaking Part 2 are summarised in the following table:

| Steps                                                                                                                                                       | Objectives and description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1 – Mapping of the applicable legislation in the engineering industries and wider sub-sectors, in the EU and international competitor countries</b> | <p>Develop understanding of the regulatory environment in which the EU engineering industries have been operating in the past decade.</p> <p>Consider how this differs between EU countries and international competitors (e.g. the US, Japan, South Korea and BRICs).</p> <p>Ensure that the mapping covers all the main applicable legislation e.g. industrial product, environmental and horizontal regulations, other types of applicable legislation (e.g. health and safety-related, labour market, cybersecurity and data protection and privacy-related EU legislation).</p> <p>Examine any issues in the transposition of EU Directives by Member States, such as incorrect transposition, and gold-plating of minimum harmonisation Directives at national level.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Step 2 – Mapping of the administrative requirements and information obligations for economic operators.</b>                                              | <p>Identify and analyse administrative requirements and information obligations for economic operators stemming from the applicable EU regulations.</p> <p>Identify similarities and differences in the requirements across different types of applicable EU legislation.</p> <p>Consider how far economic operators in the EU engineering industries may be benefiting from the more common horizontal requirements introduced through the New Legislative Framework (NLF) (e.g. common rules for placing products on the market, CE marking requirements).</p> <p>Consider in the case of industrial product regulations the degree of effectiveness of conformity assessment procedures available to economic operators (especially manufacturers) across different legislation and whether this is sufficiently flexible (e.g. Self-Declaration of Conformity approach for some product groups, but mandatory third-party testing and EC-type examination by notified bodies depending on the level of risk).</p> <p>In the case of environmental, horizontal, data protection and privacy and other types of legislation, we have mapped and analysed the main administrative compliance requirements for economic operators and any information obligations (e.g. introduction of reporting requirements in database form under some environmental legislation).</p> |
| <b>Step 3 – Comparative assessment of the regulatory</b>                                                                                                    | <p>Analysis of differences and similarities between the EU regulatory regime (e.g. key requirements, conformity assessment procedures, mandatory third-party testing or self-testing etc.) and those in third</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

| Steps                                                                                                           | Objectives and description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>environment in the EU and internationally for the engineering sectors (and product groups) within scope.</b> | <p>country competitor countries.</p> <p>Assessment of the extent to which this has impacted on sectoral competitiveness.</p> <p>The comparative level of ambition of the EU regulatory environment, as opposed to different global regulatory jurisdictions was considered.</p> <p>The likely evolution of legislation in future was then considered taking account of the implications of new technologies, digitalisation, Industry 4.0 (robotisation, automation), and the (Industrial) Internet of Things, as well as increased environmental legislation in the context of the Green Deal, sustainable industrial policy and Circular Economy Action Plan.</p> |
| <b>Step 4 – Qualitative assessment of causal links between regulation and performance.</b>                      | <p>Examination of the impacts of EU regulation on sectoral competitiveness.</p> <p>Assessment of the impacts of regulations on market behaviours of individual firms and on SMEs.</p> <p>Consideration of the complex interplay between different types of applicable EU legislation, including the cumulative effects.</p> <p>The impact of possible future changes to legislative requirements in the EU and internationally on economic operators.</p>                                                                                                                                                                                                           |
| <b>Step 5 – Assess causal links between regulation and performance.</b>                                         | <p>Qualitative assessment of causal links between regulation.</p> <p>Assessment of how far changes in the performance of the EU engineering industries may have been influenced by the regulatory framework, and the degree of stability and change in the EU legal framework in the period within scope.</p>                                                                                                                                                                                                                                                                                                                                                       |

The scope of the legal mapping (EU, international) is outlined in the main report.

The main data and information sources used to inform the mapping of the regulatory framework applicable to the EU engineering industries, the data collection process to inform the analysis of impacts were:

- **Desk research and documentation review;**
  - Mapping and review of key applicable EU legislation in the EU engineering industries;
  - Mapping of the obligations and requirements for economic operators to comply with applicable legislation;
  - Mapping and comparative assessment of international legislation;
- **Interview programme** e.g. with industry associations representing the EU engineering industries, and with notified bodies/ representatives from testing laboratories;
- **Gathering and analysis of the online survey responses.** In particular, the responses from industry associations, manufacturers and from notified bodies and market surveillance authorities (MSAs) were reviewed to identify useful feedback. The latter survey was the most useful.



Part 2 provides an assessment of the regulatory framework applicable to the EU engineering industries. The Tender Specifications require (1) mapping the applicable EU regulatory framework and examining how key legislation has evolved in the past decade (2) a comparative assessment of the current baseline situation in the EU with international legislation<sup>527</sup> and (3) a review of how the regulatory framework might evolve in future, considering the ongoing fitness for purpose of the body of applicable product legislation, and the impact of emerging new technologies linked to digitalisation and Industry 4.0, especially artificial intelligence (AI), machine learning, robotisation and automisation, and related developments in the industrial internet of things (IIoT).

The extent to which there are differences between Member States in terms of how EU legislation is being transposed into national legislation, implemented and enforced has also been considered. This includes an examination of the issue of gold-plating (going beyond the minimum requirements in national legislation).

### **1.2.2 Literature review**

A desk research-based review of literature on the EU and international regulatory environment applicable to the EU engineering industries was undertaken in selected key competitor countries. This assessed the:

- **Applicable EU legislation** across different types of directives and regulations (e.g. relating to industrial products, environmental legislation, horizontal legislation, legislation safeguarding data protection and privacy, cybersecurity, energy efficiency legislation, consumer and health protection, occupational health and safety legislation and labour market laws;
- **Extent of continuity and changes in the body of EU legislation applicable to the EU engineering industries;**
- **Applicable Legislation in international competitor countries (US, Japan, South Korea and the BRICs countries – Brazil, Russia, India and China)** spanning the same legislative areas detailed above. It also reviewed evolving legislative developments and future scenarios relating to emerging technologies such as AI and cybersecurity.
- **Potential future changes to existing, and the possible introduction of new EU legislation.** The impact of new technologies such as AI and machine learning, and the increased deployment of Industry 4.0 technologies on the legal framework is considered. The impact of increased attention by regulators to cybersecurity, and the impacts on the regulatory framework of the Green Deal are also considered.

Various documents were reviewed, such as EU legislative texts, reports and national policy and regulatory documents outlining the legal framework in third countries. In addition, evaluations and impact assessments pertaining to the possible revisions of existing EU legislation were reviewed (e.g. consultation responses and position papers to the IA on **possible revisions to the 2006 Machinery Directive (2006/42/EC)** to accommodate developments in AI and machine learning, two published IAs on the possible activation of different delegated acts under the Radio Equipment Directive (Directive **2014/53/EU**), **focusing on** possible safeguards for strengthen product security regarding data protection and privacy and protection from fraud and the question of software and firmware updates.

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<sup>527</sup> Regarding the scope of the mapping and analysis of international legislation applicable to the EU engineering industries if they export to countries outside the EU, the regulatory frameworks applicable in third country competitor countries, such as the **US, Japan, South Korea** and the **BRICs (Brazil, Russia, India and China)** were mapped.

As regards future scenarios, two types of literature were consulted:

- **The impact of new technological developments and innovation on EU and international legislation.** National policies and strategies relating to fostering the development of emerging areas such as digitalisation, Industry 4.0 and Artificial Intelligence (AI) were identified both in the EU and third countries.
- Relevant information as regards **possible future regulation on AI in Europe** and differences in approaches between the EU and third countries as to whether AI needs to be regulated.
- **The impact of increased attention to the environment and sustainability.** The impact of changes to key EU political priorities of the new Commission, such as the adoption of the Green Deal, associated regulatory developments, such as the proposal for a new EU climate law, and the renewed focus on sustainability and on strengthening the circular economy are considered.

A detailed bibliography setting out the key documentation consulted can be found in Annex 1.

### **1.2.3 Data collection and analysis**

Key activities for the data collection phase were:

- An interview programme with key stakeholders from industry associations, large firms and SMEs, notified bodies and representatives of testing laboratories to review the applicable legislation, its potential impact in terms of market access barriers.
- Targeted stakeholder consultation through an online survey-based questionnaire.
- Conducting a stakeholder workshop on the impacts of EU regulation on the EU engineering industries. This was held through a webinar on May 15<sup>th</sup>, 2020.

Once the secondary data had been collected, **data analysis was undertaken focusing on the impacts of** regulatory developments in the past 5-10 years and potential new regulatory developments likely to emerge and affect European industry in the next 5-10 years, especially those linked to digitalisation, AI and the growing deployment of Industry 4.0 practices in advanced manufacturing.

The data collection and analysis focused on mapping the applicable legislation in the engineering industries and wider sub-sectors, in the EU and international competitor countries (i.e. Step 1). In both the EU and the international competitor countries, legislation applicable to the mechanical, electronic and electrical engineering industries has been identified, reviewed and mapped in the EU and selected third countries.

The main requirements for economic operators in the EU have been identified and analysed (Step 2) and feedback on compliance costs was sought through the online survey. A comparative assessment of the regulatory environment in the EU and in major competitor countries internationally for the engineering sectors was undertaken (Step 3).

To illustrate the impacts of EU regulation on the engineering industries, case studies have been developed to examine the impacts of the WEEE and RoHS Directives and the REACH Regulation on EU engineering industries.

For each of the competitor third countries examined (the US, Japan, South Korea and BRICs), the legislative frameworks for each country have been reviewed through desk research, supported by some interviews with relevant industry associations (e.g. from the US, Japan and Brazil, for example).

The future evolution of the legal framework to accommodate increased attention to environmental and sustainability issues was then considered. In particular, as part of the

Green Deal, a package of interventions has already been envisaged. The implications of these proposals, such as the proposed EU Climate Change law, were considered. Moreover, the updated EU Circular Economy Action Plan 2020 was also assessed, as this has implications for European industry.

#### **1.2.4 Assessment of links between regulation and performance**

The extent to which a causal link can be established between EU regulation and sectoral performance was examined. Linkages between EU regulation and sectoral performance were undertaken using qualitative assessment based on interview feedback with industry associations. A range of **methodological challenges** were considered in the analysis:

- The relationship between regulation and growth is complex. Regulation can serve both as a driver and inhibitor of industrial competitiveness and innovation;
- Since a multiplicity of different pieces of legislation will be applicable to a given product, it was difficult to isolate the specific impact on sectoral performance of EU regulations and to determine a causal link quantitatively, therefore a qualitative approach was adopted.
- The views of industry associations were particular taken into account.
- The methodology was adapted somewhat to take the impacts of the COVID-19 impact into consideration. A key message from industry associations was that there should be a pause in proposed regulatory changes, and that although this would cause some regulatory uncertainty in the interim, EU engineering industries face considerable demand-side (and still some supply side challenges).

#### **1.2.5 Scenario building.**

Future alternative scenarios were developed for the regulatory analysis part, which were validated with relevant stakeholders through interviews and the webinars. The scenario modelling was based on the findings from the literature review and interview programme data analysis.

Based on the legal mapping of the baseline situation, we then **analysed how far the existing regulatory framework is likely to change in the short, medium and longer term** to reflect technological developments. Based on this assessment of recent key regulatory trends and developments, **alternative scenarios for the future evolution of regulations up to 2030** for the electronic, electrical and mechanical engineering sector and for ICT were developed. The scenario modelling could potentially consider the situation in different five-year junctures e.g. 2020, 2025 and 2030. The proposed approach is consistent with the approaches used for scenario building in Parts 1 and 3 of the study. This will ensure that the outcomes and policy recommendations from all three parts are integrated into the final study results.

The approach to scenario building followed the following steps:

- Identification of a **clear regulatory baseline situation.**
- **Development of alternative future scenarios to the development of the regulatory landscape** both in the EU and internationally, considering any differences in the likely evolution of the regulations in the short, medium and longer-term future (2020, 2025 and 2030 respectively).
- **Integration of a comparative dimension to the scenario modelling to compare the likely future evolution of the EU regulatory framework**, and in key competitor countries outside the EU.

Policy recommendations were informed by the scenario analysis.

### **1.3 METHODOLOGY - PART 3 – IMPACT OF DIGITALISATION AND INDUSTRY 4.0**

Various methodologies have been used to obtain relevant information and data, as well for analysing the results using triangulation in order to derive founded conclusions. In the following section we describe the qualitative and more quantitative approaches.

#### **1.3.1 Literature review and interviews**

We have reviewed key documentation as part of the desk research as well as part for preparing the interviews with various stakeholders (industry organisations, companies, academia and research organisations, RTOs and cluster organisations). The literature review and interviews focused on gathering information about the particular themes and topics of Part 3 of the study, more specifically:

- 1) The (comparative) state of digitalisation of the EU engineering industry;
- 2) The share of innovation earmarked for digitalisation based on e.g. patent data;
- 3) Investments in digitalisation;
- 4) The effects of digitalisation on:
  - a. The competitive position in the global market across different branches of the EU engineering industry;
  - b. Reshoring of either entire firms or of particular production functions back to the EU;
- 5) The challenges in assimilating digital technologies, for:
  - a. The EU engineering sector as a whole;
  - b. SMEs in the EU engineering sector;
- 6) The opportunities and solutions for flexible adaptation to digitalisation;
- 7) The effects of the regulatory framework;

Within the literature review major sources have been identified in a top down approach, from the general to the specific. Literature providing an overview of the effects of digitalisation on the competitiveness of the EU engineering industries is scarce. Apart from the past competitiveness studies that provided a first view on the issue (ECSIP Consortium, 2013) and (ECSIP Consortium, 2012) relatively little is known on the competitiveness effect of digitalisation on the EU engineering industry. On the contrary, a wide body of literature exists on the impact, importance and future opportunities of digitalisation for industry as a whole. A reasonable set of studies exist on (particular sub-sectors or activities of) engineering. Yet the combination of both is largely void. Therefore, our overall analytical approach for the literature review has been to:

- i) identify the major impacts on industry in general (mechanisms, effects);
- ii) assess similar mechanisms for the EU engineering industry;
- iii) identify the sector specific effects, underlying mechanisms for the EU engineering sector.

Against this background the questions specifically referred to in Part 3 (see above) have been addressed, allowing to identify existing information gaps and elaborate further analysis using information from data, the surveys and interviews. In the course of the

project new sources of studies, articles and reports have been detected through cross-referencing, especially through interviews, and have been included.

### **1.3.2 Data collection and analysis**

The data collection in Part 3 focuses on the digitalisation of the EU engineering industry, compared to its main trading partners around the world, notably the US, Japan, China, South-Korea, Russia and India.

- **Step 1:** Identification of the relevant dimensions and data on the digitalisation aspects for the EU engineering industry.
- **Step 2:** Data collection and documentation of the evolution of the EU engineering industry and its main competitors around the world.

A two-tier approach has been followed analysing in parallel:

- i) publicly available data sources such as Eurostat, OECD and
- ii) proprietary data, specifically the digital patents dataset.

As with the literature review, the analysis allowed us to identify the relevant indicators for this study, data gaps, as well as potential avenues for further elaboration of the study which have been further explored and assessed in view of answering the research questions in Part 3.

The publicly available data sources analysed comprise those from Eurostat, the different DGs of the European Commission, international organisations like OECD, UN, World Economic Forum and private research institutes and consultancies (IMD, Accenture, ...). An inventory was made of all available indicators that refer to different aspects of digitalisation, both at enterprise level as well as at consumer or citizen level. For each of the indicators (or sets of indicators) an inventory with the following dimensions was made:

- facets of digitalisation: infrastructure, investment, trade, digital skills, e-leadership and digital entrepreneurship
- focus on the engineering sector (or its subsectors)
- company size focus
- time frame for which data is available
- geographical scope of the data: EU Member State level, EU-aggregates and our main competitors (US, JP, CN, KR, RU, IN).

In order to assess the relevance of each of the data sources in answering the research questions, we scored each of the (sets of) indicators on three dimensions:

1. the conceptual relevance of the indicators: the extent to which the indicators reveal the way digitalisation influences and affects the competitiveness of an economy;
2. the availability of data on digitalisation focussed on the engineering industry;
3. the availability of comparable digitalisation data of our main competitors.

For each of these three dimensions a 'relevance' score was derived going from low (score 1) over medium (score 2) to high (score 3). The average of the scores on the three

dimensions resulted in an overall relevance score indicating the degree to which the indicators are able to give a response to the research questions.

Given the outcome of the public data source assessment, the feasibility of using product codes in Prodcom for digital goods and services was assessed. At the time of the study (2019-2020) various projects and initiatives were ongoing to monitor and measure (the effect of) digitalisation, yet no unanimously accepted definition, set of product codes and approach was readily available.

Therefore for the analysis of the performance of the EU engineering sector in terms of digital goods trading, we use the strategy to focus on one particular and important sub-sector NACE 26: 'Manufacture of computers, electronic and optical instruments' and assessed the effects of digitalisation as an example or proxy for the rest of engineering sector based on the validated methodology in EASME's ongoing 'Advanced technologies for industry' project. As will be shown further in the report, this subsector ranks third among all engineering subsectors in terms of value added creation and turnover.

As for the proprietary data an analysis was made focussing on the endogenous digitalisation capacity of the EU engineering industries. This was assessed on the basis of digital patents that were filed by the EU engineering industry in comparison to other industries, and engineering industries for major countries outside the EU.

### **Assessment of industry competitiveness and market performance with respect to digitalisation**

This assessment was done using a triangulation of results from literature review, interviews, the results from surveys, two webinars, Prognos' proprietary data on digital patents and the identification of digital goods on the basis of the intermediate results of the EASME Advanced technologies for industry' project supplemented with own expert input.

### **Using patent data to measure the digital innovation potential in the engineering industries**

We address the digital innovation potential of the EU engineering industry by looking at the digital patenting activity (also in relation to the overall patenting activity), which is the result of innovation activities of researchers, whose R&D activities can be linked to specific digital technologies and the different engineering industries.

The choice of using patent data for our analysis has several reasons. One of the most important ones is that this data, unlike more aggregate data like R&D expenditures, is one of the most complete sources of information on inventions. It offers, amongst others, detailed information on the inventor, the home country of the inventor, the technological content or references to earlier patents. Moreover, the spatial and temporal coverage of patent data is unique, allowing detailed analysis across time and countries that no other source allows. In addition, research has shown that there exists a high correlation between patent numbers and the actual R&D or technological performance of companies<sup>528</sup>, which itself can be an indicator for companies' overall competitiveness. Nevertheless, it needs to be considered that patents do not reflect all of the research and innovative efforts.

For different reasons, inventions covered by a (or several) patent(s) are not necessarily industrially applied. For instance, an invention might turn out to have not enough commercial value or a better invention can be marketed more rapidly. In some other cases, patents are filed only for strategic reasons, i.e. to block competitors.<sup>529</sup> Moreover,

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<sup>528</sup> Rassenfosse and van Pottelsberghe (2008); Hagedoorn and Clood (2003)

<sup>529</sup> OECD (2009): OECD Patent Statistics Manual. OECD Publications, France.

some inventors might prefer to keep an invention secret and to refrain from filing a patent, which would disclose their successful research efforts.<sup>530</sup> The following Table provides an overview of the most important advantages and disadvantages of patent data:

**Figure 1.4: Advantages and drawbacks of patent data**

| Advantages |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1          | Patents <b>cover a broad range of technologies</b> for which there are sometimes few other sources of data (i.e. nanotechnology).                                                                                                                                                                                                                                                                                                                                                                                     |
| 2          | Patents have a <b>close (if imperfect) link to invention</b> . Most significant inventions from businesses are patented, whether based on R&D or not.                                                                                                                                                                                                                                                                                                                                                                 |
| 3          | Each patent document <b>contains detailed information on the invention process</b> . The amount of patent data available to researchers is huge. More than one million patents are applied for worldwide each year, providing unique information on the progress of invention                                                                                                                                                                                                                                         |
| 4          | The <b>spatial and temporal coverage</b> of patent data is unique. Patent data are available from all countries with a patent system, i.e. nearly all of the world's countries.                                                                                                                                                                                                                                                                                                                                       |
| 5          | Patent data are <b>quite readily available</b> from national and regional patent offices. Unlike survey data, collection of patent statistics does not put any supplementary burden on the reporting unit (e.g. business) because the data are already collected by patent offices in order to process applications.                                                                                                                                                                                                  |
| Drawbacks  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 1          | <b>Not all inventions are patented</b> . For instance, due to low commercial value, strategic reasons like blocking competitors or preference for alternative protection (i.e. secrecy).                                                                                                                                                                                                                                                                                                                              |
| 2          | The <b>propensity to file patent applications differs significantly</b> across technical fields and company size. For instance, new or small and medium-sized enterprises (SMEs) – notably those that lack large-scale production – have more difficulty covering the costs of a patent.                                                                                                                                                                                                                              |
| 3          | Several studies have shown that the value <b>distribution of patents is highly skewed</b> . Many patents have no industrial application (hence, are of little or no value to society), whereas a few have a very high value. With such heterogeneity, <b>simple patent counts can be misleading</b> . This is not specific to patents, but a reflection of a prominent feature of the inventive process which also applies to R&D expenditure (which often results in little success, but sometimes in huge success). |
| 4          | <b>Differences in patent law and practices</b> around the world <b>limit the comparability</b> of patent statistics across countries. It is, therefore, preferable to use homogenous patent data (coming from a single patent office or a single set of patent offices). This is the reason why in this part of the study the focus is on PCT patent applications (see point (1) below).                                                                                                                              |
| 5          | <b>Changes in patent laws over the years call for caution</b> when analysing trends over time. For instance, the list of technologies covered has grown longer over time and some countries now include software and genetic sequences, which were previously excluded (see also point (1) below). Other variables such as office administration can have a substantial impact on patent counts, notably patents granted, during a particular time period                                                             |

Source: OECD (2009): *OECD Patent Statistics Manual*. OECD Publications, France, p. 27-28.

<sup>530</sup> Popp, D. (2005): "Using the Triadic Patent Family Database to Study Environmental Innovation", OECD Report, OECD, Paris.



Although there are some challenges regarding the use of patent data, it should not be discarded as a basis for statistical indicators. In fact, many statistical indicators, including the widely used indicator of GDP, have flaws.<sup>531</sup> In addition, most of the limitations and biases mentioned in **Error! Reference source not found.** can be overcome or limited by using appropriate methodologies, which makes the positive aspects clearly outweigh the negative aspects. Taking these elements into account, patent data represents “the only observable manifestation of inventive activity with a well-grounded claim for universality”.<sup>532</sup>

### (1) Creation of an overall patent data base

In a first step, information on all patents filed worldwide by companies and research institutions within the period of 2007 and 2017<sup>533</sup> was downloaded and stored. For the patent analyses, we rely on data from the EPO Worldwide Patent Statistical Database (PATSTAT) of the European Patent Office. In this database more than 100 million patents of all leading industrial and developing countries and thus all economically significant states of the world. In order to overcome some of the previously mentioned challenges for patent analysis the following methodological aspects have been considered:

#### Use of PCT patent applications

As discussed before, (i.e. drawbacks 4 and 5 in **Error! Reference source not found.**) differences in patent law and practices around the world can limit the comparability of patent statistics. Amongst others, the patentability of software / computer implemented (CI) inventions or business methods is not identical in the US and Europe. For instance, a report from the European Commission published in 2016 concludes that “*companies tend not to patent cloud computing technologies in Europe [at the EPO] as much as they do in the U.S [at the USPTO]*” and that this “*may at least in part stem from a high threshold for patent eligibility for CI inventions in Europe*”<sup>534</sup>. Therefore, the number of CI patents might be overall somewhat higher at the USPTO than at the EPO. It needs, however, to be stressed that the report also states that “*it cannot be concluded that, as of today, one or the other methodology [EU vs. US] is clearly more liberal in assessing the patent eligibility of CI inventions in all contexts.*”<sup>535</sup> The bottom line is that indicators constructed based on information from a single patent office (i.e. either the EPO or the USPTO) show certain weaknesses. Therefore, we focus on so-called international PCT (Patent Cooperation Treaty) patent applications. These patents are recorded based on the globally uniform PCT agreement. The Patent Cooperation Treaty (PCT) procedure is international by design and is administered by the World Intellectual Property Organization. Since 2004, each application filed through the PCT designates all signatory states of the PCT (currently the PCT has 153 contracting states<sup>536</sup>). Therefore, PCT filing are often considered as a “worldwide patent application” and is much less biased than applications with national or regional offices.<sup>537</sup> Any regional legal peculiarities like the previously mentioned situation of software patents therefore have fewer distorting effects. Regional differences are also mitigated by another advantage of PCT patent applications. Using PCT applications ensures a certain degree of quality of the patents (see drawback 3 in **Error! Reference source not found.**) since the cost of filing an international patent through the PCT is

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<sup>531</sup> Popp, D. (2005).

<sup>532</sup> Trajtenberg, M. (1990). Patents as Indicators of Innovation, Economic Analysis of Product Innovation. Cambridge (MA): Harvard University Press, p.183.

<sup>533</sup> Since PCT applications are published by the WIPO only 18 months after the priority application (i.e. the date of filing), the year 2017 is the most actual year for which information on all patents filed is available. (Source: Dernis H. & Guellec, D. (2001): Using Patent Counts for Cross-Country Comparisons of Technology Output, In: OECD (ed.): STI Review: Special Issue on New Science and Technology Indicators), Paris, p. 129-146.

<sup>534</sup> Strowel, A. & Utku, S. (2016): The trends and current practices in the area of patentability of computer implemented inventions within the EU and the U.S. Study prepared for the European Commission (DG COMM), p. 41.

<sup>535</sup> Strowel, A. & Utku, S. (2016), p. 44.

<sup>536</sup> [https://www.wipo.int/pct/en/pct\\_contracting\\_states.html#note1](https://www.wipo.int/pct/en/pct_contracting_states.html#note1)

<sup>537</sup> OECD (2009).

higher than that of a simple domestic application. Inventors in general only accept these costs if their invention has international commercial potential and is still commercially promising one year after the initial domestic filing.<sup>538</sup> Filing abroad (or via the PCT) therefore suggests that there are two criteria that will be met by only some of a country's national patent applications. Hence, it is rather unlikely that inventors will file an international patent application for an invention, which they know is unlikely to be patentable abroad.

### **Use of patent families**

Another method that is used to increase the comparability of inventions across countries and to control for their quality is the use of patent families. "A patent family can be defined as all documents filed in different countries to protect the same invention. At its most basic, the family comprises a priority patent application i.e. the first application filed to protect the invention, and all subsequent patent applications".<sup>539</sup> Thus the use of patent families avoids counting several times those patents that have been filed at different IP offices with the aim to protect the very same invention. Depending on the definition of the patent family, the patents within a patent family are highly similar or the same and represent substitutes. The notion of patent families considered in this study follows the "simple family" definition, in which patent applications are directly linked through the priority filings. This means that the scope of the simple patent family is restricted to 'equivalents', i.e. patents filed at different IP offices claiming protection for the exact initial invention (i.e. priority patent). Consequently, the patent families in this study do reflect single and unique inventions. This allows to better see the possible incremental innovative steps that companies have taken in the course of the time to improve their inventions.<sup>540</sup>

### **Choosing the year to which the patent family is attributed**

The only clearly meaningful date from a technological or economic point of view is the priority date since this is the closest to the date of invention. This is also the best date to choose if the objective is to determine a country's or region's innovative performance at a particular point in time.<sup>541</sup> This means for our approach that the simple patent families are reported according to the earliest patent filing date in the family.

### **Regional attribution of the patent**

As previously explained, the patent data includes detailed information on the place of the invention. In this regard, either the country of residence of the applicant (in most cases a firm or a government body), the residence of the inventor(s) or the country of the priority application (i.e. the country where the patent was first filed) can be chosen. Each of these approaches has its merits and allows different kinds of analysis. Focussing on the applicants means focussing on "ownership". In this case, indicators reflect the innovative performance of a given country's firms, regardless of where their research facilities are located. Concentrating on the residence of the inventor(s) allows a better view of the innovative performance of the laboratories and researchers in a given country. Finally, a count by the country where the first application was filed, tells us more about the attractiveness of that country's patenting process.<sup>542</sup> Since our analysis has the objective to identify the innovative performance of the (digital) research done in the engineering industry, we focus on the second approach and use the inventor(s)' residence for attributing the patent to a country. If researchers from more than one country were

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<sup>538</sup> Applicants that wish to protect their invention in more than one country have 12 months from the priority date to file application in other conventions regions or under the PCT.

<sup>539</sup> Dernis H. & Guellec, D. (2001), p. 143.

<sup>540</sup> Dernis H., Dosso M., Hervás F., Millot V., Squicciarini M. and Vezzani A. (2015): World Corporate Top R&D Investors: Innovation and IP bundles. A JRC and OECD common report, Publications Office of the European Union, Luxembourg.

<sup>541</sup> Dernis H. & Guellec, D. (2001)

<sup>542</sup> ebd., p.137.

involved in the patenting process, a proportional allocation is used. For instance, if two researchers, one living in France and one in Italy, file a patent together, the patent will be allocated for 50 % to France and for 50 % to Italy. In the case of three researchers, e.g. two from France and one from Italy, the allocation would be 66,3% France and 33,3% Italy.

## (2) Defining digital patents

As for the interim report, the definition of a patent family as digital or not was done in a two-step procedure. First, a set of “core digital technologies” was defined. Again, this is done by using the International Patent Classification (IPC)<sup>543</sup> and a classification of patent classes into digital technology areas. Whereas for our first analysis in the interim report a by Prognos adapted framework of Schmoch (2008)<sup>544</sup> was used, the progress report now provides an updated and more detailed framework on the basis of the work of Inaba, T. and Squicciarini, M. (2017)<sup>545</sup>. Their paper proposes a revised version of the initial OECD definition of ICT-related technologies from 2003<sup>546</sup>.

This new version stems from a careful analysis of ICT technologies and products and in addition relies on the in-depth knowledge of a Japan Patent Office expert specialised in the examination of ICT-related patents. In this way, they took into account more recent developments in the field of ICT. In order to update the old ICT-classification, they reviewed some of the most important existing IPC-based classifications, including Schmoch (2008) or Van Looy et al. (2014)<sup>547</sup>. On the one hand, they excluded patent classes originally tagged as ICT but in fact, exclusively pertain to other technological domains and that should no longer be used in conjunction with ICT-related technologies. On the other hand, they included new patent classes that did not yet appear in existing ICT definitions (e.g. when technology classes only appeared in more recent versions of the IPC taxonomy). This new taxonomy has also been used in more recent reports measuring digitalisation (e.g. Colecchia, A. et al. (2019) or Paunov et al. (2019)<sup>548</sup>).

The new ICT taxonomy is subdivided into 13 main and 24 sub-technology areas, which are defined by their specific technical features and functions they are supposed to accomplish. The advantage of this detailed classification is that it allows for our later analysis to see which kind of digital technologies are effectively used and/or developed in the European engineering industry. The following table provides an overview of the main and sub-technology areas and the related IPC codes.

### Table 1.1: Core areas of digital technologies

*The first two columns refer to the technology areas according to Inaba, T. & Squicciarini, M. (2017)., the enumerations in the last column correspond to the used patent classes (IPC codes)*

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<sup>543</sup> The IPC provides a classification of patents and utility models according to the different areas of technology to which they pertain. The IPC divides technology into eight sections with approximately 70,000 subdivisions.

<sup>544</sup> Schmoch, U. (2008): Concept of a Technology Classification for Country Comparisons. Final Report to the World Intellectual Property Organisation (WIPO). Accessible here: [http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/pdf/wipo\\_ipc\\_technology.pdf](http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/pdf/wipo_ipc_technology.pdf)

<sup>545</sup> Inaba, T. & Squicciarini, M. (2017): ICT: A new taxonomy based on the international patent classification”, OECD Science, Technology and Industry Working Papers, 2017/01, OECD Publishing, Paris.

<sup>546</sup> van Looy, B., Vereyen, C., Schmoch, U. (2014): Patent Statistics: Concordance IPC V8 - NACE REV.2, Luxembourg

<sup>547</sup> Colecchia, A. et al. (2019): World Corporate Top R&D Investors – shaping the Future of Technologies and of AI. A JRC and OECD common report, Publications Office of the European Union, Luxembourg

<sup>548</sup> Paunov, C. et al. (2019): On the concentration of innovation in top cities in the digital age, OECD Science, Technology and Industry Policy Papers, 2019/85, OECD Publishing, Paris.

| Main technology area                     | Sub technology area                   | IPC codes                                                                                                                                                               |
|------------------------------------------|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. High speed network                    | Digital communication technique       | H03K, H03L, H03M, H04B1/69-1/719, H04J, H04L (excluding H04L9, H04L12/14)                                                                                               |
|                                          | Exchange, selecting                   | H04M3-13,19,99, H04Q                                                                                                                                                    |
|                                          | Others                                | H04B1/00-1/68, H04B1/72-1/76, H04B3-17 (excluding H04B1/59, H04B5, H04B7), H04H                                                                                         |
| 2. Mobile communication                  | /                                     | H04B7, H04W (excluding H04W4/24, H04W12)                                                                                                                                |
| 3. Security                              | Cyphering, authentication             | G06F12/14, G06F21, G06K19, G09C, G11C8/20, H04K, H04L9, H04M1/66-665, H04M1/667-675, H04M1/68-70, H04M1/727, H04N7/167-7/171, H04W12                                    |
|                                          | Electronic payment                    | G06Q20, G07F7/08-12, G07G1/12-1/14, H04L12/14, H04W4/24                                                                                                                 |
| 4. Sensor and device network             | Sensor network                        | G08B1/08, G08B3/10, G08B5/22-38, G08B7/06, G08B13/18-13/196, G08B13/22-26, G08B25, G08B26, G08B27, G08C, G08G1/01-065                                                   |
|                                          | Electronic tag                        | H04B1/59, H04B5                                                                                                                                                         |
| 5. High speed computing                  | /                                     | G06F5, G06F7, G06F9, G06F11, G06F13, G06F15/00, G06F15/16-15/177, G06F15/18, G06F 15/76-15/82                                                                           |
| 6. Large-capacity and high-speed storage | /                                     | G06F3/06-3/08, G06F12 (exclude G06F12/14), G06K1-7, G06K13, G11B, G11C (exclude G11C8/20), H04N5/78-5/907                                                               |
| 7. Large capacity information analysis   | Database                              | G06F17/30, G06F17/40                                                                                                                                                    |
|                                          | Data analysis, simulation, management | G06F17/00, G06F17/10-17/18, G06F17/50, G06F19, G06Q10, G06Q30, G06Q40, G06Q50, G06Q90, G06Q99, G08G (exclude G08G1/01-065, G08G1/0962-0969)                             |
| 8. Cognition and meaning understanding   | /                                     | G06F17/20-17/28, G06K9, G06T7, G10L13/027, G10L15, G10L17, G10L25/63,66                                                                                                 |
| 9. Human-interface                       | /                                     | H04M1 (exclude H04M1/66-665, H04M1/667-675, H04M1/68-70, H04M1/727), G06F3/01-3/0489, G06F3/14-3/153, G06F3/16, G06K11, G06T11/80, G08G1/0962-0969, G09B5, G09B7, G09B9 |
| 10. Imaging and sound technology         | Imaging technique                     | H04N (excluding H04N5/78-5/907, H04N7/167-7/171), G06T1-9 (excluding G06T7), G06T11 (excluding G06T11/80), G06T13, G06T15, G06T17-19, G09G                              |

| Main technology area                 | Sub technology area     | IPC codes                                                                                             |
|--------------------------------------|-------------------------|-------------------------------------------------------------------------------------------------------|
|                                      | Sound technique         | H04R, H04S, G10L (excluding G10L13/027, G10L15, G10L17, G10L25/63,66)                                 |
| 11. Information communication device | Electronic circuit      | H03B, H03C, H03D, H03F, H03G, H03H, H03J                                                              |
|                                      | Cable and conductor     | H01B11                                                                                                |
|                                      | Semiconductor           | H01L29-33, H01L21, 25, 27, 43-51                                                                      |
|                                      | Optic device            | G02B6, G02F, H01S5                                                                                    |
|                                      | Others                  | B81B7/02, B82Y10, H01P, H01Q                                                                          |
| 12. Electronic measurement           |                         | G01S, G01V3, G01V8, G01V15                                                                            |
| 13. Others                           | Computer input-output   | G06F3/00, G06F3/05, G06F3/09, G06F3/12, G06F3/13, G06F3/18                                            |
|                                      | Other related technique | G06E, G06F1, G06F15/02, G06F15/04, G06F15/08-15/14, G06G7, G06J, G06K15, G06K17, G06N, H04M15, H04M17 |

Source: Prognos AG (2020) based on Inaba, T. & Squicciarini, M. (2017).

As for the previous report, every patent family which is described by at least one technology class that belongs to this core definition of digital technologies, will be considered as a digital patent family. We call this approach “technological diffusion”. This means that for a patent family associated with a digital technology class, all other (a priori non-digital) technology classes are marked as digital as well. In doing so, we allow that non-digital technology classes are defined as digital as far as these technology classes are associated with a patent family jointly with a digital technology class. The box below provides an example of this approach.

### i

#### Counting digital patents

Consider a patent A, which is assigned to four different patent classes. One of these patent classes is part of the core area of digital technologies (e.g. electrical digital data processing), the other three are not. In this case, patent A is counted as a digital one. Consider another patent B, which is assigned to six different patent classes. Here, too, one patent class belong to the core area of digital technologies, whilst the other belong to various other categories. Again, patent B will be considered as being a digital patent. Take patent C, which is defined by five different patent classes. Here, three out of the five patent classes belong to the core area. As before, patent C will be fully counted as a digital patent.

The examples show that the three patents, A, B and C, are counted equally as a digital patent. The decisive factor for classifying a patent as digital, is only whether the patent was defined by at least one patent class from the core area of digital technologies.

### (3) Assignment of patent families to economic sectors (NACE Rev. 2)

Since the patent data does not directly reveal in which sector a researcher worked when he filed a patent, additional steps need to be performed before being able to analyse the

digital innovation capacity of the EU engineering industries. This step consisted of assigning the technology classes that define each patent via product level assignments to economic sectors based on the ISIC Rev. 4 classification.

Regarding the link between technological (i.e. patent) and sectoral classifications, there have been several approaches in the literature so far.<sup>549</sup> For a consistent and at the same time well-founded conversion of technology classes into industry-relevant digitalisation values, we use for this study a so-called “concordance table”, which has been developed by Lybbert and Zolas (2014).<sup>550</sup> In this paper, concordance tables for technology classes (based on IPC codes) on the one hand and sectoral or product classifications on the other hand has been applied. In these concordance tables, each technology class receives a weight between 0 and 1 which corresponds to the relevance of the technology class of the sector or product for the technology class. In total, all the weights of the sectors or products a specific technology is used for, add up to one. This ensures that each patent and each technology classification is fully described by the economic sector or product. Based on this concordance table, it can be estimated to which extent a given patent family in the database (with their respective technology classification) can be assigned to sectors or products belonging to the engineering or any other industry.<sup>551</sup>

However, this specific concordance might be flawed by the high sectoral aggregation level. The keyword search algorithm of Lybbert and Zolas (2014) could lead to an imprecise mapping of technology classes to sectors. Therefore, we use another concordance table of Lybbert and Zolas (2014) that transforms IPC codes to production codes. Since production codes are much more detailed as compared to the more aggregated sectoral codes, the mapping of IPC technology classes to products provided by Lybbert and Zolas (2014) overall provides more robust results. In a second step, the production codes are assigned to ISIC codes. For this approach, production codes are required for which both a concordance table with IPC codes is available and a correspondence table to ISIC codes exists. Since such a production code does not exist, we use the concordance table from IPC to HS codes (Harmonized System 2007). Then we apply the correspondence table from HS codes to CPC codes (Central Product Classification Version 2.1). Finally, we transform the CPC codes to ISIC codes.

The assignment of technology classes to products and sectors gives reasonable results for nearly all sectors. However, for sector 33 (Repair and installation of machinery and equipment), no patent assignment to sectors via product codes is feasible due to its service-oriented structure. For this sector, results are based on the IPC to ISIC concordance table provided by Lybbert and Zolas (2014). Furthermore, for specific IPC-HS-concordances, a plausibility check was performed to identify and, if necessary, correct specific assignments of IPC technology classes to HS product codes. The underlying reason is that results from keyword search algorithms, as applied by Lybbert and Zolas (2014), in general are prone to minor assignments errors that not always can be identified by the authors. In total only 7 out of 7736 IPC-HS assignments were adapted. Additionally, some correspondence between HS and CPC as well as between CPC and ISIC are not unique (i.e. one CPC product code might be assigned to two different ISIC sectors). For these rare cases, a uniform distribution is applied.

We use the concordance table which assigns a technology classification to various sectors.

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<sup>549</sup> Neuhausler, Frietsch & Kroll (2019) provide a recent overview on the various approaches that currently exist.

<sup>550</sup> Lybbert, T. & Zolas, N. (2014): Getting patents and economic data to speak to each other: An “algorithmic links with probabilities” approach for joint analyses of patenting and economic activity, Research Policy, Vol. 43.

<sup>551</sup> More concretely, we applied the concordance table which connects two-digit ISIC Rev.4 codes to 4-digit IPC. For additional and more detailed analyses, concordance tables connecting three or even four-digit ISIC Rev.4 codes to IPC are required (and available).

## **ANNEX 9 – SURVEY ANALYSIS**

See standalone publication. Three surveys were conducted:

The response rate to these surveys is now summarised.

- Survey of industry associations – 47 responses;
- Survey of testing and certification laboratories, Market Surveillance Authorities and Notified Bodies – 41 responses; and
- Survey of individual manufacturers and other economic operators – 32 responses.

### **1. ANALYSIS OF TARGETED STAKEHOLDER SURVEYS**

This document sets out the analysis of the results from the three targeted stakeholder surveys for the *"Study on the Competitiveness of the EU Engineering Industries and the Impact of Digitalisation"*.

#### **1.1 INTRODUCTION**

##### **1.1.1 Data collection for survey and challenges**

Three surveys were carried out over a period several months, following their launch in September 2019. A repeated effort was made to gather survey responses between September 2019 to end of May 2020. Personalised survey invitations were sent to more than 200 stakeholders, with follow-up emails sent to non-respondents. In addition, the survey was promoted on LinkedIn and Twitter and the Commission's DG GROW promoted the survey via their website. The social media materials regarding the survey generated significant publicity. For instance, on LinkedIn, the survey was promoted on three separate occasions over a period of several months, with more than 2000 views.

Whilst there were successes in generating useful responses from industry associations, there were difficulties in obtaining responses from other types of stakeholders. This was linked to the general problem of survey fatigue. However, the most significant challenge was that the study is ambitious and broad-ranging in scope. As it mainly covers strategic issues relating to competitiveness and digitalisation, this narrowed the audience in terms of prospective stakeholders interested in contributing.

##### **1.1.2 Survey sample and scope to quantify responses**

47 responses were received from industry associations from both the national and EU levels. It should be noted that some responses from industry associations in particular were from the largest industry associations at both an EU and national level. These are highly representative of the industry as a whole across the three main branches covered by this study. For instance, umbrella industry associations that represent the interests of many different national engineering associations responded and provided a single coordinated response. As the response from umbrella associations represented the views of many different associations, which collectively have a membership consisting of thousands of engineering firms, these have been accorded a greater weighting in the survey analysis.

There were 32 responses from manufacturers and economic operators, which represented both SMEs and large companies from Europe. In addition, 40 responses were received from market surveillance authorities (MSAs), testing laboratories and certification, notified bodies and from national authorities. However, not all 40 respondents answered all questions, the number of completed questionnaires was 25, from which the majority were



MSAs or testing and certification bodies (including notified bodies) from all EU Member States and Norway, Liechtenstein and Switzerland.

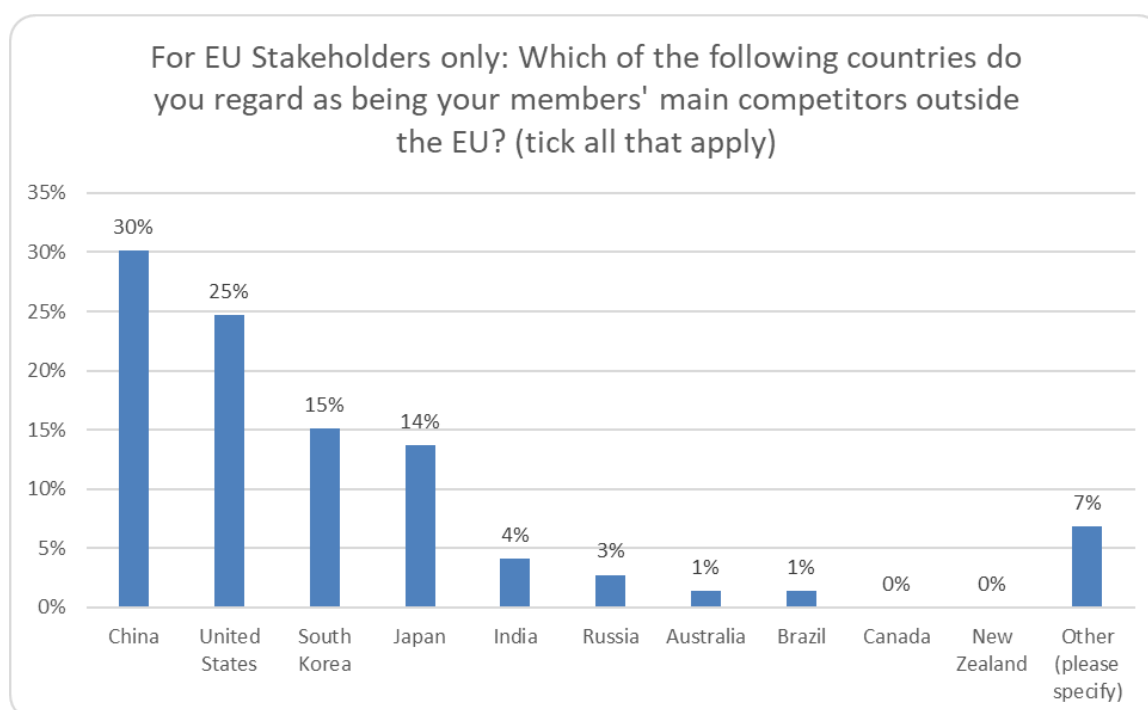
As there were a relatively limited number of responses overall, and some respondents skipped many questions, a mainly qualitative approach was adopted to assessing feedback concentrating on the useful completed responses. A few questions have also been analysed quantitatively where possible.

## 1.2 SURVEY FINDINGS – SURVEY OF INDUSTRY ASSOCIATIONS

The findings from the survey of industry associations are now presented, adopting a predominantly qualitative approach. As explained in the introduction outlining the survey sample, 47 responses were received. Considering that some of these associations represent many thousands of engineering firms, the survey feedback can be considered as being broadly representative of the EU engineering industry, as some umbrella associations represent a very large number of associations at national level. Moreover, respondents came from across the three main branches of the engineering industries covered by this study.

Survey respondents were asked about their perceptions as to the **major competitors for the EU engineering industries**. Whereas some industry associations pointed to China and the US, others mentioned a broader range of countries, such as not only China and the US, but also Japan and South Korea. There were some variations, however. For example, a national mechanical engineering industry association mentioned China as the main competitor, but also Vietnam and Taiwan. A European-level mechanical engineering industry mentioned China, Japan, Russia, South Korea and the US as key competitors. A Spanish industry association from a vertical industry (food and drink) that uses intermediate inputs from the engineering industries mentioned Brazil, China, Russia and the US as competitors.

**Figure 1.1: For EU Stakeholders only: Which of the following countries do you regard as being your members' main competitors outside the EU?**



Source: CSES' survey of Engineering Industry Associations and Professional Associations of Engineers

As regards the question as to whether looking back over the past 5-10 years, there has been a **change in the competitiveness of the European engineering industries, relative to its major global competitors**, an EU industry association (mechanical) noted that the competitiveness situation has worsened moderately overall. The issue of unfair trade was mentioned. Other industry associations concurred that whilst Europe remains strongly competitive in mechanical engineering, global competitors are catching up, especially in Asia. In the electric components and semi-conductor sectors, there was an acknowledgement of a weakening in the competitive position.

A major EU umbrella association representing many national engineering associations noted that weaknesses in the competitiveness of the EU engineering industries in the past 5-10 years are linked to a number of factors, such as:

- Insufficient investment in research, development and innovation;
- Comparatively high unit labour costs in the EU;
- Productivity levels not being high enough; and
- Increases in energy prices which have impacted some engineering subsectors in some countries.<sup>552</sup>

In terms of the overall prospects for the EU engineering industry and the challenges and opportunities for growth and development, survey respondents were asked to look ahead over the short-term (1-3 years) and medium-term (4-10 years) and to comment on how today's competitiveness drivers are likely to evolve over the coming decade to 2030.

Looking ahead, there were different views regarding the main challenges and opportunities faced by the EU engineering industries.

A response was received from a major EU industry association which represents 32 different national industry associations and 15 European sector associations.<sup>553</sup> As this represented the views of many industry associations across the EU-27, it is worth examining the feedback. Regarding the **short-term**, a number of observations relating to competitiveness were made:

- **Challenges** - low productivity growth, political uncertainty regarding the current trade environment (e.g. due to trade wars) impacting on growth in the short-term.
- **Opportunities** - digital transformation, but only if there are appropriate framework conditions in place, including ensuring that there is a supportive regulatory framework to facilitate wider take up of new technologies and to accommodate new technological developments, such as AI. The EU engineering industry also has an opportunity to play a leading role in the development of clean technologies to support reduction in climate-change inducing emissions through digital transition.

As for the **medium-term**, there were seen as being incremental opportunities for European engineering firms to develop their competitiveness by further embracing digital transformation. At the same time, there may be increased uncertainty regarding how digital transformation will affect different parts of European industry, and what kind of structural adjustments may be required, especially when there are short-term uncertainties regarding productivity growth and the trade environment, which may impact on current growth. There may also be continuing opportunities (as is also the case for the

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<sup>552</sup> The point about increased energy prices was however made pre-COVID 19, and the significant decline in oil and gas prices due to weaker demand, although how sustainable the latter is, is uncertain at this early stage as regards the pandemic's economic impacts.

<sup>553</sup> Consultations took place between this major EU industry association and its national members prior to this submission. Therefore, as the response represented the views of many engineering industry associations, it has been accorded a greater weighting.

short-term) as regards Europe developing competitive strengths in clean technologies to facilitate the transition to more climate-friendly and sustainable approaches.

Industry associations were also asked to **rank the current top 3 most important competitiveness factors** for European firms. The major umbrella EU-level industry association, representing large numbers of engineering associations across Europe asked its members for feedback on this issue. The top 3 responses were:

1. Degree of innovation embedded in the product;
2. Reliability and trust in the final product; and
3. Technological factors.

Perceptions as to the main competitiveness attributes of international firms in the EU engineering industries from an EU perspective were seen as being:

1. Competitive labour costs;
2. Use of big data to improve operating efficiencies; and
3. Quality / cost ratio of manufacturing process.

In other words, the wider adoption of Industry 4.0 technologies, such as robotisation, automation and the use of big data, combined with lower labour costs help non-European manufacturing firms to have some degree of competitive edge, at least in sub-sectors of engineering in terms of offering a strong quality / cost ratio in the manufacturing process overall.

This can be contrasted with the views of industry associations in other countries that responded to the survey who identified a different series of top 3 competitiveness factors, such as an EU industry association in the mechanical engineering sector, which identified the following three competitiveness drivers for European firms:

1. Technological factors;
2. Quality / cost ratio of manufacturing process; and
3. Safety of final product.

Among the main the competitive advantages of European Engineering firms were perceived as being having access to a well-educated labour force in mechatronics, and an emphasis on innovation and quality in the production process.

Regarding the three most important factors within your industry, in instances when European engineering companies have a competitive advantage over their counterparts in competitor countries outside the EU, the same mechanical engineering industry association identified the following as being the most important:

1. Quality / price ratio of final product;
2. Competitive labour costs; and
3. Access to digital skills.

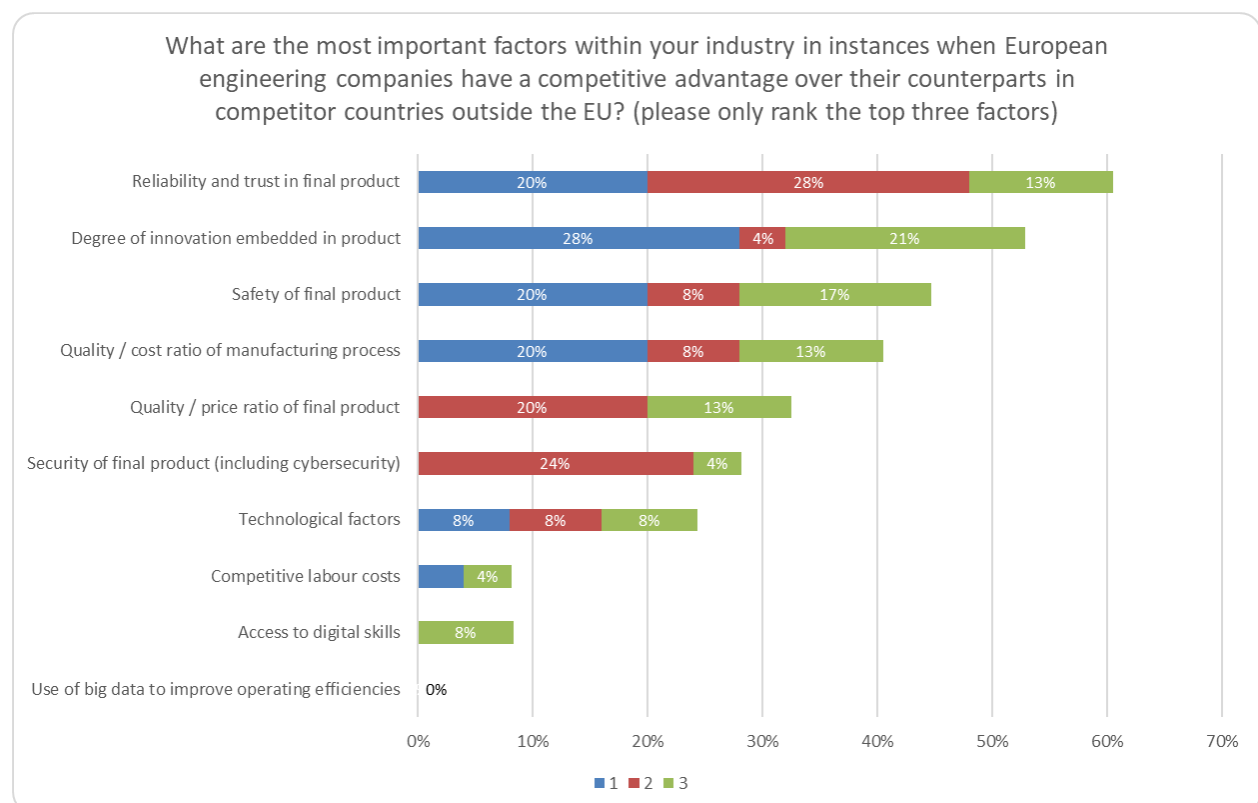
As regards further detailed feedback on the competitive advantages of engineering firms from countries outside the EU, these were viewed as including **lower production costs** due to lower labour costs, strong **support from national governments for key strategic sectors and "buy local" initiatives**.

In addition, concerns were raised regarding the extent to which European firms experience a **level playing field when trading internationally due to unfair trade and state subsidies** in some engineering sub-sectors. A specific example was raised through the interview programme which reinforces this concern. For instance, in the **electronic**

**components and semi-conductor sectors**, it was pointed out that in the US and China, there has been significant national government support through subsidies and grants to the industry itself, and major scale investment in R&D&I. This has somewhat been addressed at EU level by investment in R&D&I through public-private partnerships, such as ECSEL, a public-private partnership for electronic components and systems, which manages a research and innovation programme for the development of a strong and globally-competitive electronics components and systems industry in the EU. However, the perception remains that in certain strategic sub-sectors, firms in some countries have an unfair competitive advantage.

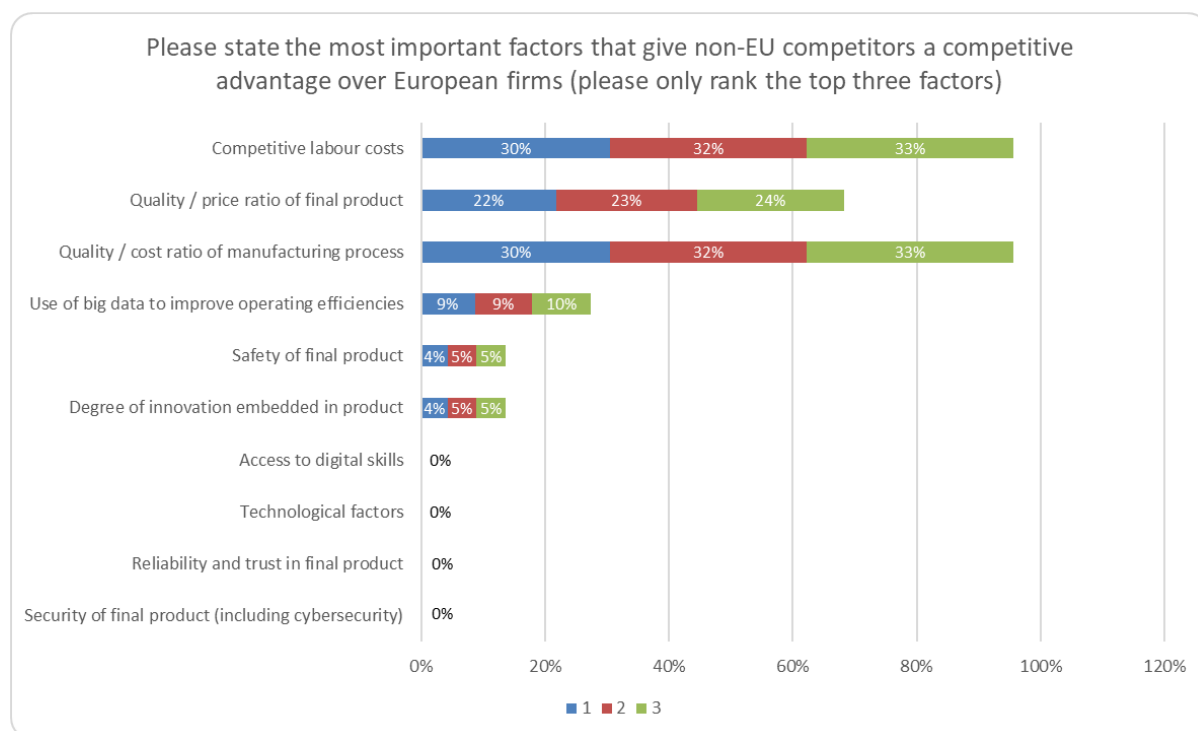
Across the survey sample, there was a broad consensus that competitiveness factors such as quality/ cost ratio of manufacturing process; safety of final product and technological factors were very important in the past 5-10 years to the June 2020 baseline.

**Figure 1.2: What are the most important factors within your industry in instances when European engineering companies have a competitive advantage over their counterparts in competitor countries outside the EU?**



Source: CSES' survey of Engineering Industry Associations and Professional Associations of Engineers

**Figure 1.3: Please state the most important factors that give non-EU competitors a competitive advantage over European firms**

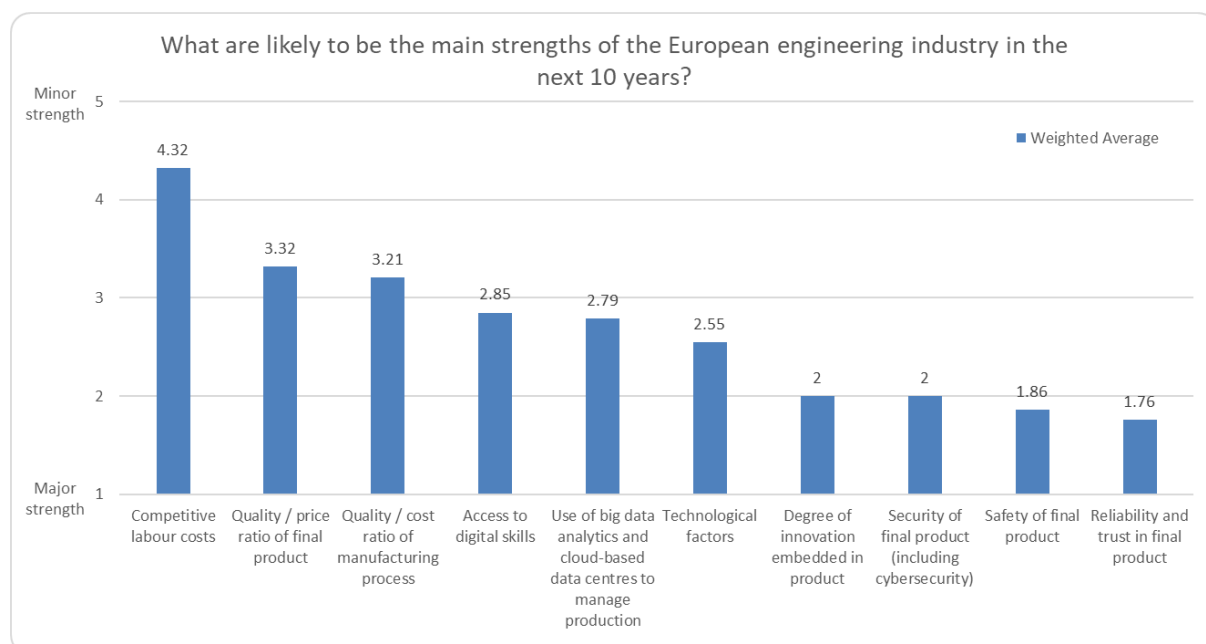


Source: CSES' survey of Engineering Industry Associations and Professional Associations of Engineers

Looking ahead to the next decade, survey respondents were asked about the main competitiveness drivers for the EU engineering industries and how these were expected to evolve.

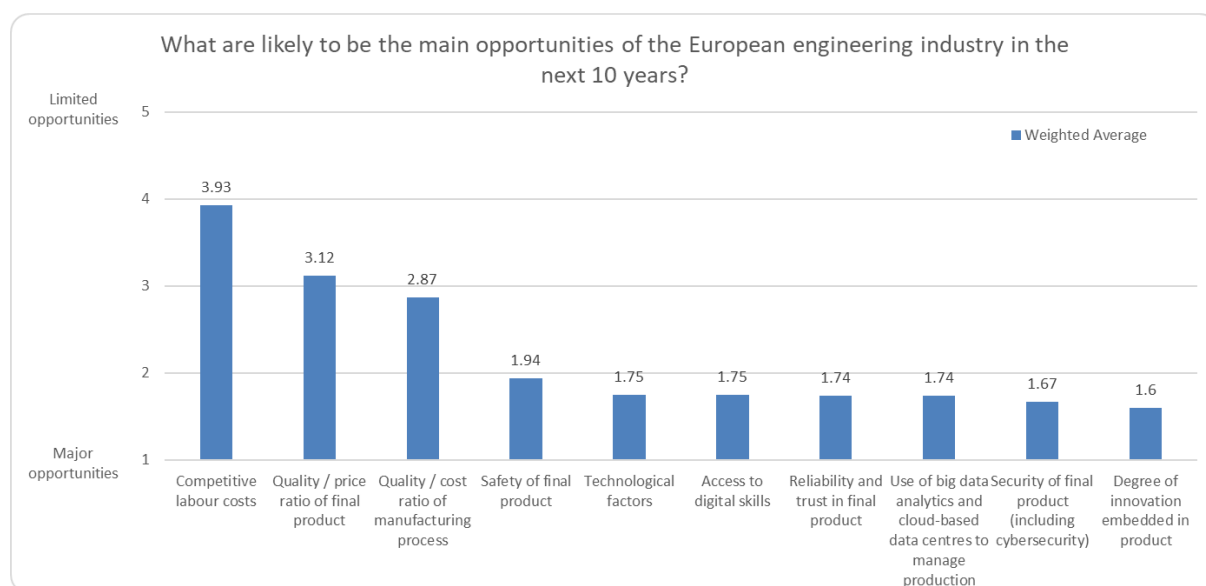
The large umbrella industry organisation at EU level (which consulted its national members) identified a number of competitiveness factors for EU firms that are likely to be especially important in future. As can be seen from the figures below, the factors that were perceived as the **main strengths and opportunities of the European engineering industry in the next 10 years** were 1) competitive labour costs; 2) Quality/ price ratio of the final product 3) Quality / cost of manufacturing process.

**Figure 1.4: What are likely to be the main strengths of the European engineering industry in the next 10 years?**



Source: CSES' survey of Engineering Industry Associations and Professional Associations of Engineers

**Figure 1.5: What are likely to be the main opportunities of the European engineering industry in the next 10 years?**



Source: CSES' survey of Engineering Industry Associations and Professional Associations of Engineers

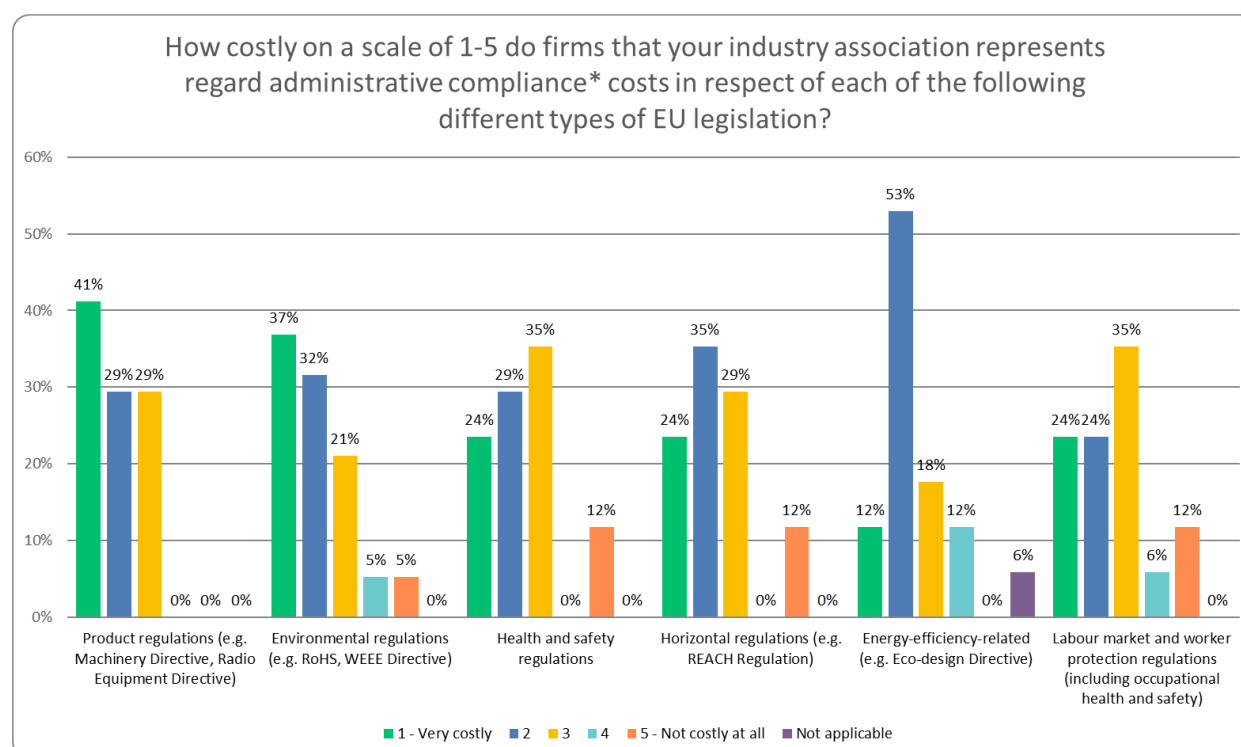
These competitiveness factors are interesting, as they were corroborated with the findings through the interview programme. A number of interviewees noted that Europe has some competitive strengths in niche areas such as producing sensors for the automotive industry and producing internet-connected IoT products that are cyber-secure where there are globally-leading competitive advantages. This links in to the findings from the regulatory analysis, which suggest that there is demand from consumers and some industry players for a clearer regulatory regime – perhaps horizontal in the medium term (covering all

industrial products) that ensures minimum baseline security requirements in products. It was seen that although regulation may be costly initially, strong product security is a valuable USP and could be a European competitive advantage, as European brands are seen as being trusted and reliable from a security perspective. This is not to suggest that non-European manufacturers are not seen as reliable, but that Europe could capitalise on a perceived strength in this area.

Regarding the EU and international framework applicable to engineering industry, respondents were asked **how far this regulation changed over the past 10 years**. For some industry associations the regulation suffered substantial changes in the past decade, as one organisation representative of Europe's technology industries pointed out the EU industry covers different subjects and regulations, thus the changes have differed depending on the regulation. For the environment or energy sector the changes have been substantial whereas minimal changes applied to other legislation, such as the Machinery Directive that has not been amended over the past 10 years. However, for other industry associations the EU legislation suffered minimal changes.

Survey respondents were then asked **how costly it is for firms this EU legislation in terms of administrative compliance**, such as the costs of preparing a SoC, technical documentation on which conformity assessment procedure was utilised or testing costs, and in terms of **substantive compliance costs**, such as the research or the development and innovation costs in designing new products that are compliant with relevant EU legislation. Overall, respondents perceived energy efficiency related legislation like the Eco-design directive, the product regulations, and the environmental regulations as the costliest, both in respect of administrative compliance and substantive compliance costs. The following two figures show how industry associations rated on a scale of 1-5 (being 1 very costly and 5 not costly at all) the different types of EU legislation.

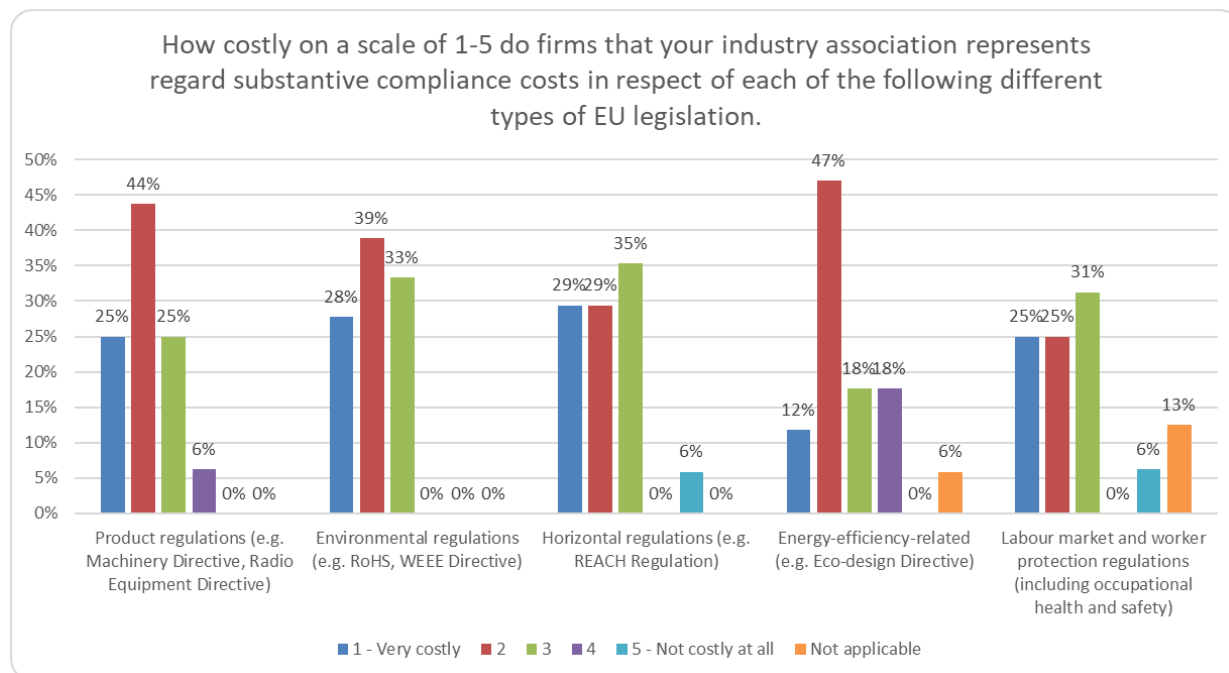
**Figure 1.6: How costly on a scale 1-5 do firms that your industry association represents regard administrative compliance costs in respect of each of the following different types of EU legislation**



Source: CSES' survey of Engineering Industry Associations and Professional Associations of Engineers



**Figure 1.7: How costly on a scale 1-5 do firms that your industry association represents regard substantive compliance costs in respect of each of the following different types of EU legislation**



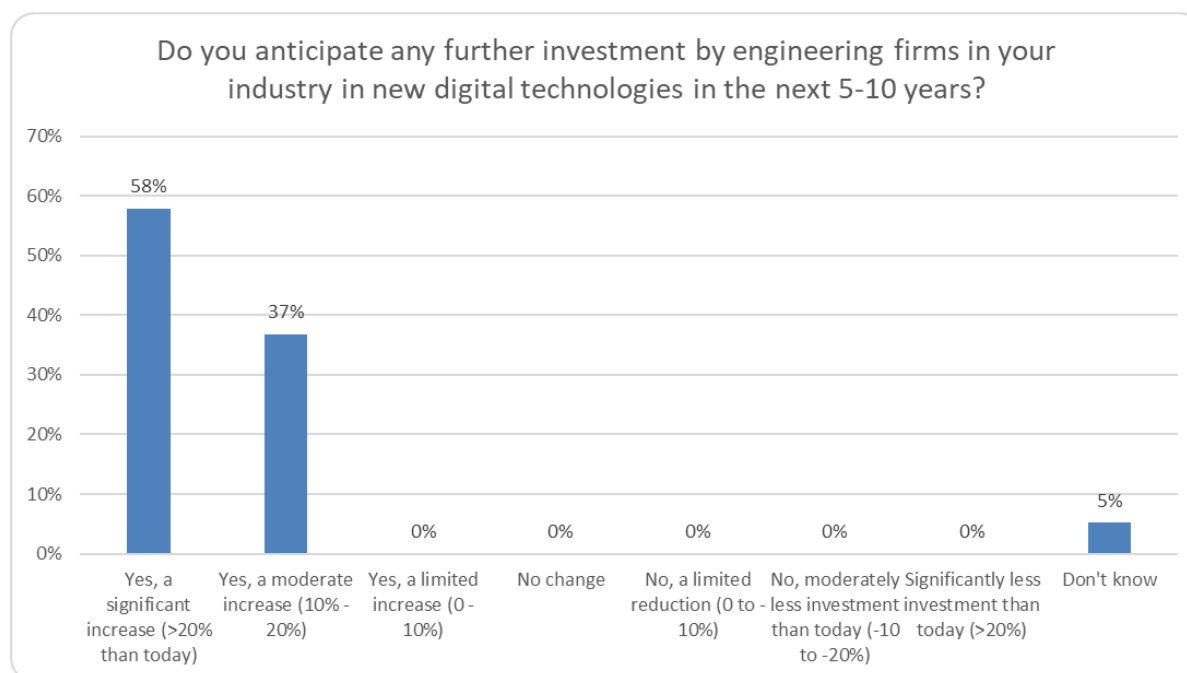
Source: CSES' survey of Engineering Industry Associations and Professional Associations of Engineers

As regards the question as to whether EU regulations applicable to the manufacturing of industrial products **affect SMEs in the European engineering industries more than large companies**, there were differing views, some respondents answered that the legislation affects equally to both SMEs and large companies. A mechanical industry association pointed out production volume determines the level of burden. However, on the whole, industry associations perceived that EU regulations are more burdensome for SMEs than for large companies. An electronic industry association highlighted that in order for SMEs to innovate and operate the regulation must be flexible and require minimum bureaucracy since they have less available resources.

The survey then asked participants if the **EU legislation is more burdensome for the engineering sectors compared to the international legislation**. For the industry associations that answered this question (not all the 47 respondents answered it) European legislation is more burdensome than international legislation applicable to the engineering sectors especially in some kind of legislations such RoHS, MD, LVD the conformity assessment procedures and EU environmental standards. An EU industry association commented that *"EU environmental standards are often higher than in non-EU countries. This turns generally into higher costs for EU manufacturers, however, depending on the case can also supports global technology leadership. EU reporting obligations increase at all strands and increasingly turn into a burden. Market access is often not reciprocal"*.

Looking ahead to the next 5-10 years, respondents were asked if they **anticipated any further investment by firms in new digital technologies**. As the figure below shows, industry association expect an increase in the coming years.

**Figure 1.8: Do you anticipate any further investment by engineering firms in your industry in new digital technologies in the next 5-10 years?**



Source: CSES' Survey of Engineering Industry Associations and Professional Associations of Engineers

The survey questionnaire did not include questions relating the impact of COVID-19, however, some respondents mentioned this in their open responses. For instance, in response to the question relating the prospects for the engineering industry in terms of the challenges and opportunities for growth and development a EU industry association commented that in the short-term (1-3 years) COVID-19 represents a decrease in world demand incorporation of new actors with competitive capacity (e.g. India). Another industry association from Estonia commented that COVID-19 has exposed risks of long supply chains.

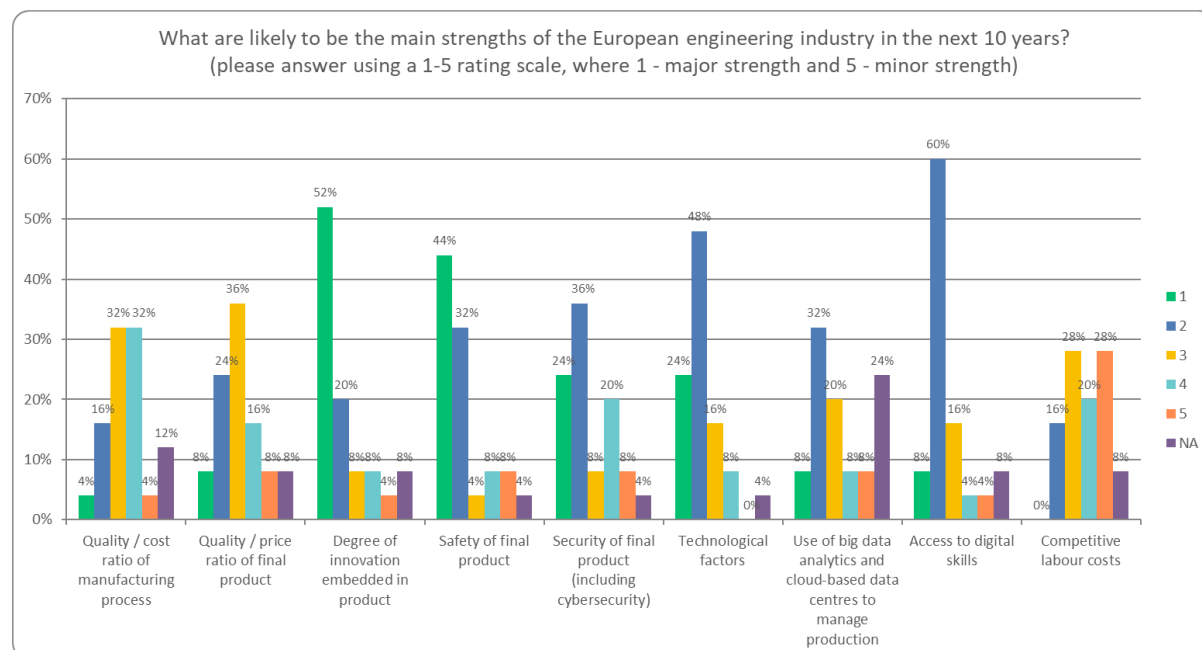
### Survey findings – Survey of testing and certification bodies, notified bodies and market surveillance authorities (MSAs)

40 responses were received from a combination of testing and certification bodies, notified bodies and MSAs. However, not all 40 respondents answered all questions, the number of completed questionnaires was 25, from which the majority were MSA or testing and certification bodies (including notified bodies) from all EU Member States and Norway and Switzerland. There were also three national authorities from Lithuania, Malta and Switzerland. All the respondents worked in at least one of the three main branches of the engineering industry: electrical, electronic and mechanical.

Respondents were asked to identify the **main strengths of the European engineering industry in the next 10 years**. As can be seen from the following chart, respondents identified 1) the degree of innovation embedded in the product and 2) the safety of the final product as being the foremost factors determining competitiveness. Other secondary, but important competitiveness factors were seen as continuing to be the security of the final product (including cybersecurity) and access to digital skills and technological factors. This is interesting in that interview feedback from industry associations in wider recent evaluations and impact assessments of different pieces of EU industrial product legislation also found that product security generally (and cybersecurity in particular) could be a

future area of competitive advantage for the European engineering industries.<sup>554</sup> A Testing and Certification Body and also a notified body in Italy provided a complete response. They identified the main strengths of the European engineering industry in the next 10 years as including the use of big data analytics and cloud-based data centres to manage production, access to digital skills and the safety of the final product.

**Figure 1.9: What are likely to be the main strengths of the European engineering industry in the next 10 years?**

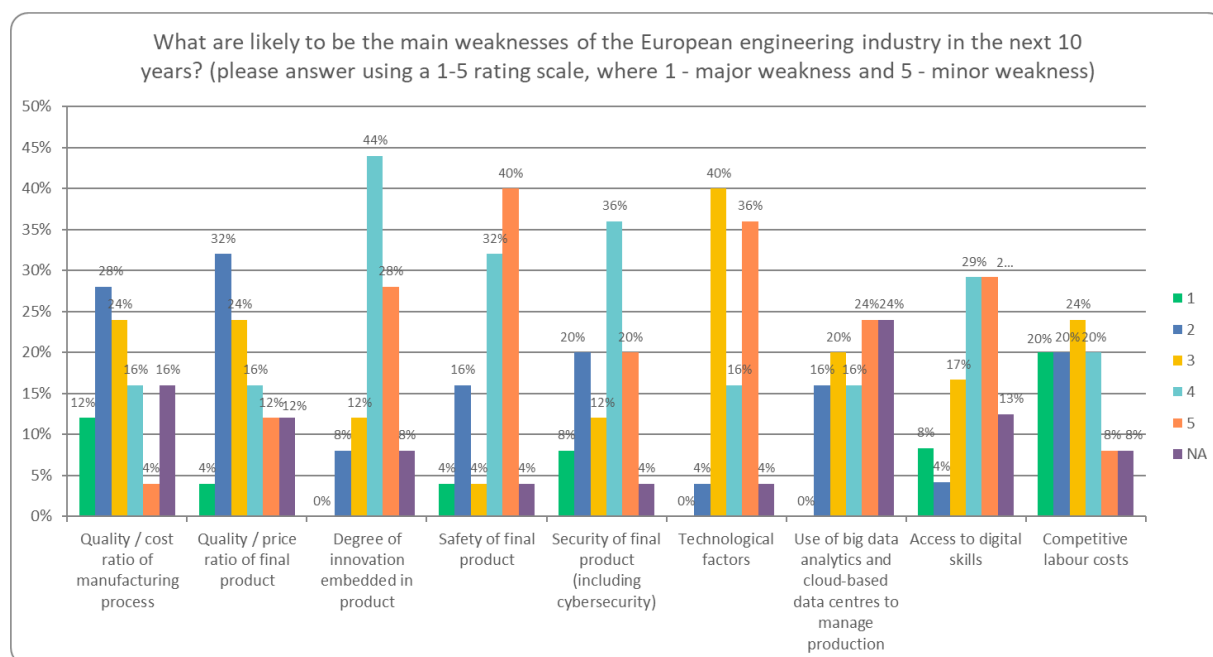


Source: CSES' survey of testing and certification bodies (incl. notified bodies) and MSAs

**The main weaknesses of the European engineering industry in the next 10 years** were seen by this respondent as including 1) the quality / price ratio of final product 2) competitive labour costs. And 3) quality/ cost of manufacturing process.

<sup>554</sup> See for example the *Impact Assessment on Increased Protection of Internet-Connected Radio Equipment and Wearable Radio Equipment*, published April 2020 <https://ec.europa.eu/docsroom/documents/40763>

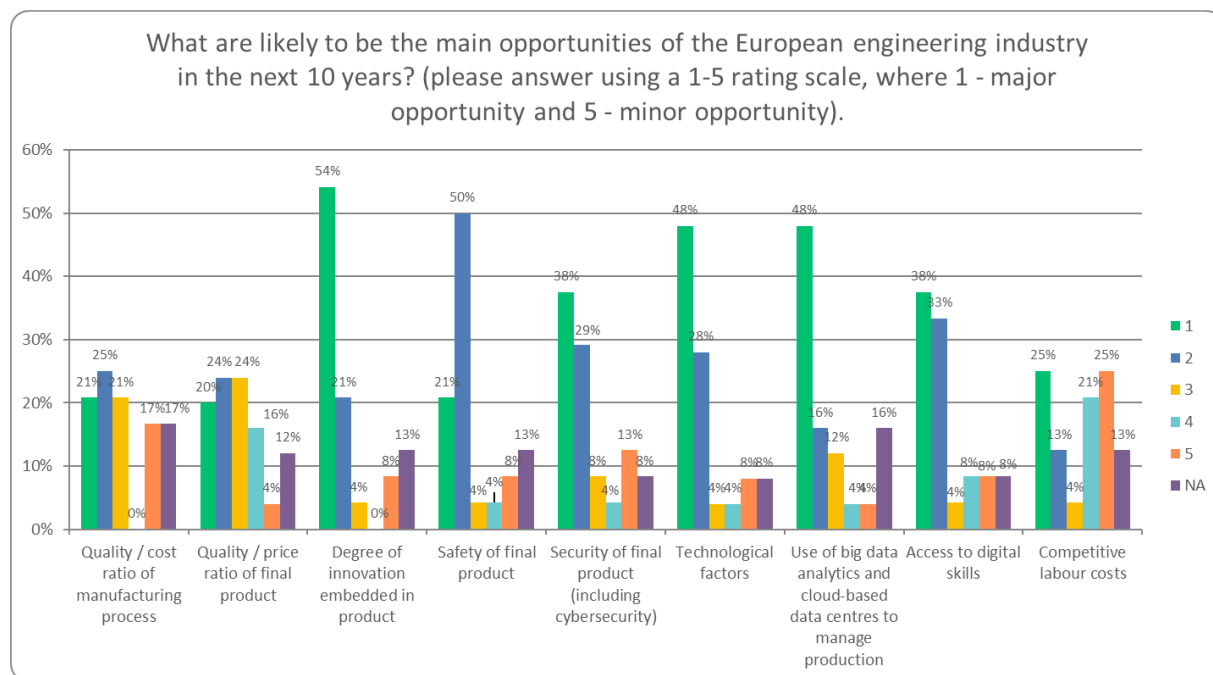
**Figure 1.10: What are likely to be the main weaknesses of the European engineering industry in the next 10 years?**



Source: CSES' survey of testing and certification bodies (incl. notified bodies) and MSAs

The main **opportunities** identified were degree of innovation embedded in product, technological factors and use of big data analytics and cloud base data centres to manage production.

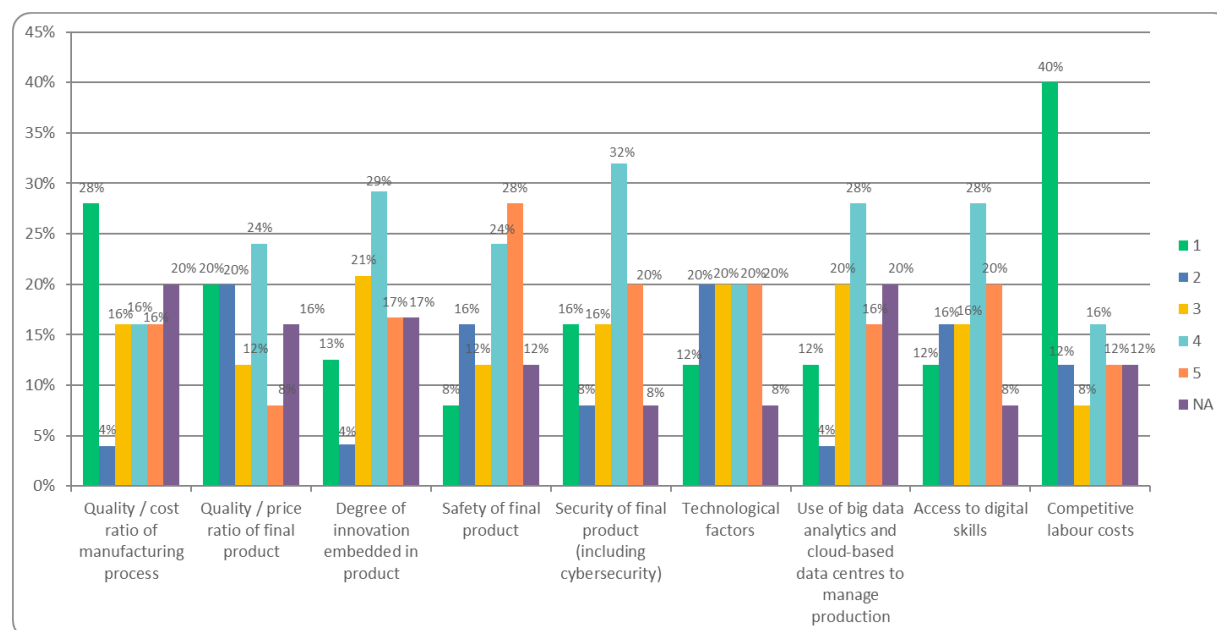
**Figure 1.11: What are likely to be the main opportunities of the European engineering industry in the next 10 years?**



Source: CSES' survey of testing and certification bodies (incl. notified bodies) and MSAs

Regarding **competitive threats for the European engineering industry in the next 10 years** competitive labour costs was seen as one of the main threats by most respondents, other threats identified by MSAs and notified bodies were the quality / cost ratio of manufacturing process and the quality / price ratio of final product. Interestingly, lack of access to sufficient digital skills was also seen as a major weakness. This can be contrasted with the views of other respondents, who thought that such skills were reasonably widely available.

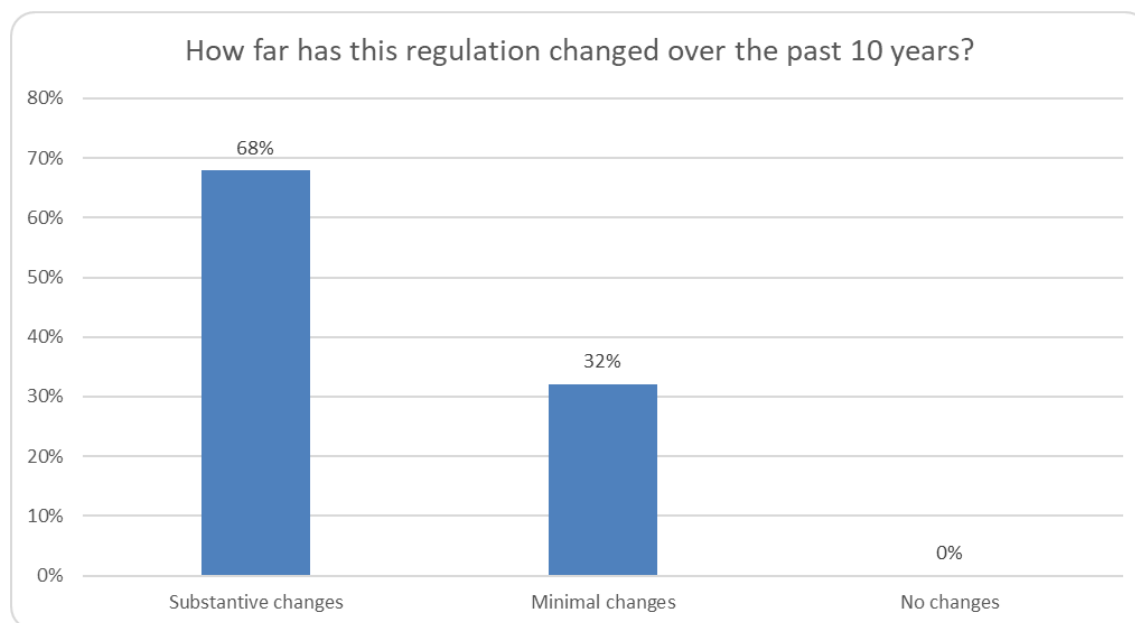
**Figure 1.12: What are likely to be the main threats of the European engineering industry in the next 10 years?**



Source: CSES' survey of testing and certification bodies (incl. notified bodies) and MSAs

Respondents were asked **how far EU regulation has changed in the past 10 years**. Several respondents suggested that there have been substantive changes, such as the continuing alignment through the recasting of Directives through the New Legislative Framework (NLF), which has extended responsibility in a value chains context throughout the supply chain to a broader range of economic operators than was the case in the past. However, perceptions varied as to how far the legal framework has been stable, as one MSA from Sweden pointed out it depends on the legislation, the majority of legislation has had minimal changes but there have been some types of legislation like energy-related where the changes had been substantive. As can be seen from the chart, 32% of respondents took the view that the changes had been minimal.

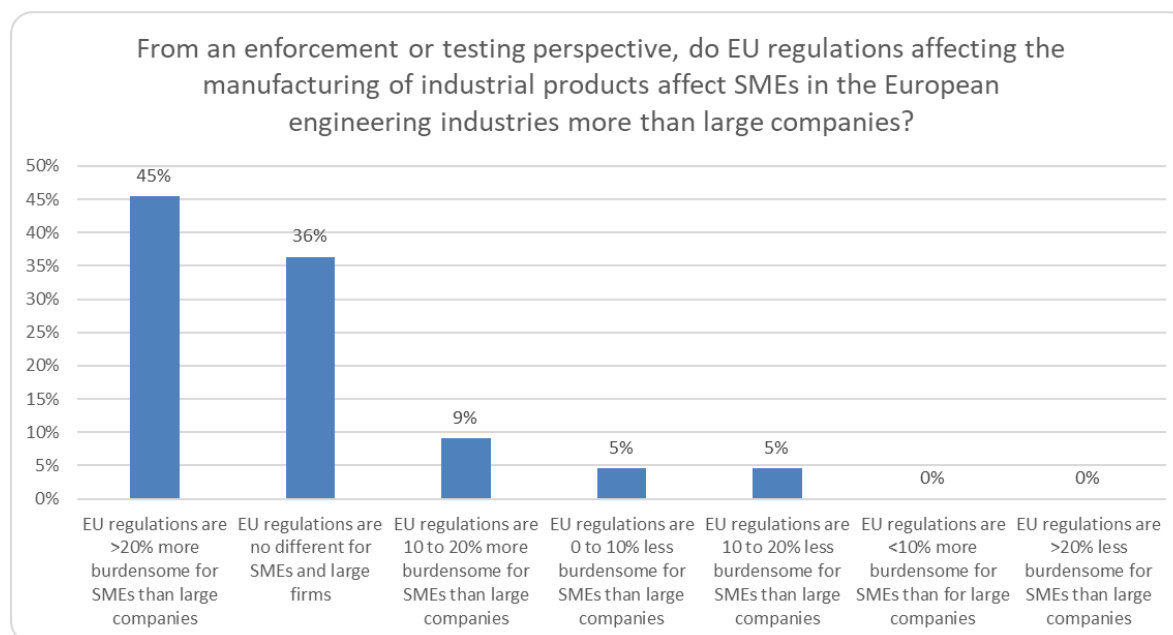
**Figure 1.13: How far has this regulation changed over the past 10 years?**



Source: CSES' Survey of testing and certification bodies (incl. notified bodies) and MSAs

As regards the question as to whether from an enforcement or testing perspective, do EU regulations affecting the manufacturing of industrial products **affect SMEs in the European engineering industries more than large companies**, as with the other categories of stakeholders, there were differing views. Some respondents, such as a notified body from Switzerland, perceived that EU regulations do not affect SMEs and large firms differently since *"all products from all manufacturers have to fulfil the same EHSR and standards"*. However, there were more respondents that perceived that EU regulations are >20% more burdensome for SMEs than large companies. An MSA from the Netherlands commented that according to the results of their investigations, they have found out that big enterprises are more likely to comply with the legislation than small enterprises and if large companies do not comply they often fix the non-compliances in a short period of time. Whereas SMEs require more help, resources and time to fix non-compliances. Other MSAs such as an MSA from Liechtenstein and another one from Malta, selected the option that EU regulations are >20% more burdensome for SMEs than large companies. They expressed the view that the main issue is awareness and willingness by SMEs to obey the law: *"Unfortunately, a lot of SMEs would not have dedicated personnel to deal with legal compliance and do not wish to expand financial resources to employ consultants on this regards. couple that with the fact that potentially non-compliant products are cheaper to buy making for a higher mark-up, then it is in the interest of most SMEs not to follow regulations"*.

**Figure 1.14: From an enforcement or testing perspective, do EU regulations affecting the manufacturing of industrial products affect SMEs in the European engineering industries more than large companies?**



Source: CSES' survey of testing and certification bodies (incl. notified bodies) and MSAs

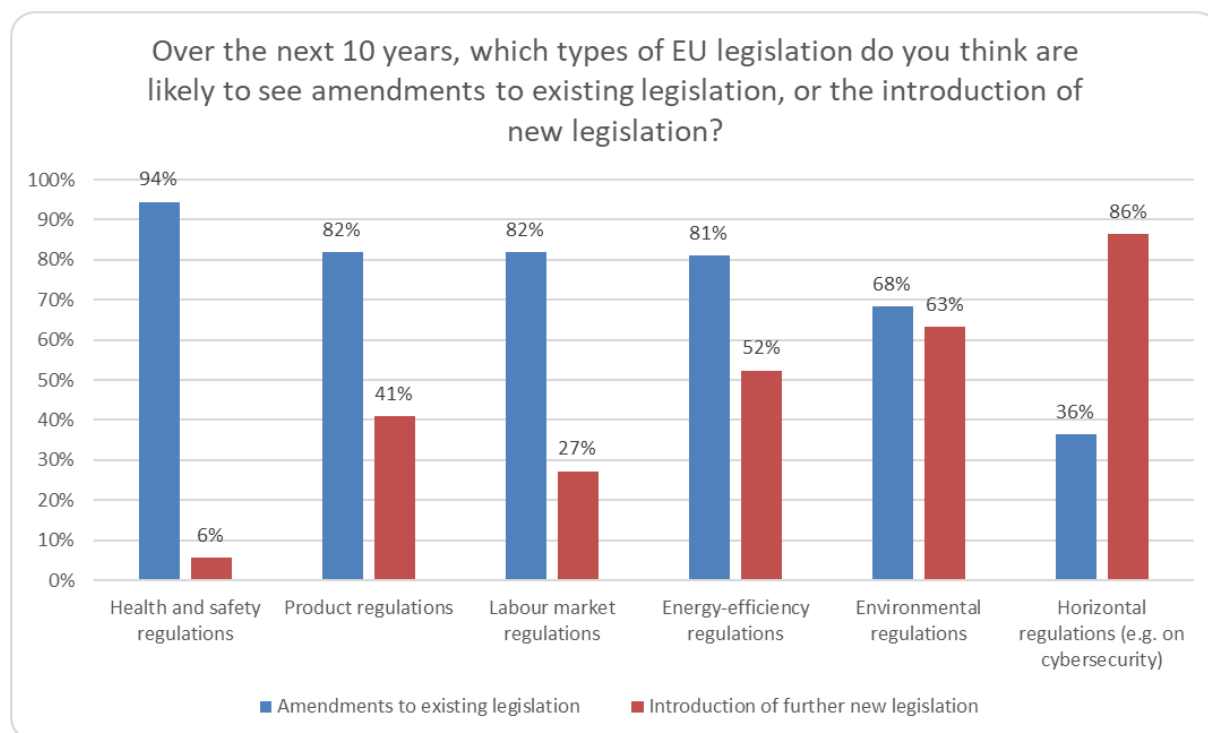
Respondents were then asked to comment looking across the broad spectrum of EU legislation as to whether **looking ahead over the next 10 years, there were likely to be further changes to different types of EU legislation applicable to the EU engineering industries.**

An interesting finding was that there is expected to be further new legislation for specific types of legislation, such as (1) Product regulations (2) Energy-efficiency regulations and (3) Horizontal regulations (for instance, the possibility of legislation covering all industrial products on cybersecurity over the medium-long term (which has also been raised by interviewees from industry associations).

As regards other types of legislation, such as (1) environmental regulations (2) labour market regulations and (3) health and safety regulations, there were expected to be amendments to existing legislation, rather than new legislation introduced. Respondents were asked for their general views on particular types of legislation as a whole. Of course, there may still be exceptions. For instance, in the environmental domain, some stakeholders also identified the potential scope for new EU legislation to be introduced, and not only existing EU legislation being modified, such as the proposed new EU climate law.



**Figure 1.15: Over the next 10 years, which types of EU legislation do you think are likely to see amendments to existing legislation, or the introduction of new legislation?**



Source: CSES' survey of testing and certification bodies (incl. notified bodies) and MSAs

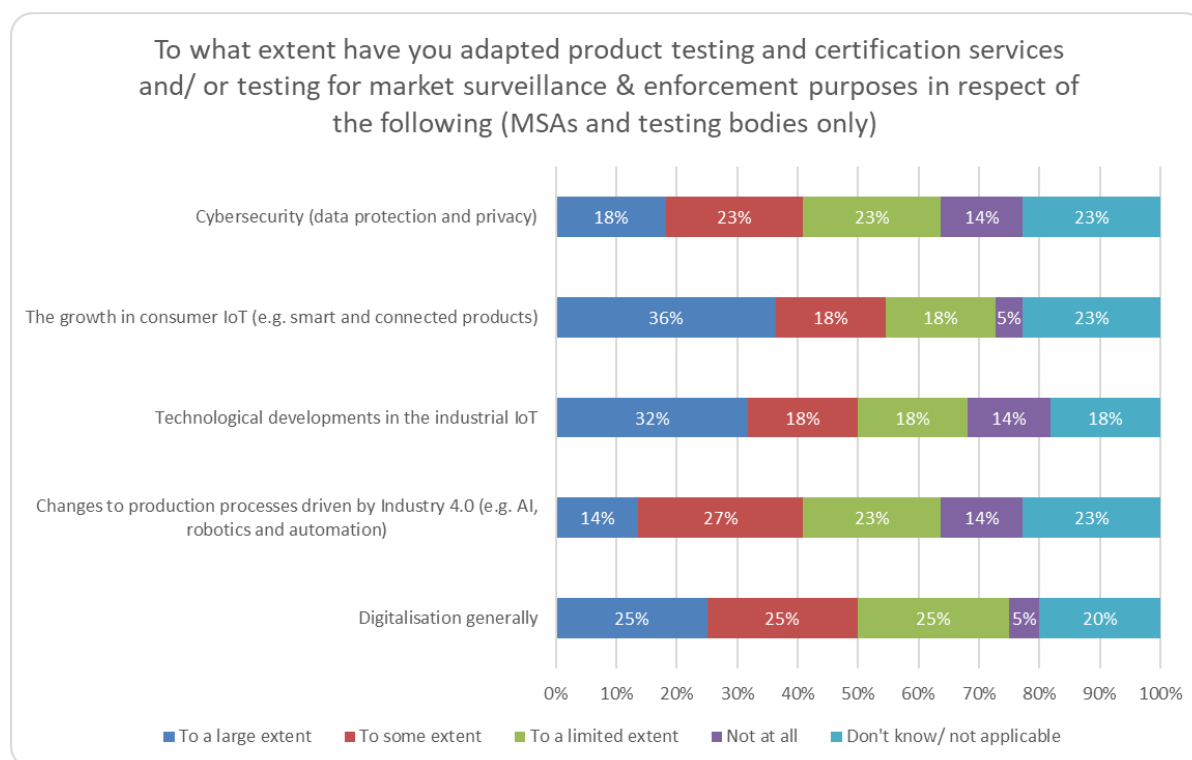
A Market Surveillance Authority from Lithuania noted that a challenge identified for MSAs and testing bodies is that only limited adaptations have been made to reflect increasingly important areas of product testing by laboratories and testing for market surveillance purposes that are being driven by digitalisation. The specific trends linked to digital transition include, *inter alia*: (1) general developments in digitalisation, (2) changes to production processes driven by Industry 4.0 (e.g. AI, robotics and automation), (3) technological developments in the industrial IoT, (4) the growth in consumer IoT (e.g. smart and connected products) and (5) increased attention to product security and (including data protection and privacy) and broader cybersecurity issues.

The interview feedback partly corroborates this finding, as it was found that whilst some testing bodies and MSAs have the technical capacity to check products and / or machinery and advanced manufacturing facilities and processes for these new areas, many other do not have the necessary specialist capabilities. For example, many MSAs are used to checking the safety characteristics of industrial products, but much less so product security. Yet stakeholders are pointing to the increased interconnectedness between product security and safety, which could well have implications for the future development of EU industry product legislation, where safety has been the primary concern, reflecting the underlying legal base set out in Art. 114 of the TFEU.<sup>555</sup>

Nevertheless, some respondents did state that they had adapted their services to a significant extent to accommodate the above-mentioned developments linked to digitalisation and Industry 4.0. The following two charts illustrate these findings:

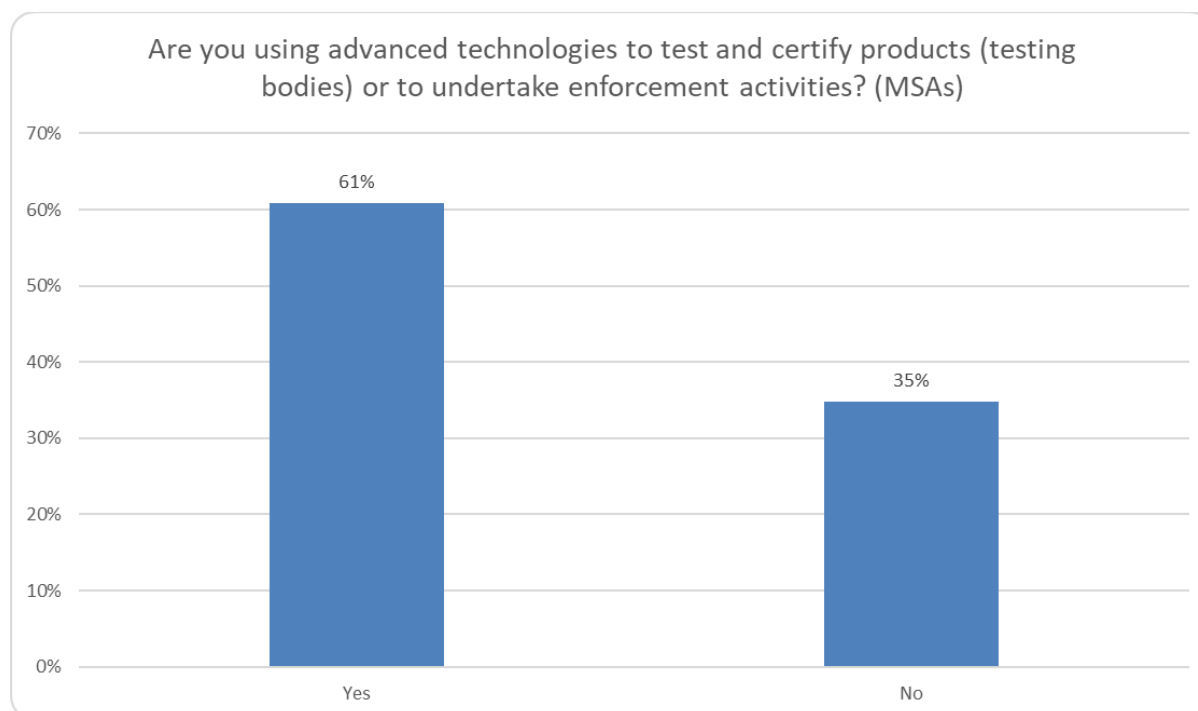
<sup>555</sup> Article 114 TFEU is the legal basis for harmonisation measures aiming to establish the internal market. It emphasises the objective of ensuring a high level of protection (including consumer protection) and keeping up with new developments based on scientific facts.

**Figure 1.16: To what extent have you adapted product testing and certification services and/or testing for market surveillance & enforcement purposes**



Source: CSES' survey of testing and certification bodies (incl. notified bodies) and MSAs

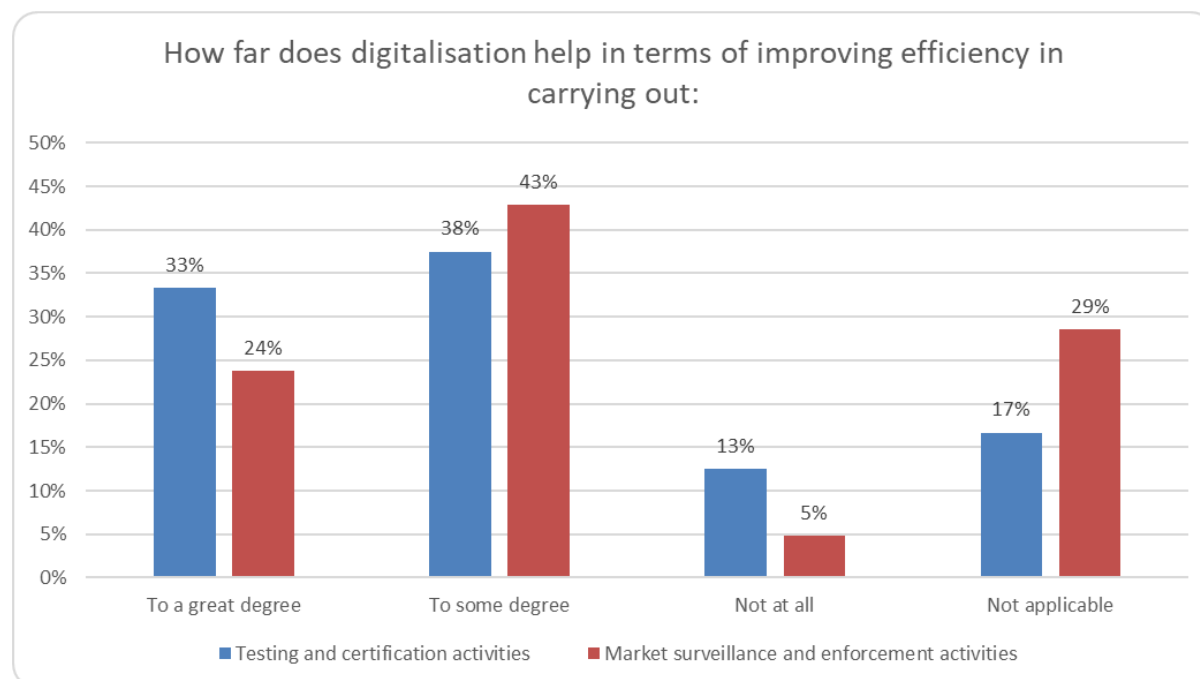
**Figure 1.17: Are you using advanced technologies to test and certify products or to undertake enforcement activities?**



Source: CSES' survey of testing and certification bodies (incl. notified bodies) and MSAs

A further issue explored was the scope for digitalisation to assist MSAs and testing bodies in carrying out their activities in a more efficient and effective way. Several respondents noted that digitalisation provided them with a means of improving their operating efficiency in undertaking testing and certification activities and in the case of MSAs, market surveillance and enforcement activities "to a great degree".

**Figure 1.18: How far does digitalisation help in terms of improving efficiency in testing and certification activities and market surveillance and enforcement activities**



Source: CSES' survey of testing and certification bodies (incl. notified bodies) and MSAs

Although there were no specific questions about the impact of COVID-19 in the questionnaire, some respondents mentioned this in their open responses. For instance, in response to the question "How has the integration of digital technologies (including AI, the IoT, robotics, software, advanced automation etc.) into manufacturing processes affected how you enforce, test or certify products?", the notified body from France stated that an advantage of the use of digital technologies was that "during Covid-19, certification process have continued uninterrupted in a fully efficient way".

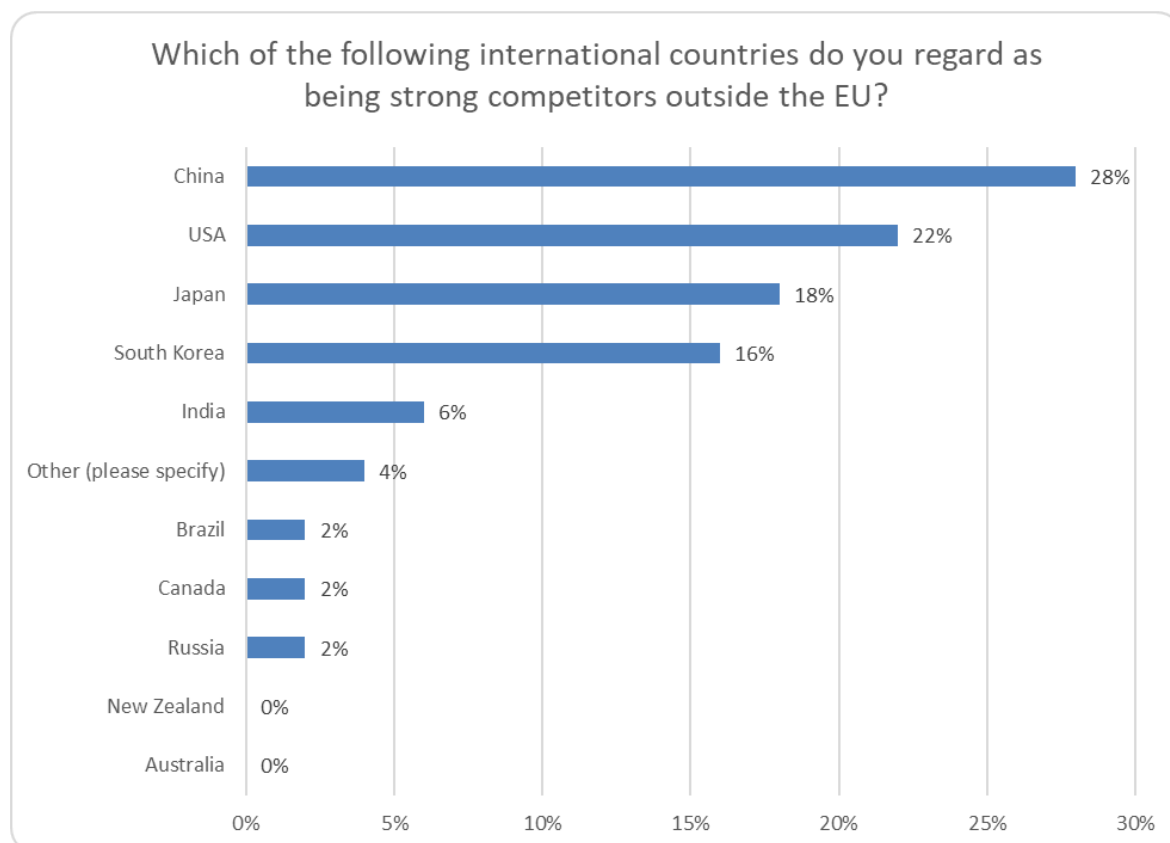
### Survey findings – Survey of Manufacturers and other Economic Operators

The 32 manufacturers and economic operators represented in the survey are SMEs and large companies active in the three main branches of the engineering industry: electrical, electronic, and mechanical engineering. Most of the respondents were based in the EU (e.g. Portugal, France, Germany, Spain) although a great number of them, apart from operating in several markets within the EU, operate outside the EU.

Survey respondents were asked about their perceptions as to the **major competitors for the EU engineering industries**. The firms selected a range of countries that were perceived as strong competitors outside the EU. Almost all firms pointed to China among the major competitors, whereas there were some variations in the rest of competitors, USA, Japan and South Korea were also seen as strong competitors together with China. Two firms mentioned Brazil as a key competitor and one large company from Germany mentioned that Canada and Brazil might become stronger in the near future. A Portuguese

electrical and electronic SME mentioned China and India as competitors. The same competitors were selected by an electronic company from France, although apart from China and India the firm mentioned South East Asia (e.g. Indonesia, Vietnam, Thailand) as strong competitors outside the EU.

**Figure 1.19: Which of the following international countries do you regard as being strong competitors outside the EU?**



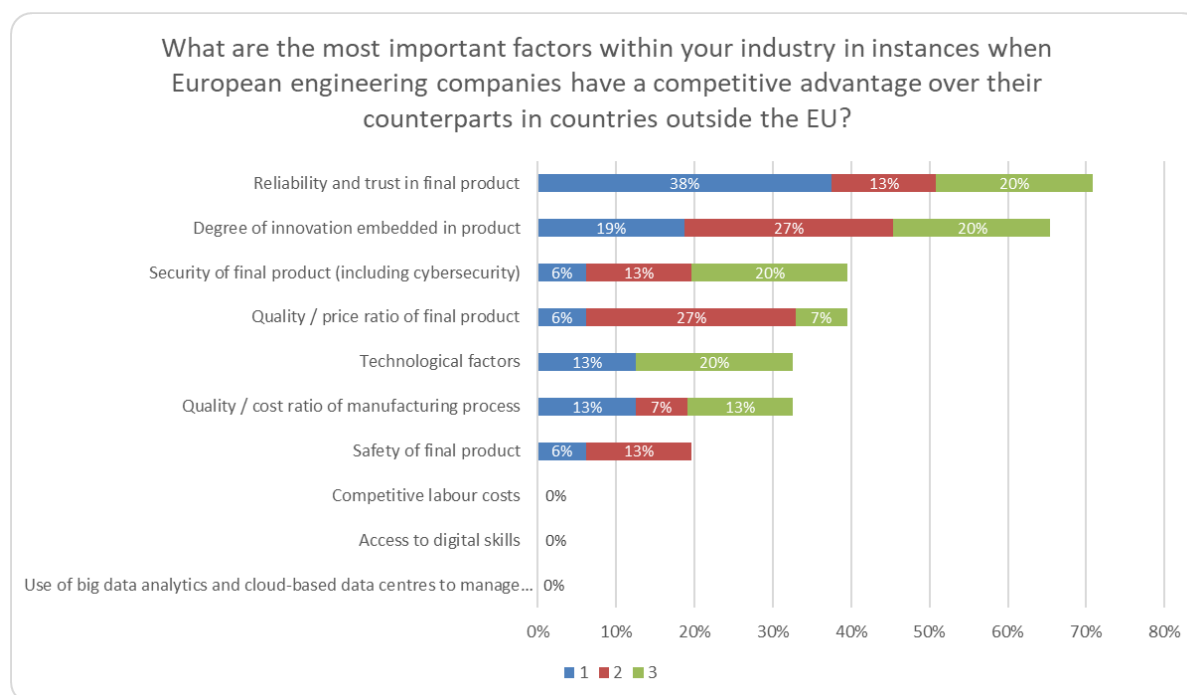
Source: CSES' survey of Manufacturers and other Economic Operators

Respondents were asked about the prospects of their enterprise in terms of its **future cumulative growth potential (turnover)** over the medium-term (5 years) and long-term (10 years) compared with today. Overall, the prospects were similar for both terms, most respondents suggested that their enterprise will have a steady growth (10-20%) or a modest growth (0%-10%) at both the medium-term and the long-term. There were some exceptions, as one large company from Germany that suggested that it will be no change in the medium-term because of the expected global slowdown due to factors such as environmental regulations or the industrial and market transformation towards digitalisation that will contribute to estimated flat to marginal growth expectations. Another large company suggested that it was difficult to predict the cumulative growth because of the COVID-19 situation and its impact to the automotive and avionic industries growth or decline since they consume electronics.

There were different views regarding the most important **factors that gave firms a competitive advantage**. Respondents were asked about the most important factors that give EU engineering companies a competitive advantage over countries outside the EU and vice versa (i.e. the factors that give firms outside the EU a competitive advantage over European firms). As can be seen from the following charts the most important factors selected were:

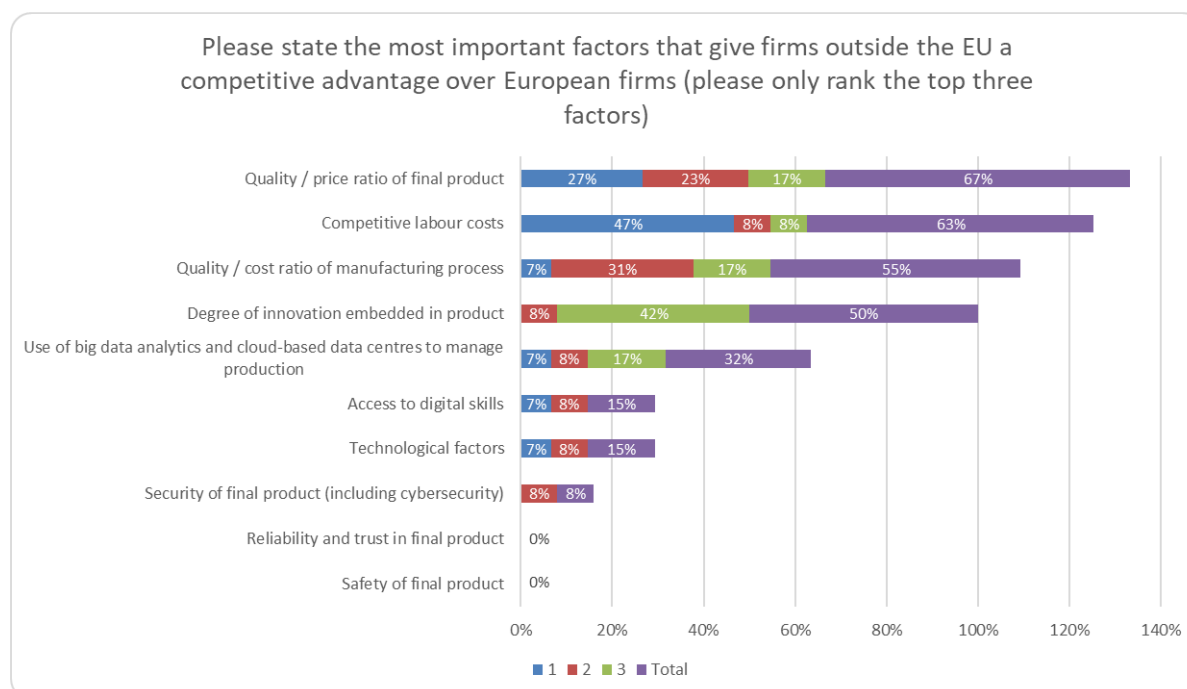
- **Factors for EU firms** – Reliability and trust in final product; degree of innovation embedded in product; quality/ cost ratio of manufacturing process.
- **Factors for non-EU firms**- Most of respondents selected competitive labour costs as the most important factor that give firms outside the EU a competitive advantage. Other factors were quality/ price ratio of final product or degree of innovation embedded in product.

**Figure 1.20: What are the most important factors within your industry in instances when European engineering companies have competitive advantage over their counterparts in countries outside the EU?**



Source: CSES' survey of Manufacturers and other Economic Operators

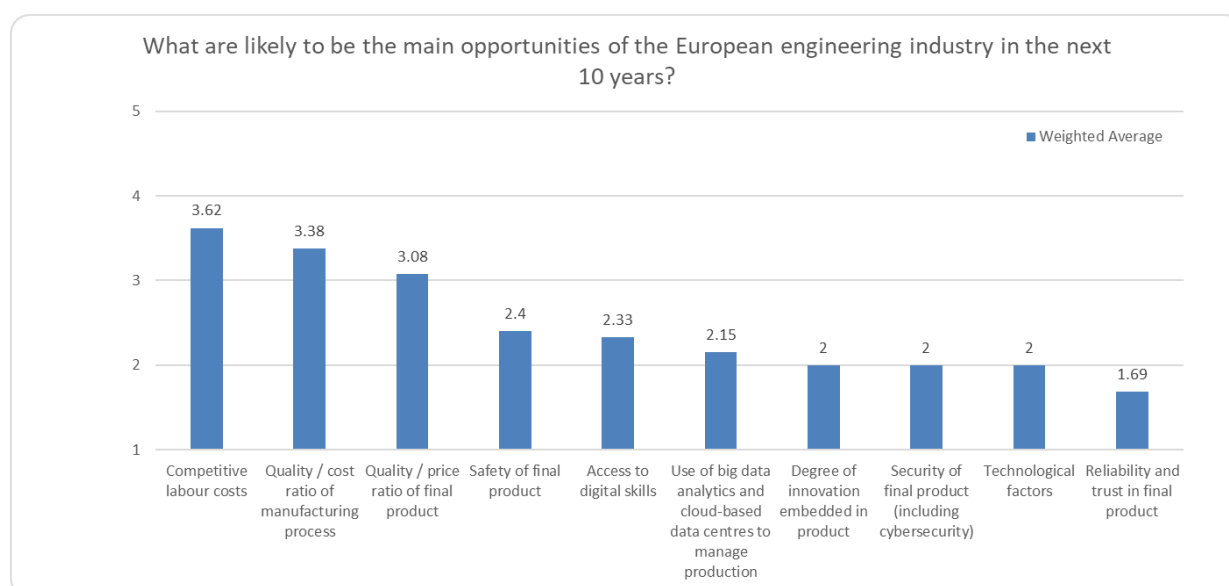
**Figure 1.21: Please state the most important factors that give firms outside the EU a competitive advantage over European firms**



Source: CSES' survey of Manufacturers and other Economic Operators

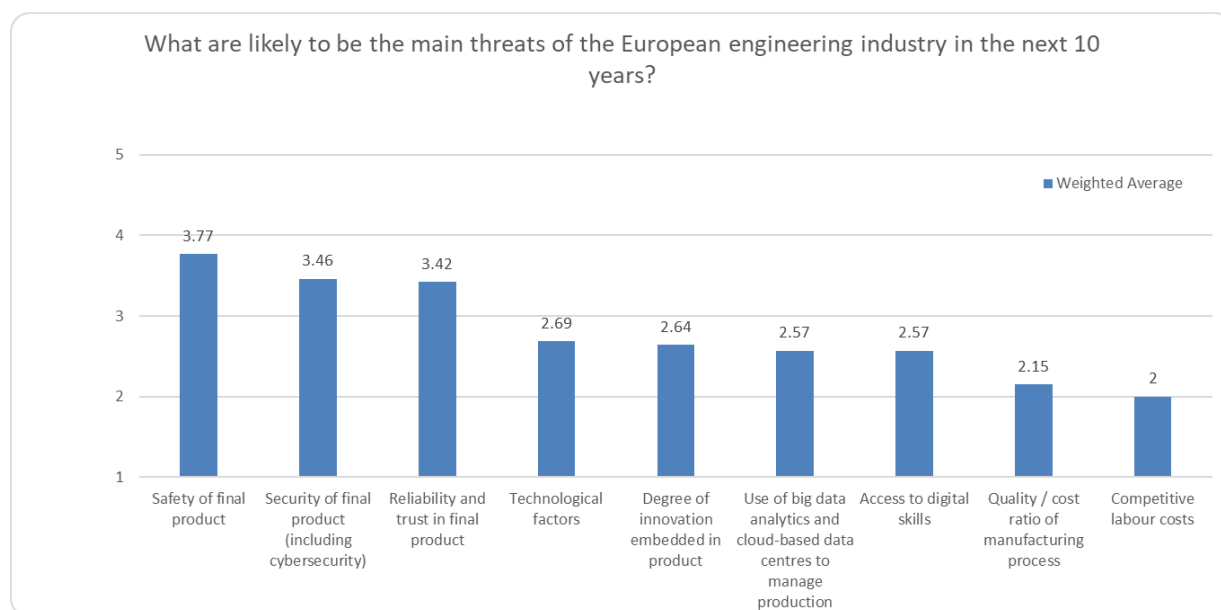
Regarding the **main challenges and opportunities faced by the EU engineering industries in the next 10 years**, firms saw competitive labour costs as the main opportunity of the European engineering industry. Other factors regarded as opportunities by respondents were quality/ costs ratio of the manufacturing process and quality/ price ratio of the final product. On the other hand, respondents perceived the safety; reliability and trust; and security of final product as the main **threats** of the European engineering industry in the next 10 years.

**Figure 1.22: What are likely to be the main opportunities of the European engineering industry in the next 10 years?**



Source: CSES' survey of Manufacturers and other Economic Operators

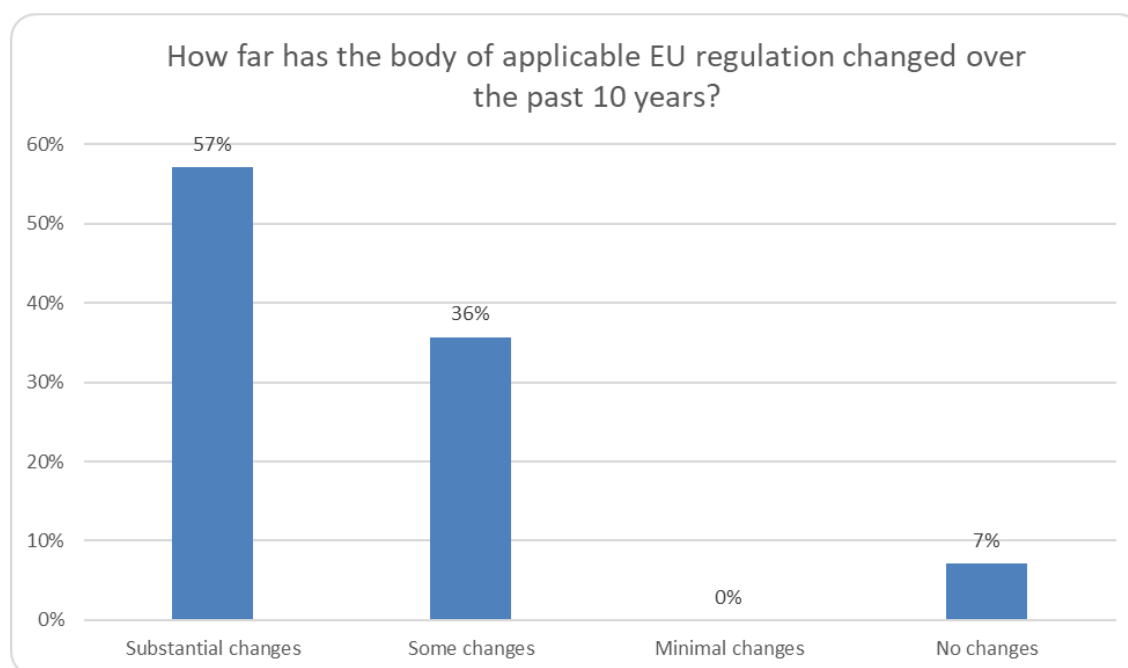
**Figure 1.23: What are likely to be the main threats of the European engineering industry in the next 10 years?**



Source: CSES' survey of Manufacturers and other Economic Operators

Survey respondents were asked **how far EU regulation has changed over the past 10 years**. Several respondents suggested that there have been substantive changes. A Spanish SME commented that there have been continuous significant changes that had been burdensome for their firm due to the required revision of their designs, products, and processes. Other respondents answered that there have been some changes in the EU regulation in the past decade and 10% of respondents thought that there have been no changes.

**Figure 1.24: How far has the body of applicable regulation changed over the past 10 years?**

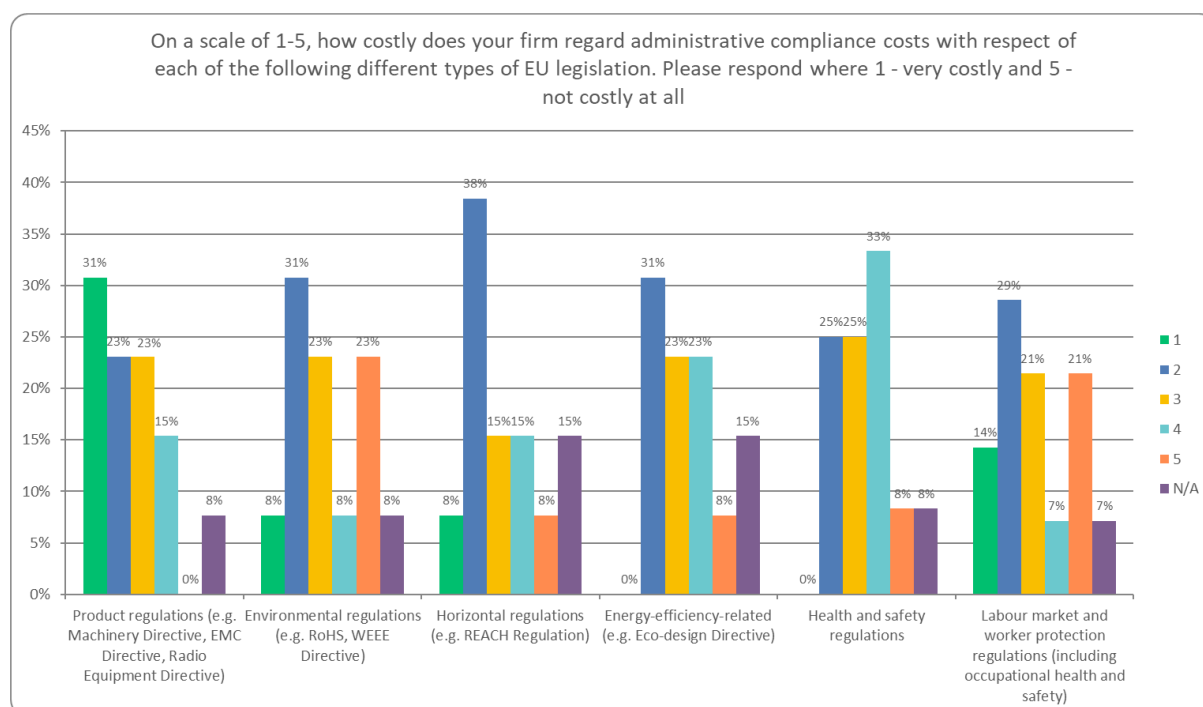


Source: CSES' survey of Manufacturers and other Economic Operators



Respondents were then asked to rate EU legislation in terms of **how costly the administrative compliance costs are to their firms**. Across the selected EU legislation applicable to firms in the EU engineering industry, respondents perceived horizontal regulation (such as REACH Regulation) and labour market and worker protection regulations as the costliest. Perceptions varied in some types of legislations, an example could be the environmental regulations, where some respondents rated it as costly or very costly whereas other respondents answered that environmental regulations were not costly at all.

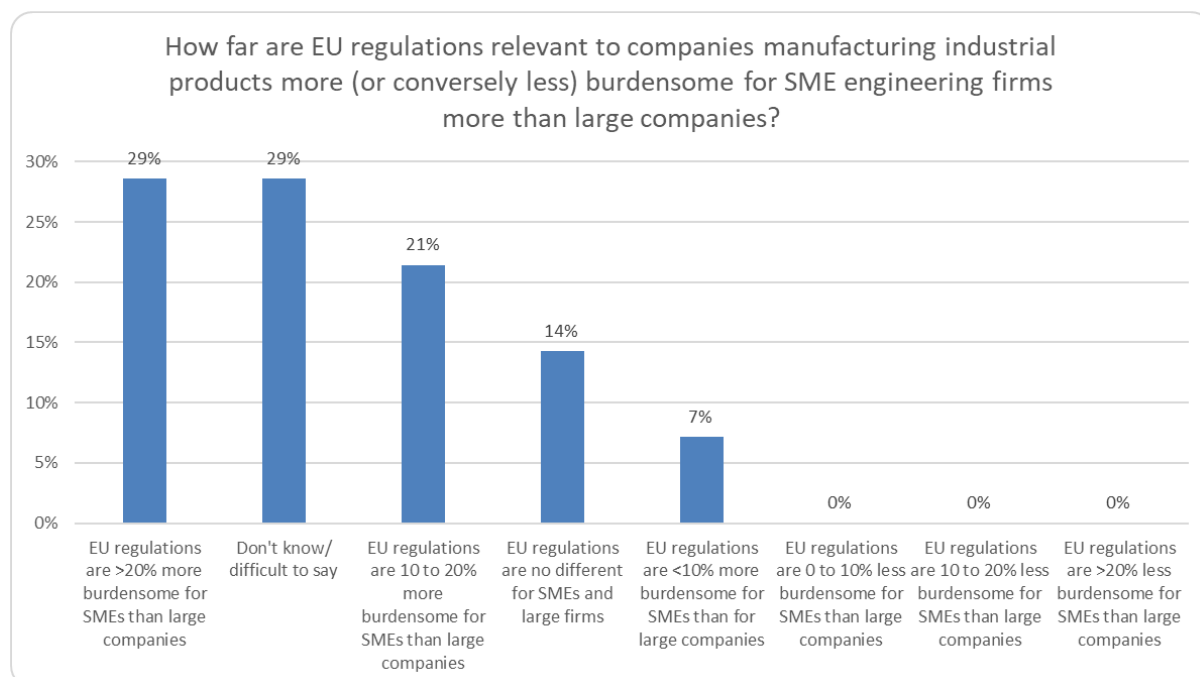
**Figure 1.25: On a scale of 1-5, how does your firm regard administrative compliance costs with respect of each of the following different types of EU legislation. Please respond where 1- very costly and 5 – not costly at all**



Source: CSSES' survey of Manufacturers and other Economic Operators

As regards the question as to whether EU regulations relevant to the manufacturing of industrial products **affect SMEs in the European engineering industries more than large companies**, a large number of firms answered that it was difficult to say, however overall firms perceived that EU regulations are more burdensome for SMEs than for large companies. From the respondents that selected the option "EU regulations are >20% more burdensome for SMEs than large companies", there were more large companies than SMEs. A medium sized firm from the UK who operate in the EU market and outside the EU commented that the relative costs are crippling to SMEs and that only large firms can afford the compliance costs. Respondent were also asked if the **digitalisation and Industry 4.0 is going to affect SMEs and multinationals differently**. A large company commented that "both can benefit from more efficient management, work and process flows, while multinationals' operation scale factor would be a competitive edge from various directions e.g. costs of implementations, positive effects towards leaner operations matching to typical SME advantages".

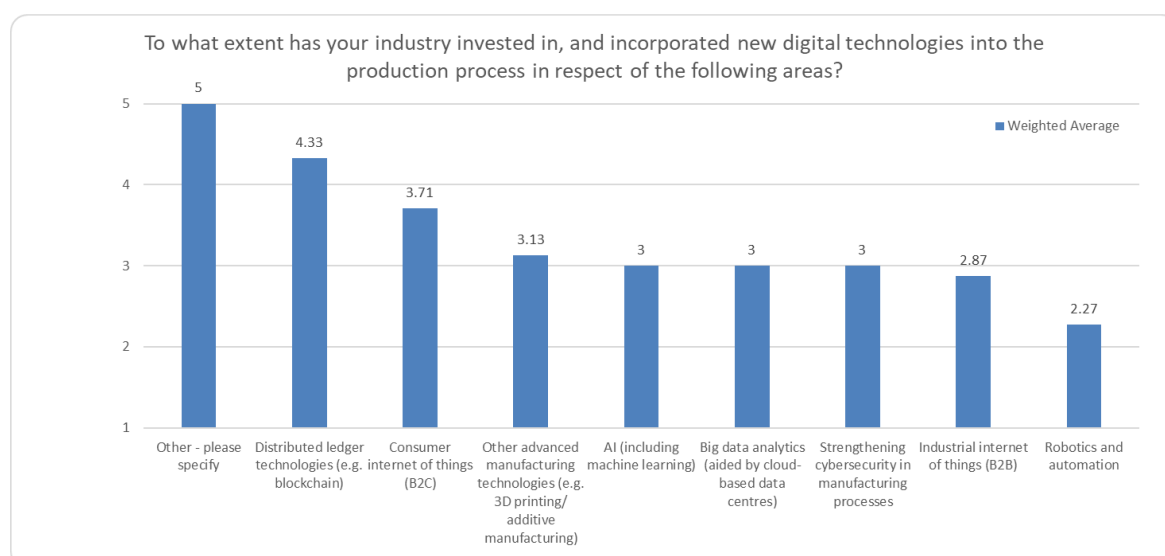
**Figure 1.26: How far EU regulations relevant to companies manufacturing industrial products more (or conversely less) burdensome for SME engineering firms more than large companies?**



Source: CSES' survey of Manufacturers and other Economic Operators

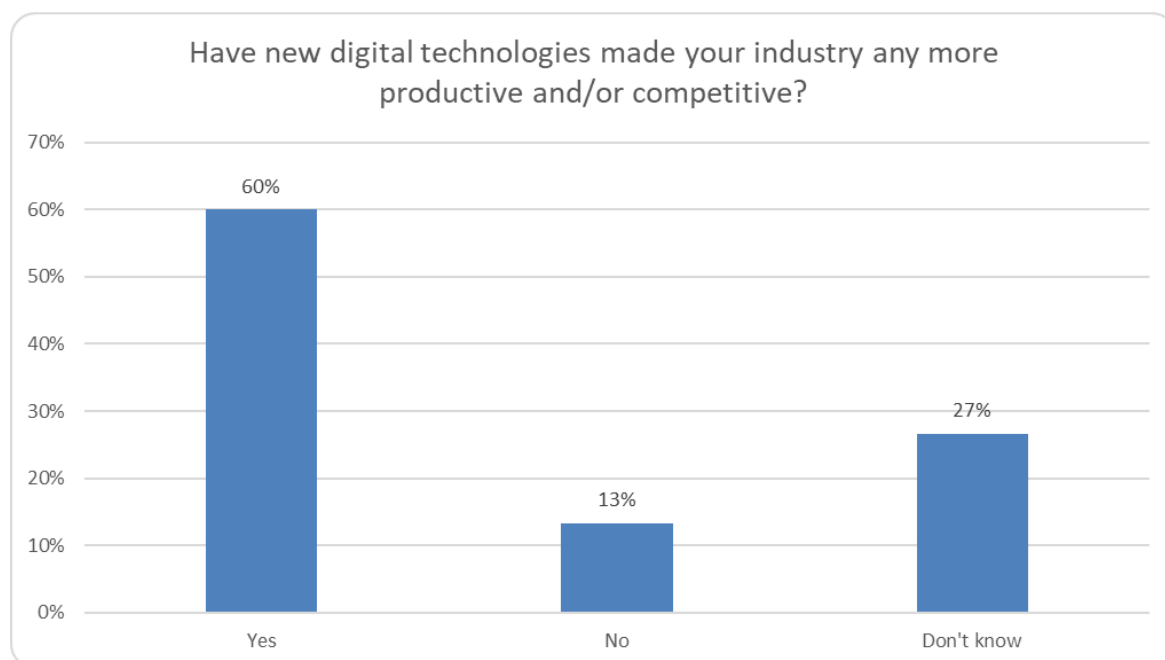
Regarding **new digital technologies**, survey respondents were asked about to what extent their **industry invested and incorporated new digital technologies into the production process**. As can be seen from the following chart, the area where firms answered that they invested most was robotics and automation, followed by the industrial internet of things (B2B). Respondents answered that the area where they invested less was distributed ledger technologies, such as blockchain. The next figure shows that most respondents perceived that **new digital technologies made their firm more productive and/or competitive**.

**Figure 1.27: To what extent has your industry invested in, and incorporated new digital technologies into the production process in respect of the following areas?**



Source: CSES' survey of Manufacturers and other Economic Operators

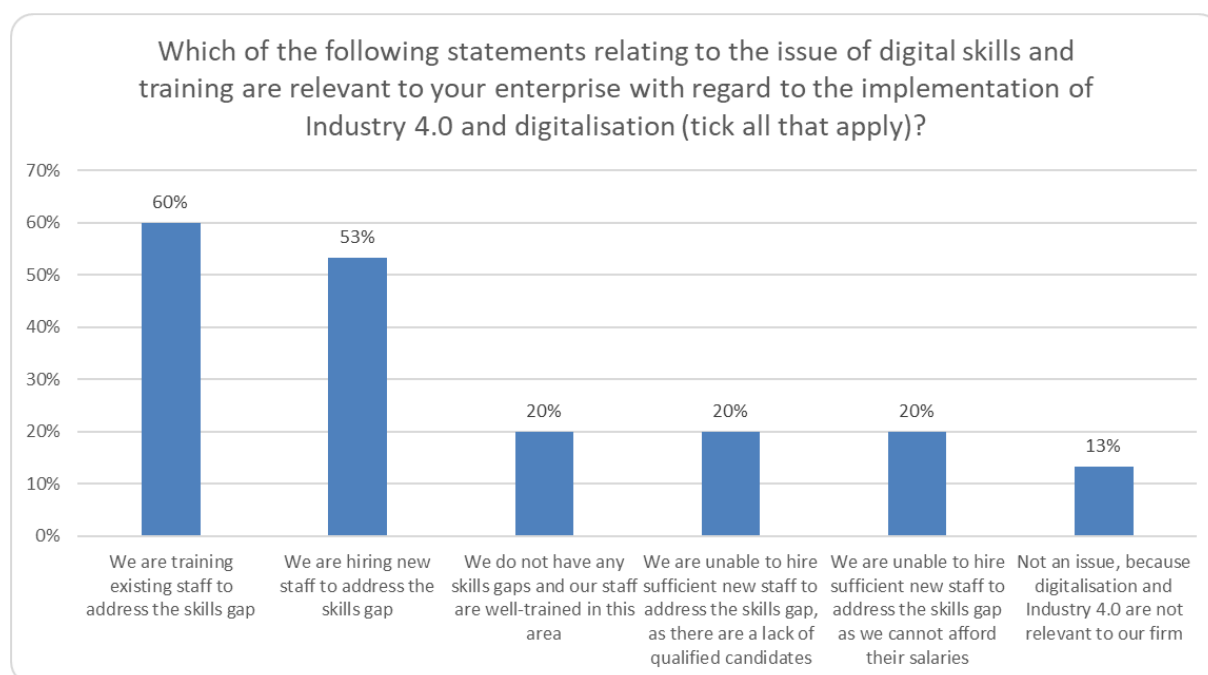
**Figure 1.28: Have new digital technologies made your industry any more productive and/or competitive?**



Source: CSES' survey of Manufacturers and other Economic Operators

Respondents were asked to select **the statements relating to the issue of digital skills and training are relevant to your enterprise regarding the implementation of the Industry 4.0 and digitalisation**, the statement that most firms selected were "we are training existing staff to address the skills gap" followed by "we are hiring new staff to address the skills gap". Finally, respondents were asked if they anticipated any further investment in new digital technologies in future and all respondents answered positively.

**Figure 1.29: Which of the following statements relating to the issue of digital skills and training are relevant to you enterprise with regard to the implementation of industry 4.0 and digitalisation?**



Source: CSES' survey of Manufacturers and other Economic Operators

### 1.3 THE IMPACT OF COVID-19 ON COMPETITIVENESS

As the surveys were drafted before the COVID-19 epidemic struck, no questions on the impact of the health pandemic on the EU engineering industries were included. Instead, the impacts of the pandemic on the EU engineering industries have been examined through desk research, interviews and in the two webinars held in May 2020. A detailed assessment of the impacts of COVID-19 on competitiveness is provided in the main report. However, there were some limited open responses from survey respondents that mentioned the ongoing short and medium-term impacts of COVID-19.

As regards the types of impacts mentioned by stakeholders, in the **Survey of industry associations**, a respondent pointed out that there will be an impact on the competitiveness of the EU engineering industry in the short-term (1-3 years) due to "COVID-19-related difficulties". A further respondent mentioned that COVID-19 represents a challenge due to the decrease in demand globally for engineering-related products and services. A further respondent mentioned that the pandemic has exposed the risks of long supply chains, which characterise some manufacturing industries. In the short-term, supply chain dislocation was also found to be a problem through interviews. The impact of the pandemic has been exacerbated for industries where there are complex and longer Global Value Chains (GVCs). As regards the impacts on specific sectors, some vertical sectors that use inputs from the engineering industries have been especially adversely affected, such as the automotive and pharmaceutical sectors.

A further medium-term impact may be that European firms will do more to secure a digital inventory of all components and parts, as missing a crucial component or part can lead to production delays. There may also be an acceleration of the trend towards reshoring specific aspects of production, and potentially some degree of shifting back aspects of production to Europe through the concept of "nearshore outsourcing", i.e. moving some production to central and eastern Europe, where even though higher cost than some alternatives, there may be a lesser risk of supply chain dislocation.

One comment was also received through the **Survey of manufacturers**. Looking ahead over the next 5 years, one enterprise noted that one of the major impacts of the pandemic has been business uncertainty, meaning that it is less possible to have foresight over future medium-term prospects at the firm level. The same respondent pointed to the automotive and avionic industries as being especially at risk of being impacted by the pandemic as they are major purchasers of electronics.

Turning to the **Survey of Market Surveillance Authorities (MSAs)**, in response to the question, "How has the integration of digital technologies into manufacturing processes affected how you enforce, test or certify products?" one MSA respondent mentioned that digitalisation had helped their market surveillance authority to continue operating efficiently "during Covid-19, the certification process has remained fully efficient".

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