European Commission

April 2021

Advanced Technologies for Industry – Sectoral Watch

Technological trends in the machinery industry

This report was prepared by Dr. Palina Shauchuk and Kincsö Izsak from Technopolis Group.

EUROPEAN COMMISSION

European Innovation Council and Small and Medium-Sized Enterprises Executive Agency (EISMEA)

Unit I-02.2 – SMP / COSME Pillar

E-mail: EISMEA-COSME-ENQUIRIES@ec.europa.eu

Directorate General for Internal Market, Industry, Entrepreneurship and SMEs

Unit D.2 – Industrial Forum, alliances, clusters

E-mail: GROW-ATI@ec.europa.eu

European Commission

B-1049 Brussels

PDF ISBN 978-92-9460-574-0 doi:10.2826/885867 EA-08-21-056-EN-N

April 2021

Table of contents

Section

Introduction

This sectoral report has been prepared in the framework of the '*Advanced Technologies for Industry'* (ATI) project, initiated by the European Commission's Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the European Innovation Council and Small and Medium-Sized Enterprises Executive Agency.

It analyses trends in the generation and uptake of advanced technologies, related entrepreneurial activities and skills needs in the machinery sector. It interprets data from a list of data sources compiled to monitor advanced technologies and their applications in industry across Europe and key competitor economies.

The starting point of this analysis has been sixteen advanced technologies that are a priority for European industrial policy and that enable process, product and service innovation throughout the economy and hence foster industrial modernisation. Advanced technologies are defined as recent or future technologies that are expected to substantially alter the business and social environment and include Advanced Materials, Advanced Manufacturing, Artificial Intelligence, Augmented and Virtual Reality, Big Data, Blockchain, Cloud Technologies, Connectivity, Industrial Biotechnology, Internet Of Things, Micro and Nanoelectronics, Mobility, Nanotechnology, Photonics, Robotics, Security.

The relevance of these specific technologies in the machinery industry has been explored through patent analysis and data on private equity investments, skills and technology uptake. The full methodology behind the data calculations is available here: https://ati.ec.europa.eu.

This report is structured as the following:

- The first section sets the industrial context.
- The second section analyses technological trends in advanced technologies applied in the machinery industry based on patents and text-mining of company websites.
- The third section presents findings about private equity investment and startup/spinoff activity.
- The fourth section explores the supply and demand of skills related to advanced technologies in the machinery industry.
- The fifth section concludes with a short future outlook.

Section 1

1. Setting the scene: industrial context

Key messages

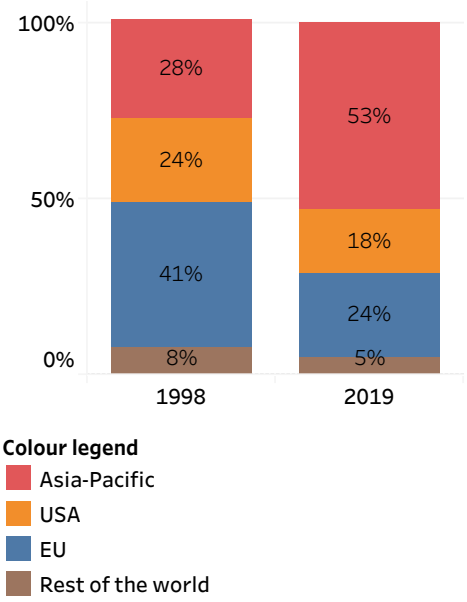
The machinery sector is a **major contributor to the European economy**, with a current annual **turnover of €700 bn**. Machinery and equipment manufacturing was the main business activity of 80 000 enterprises across the EU27 in 2018. These enterprises employed 3 million persons in the EU27 in 2018, according to Eurostat figures.

The Covid-19 pandemic had a huge impact on the European machinery industry resulting in supply chain disruptions, drop in demand and liquidity problems. Nevertheless, the pandemic has been also a window of opportunity to **rationalise European production, revise supply chains and push for more digitalisation and green models.**

1.1 Machinery industry value chain: market size and evolution

The machinery sector is one of the largest and most competitive sectors in the area of manufacturing. For many decades, European and US machinery manufacturers dominated the global machinery market. However, as seen in Figure 1 a number of Asian players are now growing in strength.

Figure 1: Production of machinery by region



Source: IHS World Industry Service

Major competitors in global machinery markets include China (key player on the Asian market), Germany, the US, Japan and Italy. In 2019 China's market share increased to 28 percent. China, Germany and Japan were the three leading machinery manufacturers globally, while the US (€4.3 bn) and Italy (€5.9 bn) accounted for six and eight per cent of global share respectively[1]. The first five countries in the ranking account for 73% of the total global machinery turnover.

Machinery and equipment manufacturing industries provide a range of essential products and technology for applications in several other manufacturing and services industries. They provide for example equipment for use in mining, manufacturing, textile, energy, agriculture, medicine and construction, as well as producing domestic appliances. The market is driven by technological innovation in machinery and advancements in process control. Increased efforts by key industry players in order to produce highly efficient equipment and machinery are factors that fuel the growth of the market.

The global **textile machinery** market was €34.1 bn in 2018 and is expected to reach €54.4 bn by the end of 2025, growing at a compound annual growth rate (CAGR) of 6.2% between 2019 and 2025[2]. The textile machinery market is very dynamic due to constant technological advancements. The demand for textile machinery is affected by increasing market demand for home textiles, furniture upholstery, automobile textiles, as well as fashion trends. The major textile machinery exporting countries are China, Switzerland, Italy and Germany. Asia-Pacific region is the biggest and fastest growing region for textile machinery.

The construction machinery sector includes those machineries and equipment that have major role in the construction process. The global construction machinery market was valued at

[1]https://www.statista.com/statistics/264213/leading-countries-in-machine-tool-production-based-on-market-share/#:~:text=China%2C%20Germany%20and%20Japan%20were,global%20machine%20tool%20production%20respectively.

[2]https://dataintelo.com/report/textile-machinery-market/

approximately €123.9 bn in 2018 and is anticipated to grow with a growth rate of more than 7.5%[3]. The machineries include crane, telescopic handling, excavator and others. Asia Pacific region is considered as the fastest growing region in the global construction machinery due to the rapid expansion in construction and real estate industry.

The global **agricultural machinery** market was valued at €137.9 bn in 2019[4]. Agricultural machineries cover a wide range of equipment employed at various stages of agriculture. The range varies from simplest tools such as hand trowel to threshing machines, slurry trailer and high-end engineered tractors. Advanced farming machinery such as spraying equipment, hay and forage equipment, harvesters, and irrigation and crop processing equipment is being used in various processes to enhance overall crop output and quality. Adoption of advanced technologies by farmers is a key factor driving the market. For instance, agricultural robotics, such as ground-based sensors, autonomous tractors and flying drones, are already helping farmers in producing food at lower costs to satisfy growing demand for food[5].

Growing number of surgeries and technological advancements such as anaesthesia monitoring and advanced neuromuscular monitoring systems are stimulating the **medical machinery** market growth. The **medical device industry**, composed of medical equipment or devices such as in-vitro diagnostic devices, diagnostic imaging equipment, dental equipment and supplies, ophthalmic devices, cardiovascular devices, hospital supplies and other medical devices, is an eminent part of the healthcare sector. The global medical devices market reached a value of nearly €407.6 bn in 2019[6]. Established centres of this market comprise the US and Western Europe. Nevertheless, industry trends show that Asia with a predominant role from China, are expected to play a leading position in the upcoming years[7]. The global anesthesia machinery market is estimated to nearly double its size by 2026 from €1.7 bn in 2018[8]. Currently, the global anesthesia machinery market is in high demand of using computer-controlled anesthesia machines. This factor creates a profitable opportunity for medical device companies to invest in the market. Medical machinery has become also more important during the Covid-19 pandemic.

The business environment of the machinery industry is changing fast. Digitalisation, complex new offered products, qualified personnel are the potential opportunities or barriers of growth which in turn increasingly cast doubt on the sustainability of traditional business models. In order to keep pace with these developments, for example, Chinese competitors provide the industry with competitive pricing and better time to market, while the US machinery industry is developing new and creative business models.

Digitalisation facilitates product development and gives new opportunities across various processes of the industrial machinery value chain from designing the product to its production, sales and offering after-sales services.

1.2 European strengths in machinery

Machinery and equipment manufacturing[9] was the main business activity of 80 000 enterprises across the EU27 in 2018. These enterprises assured employment for 3 million persons in the EU27 for the same year. The machinery sector is a **major contributor to the European economy**, with a current annual turnover of €700 bn[10]. In 2018, the EU countries with the highest value added generated by the sector were Germany (€108 bn) and Italy (€37.2 bn), followed by France and the Netherlands.

The machinery and equipment manufacturing sector in Germany is the largest among the EU27 Member States, with a nominal turnover increase to €226 bn in 2018[11]. German machinery industry's strength is driven by Germany's proven engineering tradition, its position as a technology development leader and a highly diversified industrial base. The total annual revenue of the machinery and equipment industry in Italy was €124 bn in 2018. Revenue from the manufacturing of agricultural and forestry machinery amounted to €9.5 bn for the same year[12]. Agricultural machinery businesses were expecting a slight sales decrease in 2019[13]. The French agricultural machinery market was valued at €5.15 bn in

[3]https://www.marketstudyreport.com/global-construction-machinery-market-size-research?gclid=Cj0KCQiA3smABhCjARIsAKtrg6Lk0qqQpKnKXIPHeAtZCDb7IfzvQjjxb2XdRVcE3UbRSPG50OlhDMgaAmYAEALw_wcB

[4]https://www.grandviewresearch.com/industry-analysis/agriculture-equipment-market

[5]https://www.grandviewresearch.com/industry-analysis/agricultural-machinery-market

[6]https://www.thebusinessresearchcompany.com/report/medical-devices-market#:~:text=Medical%20Devices%20Market%20Definition&text=The%20medical%20device%20industry%20includes,supplies%20and%20other%20medical%20devices.

[7]https://www.statista.com/topics/1702/medical-technology-industry/

[8]https://www.medgadget.com/2020/07/anesthesia-machinery-market-size-worth-usd-3288-million-by-2026-cagr-6-3.html

[9] Captured as NACE C28 - Manufacture of machinery and equipment n.e.c.

[10] Eurostat, SBS, SBS_NA_IND_R2

[11]https://www.gtai.de/gtai-en/invest/industries/machinery-equipment-industry-68638

[12]https://www.statista.com/statistics/532942/italy-turnover-machinery-equipment-industry-by-sector/#:~:text=Revenue%20of%20the%20machinery%20and%20equipment%20industry%20in%20Italy%202018%2C%20by%20sector&text=The%20total%20annual%20revenue%20of,amounted%20to%209.5%20billion%20euros

[13]https://atradiuscollections.com/global/reports/market-monitor-machines-italy-2018.html

2018. Tractors manufacturing accounts for nearly 30% of the French agricultural machinery market.

According to the Eurostat statistics on the manufacture of machinery and equipment, the manufacturing of other special-purpose machinery was the largest in terms of wealth creation, accounting for about 10% of value added generated in the EU27's machinery and equipment manufacturing sector (see Figure 2). The next largest subsector was that of metal forming machinery and machine tools, that generated 8% of machinery equipment manufacturing value added, followed by agricultural and forestry machinery and machinery for mining, quarrying and construction.

Across the 27 EU Member States, the production value of the metal forming machinery industry reached approximately €45 bn in 2018. The development of this sector is significantly influenced by demand from the automobile and steel sectors, as well as machinery and equipment manufacturing. In 2018, the European countries with the highest volume of metal forming machinery production were Germany (€25.4 bn) and Italy (€10.4 bn), followed by Switzerland (€4.3 bn), Spain (€1.9 bn) and Austria (€1.8 bn)[14].

Germany is one of the largest markets for agricultural machinery in Europe supported by the large turnover for this industry in the country (€15.5 bn)[15]. The country is one of the largest exporters of agricultural machinery in the world, the largest manufacturer and the second-largest consumer of agri-machinery in Europe. Italy's agricultural machinery sector is predominately an export-based market where it supplies majorly to the US and EU as the domestic market usage of agricultural machinery is very limited as compared to exports. The increase in the need for farm mechanisation and the rise in technological advancements are some of the factors driving the market growth[16].

Germany has played the leading role among the top textile machinery manufacturers in Europe with the largest turnover (€5.7 bn). German textile machinery is characterised by its high quality and customer-specific production. Italian textile machinery sector is the second foremost machinery manufacturer comprising around 900 companies, employing more than 14 000 people and producing machinery for a total cost of €3.5 bn per year[17], with exports amounting to 80% of total sales[18].

1.3 Environmental challenges

The management of the natural environment is becoming essential within manufacturing as customers, suppliers and the public require the manufacturers to minimise any negative environmental effects of their products and operations. In order **to reduce a major portion of the estimated 51 gigatons (Gt)**[19] of Greenhouse gases (GHG) emissions released into the atmosphere each year, machinery and equipment manufacturers have to play a key role in this effort.

The use of machinery is an inevitable part of construction works. The main source of energy for most construction machinery has been mainly **diesel fuel[20]**, and as a consequence, different tailpipe pollutants are released to the air[21], such as carbon dioxide (CO2), sulfur dioxide (SO2), nitrogen oxides (NOx), and particulate matter (PM)[22]. Non-road mobile machinery is also equipped with diesel engines and thus significantly contributes to the overall emissions of pollutants in the atmosphere[23]. In Europe non-road mobile machinery contributes with up to 30% of the traffic pollution and around 7% of particulate matter and 16% of nitrogen oxides[24]. China declares the total emissions of nitrogen oxides and particulate matter from construction machinery and agricultural machinery reached 3.7 m tons and 320 000 tons of emission respectively in 2017. Non-road diesel mobile machinery has become the main source of emissions in China[25].

The other major factor to consider when evaluating the environmental impact is the impacts of HVAC-system operation. The impact of HVAC systems on the environment is comparably small. Nevertheless, the carbon emissions of HVAC systems are still a contributor to the global issue of pollution. Renewable energy use is becoming more widespread in heating and cooling products for end-users of HVAC systems[26].

Various solutions and approaches have been suggested to decrease emissions in the construction machinery sector. The European Commission mandated a **series of directives to restrict emissions from construction machinery[27]**. These directives have been kept up-to-date to support Europe in reaching its mitigation goals by highlighting maximum allowed emission levels in consecutive stages.

[14] Eurostat, 2020
[15] Eurostat, 2020
[16] https://www.mordorintelligence.com/industry-reports/europe-agricultural-machinery-market
[17] Eurostat, 2020
[18] http://filcontrol.com/news/textile-machinery-strong-demand-whole-world/
[19] United Nations, 2017
[20] Lewis and Rasdorf 2017
[21] Bruce et al. 2001
[22] https://www.aefaulks.co.uk/environmental-impact-of-construction-machinery/
[23] https://ec.europa.eu/growth/sectors/automotive/environment-protection/non-road-mobile-machinery_en
[24] http://www.sootfreecities.eu/sootfreecities.eu/public/measure/non-road-mobile
[25] Huanxing, et al. 2020
[26] https://www.ecomena.org/impact-of-hvac-on-environment/
[27] EC (2010) Directive 2010/26/EU

Figure 2: Manufacture of machinery and equipment not classified elsewhere structural profile, 2018

Source: authors based on Eurostat, 2020

Textile industry is known as the biggest polluter in the world. This industry has already caused vast damage to the environment. European textile machinery manufacturers reflected about this issue by quickly turning towards the production of eco-friendly machines. Textile manufacturers in Europe are generally certified with Global Organic Textile Standard (GOTS) which portrays their eco-friendly quality standards. The top 3 countries in Europe for certified facilities are Germany (684), Italy (585) and Portugal (449)[28]. In fact, largest textile manufacturers of the world like India and **China prefer to import European machineries in comparison to using their country made machineries** or importing it from other countries, due to proven global eco-friendly beneficial properties[29].

1.4 Growth prospects in times of Covid

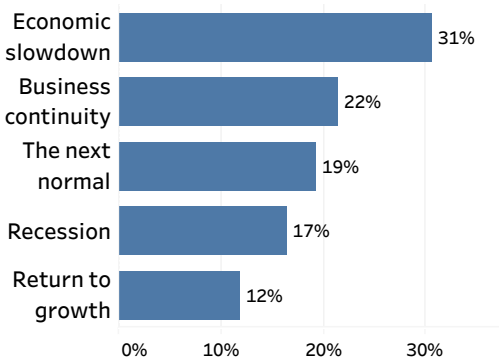
Machinery industry serves every industry, from consumer goods to equipment. Before the Covid-19 outbreak, the machinery sector struggled with slow growth in automotive, agricultural and mining equipment. This sector was expecting low levels of growth in 2020. The machinery industry is now being further weakened as a result of lockdowns. Most of the business in this sector has seen demand drop and plants idle as the coronavirus spreads worldwide. With demand dropping and more economic uncertainty ahead, many companies delayed new machinery purchases, postponed scheduled upgrades or cancelled existing orders. Service requests have also fallen due to many production lines being idle.

The results of VDMA (the Association of German Mechanical and Plant Engineering) survey[30] indicated that 77% of European machinery companies surveyed in April 2020 reported a strong or very strong drop in demand and 89% of respondents were experiencing some negative effects from Covid-19.

The Advanced Technologies for Industry (ATI) survey, conducted in November 2020, investigated the uptake of advanced technologies. One of the questions of this survey addressed the organisation's current position with respect to COVID-19 impact.

More than 30% of respondents from the manufacturing (discrete/process) sector indicated that the revenue is **slowing down** and the organisations take a cost-optimisation mode. 22% of all organisations have **responded to the crisis** by focusing on the business continuity of manufacturing. About 19% of companies indicated their position as the **new normal** where they are trying to operate more digitally. Of those who answered, 17% are focused on **building business resiliency** due to the expected prolonged revenue decline. On the other hand, 12% replied that their **revenue is returning** and they are planning to invest more aggressively.

Figure 3: Current Covid-19 impact in the manufacturing sector, 2020



Source: ATI Survey, 2020

[28]https://global-standard.org/news/gots-annual-press-release-world-gots-certifications-in-2020-reach-five-figures-for-the-first-time

[29]https://www.fibre2fashion.com/industry-article/6236/is-importing-textile-machinery

[30] https://www.vdma.org/en/

Section 2

2. Technological trends

Key messages

Technological transformation, and digitalisation in particular, allows the machinery industry to grow and stay competitive also globally. **Advanced Manufacturing Technologies (including 3D printing) and Advanced Materials** are the most relevant for this sector among the advanced technologies in the focus of this report and also the ones with the highest innovation potential embedded in machinery. **The European machinery industry is under a lot of pressure to be innovative**. Today, advanced technologies are also critical in addressing the challenges of the Covid pandemic era.

Before Covid times, **Advanced Manufacturing Technologies** have represented a technological field where European machinery firms patented the most. Further relevant technology fields included **Micro- and Nanoelectronics** and to a lesser extent **Advanced Materials**. The use of online applications in machinery industry has been increasingly growing, which opens up a whole array of advantages and especially it is an essential stage **towards Industry 4.0 or Smart Industry**. **Internet of Things** is a dynamically developing concept which is expected to grow substantially in industrial equipment and machinery. The use of **Robotics** in machinery has been steadily growing.

Artificial Intelligence in machinery is still in its enfancy. It is expected to provide a new avenue for companies to assist in the entire manufacturing value chain, provide detailed quantitative current market data and address key strategic issues. **Blockchain has not yet been adopted** by the machinery industry (except for some limited number of use cases) although it has a lot of potential. Companies in the machinery sector with embedded Blockchain technology could possibly increase their aftermarket service revenue.

Augmented reality and virtual reality technologies and tools are expected to be in higher demand as a result of the Covid-19 pandemic, especially for the equipment production sector. AR/VR are able to assist the building of trucks and loaders on the production line, as well as virtual tools to help design the new trucks from remote locations.

2.1 Technology shifts and advances

Machinery companies are at the core of technological transformation. The machinery industry is creating tailored, digitally-enabled, intelligent connected products. Increasingly, innovative processes like connected manufacturing, predictive maintenance and pioneering service models are used. Digitalising the machinery industry allows growing the business while reducing the risk of becoming irrelevant as the market evolves globally.

Technological innovations created new business models and opportunities for machinery companies. Connectivity and analytics allow creating a comprehensive range of applications for industrial machinery. For instance, packaging systems have become highly advanced[31,32]. These systems have given companies the ability to monitor production, to control machines remotely through mobile applications or optimise the machine's performance through updates. The packaging systems are also progressively developing in the direction of quality assurance, notifying operators of worn parts needing replacement or adjusting the packaging process, based on data analysis.

Advanced Manufacturing Technologies and Advanced Materials are the most relevant advanced technologies and also the ones with the highest innovation potential for machinery. The European machinery industry is under a lot of pressure to be innovative.

The industrial machinery sector has been severely impacted by the Covid-19 outbreak. Covid-19 has revealed that machinery companies need digitised processes to keep operations running during a crisis. For instance, digital collaboration models have become a norm as teams work remotely. The full automation in warehouses helped to keep productivity at high levels. Companies should therefore continue to explore digital processes in more depth. Greater

[31] https://www.bain.com/insights/how-industrial-machinery-makers-are-capturing-digital-opportunity/

[32] https://www.businesswire.com/news/home/20200520005591/en/Global-Packaging-Machinery-Market-Assessment-2020-2025---Need-for-Packaging-Machinery-Suppliers-to-Leverage-Disrupting-Trends-to-Remain-in-Business---ResearchAndMarkets.com

use of advanced analytics and Big Data have the potential to optimise risk management also for a post-pandemic era.

2.2 Patent applications filed by machinery industry firms

Technology developments can be tracked by patenting activities related to the specific sectoral activities based on patent-based classifications. It has to be noted that the machinery (including electrical, medical and optical) equipment sector together with manufacturing and the chemical sectors use all forms of IPR protection more intensively than the other sectors (hence patents tell only part of the reality). However, for any given mode of IP protection, there is a significant number of firms in the sector that either regard it as important or actually use it[33].

In order to understand the specific patenting activities, the analysis of machinery patent applications conducted within the framework of the ATI project was based on the international patent classification, provided by the World Intellectual Property Organisation. This classification includes a comprehensive schematic for the classification of patents in the area of machinery that allows to identify the patent areas in the International Patent Codes (IPC codes) that are specific to the sector. By using this approach, we can representatively capture the patenting activity at EU and global level in the machinery sector and observe trends in distribution and development as indicated in this section.

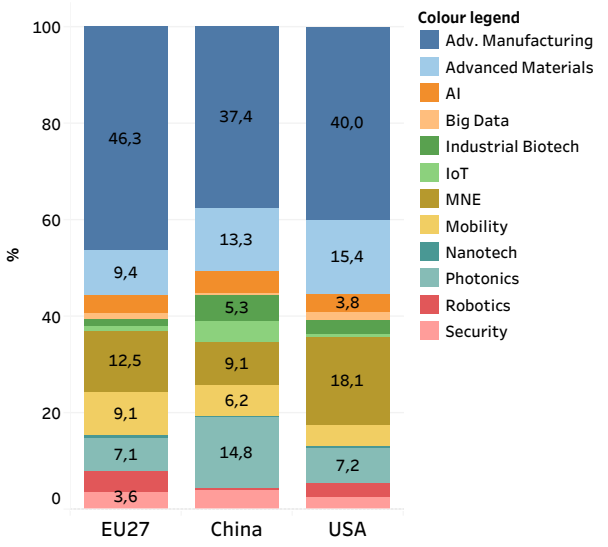
As it was expected, with regard to new technology development, **Advanced Manufacturing Technologies** represent the technological field where European machinery firms tend to patent the most (Figure 4). Further relevant technology fields include **Micro- and Nanoelectronics** and to a lesser extent **Advanced Materials**.

Patent applications in Advanced Manufacturing Technologies represent just over 46% of all advanced technology patents filed by machinery companies in the EU27 (Figure 4). This technology is also linked to innovation in green/sustainable technologies of machinery. Overall, the highest share of patents in Advanced Manufacturing Technologies is filed by the EU27, followed very closely by the US and China which are the major competitors in global machinery markets.

Nearly 13%, 10% and 9% of all patents filed by European machinery companies are attributable to **Micro- and Nanoelectronics, Advanced Materials** and **Mobility** respectively.

The total amount of patents related to Micro- and Nanoelectronics filed by US companies during the period 2010-2017 were twice as higher in comparison with the EU27 and China.

Figure 4: International comparison of technology patents by machinery firms in 2010-2017



Source: ATI, 2019 Fraunhofer ISI calculations

European machinery companies are less well positioned in Advanced Materials technology when compared with China and the US. Nearly 16% of all advanced technology patent applications filed by machinery companies in the US are related to this field, followed by China (13%) and the EU27 (9%) (see Figure 4).

Artificial Intelligence (AI) in machinery applications is currently moving from a vision to reality. Many current applications already use AI and the technology is poised to change what automation looks like in the near future. Currently, as depicted in Figure 4, 3.5% of all advanced technology patents filed by machinery companies in the EU27 between 2010 and 2017 can be attributed to the field of AI. The greatest share of AI patent applications have been filed in China (4.4%), followed by the US (3.8%).

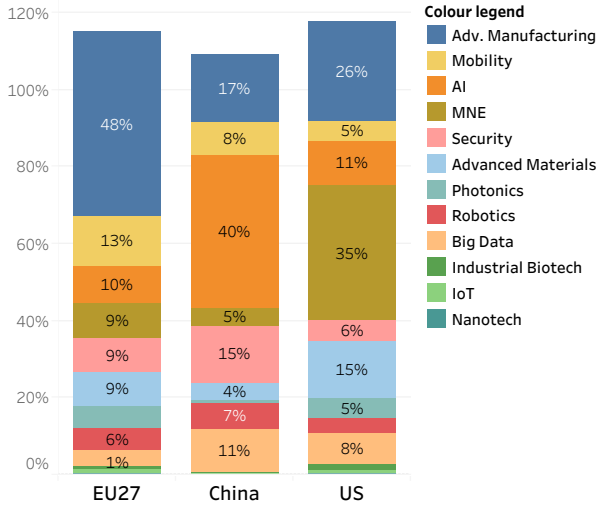
Robotics technology equips machinery sector with the efficiency-enhancing, cost-reducing tools that are needed to maintain the competitive advantage in an increasingly globalised machinery manufacturing industry. Currently, 4.3% of all advanced technology patents filed by machinery companies in the EU27 between 2010 and 2017 can be attributed to the field of Robotics. As indicated in Figure 4, even less of Robotics patent applications have been filed in the US (3%), followed by China (0.4%).

Big Data or **Internet of Things** patent applications have not been extensively filed by

[33] Hall, 2013

machinery industry firms. Big Data is still evolving and is considered as a driving force behind many revolutionary waves of digital transformation.

Figure 5: International comparison of technology patents by machinery firms in 2016-2018



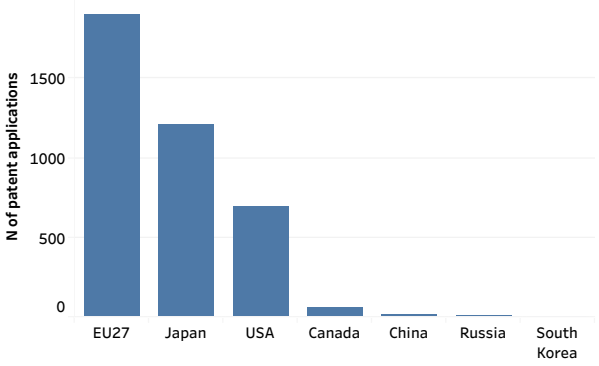
Source: ATI, 2021 Fraunhofer ISI calculations

The updated distribution of technology patents by machinery firms for the 2016-2018 period is presented in Figure 5. Regarding the evolution of technology patents in machinery, Advanced Manufacturing Technologies (48%) remain the technological field where European machinery firms tend to patent the most, followed by Mobility (13%) and Artificial Intelligence (10%). China takes a leading position in AI. Nearly 40% of all advanced technology patent applications filed by machinery companies in China are related to this field, followed by Advanced manufacturing (17%) and Security (15%). Currently, as depicted in Figure 5, 35% of all advanced technology patents filed by machinery companies in the US between 2016 and 2018 can be attributed to the field of Micro- and Nanoelectronics, followed by Advanced Manufacturing (26%) and Advanced Materials (15%).

2.3 International comparison of patenting trends in machinery innovation

When looking at patenting trends in the field of machinery overall, EU27 is a global leader followed by Japan, the US in third place followed by Canada which is significantly less active in machinery patenting. The graph also shows that China produces a relatively small number of patents nonetheless it has a leading position in the machinery market.

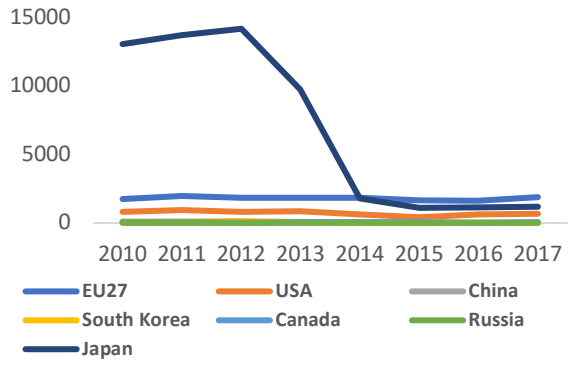
Figure 6: International comparison of total patent applications of machinery industry firms in 2017



Source: ATI, 2019 Fraunhofer ISI calculations

Regarding the evolution in global patent applications, Figure 7 sketches out the number of global machinery patent applications for the EU27 relative to major competitors and other countries. The trends in machinery patenting over time, however, point to a drastic declining of patent activities only for Japan. The number of patents in **the US and EU27 have gradually been increasing since 2015**. All other countries indicate a relatively stable position in terms of the number of patents over the years. Although Russia is a leading technology producer in several fields, such as space equipment and energy machinery, its patent activity is the most ineffective in comparison with other countries. The Russian machinery industry suffers from outdated production methods[34].

Figure 7: International comparison of total number of machinery patents per year, in 2010-2017



Source: ATI, 2019 Fraunhofer ISI calculations

2.4 Technology adoption by machinery companies

With the aim of exploring the role of advanced technologies in shaping industrial transformation

[34] Szirmai, A. (2012). Industrialisation as an engine of growth in developing countries, 1950–2005. Structural change and economic dynamics, 23(4), 406-420.

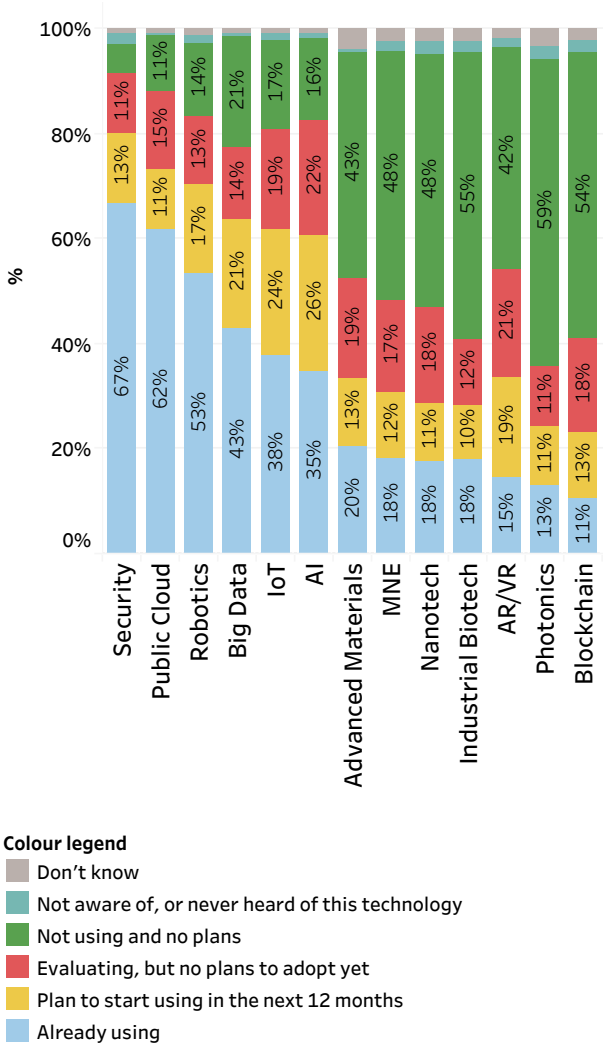
in Europe, the Advanced Technologies for Industry (ATI) survey was conducted between October and November 2020[35]. This survey investigated the uptake of advanced technologies, including their level of adoption, the associated industry-specific use cases, the digital transformation drivers that are sustained by these technologies, their expected business impacts as well as the enabling conditions.

Although the survey has not investigated the machinery industry in particular, it provides an insight into the uptake of advanced technologies in the related discrete and process manufacturing sectors. Organisations active in the Manufacturing (discrete/process) sector were surveyed about their use of advanced technologies. The survey found that more than 60% of the respondents from the manufacturing sector have adopted Security and Public Cloud. 53% apply Robotics, 43% use Big Data and less than 40% of respondents indicated that they are using Internet of Things (IoT). Nonetheless, 59% of respondents indicated that they are not using Photonics, 55% of manufactures are not planning to use Industrial Biotechnology and almost the same percentage Blockchain (54%). On average, 2% of organisations active in the manufacturing sector indicated their unawareness of listed advanced technologies.

The use of online applications in the machinery industry has been increasingly growing, which opens up a whole array of advantages and especially it is an essential stage toward Industry 4.0 or Smart Industry. For instance, remote operations help to control devices from a single central control centre and provide support and maintenance of machines. Data derived from machines can be used for monitoring and optimisation[36]. Nevertheless, online connections increase vulnerability to attacks. **Cybersecurity** attacks can have a devastating effect on machinery production and hence safety plays a critical role.

The use of **Robotics** in the machinery industry has been steadily growing. The International Federation of Robotics (IFR) estimated in their annual World Robotics report that one of the largest buyers of robots was the machinery industry, which accounted for about 10% of total demand in 2018. Compared to 2017, shipments slightly decreased by 1%. Countries like Finland, Sweden, Switzerland, Belgium, Austria, Italy and Denmark are considered to be among the ones most **widely deploying robots** in the machinery industry[37].

Figure 8: Advanced technology uptake in the manufacturing sector, 2020



Source: ATI Survey, 2020

Internet of Things (IoT) is a dynamically developing concept which is expected to grow substantially in industrial equipment and in the machinery industry[38]. IoT technology gives an opportunity for **substantial IoT revenue growth** and margin expansion in machinery. IoT

[35] The Advanced Technologies for Industry Survey sample consisted of 1547 interviews of European organisations with more than 10 employees in the Denmark, France, Germany, Italy, Poland, Spain and Sweden. The survey was carried out between October and November 2020. A computer-aided telephone interviewing (CATI) and computer-assisted web interviewing (CAWI) systems were used. Additional information on survey methodology can be found in the Advanced Technologies for Industry Survey - Methodological Report: https://ati.ec.europa.eu/reports/eu-reports/advanced-technologies-industry-methodological-report

[36] https://www.technolution.com/perform/2020/10/05/better-security-needed-for-online-industrial-machinery/

[37] https://www.roboticsbusinessreview.com/research/world-robotics-report-global-sales-of-robots-hit-16-5b-in-2018/

[38] https://www.mckinsey.com/industries/advanced-electronics/our-insights/iiot-platforms-the-technology-stack-as-value-driver-in-industrial-equipment-and-machinery

is increasingly part of agricultural equipment as well. The digitalisation of agriculture is based on the development and introduction of new tools and machines in production. For instance, with the help of IoT, producers of agricultural machinery are able to provide intelligent fleet management and the use of data from the field to over-the-air updates of software and firmware[39]. Such services allow to increase the efficiency in farming, enable effective use of the machinery and reduce the need for manual labour[40].

The use of **Artificial Intelligence (AI)** in machinery is still in its infancy. AI in machinery can be used for assisting the entire manufacturing value chain, providing detailed quantitative current market data and in addressing key strategic issues.

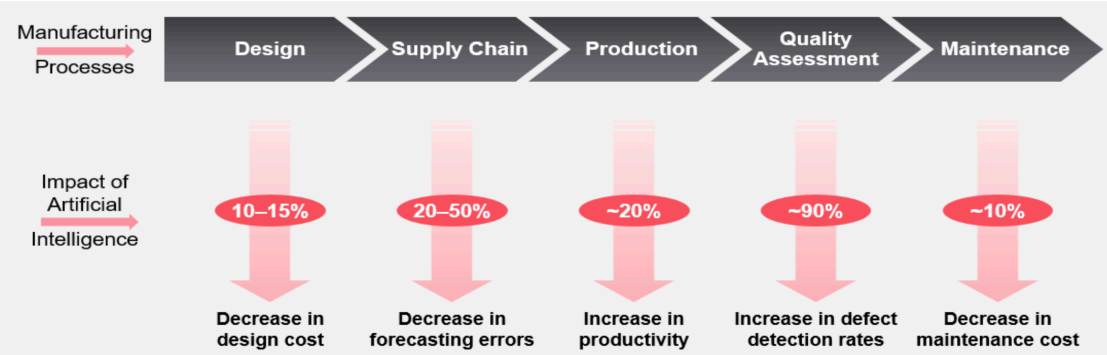
Maintenance is one of the main applications for AI in machinery. Machinery manufacturers can use this technology for machine efficiency in order to minimise or eliminate unplanned downtime.

Intelligent quality inspection is a key AI application in the machinery space. This AI technology will allow machinery manufacturers to utilise machine learning and advanced image recognition systems to automate the visual inspection and fault detection of small components of the equipment. Dynamic simulation and optimisation of processes will allow end users to plan their machine use efficiently, plan material flow and supply dynamically, and anticipate possible shock scenarios[41].

The use of **Augmented Reality and Virtual Reality (AR/VR)** is also still limited in the machinery industry. Virtually-focused production technologies are expected to be in higher demand as a result of the Covid-19 pandemic, especially for the equipment production sector. The manufacturer could possibly use AR/VR technology to assist the building of trucks and loaders on the production line, as well as virtual tools to help design the new trucks from remote locations. For instance, equipment customers could employ this technology to see a series of different product and vehicle looks overlaid on their smartphone device when building their ideal truck online[42].

Blockchain has not yet been adopted by the machinery industry (except for some limited number of use cases) although it has a lot of potential. The features of this technology could help and support machinery companies in tracking and tracing products and components in a safe way throughout their entire lifecycle and offer greater transparency of transactions within a cloud platform[43]. Companies in the machinery sector with embedded Blockchain technology could possibly increase their aftermarket service revenue[44].

Figure 9: Usage of AI to improve processes in the manufacturing value chain



Source: FutureBridge analysis[45]

[39]https://bosch.io/industries/agricultural-machinery/
[40] Please also see the ATI analysis on the agri-food sector available here: https://ati.ec.europa.eu/reports/sectoral-watch/technological-trends-agri-food-industry
[41]https://www.futurebridge.com/blog/artificial-intelligence-in-industrial-machinery/
[42]https://www.oemoffhighway.com/engineering-manufacturing/article/21172020/equipment-manufacturers-prepare-for-augmented-and-virtual-reality-initiatives
[43]https://www.digitalistmag.com/iot/2018/04/26/what-is-future-of-industrial-machinery-industry-06111935/
[44]https://www.the-future-of-commerce.com/2017/09/27/imc-trends-industrial-manufacturing-by-2022/
[45]https://www.futurebridge.com/blog/artificial-intelligence-in-industrial-machinery/

Section 3

3. Venture capital investment and startup creation

Key messages

Europe's machinery industry has been witnessing an increasing venture capital investment since 2015. The EU27 takes the lion's share of venture capital (VC) investments, followed by the US and China. With that, the highest number of funding rounds is also the utmost in the EU27 indicating strong startup activities in Europe, followed by the US and China with significantly less number of funding rounds.

Hotspots of advanced technology related VC investment in machinery are concentrated in **Germany, Sweden**, **Italy and France.** Nevertheless, Italy and Germany had the highest number of funding rounds in the EU27. Europe's machinery sector is a clear 'destination' for foreign investors outside the EU27[46], showing significant growth in the majority of countries since 2013.

Most startups are located in **Germany (19%), France (16%), Spain (12%), the Netherlands (11%)** and together they make up almost 60% of the startup creation in the machinery industry in the EU27. Other important players are Sweden and Poland. The largest source of funding has come from seed (30%) followed by grant (20%), venture unknown series (20%), then series A and acquisition funding types.

3.1 Private equity and VC investment in the machinery industry

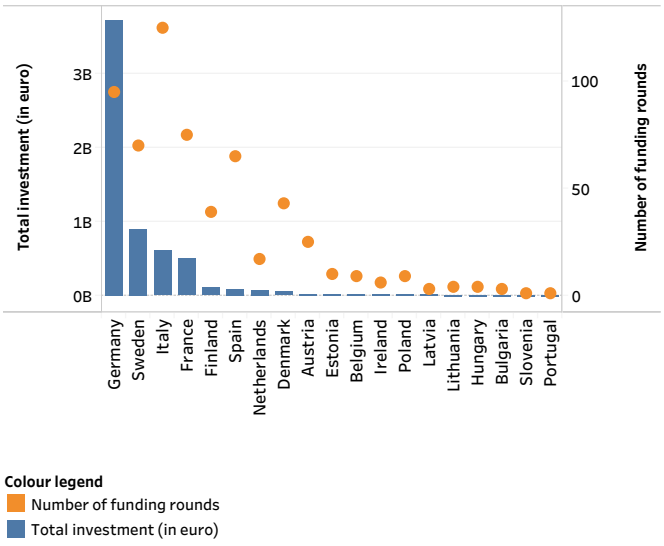
The scale of venture capital and private equity investment was tracked using a combined set of Crunchbase and Dealroom data. From the joint database, companies were selected by filtering for the 'machinery manufacturing' category.

Crunchbase provides information on venture capital-backed innovative companies. Dealroom contains the same type of information but with a better coverage for Europe. The investment figures presented in this section refer only to the funding rounds where a value has been disclosed.

The analysis reveals that there are certain hotspots of VC activity in the area of machinery innovation in Europe, such as **Germany, Sweden**, **Italy and France,** as depicted in Figure 10 in terms of the total amount of investment. Although Italy only managed third position regarding total investment, it ranks first in terms of the number of funding rounds.

Indeed, the number of VC-backed firms in the machinery field in the EU27 has been the highest in Germany, Italy and France, followed by Spain and Sweden. The share of VC-backed firms has been also compared to the total number of machinery firms active, as captured by the Eurostat Structural Business Statistics (see Figure 11).

Figure 10: Private equity and VC investment in machinery, 2000-2020



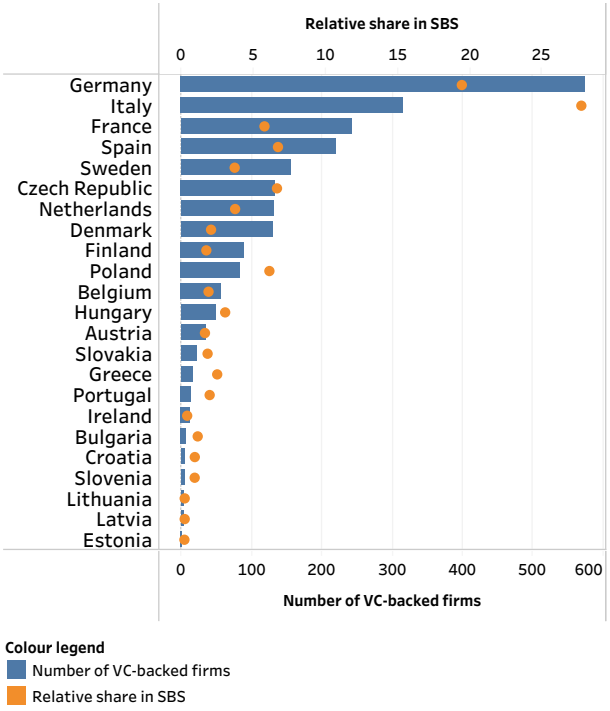
Source: Technopolis Group based on Crunchbase and Dealroom data

Italy has a long history of producing equipment that helps manufacturing plants operate efficiently both domestically and globally. The total annual revenue of the machinery and equipment industry in Italy was €124 bn. In 2018, revenue from the manufacturing of agricultural and forestry machinery amounted to €9.5 bn[47]. High growth in Italy is thanks to its food production equipment,

[46] Investment of foreign companies in affiliates located in European countries over which foreign companies have control.
[47]https://www.statista.com/statistics/532942/italy-turnover-machinery-equipment-industry-by-sector/

packing equipment, construction equipment and metallurgical machinery. It was expected to propel growth in investments in machinery and equipment to 3.4% in 2018[48]. Germany takes a leading position as a producer and exporter of the global machinery and equipment industry, especially in the high-end machinery and equipment industry and offers many investment opportunities to foreign investors[49].

Figure 11: Number of VC-backed firms in the field of machinery and share relative to the share of machinery companies in total number of firms in Structural Business Statistics, 2010-2020

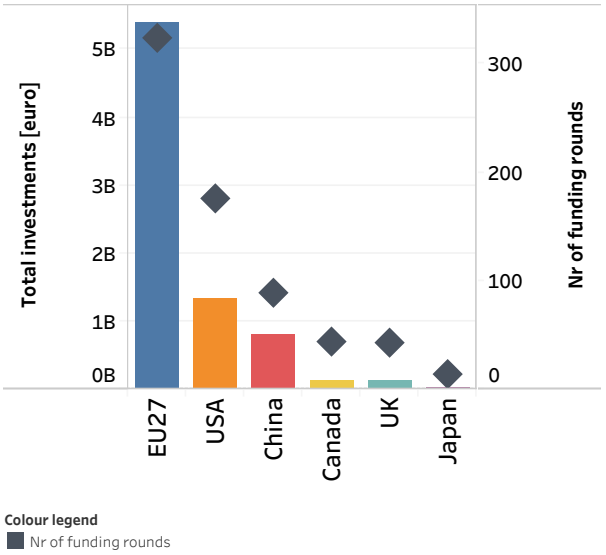


Source: Technopolis Group based on Crunchbase and Dealroom data

Note: Share is calculated to the total firms in C28 in Structural Business Statistics (SBS)

Europe's machinery industry takes the lion's share of private equity and VC investments, as shown in Figure 12[50]. VC investments in machinery for the US and China are lower. The number of funding rounds is also the highest in the EU27 indicating strong startup activities in Europe, followed by the US and China with a significantly lower number of funding rounds.

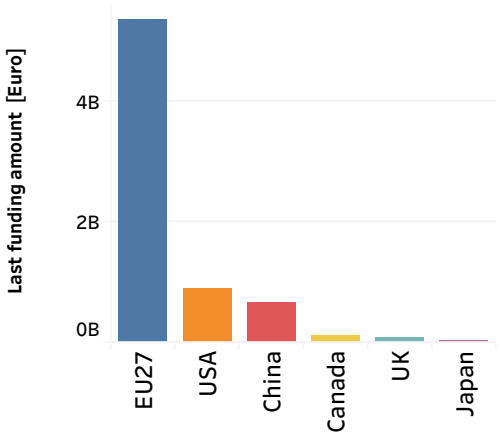
Figure 12: Venture capital investment in machinery (2010-2020), an international comparison



Source: Technopolis Group based on Crunchbase and Dealroom data

In this international comparison, for the funding 2010-2020 period, differences between the EU27 and key players such as the US and China are evident. The EU27 took a leading position and scored the highest last funding round (over €5 bn), followed by the US and China.

Figure 13: Last funding amount (2010-2020) in international comparison



Source: Technopolis Group based on Crunchbase and Dealroom data

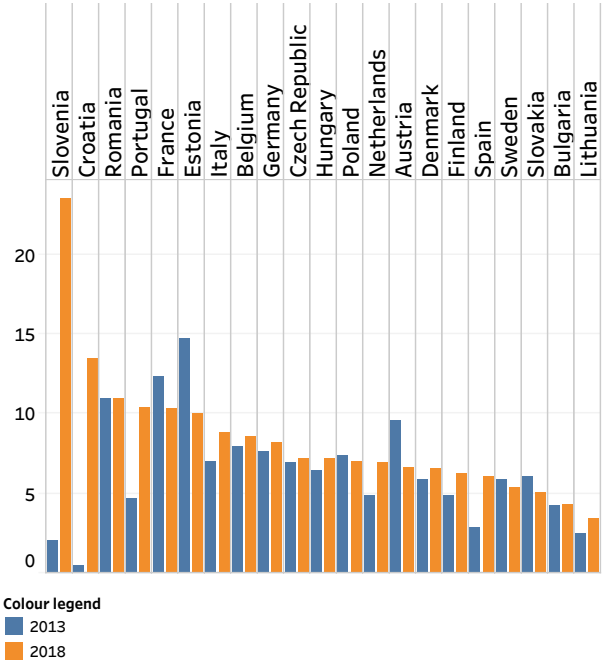
Europe's machinery industry is a clear 'destination' for foreign investors outside the EU27[51], showing significant growth in the majority of countries since 2013, the year when statistical data was first

[48]https://www.gmisummit.com/wp-content/uploads/2018/10/GMIS-Italy_For-Review_GMC.pdf
[49]https://www.market-prospects.com/articles/germany-machinery-and-equipment-industry#:~:text=According%20to%20data%20from%20the,revenue%20was%201.5010%20billion%20euros.

[50] Due to restrictions in the available dataset, Russia and South Korea are not presented.
[51] Investment of foreign companies in affiliates located in European countries over which foreign companies have control.

provided (see Figure 14). Croatia and Slovenia experienced the largest increases. The highest extra-EU28 investment per person employed were recorded in Slovenia, Croatia, Romania and Portugal.

Figure 14: Investments per person employed in the machinery industry by foreign (extra-EU28) companies in thous. € per person employed

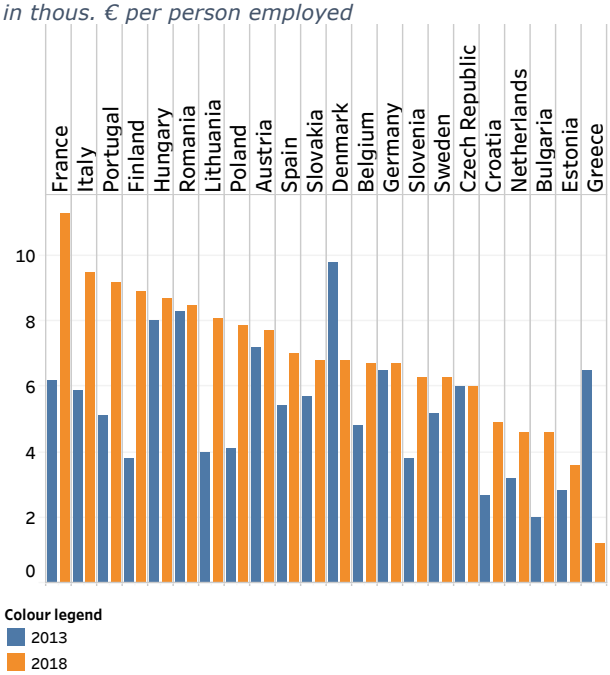


Source: Eurostat, SBS
Note: Data refers to investments made by parent companies resident outside the EU28. In the case of Ireland, Greece, Cyprus, Latvia, Luxembourg and Malta there are no data available for 2013/2017. For Estonia we used the data for 2017/2018 and for Croatia 2013/2017

In some cases, the investments of EU27 companies in the neighbouring European countries is comparably high, which means that companies actively invest in the machinery industry of other countries within the EU (Figure 15).

France, Italy and Portugal attracted the highest investments in machinery companies. Further countries reporting high investments from other European countries are Finland, Hungary and Romania. Finland, Bulgaria and Romania recorded the largest intra-EU28 investment rise between 2013 and 2018.

Figure 15: Investments per person employed in machinery industry by foreign (intra-EU28) companies, in thous. € per person employed



Source: Eurostat, SBS
Note: Data refers to investments made by parent companies resident inside the EU28, in the case of Ireland, Cyprus, Latvia, Luxembourg and Malta there are no data available for 2013/2017. For Estonia we used the data for 2017/2018 and for Croatia 2013/2017

3.2 Machinery industry startups

With the aim of exploring entrepreneurial trends in the European machinery industry, the number of startups from 2009 until 2019 was analysed based on Crunchbase and Dealroom data. Startups[52] represent the most recent trends of technology development in the industry and typically respond rapidly to industry needs.

The country distribution of startups is visualised in Figure 16. Most startups reflected in the dataset are located in **Germany** (19%), **France** (16%), **Spain** (12%), the Netherlands (11%) and together they are making up almost **60% of the startup creation** in machinery industry in the EU27. Other important players are Sweden and Poland. However, it is the machinery industry in France, Italy, Sweden and Germany that witnessed the highest VC investment amount followed by Spain and Estonia.

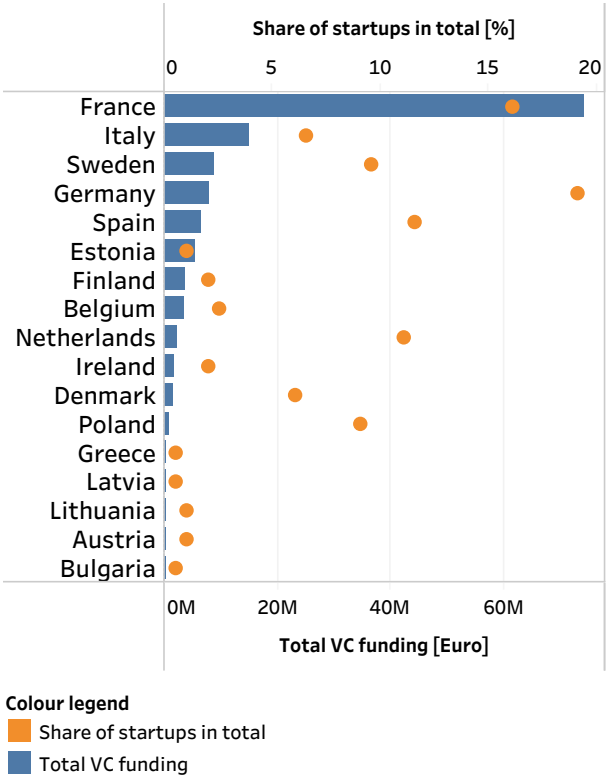
In France, the list is led by Newheat[53], a company established in 2015 which provides sustainable and innovative heat solutions. Advance MicroTurbines is an Italian startup, established in 2016, which develops a microturbine for local

[52] In this report startups are defined as companies that have been created between 2009 and 2019

[53] https://newheat.com/about/

generation of electricity from pressurised gases. Shift.bz is one of the leading startups in Germany. This company was created in 2018 and its main activity is to provide metal CNC-machined parts and machining service for customers in the EU.

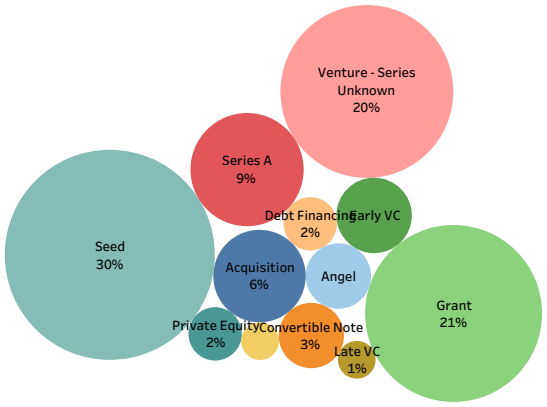
Figure 16: Startup creation and VC investment in startups in the machinery industry in the EU27 (2010-2020)



Source: Technopolis analysis based on Crunchbase and Dealroom data

Figure 17 shows the prominence of different funding types in the machinery industry among startups in the EU27 countries from 2010 until 2020. The largest source of funding has come from seed (30%) followed by grant (20%), venture unknown series (20%), then series A and acquisition funding types.

Figure 17: Type of funding in the machinery industry in the EU27 (2010-2020)



Source: Technopolis analysis based on Crunchbase and Dealroom data

Most of the startups (17% of the total sample) innovate in the area of biotechnology, construction, agriculture/farming, energy.

The topic of sustainability and climate protection is becoming more and more central to the industry. More and more machinery manufacturers are devoting themselves to this subject.

Section 4

4. Skills supply and demand

Key messages

The European machinery industry will need to make critical decisions to continue investing in reskilling and upskilling its personnel in particular related to Robotics, the Internet of Things and Artificial Intelligence.

Within the registered professionals on LinkedIn employed in the machinery industry, **Advanced Manufacturing** related skills represent by far the highest share in the EU27, reflecting a high demand for specialists with core skills. The second largest professional group is linked to relevant skills in the area of **Robotics**. Further prominent categories with high relevance include technological skills related to **IoT and Cloud**.

Germany, Italy, Finland, Sweden are leading the list in terms of the number and share of professionals employed in the machinery industry and with advanced technology skills. More specifically, professionals with Advanced Manufacturing skills are most represented in Finland, Sweden, Germany, Italy, France and the Netherlands, and AI and Big Data are prominent in Finland, Belgium and the Netherlands.

In the past year (2019-2020), professionals with skills in **Blockchain** followed by **Cybersecurity** and AR/VR have grown the most in the machinery industry. The most demanded skills by European machinery firms in 2020 were related to analytics, business intelligence and inventory management, as captured by LinkedIn data. **Cybersecurity is a key competence** where the machinery industry is still lagging behind.

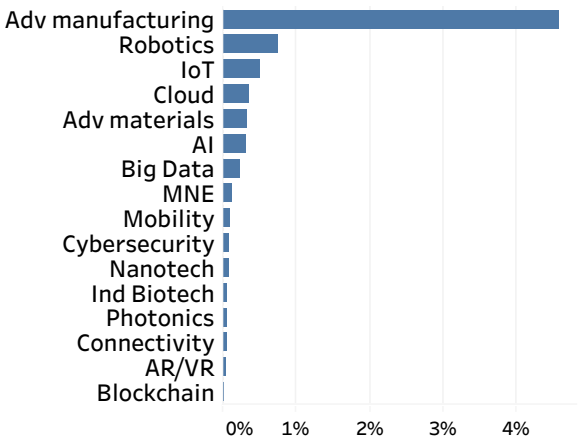
4.1 Availability of new technological skills – prominence of Advanced Manufacturing

The machinery industry will need to equip its employees with new competences in particular in the area of design, data processing and maintenance of additive production methods[54]. Skillsets are gradually evolving towards a mix of conventional competences in traditional manufacturing and skills in 3D printing methodologies and robotics.

These competences are needed across the whole value chain such as in the design, processing, testing and maintenance. Soft skills are also becoming more relevant especially related to Industry 4.0 technologies.

Figure 18 illustrates the general distribution of technological skills in the machinery industry across all EU27 countries, while Figure 18 displays the geographical distribution of these technological skills. Based on an analysis of LinkedIn[55] data, Figure 18 thus provides a picture of the supply of professionals with advanced technological skills relevant to the machinery industry in 2020. Within the registered professionals on LinkedIn employed in the machinery industry, **Advanced Manufacturing** tops by far the list in the EU27, reflecting the importance of this field and high demand for specialists with core skills.

Figure 18: Share of professionals with advanced technology skills employed in the machinery industry in total machinery industry professionals, EU27, 2019



Source: Technopolis Group based on LinkedIn analysis

[54] Geerts and Renda (2019). The Machine Tool Industry's Changing Skills Needs: What is the Impact of Additive Manufacturing Technologies?

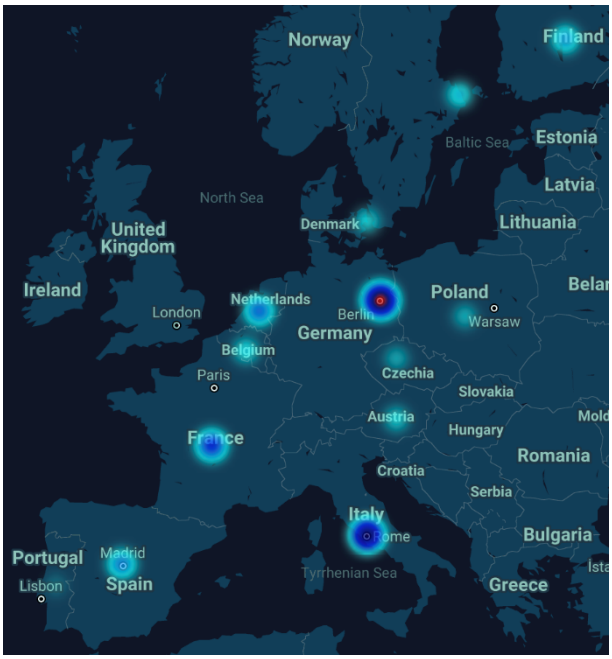
55 To harvest the data from LinkedIn, keywords capturing skills by advanced technology have been defined and reviewed by technology experts. Queries have subsequently been constructed to filter the database by location and industry.

In second place, **Robotics** skills reflect the trend of moving towards automated processes and the need for specialists that can work together with robotics solutions.

Further prominent categories with high relevance for the European machinery industry include **the Internet of Things, Cloud technologies, Advanced Materials, AI and Big Data.**

Figure 19 indicates that **Germany and Italy** are leading the list in terms of absolute number of professionals employed in the machinery industry and with advanced technology (AT) skills. When we look at the share compared to total industry professionals (as captured by LinkedIn), we find **Finland, Sweden and Germany** on the top followed by Italy and the Netherlands.

Figure 19: Concentration of professionals with advanced technology skills in the machinery industry in the EU27



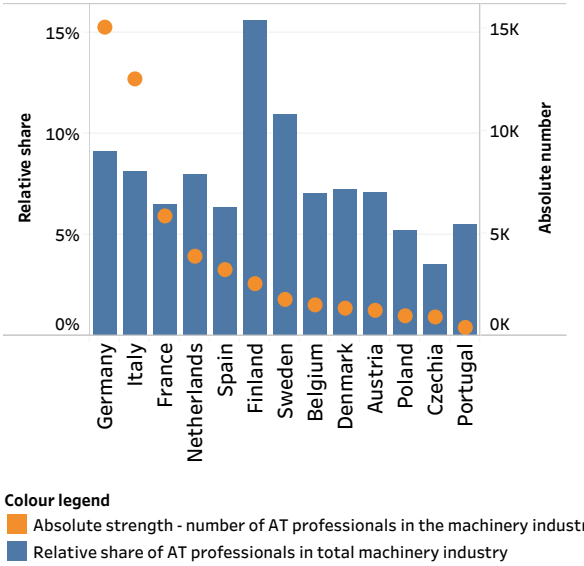
Source: Technopolis Group based on LinkedIn analysis using geolytics map

Note: Only countries with above median total industry professionals are displayed

In the next figures we highlight some of the relevant advanced technologies and depict the patterns of related skilled professionals employed in the machinery industry. We will indicate both the absolute number of professionals with the specific skill (as registered on LinkedIn) and the relative share of the total industry professionals. This provides insight both into the overall strengths (i.e. which country has the most AI professionals in machinery) but also relative advantages (which country has the most professionals in certain technologies relative to the people employed in the machinery industry).

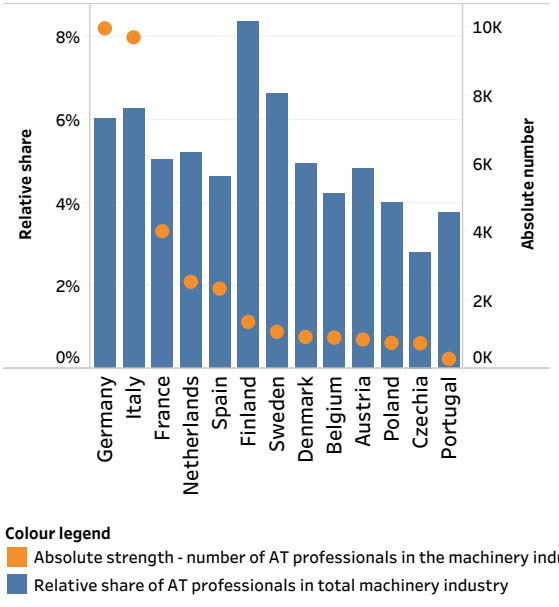
Figure 20 demonstrates the allocation of employees in the machinery industry with technological skills related to **Advanced Manufacturing Technologies** among the top EU countries. The country list of the highest number and share of advanced technology professionals employed within the total machinery industry professionals are led by Finland, Sweden, Germany, Italy, France and the Netherlands. The increasingly automated production processes and robots used on machinery plants require professionals with Robotics and Advanced Manufacturing skills.

Figure 20: Professionals on LinkedIn employed in the machinery industry and with skills in advanced technologies



Source: Technopolis Group analysis based on LinkedIn

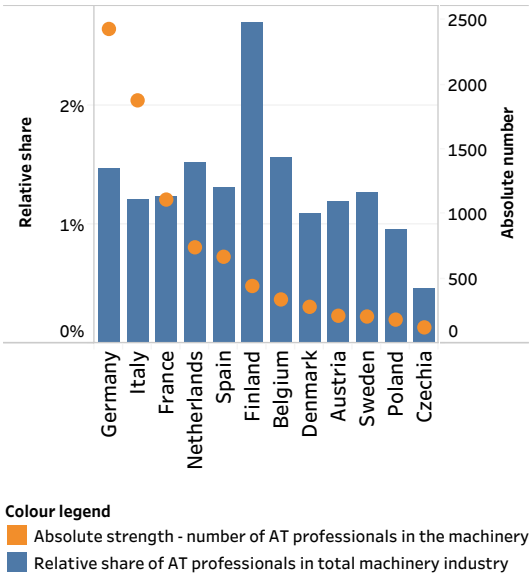
Figure 21: Machinery industry professionals with skills in Advanced Manufacturing and Robotics among top EU27 countries



Source: Technopolis Group based on LinkedIn analysis

The share of professionals with **AI and Big Data** skills within the total number of professionals in the machinery industry is the highest in Finland, Belgium and the Netherlands as the analysis of LinkedIn data shows (see Figure 22).

Figure 22: Machinery industry professionals with skills in Artificial Intelligence and Big Data in top EU27 countries, 2019

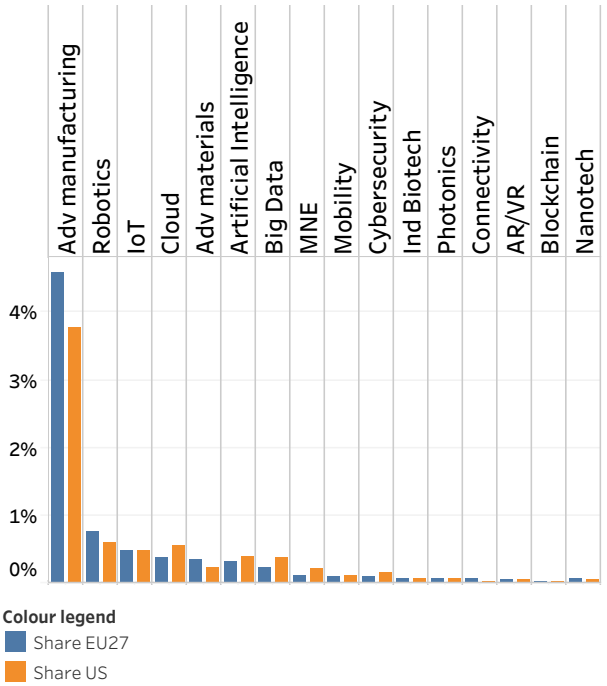


Source: Technopolis Group based on LinkedIn analysis

The next figure demonstrates the skills supply in advanced technological across EU countries in comparison with the US.

As shown in Figure 23, the EU27 holds a higher share of professionals with skills in **Advanced Manufacturing, Robotics, Advanced Materials and Nanotechnology** than the US. The results clearly demonstrate that the US has more advanced technologies professionals in AI, Big Data, Cloud, Security than the EU27.

Figure 23: Machinery industry professionals with skills in advanced technologies in the EU27 and US



Source: Technopolis Group based on LinkedIn analysis

4.2 Demand for new skills Big Data and AI

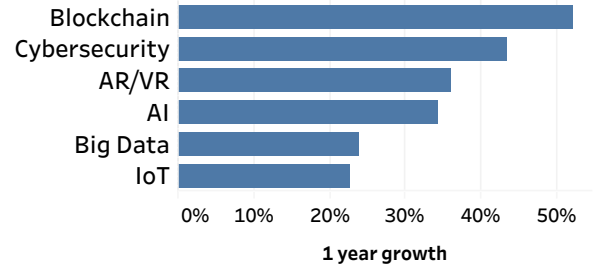
After analysing the availability of technological skills in the machinery industry it is also important to look at which skills have been the most common in recent hires. In order to measure this demand, the one-year growth rate of technological skills can be analysed by comparing the skills indicated in 2019 and its change to 2020.

Figure 24 visualises the five technological skills that showed the highest growth within the last year (from 2019 to 2020) among EU27 countries. We see Blockchain, Cybersecurity, AR/VR and Artificial Intelligence on the top.

Blockchain is also particularly relevant as the machinery industry will be able to benefit from this technology and enhance the tracking and tracing products and components in a safe and secure way throughout their entire lifecycle. Blockchain is

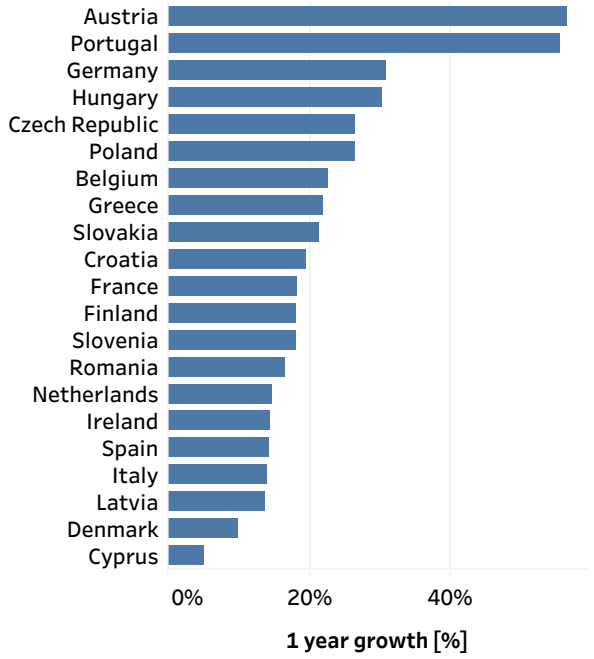
expected to provide companies greater transparency of transactions within a cloud platform, hence it is not a surprise that this is the field where competent professionals are in high demand.

Figure 24: Top one-year growth of advanced technology related skills (2019-2020)



Source: Technopolis Group based on LinkedIn analysis

Figure 25: EU countries with highest one-year growth of advanced technologies professionals in the machinery industry



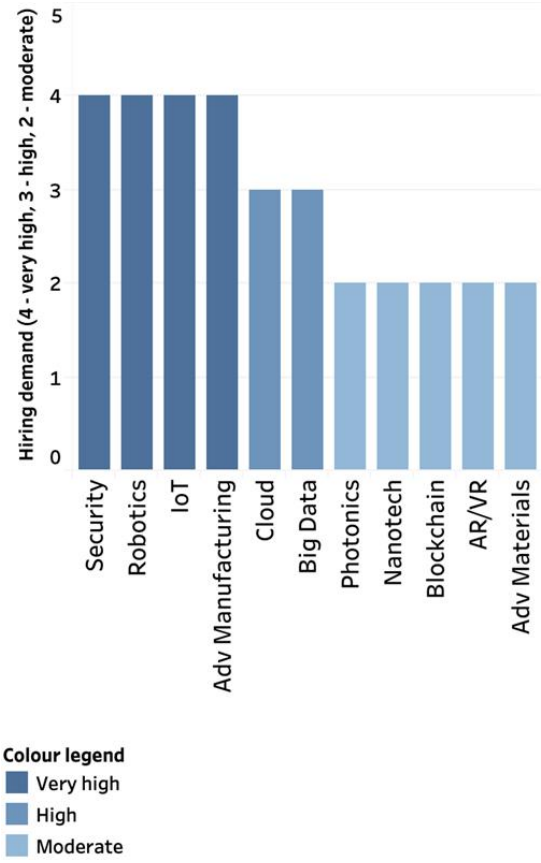
Source: Technopolis Group based on LinkedIn analysis

Figure 25 illustrates the general distribution of the one-year growth rate in technological skills as observed in the machinery industry across all EU27 countries. Austria (+56%), Portugal (+55%), Germany (+30%) and Hungary (+30%) experienced the highest rise in demand for professionals in advanced technologies.

Based on the skills requirements listed in the jobs posted on LinkedIn by European machinery industry firms, all advanced technology skills are demanded by the machinery industry, but most importantly the Advanced Manufacturing, IoT and Robotics skills have been in very high demand (see Figure 26). Hiring demand is defined as the share of job ads published on LinkedIn and requiring the specific skill.

The most demanded skills by European machinery firms showing the greatest increase in 2020 were related to analytics, business intelligence, social media and inventory management, as captured by LinkedIn data.

Figure 26: Hiring demand in the machinery industry, Dec 2019-December 2020



Source: Technopolis Group based on LinkedIn analysis

Section 5

5. Future outlook: challenges and opportunities

5.1 Innovation in advanced technologies

The machinery industry has constituted a key pillar of the industrial revolution in the past and also currently. It is not just a target of digital developments but it is driving technological transformation of other industries itself. The machinery sector is characterised as a medium-to-high category in terms of technological intensity and as a knowledge-intensive industry. As presented above, it is mainly advanced manufacturing and robotics that has a large impact on the industry while it is a slow adopter of other digital technologies such as AI or AR/VR.

The machinery sector has faced massive disruptions in its operations as a consequence of the Covid-19 pandemic. But Covid created also an opportunity to push the machinery industry to test new digital-based solutions. This momentum should be kept in order to further modernise the industry. Digital transformation is critical now to safeguard market leadership. Nevertheless, creating new digital-based machinery plants will require significant investments.

An issue might be that existing EU policy measures do not optimally stimulate R&D activities in the machinery which makes more difficult to improve business conditions for this industry. For example, incentives for engaging in innovation activities in the machinery sector are considered still to be weaker in the EU in comparison to the situation in some developing economies in Asia and in the US[56].

5.2 Use of hybrid machine tools

The future of the machinery industry is driven by the emergence of hybrid technologies. Hybrid machine tools combine additive and subtractive processes and enable not just a more efficient use of resources, but also production of complex parts. Nevertheless, this particular field is still in its early stage and further technological challenges prevail that need to be overcome including process planning, decision planning, use of cutting fluids and post-processing[57]. Hybrid manufacturing leverages the advantages of additive manufacturing and the high precision of traditional machinery methods. This means that once a part can be additively created and machined in a single operation, the production process can be accelerated[58].

These hybrid technologies are also relevant to accelerate processes in medical machinery which can also tackle some of the challenges of the current Covid crisis.

5.3 Greening industrial machinery

A big part of research and innovation spending in the machinery industry is dedicated to testing new approaches for improving energy efficiency and performance of machines, as well as developing new low energy and resource consuming manufacturing tools and techniques[59].

The increasing popularity of green technologies has led to an upsurge in demand for the industrial machinery in photovoltaic and in wind turbines manufacturing companies. Automated machinery can save time, improve quality and at the same time diminish the operational costs of a manufacturing company[60].

Nevertheless, gaining the full benefits of green technologies in the machinery industry will require a considerable investment of around €10 tn by 2050[61].

5.4 Revision of the Machinery directive

One of the main legislations relevant for the machinery industry at EU level is the Machinery Directive 2006/42/EC[62]. The directive promotes the free movement of machinery within the single market guarantees a high level of protection for EU workers and citizens. This Machinery Directive is under revision now and it is expected that a new legislative proposal will be adopted in the beginning of 2021. The revision of the Machinery Directive's concerns an update with regard to the safety levels necessary to account for the latest technological progress and digital innovations.

---

[56]https://rio.jrc.ec.europa.eu/sites/default/files/report/RnI_investments_KI0216558ENN.pdf
[57] Cortina et al., 2018
[58] https://amfg.ai/
[59]https://circulareconomy.europa.eu/platform/sites/default/files/circular_economy_report.pdf
[60]https://www.hexaresearch.com/research-report/industrial-machinery-market#:~:text=The%20increasing%20popularity%20of%20green,in%20wind%20turbines%20manufacturing%20companies.&text=Automated%20machinery%20saves%20time%2C%20improves,cost%20of%20a%20manufacturing%20company.
[61]https://www.bcg.com/en-be/publications/2020/for-machinery-makers-green-tech-creates-green-business
[62] https://ec.europa.eu/growth/sectors/mechanical-engineering/machinery_en

Bibliography

CECIMO Circular (2019). Economy Report. The diverse and globalised world of machine tools, available at:https://circulareconomy.europa.eu/platform/sites/default/files/circular_economy_report.pdf.

Cortina, Arrizubieta, Ruiz, Ukar, Lamikiz (2018). Latest Developments in Industrial Hybrid Machine Tools that Combine Additive and Subtractive Operations 2018 Dec; 11(12): 2583. Published online 2018 Dec 18. doi: 10.3390/ma11122583

European Comission (2016). Final report. R&D Investments and Structural Changes in Sectors.

Geerts F and Renda V. (2019). The Machine Tool Industry's Changing Skills Needs: What is the Impact of Additive Manufacturing Technologies? Knowledge Transfer and Standards Needs in Additive ManufacturingRead first chapter Publisher: Springer International Publishing

Global Textile Machinery Market Report, History and Forecast 2014-2025, Breakdown Data by Manufacturers, Key Regions, Types and Application.

Hall, B. H. (2013). Is intellectual property important for future manufacturing activities. Future of Manufacturing Project Evidence Paper, 12.

Huanxing, C., Gang, L., Ying, Y., Liang, J., & Shunli, L. (2020). Review and Outlook of China Non-Road Diesel Mobile Machinery Emission Standards: Stricter emissions standards for better air quality in China. Johnson Matthey Technology Review, 64(1), 76-83.

Lewis, P., & Rasdorf, W. (2017). Fuel use and pollutant emissions taxonomy for heavy duty diesel construction equipment. Journal of Management in Engineering, 33(2).

Robotics business review (2019). World Robotics Report: Global Sales of Robots Hit $16.5B in 2018.

McKinsey (2018). Equipment and machinery companies considering a transformation to embrace the Industrial Internet of Things (IIoT) need to develop a clear perspective to drive impact at scale, available at: https://www.mckinsey.com/industries/advanced-electronics/our-insights/iiot-platforms-the-technology-stack-as-value-driver-in-industrial-equipment-and-machinery.

PWC (2017). The Future of Manufacturing - Italy, available at https://www.mckinsey.com/~/media/McKinsey/Industries/Advanced%20Electronics/Our%20Insights/IIoT%20platforms%20The%20technology%20stack%20as%20value%20driver%20in%20industrial%20equipment%20and%20machinery/FINAL-REPORT-Leveraging-industrial-software-stack-advancement-for-digital-transformation.pdf

Szirmai, A. (2012). Industrialisation as an engine of growth in developing countries, 1950–2005. Structural change and economic dynamics, 23(4), 406-420.

VDMA and McKinsey (2016). How to succeed: Strategic options for European machinery Shifting growth patterns, increasing pace of digitization, and organisational change

Eurostat:

Agriculture equipment market size, share & trends analysis report by application (harvesting & threshing, sowing & planting), by Product (Tractors, Harvesters), by Region, and segment forecasts, 2019 – 2025.

Agricultural machinery market size, share & trends analysis report by application, regional outlook, competitive strategies, and segment forecasts, 2019 to 2025.

Internet sources:

https://www.statista.com/statistics/264213/leading-countries-in-machine-tool-production-based-on-market-

share/#:~:text=China%2C%20Germany%20and%20Japan%20were,global%20machine%20tool%20production%20respectively.

https://www.thebusinessresearchcompany.com/report/medical-devices-market#:~:text=Medical%20Devices%20Market%20Definition&text=The%20medical%20device%20industry%20includes,supplies%20and%20other%20medical%20devices.

https://www.statista.com/topics/1702/medical-technology-industry/

https://www.marketstudyreport.com/global-construction-machinery-market-size-research?gclid=Cj0KCQiA3smABhCjARIsAKtrg6Lk0qqQpKnKXIPHeAtZCDb7IfzvQjjxb2XdRVcE3UbRSPG50OlhDMgaAmYAEALw_wcB

https://www.medgadget.com/2020/07/anesthesia-machinery-market-size-worth-usd-3288-million-by-2026-cagr-6-3.html

https://www.gtai.de/gtai-en/invest/industries/machinery-equipment-industry-68638

https://www.statista.com/statistics/532942/italy-turnover-machinery-equipment-industry-by-sector/#:~:text=Revenue%20of%20the%20machinery%20and%20equipment%20industry%20in%20Italy%202018%2C%20by%20sector&text=The%20total%20annual%20revenue%20of,amounted%20to%209.5%20billion%20euros.

https://atradiuscollections.com/global/reports/market-monitor-machines-italy-2018.html

https://www.mordorintelligence.com/industry-reports/europe-agricultural-machinery-market

http://filcontrol.com/news/textile-machinery-strong-demand-whole-world/

https://www.hexaresearch.com/research-report/industrial-machinery-market#:~:text=The%20increasing%20popularity%20of%20green,in%20wind%20turbines%20manufacturing%20companies.&text=Automated%20machinery%20saves%20time%2C%20improves,cost%20of%20a%20manufacturing%20company.

https://www.bcg.com/en-be/publications/2020/for-machinery-makers-green-tech-creates-green-business

https://www.fibre2fashion.com/industry-article/6236/is-importing-textile-machinery

https://www.bain.com/insights/how-industrial-machinery-makers-are-capturing-digital-opportunity/

https://www.technolution.com/perform/2020/10/05/better-security-needed-for-online-industrial-machinery/

https://bosch.io/industries/agricultural-machinery/

https://www.futurebridge.com/blog/artificial-intelligence-in-industrial-machinery/

https://www.oemoffhighway.com/engineering-manufacturing/article/21172020/equipment-manufacturers-prepare-for-augmented-and-virtual-reality-initiatives

https://www.digitalistmag.com/iot/2018/04/26/what-is-future-of-industrial-machinery-industry-06111935/

https://www.the-future-of-commerce.com/2017/09/27/imc-trends-industrial-manufacturing-by-2022/

https://www.statista.com/statistics/532942/italy-turnover-machinery-equipment-industry-by-sector/

https://www.market-prospects.com/articles/germany-machinery-and-equipment-industry#:~:text=According%20to%20data%20from%20the,revenue%20was%201.5010%20billion%20euros.

https://www.gtai.de/gtai-en/invest/industries/machinery-equipment

https://newheat.com/about/

https://www.businesswire.com/news/home/20200520005591/en/Global-Packaging-Machinery-Market-Assessment-2020-2025---Need-for-Packaging-Machinery-Suppliers-to-Leverage-Disrupting-Trends-to-Remain-in-Business---ResearchAndMarkets.com

https://www.ecomena.org/impact-of-hvac-on-environment/

https://www.aefaulks.co.uk/environmental-impact-of-construction-machinery/

https://ec.europa.eu/growth/sectors/automotive/environment-protection/non-road-mobile-machinery_en

http://www.sootfreecities.eu/sootfreecities.eu/public/measure/non-road-mobile

About the 'Advanced Technologies for Industry' project

The EU's industrial policy strategy promotes the creation of a competitive European industry. In order to properly support the implementation of policies and initiatives, a systematic monitoring of technological trends and reliable, up-to-date data on advanced technologies is needed. To this end, the *Advanced Technologies for Industry* (ATI) project has been set up. It provides policymakers, industry representatives and academia with:

- Statistical data on the production and use of advanced technologies including enabling conditions such as skills, investment or entrepreneurship;
- Analytical reports such as on technological trends, sectoral insights and products;
- Analyses of policy measures and policy tools related to the uptake of advanced technologies;
- Analysis of technological trends in competing economies such as in the US, China or Japan;
- Access to technology centres and innovation hubs across EU countries.

You may find more information about the 16 technologies here: https://ati.ec.europa.eu.

The project is undertaken on behalf of the European Commission, Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the European Innovation Council and Small and Medium-Sized Enterprises Executive Agency (EISMEA) by IDC, Technopolis Group, Capgemini, Fraunhofer, IDEA Consult and NESTA.

April 2021

EA-08-21-056-EN-N

Publications Office
of the European Union