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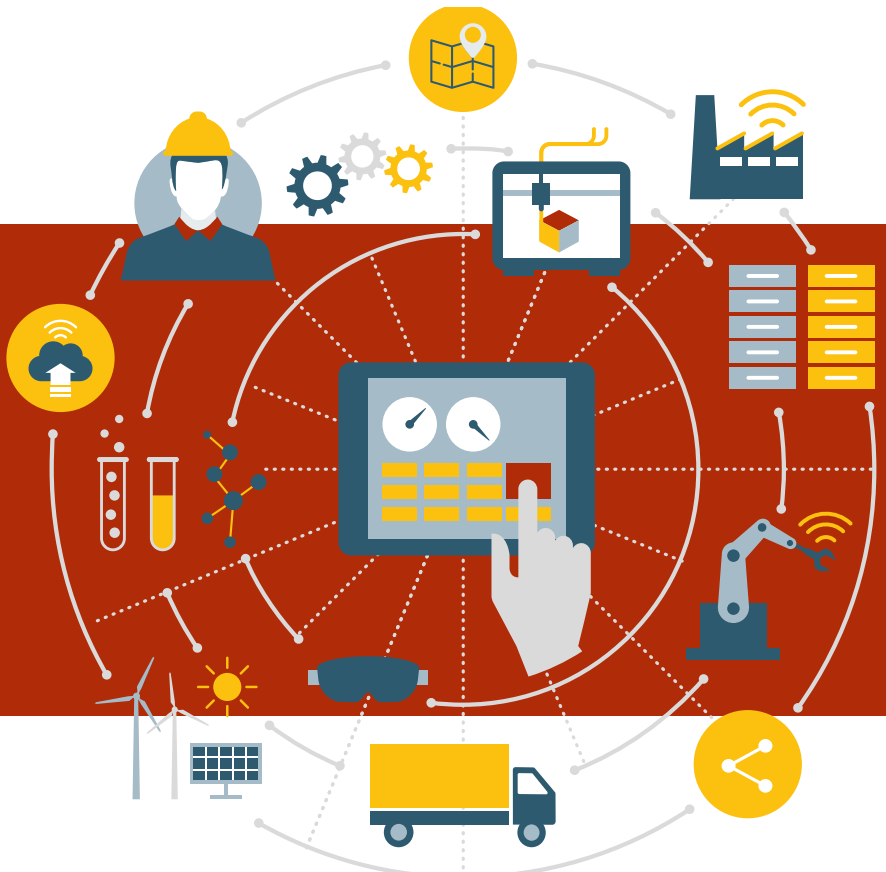

THINKING THE FUTURE OF EUROPEAN INDUSTRY

DIGITALIZATION, INDUSTRY 4.0 AND THE ROLE OF EU AND NATIONAL POLICIES

EU STUDY 3.17

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Chapter 1 focuses on global trends in the manufacturing sector. It highlights the importance that industry holds in the world economy. Indeed, in spite of the tertiary sector's increasing role in the global economy, industry still retains a large share of the economy. Among the most developed countries, South Korea has the highest share in manufacturing in the national economy (29%), followed by China and Germany with 27% and 23%, respectively. Instead, the United Kingdom, well-known for the importance of the tertiary sector, has the lowest share at 10%. As well, if we consider the countries for added value in manufacturing, China leads with almost 3,000 billion dollars in 2015, followed by the United States with 2,170 billion dollars. China's added value in manufacturing increased hugely, totaling 80% in the period 2008-2015, followed by South Korea (34%), Mexico (17%) and Germany (9%). On the contrary, in the same period many countries experienced a decrease in added value in manufacturing. Canada's added value decreased by 2%, the United Kingdom's by 3% and Italy's by 12%. The gap between China, and some emerging countries, and Europe's most developed countries concerning change in manufacturing added value is becoming more and more evident.

At the same time, a long-term decrease in employment in manufacturing is even more clear. In the period 1990-2015, all the main countries experienced significant reductions in the industry workforce. The United Kingdom halved its employment in manufacturing while France (-40%), Japan (-38%), Italy (-30%), the United States (-28%) and Germany (-27%) downsized their workforce. This long-term phenomenon of reduction in manufacturing employment is partially due to the increase in productivity. We can observe that many countries consistently increased their output per labor hour in manufacturing for the period 2002-2015. Countries such as South Korea (+94%), Japan (+49%), the United States (+47%), France (+43%) performed very well in this respect, but as well, the United Kingdom (+35%), Germany (+30%), Canada (+20%) and Italy (17%) were able to boost their productivity significantly.

We have also estimated the amount of FDI by sector, relying on data from the UNCTAD database. The service sector is the major recipient of FDI, receiving 4 trillion of dollars in 2001, 12 trillion in 2007 and 16 in 2015 (+300% in the 2001-2015 period). Instead, manufacturing shows 2 trillion of dollars in 2001, 5 trillion in 2007 and 7 trillion in 2015 (+200% between 2001 and 2015). Concerning manufacturing, the chemical sector that reveals to have the higher quota of FDI with 1.3 billion dollars, followed by food and beverages (800 million), electronics (600 million), motor vehicles (500 million) and petroleum products (400 million). The role of manufacturing in the global economy can also be evaluated by taking into account the value of cross-border M&A sales in the past years. In the last decade manufacturing competed with

services as the most valuable sector in cross-border M&A sales. Indeed, between 2008 and 2016, M&A in services reached 1.99 trillion dollars, with a growth rate of 17%, while manufacturing 1.85 trillion dollars, a growth rate of 106%.

Chapter 1 also describes manufacturing trends by sector and EU Member State. The EU is traditionally one of the most important regional areas in the world for industry, however the manufacturing sector suffered from the recent economic crisis and is still recovering. Indeed, between 2012 and 2015, the global economy averaged a growth rate in exports of 2.55%, while the European Union underperformed with an average increase of 1.65%. In the same period, China and the USA showed a growth rate of 4.9% and 2.65% respectively. However, the EU growth rate spiked up to 3.2% in 2015, representing an encouraging signal for the future.

Positive conjectures, even if weak, are confirmed if we look at the total manufacturing production index. Indeed, in 2015-2016, only 3 European countries (Portugal, Norway and Iceland – only one a EU member state) suffered a drop in total manufacturing production. Nonetheless, if we consider a longer perspective, such as the period 2016-2016, the context appears controversial. Some countries have been heavily hit by the economic downturn. For example, Italy reduced its total manufacturing production by 6.8% between 2011 and 2016, as well as Finland (-5.9%), Sweden (-5.7%), France (-1.7%), Luxembourg (-1.7%) and Spain (-0.9%). In contrast, the Euro area exhibits an average increase of 2.4% and Germany confirms the solidity of its economy with a growth rate of 2.9%.

In any case, the European Union remains a global power for the export of goods, holding in second position in the world. In 2015, its exports amounted to 1.789 billion euros, corresponding to a share of 15.5% of world exports. This share is lower than China's (17.8%, 2.056 billion euros), but higher than the United States' (13.4%, 1.548 billion euros). Moreover, the European Union has a positive trade balance, opposite to that of the USA and India that display a deficit, and of China and Russia that have a trade surplus. Among EU Member States in the period 2011-2016, Germany leads with the best export performance (+9.7%), followed by Italy (+7.4%), Ireland (+6.3%) and the Czech Republic (+5.6%). If we focus only on 2016, Germany ranked first with 1.209 billion euros in total exports. The Netherlands (514 billion euros) held second position and France third (452 billion euros). Italy and the United Kingdom completed the top five with 417 billion euros and 370 billion euros, respectively.

Moreover, the leading export countries by product groups were studied, using the SITC classification. In this field, Germany's performance in machinery and transport equipment is very significant with exports of more than one third (31.5%) of the European total in this sector. The Netherlands comes up first in the export of food, drinks and tobacco and raw materials and also has the main share of the export of mineral fuels, lubricants and related materials (26.7%). Germany is the second exporter in the above-mentioned sectors, but leads in the remaining product area – chemicals and related products, other manufactured goods, machinery and transport equipment and commodities.

EU Member States are committed to attracting digital investment. In Germany alone, more than 70 billion euros were invested in ICT in 2015. Moreover, many of the European countries are ranked high in attractiveness, also thanks to favorable tax measures. With regard to 2017 digital tax index, Ireland, Italy and Hungary represent the most attractive locations. They show negative effective tax rates equal to -10.32%, -8.84% and -6.85%, respectively. Instead, Germany is one of the less attractive countries for digital business models.

However, in a context where big international players are heavily investing in digitizing their manufacturing sector, the European Union has wide margins for improvement. An important example is the integration of multipurpose industrial robots in production. The worldwide annual supply of industrial robots increased by 214% between 2003 and 2015, from 81,000 to 254,000, that is by far the highest volume ever recorded. Despite this, out of 254,000 robot units, 63.3% of the sales were in Asia and Australia, with China alone accounting for 27% of industrial robot shipments in 2015. Instead, the European Union stood at 19.7%, representing the second largest market in the world. The countries that contributed most to the European results were Germany (7.9%), Italy (2.6%) and France (1.2%). However, in 2015 China alone outdid Europe's total sales (68,800 units compared to 50,100 units) and Asiatic robotics is expected to surge very quickly. According to forecasts, the share of Chinese robots will increase from 27% to 38.6% in 2019. North America and the European Union will reduce their quotas from 14.4% to 11.1% and from 19.7% and 16.6%, respectively. In the European Union, performance of Germany should be noted, representing the fifth largest robot market in the world. Sales today remain very high, despite a very high robot density (301 robot units per 10,000 employees).

A comprehensive methodology to measure the impact of digitization has still not been well-developed, but benefits of the increasing applications of digital technologies are evident. Strategy& found that an increase in digitization of 10% results in a 0.5% to 0.62% gain in per capita GDP and that an increase of 10% in digitization causes a decrease in the unemployment rate of 0.84%. Furthermore, where companies are concerned, cost reductions are very significant. Industries investing in digitization expect to reduce operational costs by an average of 3.6% and to improve efficiency by 4.1% annually. Moreover, most companies foresee a short term *Return on Investment* (ROI). 55% believe that an investment in Industry 4.0 technology will have a payback within two years and only 8% expect to wait for more than a five-year period for a return on investment. Technology investment appears to be very fruitful for production and export growth. Looking at Italian data, we verified that companies investing in Industry 4.0 clearly show a better performance in production and exports compared to companies producing consumer goods. Finally, still referring to the Italian context, it was noted that companies investing in new manufacturing technologies are also expected to improve their profitability indices, such as *Return on Investment* and *Return on Sales*, and their Added Value.

Chapter 2 describes the potential for an effective IoT penetration in the manufacturing industry. Industry 4.0 has the potential to improve productivity and competitiveness, increase energy and resource efficiency and effectiveness and, hence, protect the environment. It could further enable the transition to a circular economy, or industrial economy, in which end of life products are reused, remanufactured and recycled. Taken together, these developments would lead to the emergence of more sustainable production and consumption patterns, and could thus provide opportunities for developed and developing countries to achieve economic growth and sustainable development in line with the 2030 Agenda for Sustainable Development.

Nevertheless, the level of IoT deployment across Europe and in the big-five countries still remains disappointing. Whereas most common integration systems – such as ERP, CRM and SCM systems – are quite widespread across manufacturing companies, much less common is the use of RFID systems, cloud computing services of a medium-high sophistication level or BDA tools. European manufacturing companies are currently employing only 13%, 9% and 7%, respectively, of RFID, high-level cloud computing and BDA solutions. Germany is at the forefront in Europe, although there is still much more to be done even there. Linked to the spread of these technologies, however, there is the need for extensive and fast connectivity. Regarding fixed ultra-broadband network, in 2017, 76% of the EU population was on average covered (+14 p.p. over 2014), with Malta, Belgium and the Netherlands topping the ranking with almost 100% coverage. The performance of larger countries – such as Germany, Spain, Italy and France – is more lackluster, quite disappointing especially if we consider the linkage existing between connectivity and the ability of companies to analyze data, which is increasingly becoming a highly valuable asset for companies. According to the analysis performed, 10 percentage points (p.p.) more in NGA coverage approximately yields a 1.5 p.p. increase in the share of companies analyzing Big Data.

In a context characterized by an important increase in data volumes and the development of new innovative digital services, high technology and network performance is essential. In this revolutionary contest, 5G is the new generation of radio systems and network architecture that will revolutionize citizen/consumer and business lives. Indeed, 5G will allow: 1) data rates up to 100 times faster (more than 10 Gbps); 2) network latency lowered by a factor of five; 3) mobile data volumes 1,000 times greater than today; 4) battery life of remote cellular devices up to 10 years or more; 5) increasing number of devices connected to the network (1 mln per 1 sq. km); 6) possible usage of several bands from 400 MHz to 100 GHz.

According to IHS 2017 estimates, 5G will enable $12,300 billion of global economic activity in 2035 (2016 US$), that is, 4.6% of global real output in that year. The impact of 5G-enabled output varies from 11.5% in the information and communications sector to a minimum of 2.3% in the hospitality sector. By 2035, manufacturing, at $3,364 billion, will have the largest share of 5G-enabled economic activity. 5G will be a very important technology for Industry 4.0 deployment.

Industry 4.0 is the theorizing of a manufacturing paradigm based on the concept of the "Cyber Physical System" (CPS), characterized by IT systems with computational and communication capabilities that can interact with the physical systems in which they operate.

In particular, there are five technology areas considered strategic for the implementation of Industry 4.0: 1) Collaborative Robotics; 2) "Digital Factory"; 3) Advanced control and supervision of the production process; 4) Internet of Things and Big Data; and 5) Cyber Security.

Thus, 5G features offer an extraordinary opportunity for industry. New automated technologies – for example, industrial robots and autonomous driving systems – require a quick response from the system and the increase of connected devices – IoT development – also requires a high network performance. Therefore, the new generation of "mobile" connections, 100 to 1000 times faster than 4G, with low latency and high speeds allowing for the efficient connection of a very high number of devices, will be one of the most important drivers for the future in the industrial sector.

On September 14, 2016, the European Commission presented the Communication "5G for Europe: An Action Plan", and the working document, "5G Global Developments" which accompanied the first document, describing a short summary of 5G developments worldwide and the main issues impacting the anticipated deployment of 5G networks. The Commission outlined in the Action Plan several key elements and, in particular, the importance of aligning roadmaps and priorities for a coordinated 5G deployment across all Member States, starting from trial promotion and the identification of at least one major city to be "5G enabled" by the end of 2020. 5G deployment requires substantial investments and a coordinated approach which involves a harmonization of standards and a global consensus on the choice of technologies, spectrum bands and a shared roadmap.

Following this, EU Member States are launching 5G strategies, creating public funds and taking initiatives to encourage 5G deployment.

In Italy, in March 2017, the Government published a public bid for pre-commercial trials of innovative 5G networks and services in the 3.7-3.8 GHz spectrum portion. These trials will take place in 5 cities (the metropolitan area of Milan, Prato, L'Aquila, Bari and Matera) where the aim is to experiment with the 5G network not only from an infrastructural point of view but also with regard to the services.

The chapter also deals with the consequences and open issues of IoT deployment in the EU. These can be summarized in three categories – skills and the impact on the labor market; standards and interoperability; and cybersecurity.

Concerning the first aspect, six European countries (UK, Germany, France, Italy, Poland, and Spain) accounted for 70% of total data workers in 2016. The manufacturing industry is the third industry regarding the employment of data workers with a total number of about 718,000 workers in 2016. Nevertheless, the percentage of data workers out of the total of employees is still very low in the manufacturing industry (2.1%, compared to 10.7% in ICT or 9.4% in finance, which are typically the

most highly digitalized sectors). In addition, 29% of EU enterprises recruiting or trying to recruit ICT specialists reported hardships in filling those vacancies, with several countries showing even higher difficulties – such as Austria or Slovenia, where more than one in two companies searching for an ICT specialist found a serious shortage people with such skills.

According to current data and estimates for the future, there is – and there will be – a large skills gap. According to IDC, in 2016, the gap between total demand and supply of data workers was equal to 420,000 unfilled data worker positions in the EU (corresponding to 6.2% of total demand) and this is expected to rise to 769,000 (9.8% of total demand) by 2020. Poland registered the highest gap in 2016 (almost 15%), however in the scenario to 2020, the UK's skills gap is expected to more than double – from 5.5% to 13.8% – thus becoming the country that will suffer the most from the shortage of the needed data skills. Germany, France and the UK – the leading data markets – show a mid-size gap in the scenario to 2020, as the positive dynamics of supply is not able to keep up with the strong growth of demand. However, whereas Germany remains stable around 4.5% and France slips down to 2.7%, the UK the share of unfilled positions climbs to 13.8% (more than twice the present level).

This gap needs to be urgently addressed both by policy actions and by the industry. While the competence for the content of teaching and the organization of education and training systems lies within Member States, a concerted effort is required to achieve meaningful and sustainable results.

Furthermore, Chapter 2 points out the need for common standards and defines benefits for European industry that could derive from standardization. Well designed and timely European standards can support innovation in a number of ways. Existing standards can codify and spread the state of art in various technologies. They can also facilitate the introduction of innovative products by providing interoperability between new and existing products, services and processes, for example, in the field of eco-design, smart grids, energy efficiency of buildings, nanotechnologies, security and eMobility. As well, standards can help bridge the gap between research and marketable products or services. In Chapter 2, important examples of the potential of standardization are presented, such as the GSM mobile communication technology and its successors (3G, 4G…), where the European Standardization body, ETSI, has played a leading role. Standardization is also important economically. A study of the German Standardization Organization, DNI, on the contribution of standards to national economic growth has shown that in France standardization contributes directly to the growth of the national economy by up to 0.81%, or almost 25% of GDP growth. As well as the economic benefits of standardization, it represented about 1% of GDP in Germany and, in the United Kingdom, standards made an annual contribution to GBP of 2.5 billion to the economy. 13% of labor productivity growth was also attributed to standards. To reinforce the partnership between the European institutions and the European standardization community, the European Commission announced in

its Single Market Strategy the launch of a Joint Initiative on Standardization, bringing together public and private institutions and organizations in a collaborative dialogue. The initiative is driven by stakeholders (EU and EFTA Member States, standardization organizations and bodies, European industry and industry associations, SMEs, and societal stakeholders), with the European Commission playing a mainly coordinating and building consensus role. These partners will commit to modernizing, prioritizing, and speeding up the timely delivery of standards by the end of 2019.

The third important concern regards the need to protect citizens, companies and other parties from cyberattacks, i.e. cybersecurity. The main security risks involve data destruction or corruption resulting from hardware or software failures, unavailability of ICT services due to external attacks and disclosure of confidential data from intrusion, pharming, phishing attacks. Unfortunately, according to Eurostat data, only 32% of all EU enterprises have a formally defined ICT security policy, similar to manufacturing companies. Sweden, Italy and Ireland display the highest awareness of the importance of a security policy, especially in the manufacturing industry, where the number of companies aware of the importance of having a well-defined security policy is even higher than in other sectors (53%, 45% and 43% of manufacturing companies, respectively, in the three countries). EU companies seem to be relatively more worried about the risk of data destruction or corruption, while only 29% of EU manufacturing companies seems worried by the disclosure of confidential data.

Three main regulatory issues are currently at stake: 1) the need for increasing cybersecurity capabilities; 2) the need for making the EU a strong player in cybersecurity; and 3) the need for mainstreaming cybersecurity in EU policies. The chapter provides a review of several initiatives launched by both the European Commission and the European Parliament since the adoption of the EU Cybersecurity Strategy in 2013.

Finally, in Chapter 2 a synthetic index is proposed on the level of preparedness for Industry 4.0 in different EU countries. Finland tops the ranking, with a score of 100 – thanks primarily to the adoption of certain technologies (cloud computing services and Big Data analysis tools) and the relatively high level of employment of both ICT specialists and data workers – being the country at forefront of the fourth industrial revolution. The Netherlands, Germany and Denmark immediately follow. On the contrary, most Eastern countries present unfavorable conditions in the development of Industry 4.0. The worst performing country is Romania – with a score of 53 – lagging behind especially regarding infrastructural development – particularly, mobile networks – and the adoption of business integration technologies. Italy and France – two of the Big Five countries, with an important economic role played by the manufacturing industry – are positioned closer to the worst performing countries than to the best performers. More specifically, Italy only ranks 17th, mainly because of the gap in the fixed network infrastructure and, even more significantly, in digital skills, and France, ranking 25th, above only Bulgaria, Greece and Romania.

Chapter 3 analyzes the state of art concerning European and national Industry 4.0 policies. On 19 April 2016, the European Commission launched the first industry-related initiative of the Digital Single Market package aimed at building on and complementing the various national initiatives for digitizing industry, such as *Industrie 4.0* in Germany, *Smart Industry* in the Netherlands and *l'Industrie du future* in France. The purpose of the Commission's Communication on Digitizing European Industry is to reinforce the EU's competitiveness in digital technologies and to ensure that every industry in Europe, in whichever sector, wherever situated, and no matter of what size can fully benefit from digital innovations. The proposed actions are expected to mobilize close to 50 billion euros of public and private investment in the next 5 years, explore and adapt when needed the legislative framework and reinforce the coordination of efforts on skills and quality jobs in the digital age. In fact, with more than 30 national and regional initiatives for digitizing industry underway across Europe, there is a need to address standardization and examine the regulatory fitness of legislation at EU level.

The stimulation of private investment in digital innovation in all industrial sectors across the EU is a major challenge to be addressed at regional, national and EU levels. As shown with the European Fund for Strategic Investment, the EU as a whole can mobilize resources for investment, when needed, that no individual Member State could raise on its own and with a leverage effect on private investments that is far beyond the reach of many Member States. The European Commission aims at boosting digital innovations in all sectors, by means of financing Digital Innovation Hubs across Europe.

EU actions supporting such competence centers have shown not only an increase in competitiveness of existing industries, notably for SMEs, but also additional business creation in new digitized products and services, increasing the attractiveness for investments. The Commission plans to focus 500 million euros in investments from Horizon 2020 on digital innovation hubs on: networking and collaboration of digital competence centers and cluster partnerships; supporting cross-border collaboration of innovative experimentation activities; sharing of best practices and developing, by the end of 2016, a catalogue of competences; mobilizing regions with no Digital Innovation Hub to join and invest; wider use of public procurement of innovations to improve the efficiency and quality of the public sector. Overall, more than 20 billion euros are already planned to be invested in the coming 5 years in the digital-sector Public Private Partnerships (PPPs) by industry and the EU in support of strategic R&I agendas.

Other Commission priorities include providing the appropriate regulatory framework conditions, that is adopting future-proof legislation that will support the free flow of data and clarify ownership of data generated by sensors and smart devices, and to ensure the preparedness of the human capital for the digital transformation with the necessary skills. An action plan to modernize digital public services completes the EU strategy for Industry 4.0, in order to create a better environment to live, work and invest in. Overall, the

Digitizing European Industry plans should mobilize up to 50 billion euros in public and private investments to support industry digitization:

- €37 billion investment to boost digital innovation
- €5.5 billion national and regional investments in digital innovation hubs
- €6.3 billion for the first production lines of next-generation electronic components
- €6.7 billion for the European Cloud Initiative.

Moreover, several initiatives are currently in place at national levels across the EU. In Chapter 3, we focus on French, German, English and Italian government initiatives. In France, starting in 2013 President Hollande launched the New Industrial France initiative in order to assist French companies in moving upmarket and positioning themselves in the markets of the future. The government defined nine key priorities. They are meant to provide solutions to challenges in areas such as: the medicine of the future; eco-mobility; new resources; sustainable cities; transport of tomorrow; the data economy; smart objects; digital trust; and smart food production. So far nearly 2 billion euros have been provided in public support to one thousand innovative projects. The Industry of the Future project was launched by the President of the Republic on 14 April 2015. It is a cross-cutting initiative aimed at encouraging all companies to modernize their production base and use digital technologies to transform their business models in a world where digital tools are breaking down barriers between industry and services. The industry of the future project is built on five pillars:

1. developing cutting-edge technologies such as Additive Manufacturing, The Virtual Plant and the Internet of Things and Augmented Reality;
2. helping companies adapt to the new paradigm, through personalized support offered by regional platforms;
3. training employees;
4. promoting the Industry of the Future, by launching emblematic projects on a national or even European scale;
5. reinforcing European and international cooperation, with special focus on technological cooperation with Germany.

German Industrie 4.0 is a strategic plan backed by the federal government and with the involvement of the main firms in the industrial and technology sectors. Today, a total of over 300 players from 159 organizations are active in the platform, that involves a network bringing stakeholders together, discusses the various issues with them, monitors processes, raises awareness for the issues, and mobilizes businesses. The work of the platform is therefore concentrated in four areas: making content recommendations; mobilizing businesses, particularly SMEs; providing single-source support; and promoting international networking. The Platform *Industrie 4.0* also provides services for SMEs. For example, it has developed an *Industrie 4.0* compass that helps companies find the support services that are available around them. The compass lists more than 50 non-commercial support services that are available in Germany. Moreover, *Platform Industrie 4.0* has five

working groups, each of which focuses on a different subject. The working groups develop concepts and recommendations for action for the pre-competitive stage in a number of selected areas.

The Italian government presented its "Italia 4.0" project on September 21, 2016, aiming at helping companies improve their competitiveness by supporting investments, the digitalization of industrial processes, improvement in worker productivity, as well as the development of new skills, new products and new processes. The National Plan focuses on four kinds of measures, divided between strategic measures and complementary measures. As far as innovative investments are concerned, the government will invest €3.3 billion over four years, through: extension of the 140% super-amortization plan; hyper-amortization on digital goods with the possible reduction of the timeframe from seven to five years; recapitalization of the SME Guarantee Fund for €900 million; €100 million of refinancing of the "New Sabatini" law (for investment in machine tools), and a special section of the rotating business fund of the *Cassa Depositi e Prestiti.* By 2020, €2 billion will be used to fund tax credit for investment in R&D. As for venture capital, the project aims to attract €1.5 billion of early stage private investments. Moreover, the Industry 4.0 plan includes a chapter on human capital, that sets ambitious targets, including a school plan on smart manufacturing aimed at involving 8 million students in primary and secondary schools in the national plan for digital education, and an additional 250,000 high school students in an exchange between school and work. The Italian government also planned to cooperate in the definition of IoT open standards and interoperability criteria and to ensure an adequate network infrastructure with the Ultra Broadband Plan, with the target that by 2020, at least 50% of Italian companies will have access to ultra-broadband networks of 100 Mbps, while all businesses will have a network coverage of at least 30 Mbps. Finally, the Plan sets a bundle of complementary measures in order to guarantee private investments, support large innovative investments, reinforce and support internationalization of Italian companies and strengthen productivity.

While the UK initiated quite early a number of policies to foster innovation, it has only been in 2017 that it has expressed its view on a global industrial strategy to meet the new challenges of the economic environment. In January 2017, the government issued a Green Paper "Building our Industrial Strategy", seeking comments from industry. Among the main goals, the government promises to tackle the UK's poor labor productivity, improve access to capital and cultivate "world-leading" sectors. The research is built on 10 pillars: science, research and innovation, developing skills, upgrading infrastructure, supporting business growth and investment, improving procurement, encouraging trade and investment, delivering affordable energy and clean growth, cultivating world leading sectors, and driving growth across the whole country. The Green Paper also selects technologies where Britain has competitive advantages in research and development, to be supported through the government's new Industrial Strategy Challenge Fund. This new tool, created in April

2017, provides funding and support to UK businesses and researchers, part of the government's £4.7 billion increase in research and development over the next 4 years. The key areas of investments are: healthcare and medicine (£197 million in 4 years), clean and flexible energy (£246 million), and robotics and artificial intelligence (£93 million); driverless cars (£38 million), manufacturing and future materials (£26 million); and satellite and space technology (£99 million). To support delivery of the Industrial Strategy Challenge Fund, the government plans to invest £250 million over the next 4 years to continue to build the pipeline of high-skilled research talent, while Innovate UK, the government innovation agency, will be supporting a £10 million first wave of projects through the ISCF in each of the 6 areas with a number of smaller projects, starting in 2017 to 2018.

In the **conclusions**, the study contains the following **policy recommendations**:

1) *attracting FDI in digital manufacturing.* As reported in this study, among EU Member States, there are countries that rank in the first positions globally for attractiveness for digital investments. However, other countries are less attractive for digital business models. EU institutions and Member States need to stimulate FDI in digital manufacturing and private investments in Industry 4.0 technology drivers, to increase private spending in R&D and to develop open innovation relations between mature companies and high-tech start-ups. The EU could sustain business growth and attractiveness of locations for digital investments thanks to favourable and common tax measures and adequate funding support, so as to reduce the tax burdens for companies investing in digital. Of course, FDI should be open also to those extra-UE countries that comply with principles of reciprocity.
2) *Integrating robots and other digital technologies in manufacturing.* The integration of digital technologies in manufacturing in Europe is rising, but it is also disappointing for many aspects, especially if we consider the fast progress in China and other Asiatic countries in this field. Therefore, it is fundamental to provide incentives and sustain the integration of robots and other digital technologies (additive manufacturing such as 3D printing, robotics, artificial intelligence, cognitive computing, advanced material science and material bonding technologies) in the productive processes. In this respect, government procurement plays an important role. Used strategically, public procurement can encourage innovation, competition and investment in skills and technologies. It is also important to help smaller companies to access digital technologies, with special initiatives targeting SMEs.
3) *Upgrading technologies and infrastructures.* The spread of technologies such as cloud computing, radio-frequency identification technologies, ERP, CRM and SCM systems, as well as of Big Data Analytics, show great disparity across Europe. In this study, we strongly argued about the advantages of adopting these technologies in terms of cost reduction and increases in efficiency. At the same time, the spread of fast connectivity networks in

EU is still limited and geographically unbalanced. This appears quite disappointing, above all, if we consider the positive linkage existing between connectivity and the ability of companies to access new technologies and opportunities, such as analyzing data, which is becoming one major source of business value. Therefore, promoting public and private investments in upgrading digital infrastructures all over the EU is a foremost need.

4) *Investing in human capital.* Digital transformation requires well prepared human capital. Advances in automation, robotics and smart systems are increasingly transforming the nature of work, not only for repetitive tasks but also for sophisticated tasks in administrative, legal or supervisory roles. So, a massive upskilling of the workforce at all levels is required. In fact, if the immediate consequence of changes in manufacturing could be a reduction of workforce, we are also observing a shortage of skilled workers. Paradoxically, the EU labor market is facing an unprecedented demand for skilled ICT specialists and EU enterprises recruiting or trying to recruit ICT specialists report facing hurdles in filling these vacancies. This skills gap needs to be urgently addressed both by policy actions and by industry and this action goes hand-in-hand with the attempt to address painful redundancies in the labor market. The revision of the content of teaching and of the organization of Vocational Education and Training systems is required. Moreover, there is a need to support the national and local coalitions for worker up-skilling and the review of the European Qualifications Framework and to reinforce a common framework for coordination between national and EU-level initiatives and relevant policy actions. At the same time, not only should this skills gap be addressed, but the number of manufacturing companies employing ICT workers should be increased. In fact, it is still quite limited, with several countries showing more difficulties than others in introducing ICT specialists into their workforce. In this scenario, there is an important role to play for competence centers, technical universities and research organizations. Their work in transferring leading-edge technology to companies, giving advice on potential sources of funding/finance, providing space for experimentation and helping workers to find training is central to improve workers' skills and digital capabilities and increase the pace of innovation.

5) *Setting standards and guaranteeing interoperability.* As argued in this study, common standards carry an immense value for the competitiveness of enterprises, especially for those working in sectors such as transport, machinery, electro-technical products and other manufacturing industries, as well as in the field of telecommunications. The economic benefits of standards are enormous. They increase productive and innovative efficiency and allow suppliers to achieve lower per-unit costs by producing large homogeneous batches. Moreover, they can also facilitate the introduction of innovative products by providing interoperability between new and existing products, services and processes. The fragmentation

of standards acts as a barrier to the cross-border sale of products and provision of services. Therefore, well designed and timely international standards can support innovation in several ways. Therefore, we need to anticipate standards requirements and accelerate their development in Europe, by following the proposal for a 2017 work program for European standardization that identifies the services and ICT sectors as priority areas for future standard-setting, given their cross-cutting role in the economy. Thus, it is important to support the three European Standards Organizations – the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), and the European Telecommunications Standards Institute (ETSI. It is also essential to ensure the best possible coordination between national standard entities from EU Member States.

6) *Defining cybersecurity systems and policies.* The increase in the introduction of IoT in manufacturing introduces many issues relative to privacy and security data. Today many business models are built on the uninterrupted availability of the Internet and the smooth functioning of information systems. Therefore, cybersecurity incidents could disrupt the supply chain of manufacturing companies, causing serious repercussions from both an economic and a quality point of view. The existence of an ICT security policy in an enterprise means that the enterprise is aware of the importance of its ICT systems and the relevant potential risks. Nevertheless, the share of manufacturing companies with a ICT security policy in EU is still too low. Therefore, it is fundamental to increase cybersecurity capabilities, bringing them to the same level of development in all EU Member States and ensuring that information exchanges and cooperation are efficient, also at a cross-border level. The EU needs to become a strong player in cybersecurity, ensuring that all European citizens, enterprises (including SMEs), public administrations have access to the latest digital security technology, at the same time interoperable, competitive, trustworthy and complying with fundamental rights including the right to privacy. It is also important to support the emerging single market for cybersecurity products and services in the EU. In this field, both governments and the private sector have a significant role to play.

7) *Fostering international cooperation and networking.* Many European countries are setting industrial digitization at the top of their government agenda. However, it would be appropriate to coordinate all these efforts in order to provide an adequate scale. In this respect, events aimed at international networking, the sharing of best practices and multi-stakeholder dialogue could be useful and effective tools. At the same time, the EU should ask for reciprocity when allowing companies from other countries to access its market, in terms of ownership of companies holding strategic technologies in their portfolio and sales of goods and services in paramount sectors. Indeed, all these efforts should be aimed at allowing as many European companies as possible to thrive in an increasingly competitive world.

PART 1

DIGITAL TRANSFORMATION AND INDUSTRY

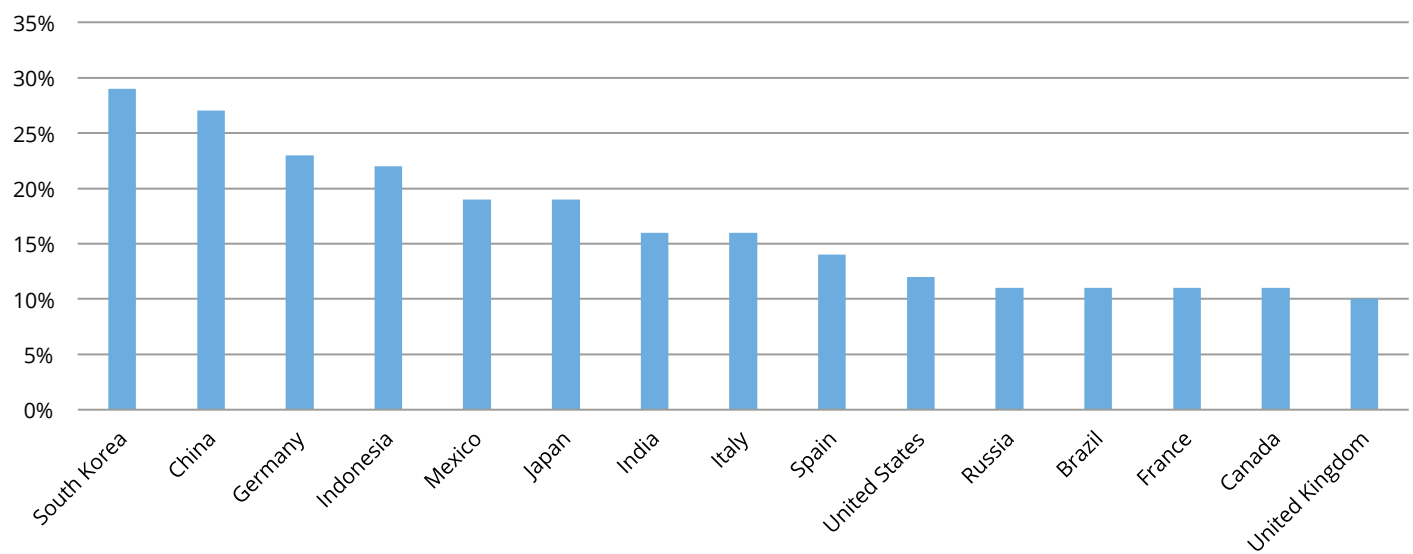
1. DIGITAL TRANSFORMATION AND INDUSTRY

1.1. GLOBAL TRENDS IN MANUFACTURING

The manufacturing sector is facing many global challenges. Foreign trade is at historically low levels and political uncertainties could undermine free flows of goods around the world. The uncertainty surrounding the manufacturing sector is evident from surveys. The Pwc Barometer 2017 reports that, in the fourth quarter of 2016, 54% of industrial manufacturers had an uncertain view of the world economy over the next 12 months, 8% more than in the third quarter. 30% of the manufacturers were optimistic, 1% more compared to the previous quarter, and 16% had a pessimistic view, 9% less than in the third quarter. Despite this, the demand for manufactured products is growing. According to the International Monetary Fund, the output should increase by 3.4% in 2017[1]. In spite of the tertiary sector's increasing role in the global economy, industry still retains a big share of the economy (Fig. 1.1). Among the most developed countries,

Fig. 1.1 Share of Manufacturing in National Economies (Manufacturing added value as percentage of Gross Domestic Product, 2015)

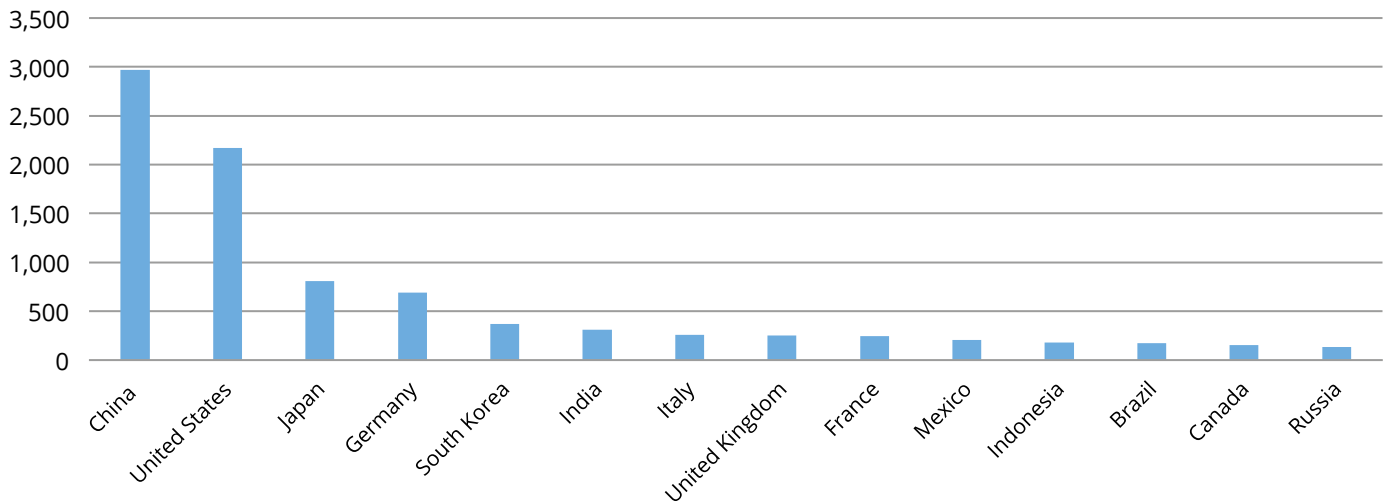
Source: I-Com elaboration on United Nations National Accounts (Main Aggregates Database data)



1 Pwc, 2017 Industrial manufacturing trends

Fig. 1.2 Leading Countries, Added Value in Manufacturing (US$ bn, 2015)

Source: I-Com elaboration on United Nations National Accounts (Main Aggregates Database data)



South Korea has the highest share in manufacturing in the national economy (29%)[2]. China and Germany follow with 27% and 23%, respectively. The United Kingdom, well-known for the importance of the tertiary sector, has the lowest share at 10%. If we consider the countries for added value in manufacturing, China is the first with almost $3,000 billion in 2015, followed by United States with $2,170 billion (Fig. 1.2). The other countries do not reach an added value in manufacturing of $1,000 billion, with Japan and Germany reaching $810 billion and $691 billion, respectively.

China's added value in manufacturing increased dramatically, totaling 80% in the period 2008-2015[3], followed by South Korea (34%), Mexico (17%) and Germany (9%). In the same period, many countries experienced a decrease in added value in manufacturing. Canada's added value decreased by 2%, the United Kingdom's by 3% and Italy's by 12% (Fig. 1.3). The gap between China and some other non-European countries, and Europe's most developed countries regarding the change in manufacturing added value has become increasingly evident.

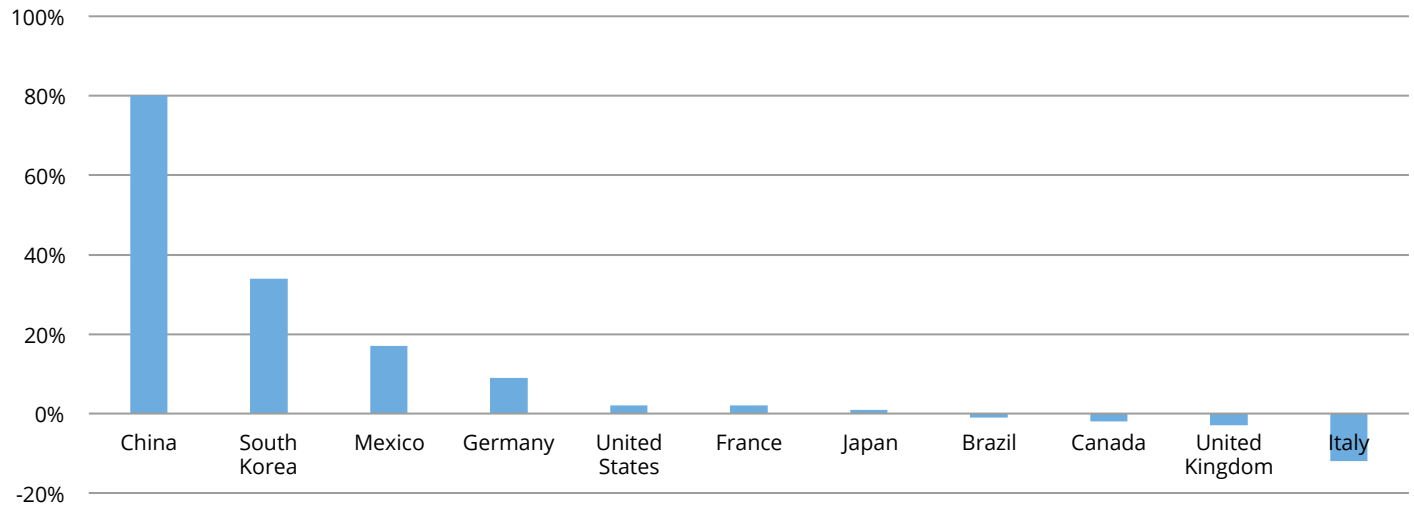
This difference is also clear when we take into account the investment in manufacturing fixed capital as share

2 Source: United Nations National Accounts Main Aggregates Database

3 United Nations National Accounts Main Aggregates Database

Fig. 1.3 Change in Added Value Manufacturing adjusted for inflation (2008-2015)

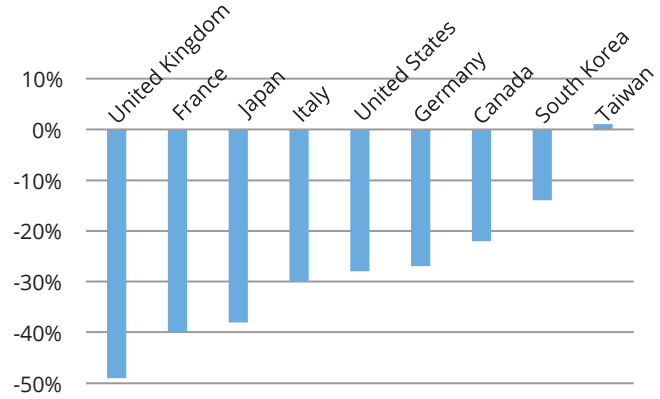
Source: I-Com elaboration on United Nations National Accounts (Main Aggregates Database data)



of GDP[4]. While South Korea shows a rate of investment pretty close to 10%, the best European performer, Sweden, is only at 4.7%, followed by Germany with 3.9%. The United States and United Kingdom have lower rates at 2.8% and 2.1%. At the same time, a long-term decrease in employment in manufacturing is even more evident. In the period 1990-2015, all the main countries experienced significant reductions in industry workforce (Fig. 1.4). The United Kingdom halved employment in manufacturing while France (-40%), Japan (-38%), Italy (-30%), the United States (-28%) and Germany (-27%)

Fig. 1.4 Manufacturing employment (Percentage change, 1990-2015)

Source: I-Com elaboration on data from The Conference Board, "International Comparisons of Manufacturing Productivity & Unit Labor Cost Trends," June 2016



4 Source: OECD, National Accounts Statistics, Capital Formation by Activity – ISIC Rev. 4.

experienced a downsizing in their workforce[5], similar to other countries. Taiwan represents a residual exception. This long-term phenomenon of reduction in manufacturing employment is a partial consequence of an increase in productivity. If we look at the output per labor hour in manufacturing for the period 2002-2015, we can observe that many countries have consistently increased their productivity (Fig. 1.5). Particularly, South Korea (+94%), Japan (+49%), the United States (+47%), France (+43%) performed very well in this respect[6], but as well, the United Kingdom (+35%), Germany (+30%), Canada (+20%) and Italy (+17%) were able to boost their productivity significantly. Therefore, we can say for sure that the most developed countries in the world experienced an important increase in productivity in the last decade.

We can also evaluate the relevance of global manufacturing by studying the amount and the direction of Foreign Direct Investments (FDI). According to a business survey conducted by the UNCTAD in the 2017, 54% of the executives interviewed expect the FDI in manufacturing to increase in the period 2017-2019. 20% of the executives have negative expectations, while 13% predict no change and 12% don't know.

The amount of FDI by sector, can be estimated by using data from the UNCTAD database (Fig. 1.6). The service sector is the major recipient of FDI, receiving $4 trillion in 2001, $12 trillion in 2007 and $16 trillion in 2015. Instead, manufacturing received $2 trillion in 2001, $5 trillion in 2007 and $7 trillion in 2015.

Fig. 1.5 Output per labor hour in manufacturing (Percentage change 2002-2015)

Source: I-Com elaboration on data from The Conference Board, "International Comparisons of Manufacturing Productivity & Unit Labor Cost Trends," June 2016

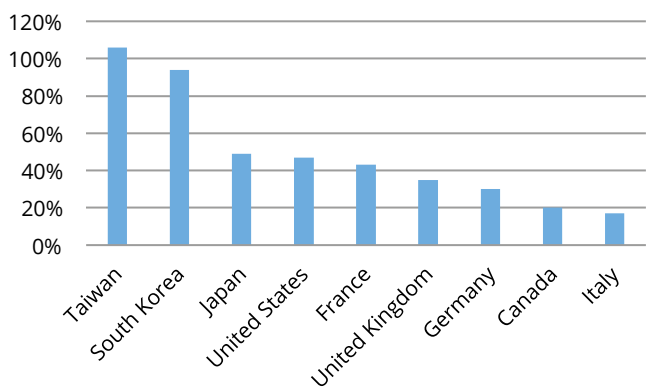
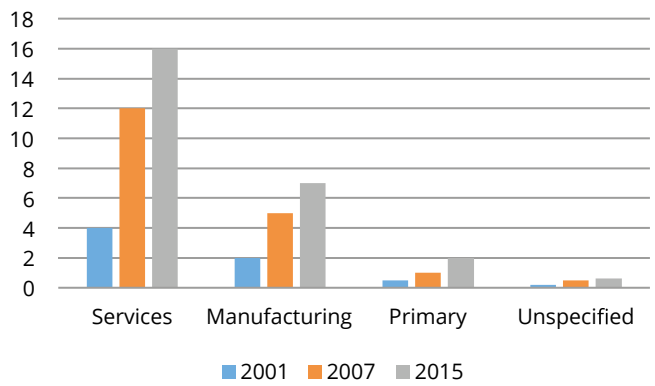


Fig. 1.6 Estimated global inward FDI stock, by sector (US$ tn)

Source: I-Com elaboration on UNCTAD (FDI/MNE database)



5 Source: The Conference Board, "International Comparisons of Manufacturing Productivity & Unit Labor Cost Trends," June 2016

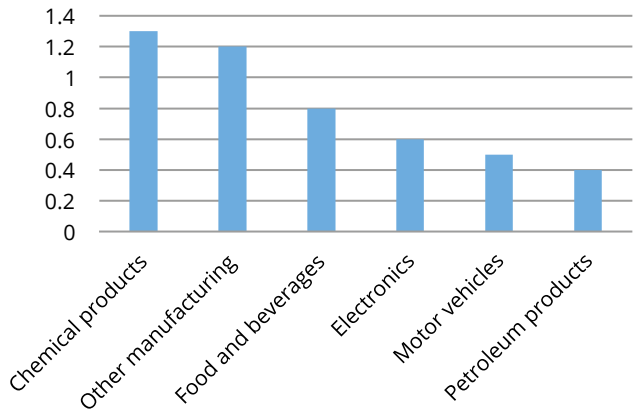
6 The Conference Board, "International Comparisons of Manufacturing Productivity & Unit Labor Cost Trends," June 2016

Overall, FDI rose from $6.7 trillion in 2001 to $25.6 trillion in 2015, a growth rate of 282%. The services and agriculture sectors increased the most (by 300%). FDI in manufacturing, instead, increased less than the average growth rate (by 200%). Then, if we consider the last year for which data is available, 2015, about two thirds of the amount of the FDI concerns the services sector, a value that is in line with the share of this sector in the global economy. Since the outbreak of the world financial crisis, the long-period shift of the FDI towards service sectors has stabilized. Instead, the primary and manufacturing sectors accounted for 6% and 26%, respectively. However, the high share of FDI concentrated in services represents a distorted picture of the importance of the sector. In fact, a big part of FDI in services is related to holding companies and regional headquarters that account for service sector by default, although parent companies might be active in manufacturing or agriculture.

However, the service sector makes up the largest part of FDI thanks to industries such as finance, business activities, trade and telecommunications. These sectors account for many trillion of dollars each year. For example, $5.6 trillion are concentrated in finance, $4.7 trillion in business activities and $2.6 trillion in trade. The manufacturing industry represents a lower FDI amount (Fig. 1.7). In fact, the chemical products sector has the highest stock of FDI at $1.3 trillion, followed by the residual category of "other manufacturing" at $1.2 trillion. Below $1 trillion of FDI, we find food and beverages ($800 billion), electronics ($600 billion), motor vehicles (500 billion) and petroleum products ($400 billion). These 5 industries,

Fig. 1.7 Global FDI stock in manufacturing, by major industry (US$ tn, 2015)

Source: I-Com elaboration on UNCTAD (FDI/MNE database)



that have been subject to the most important waves of international relocation and off-shoring production over the past decades, accounted for more than 70% of all FDI stock in specified manufacturing activities. There are also $1.6 trillion of unspecified FDI in manufacturing.

Yet, another way to evaluate the role of manufacturing in the global economy is to the take into account the value of cross-border M&A sales in the past years. As can be seen in Fig. 1.8, in the last decade, manufacturing competed with services as the most valuable sector in cross-border M&A sales. In the period 2008-2016, services show a value of $1.99 trillion, a growth rate of 17%, and manufacturing presents $1.85 trillion in value, a growth rate of 106%. In fact, manufacturing exceeded services in value of deals for the second year in a row ($403 billion in 2016 and $394 billion in 2015). This outcome has been boosted by some megadeals, such as the Anheuser-Busch Inbev – SABMiller

deal in the beverage industry. Therefore, manufacturing made an important contribution to the total value of cross-border M&A sales, that rose by about 18% to $869 billion in 2016. It represents the highest value since the outbreak of the global financial crisis. The composition of the value of cross-border M&As in manufacturing has changed over the past few years. Specifically, food, beverages and tobacco registered a significant increase (from $26 billion in 2015 to $138 billion in 2016), mostly due, as already mentioned, to the acquisition of SABMiller PLC. As well, electrical and electronic equipment increased its share in manufacturing M&As, from $27 to $74 billion in one year. Instead, because of a slowing in the "tax inversion" deals, M&As in pharmaceutical and chemical products slipped back. Pharmaceutical M&As dropped from $113 to $95 billion in 2015-2016 and chemical M&As from $49 to $35 billion. Machinery and equipment saw an increase from $24 to $31 billion.

In contrast, the contribution of the primary sector to the global value of cross-border M&A sales is much lower compared to the other sectors, declining over the past years.

Over the period 2014-2016, while cross-borders M&As were rapidly increasing their value, the value of announced greenfield investments instead rose modestly, probably because of the slow pace in the expansion of MNE

Fig. 1.8 Value of cross-border M&A sales, by sector (US$ bn, 2008-2016)

Source: I-Com elaboration on UNCTAD, cross-border M&A database

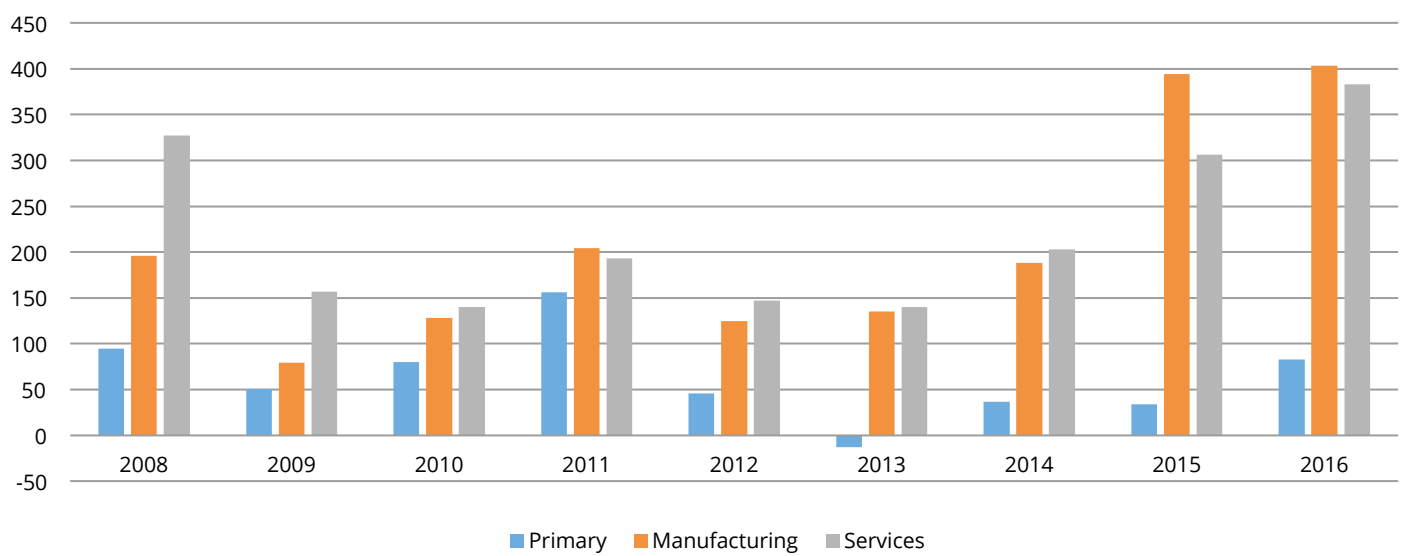
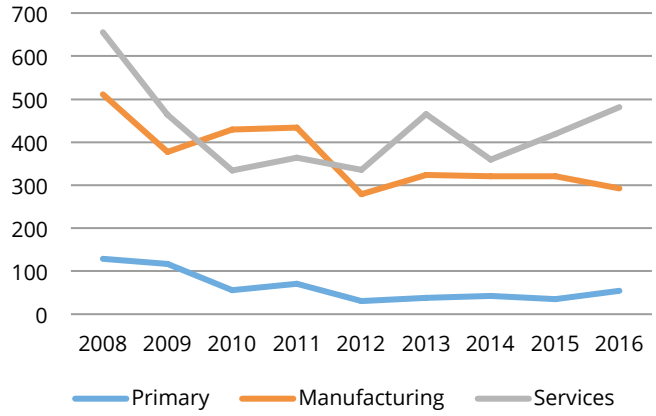


Fig. 1.9 Value of announced green¬field projects, by sector (US$ bn, 2008-2016)

Source: I-Com elaboration on UNCTAD data, based on information from Financial Times Ltd, fDi Market



production. In 2016, it increased by 7% to $828 billion, but this result was due to the investment performance in a small number of countries. On the contrary, the rest of the world saw a widespread decline. At the sectoral level, we can see diverging trends, despite, over the period 2016-2018, the decline of announced greenfield investments is generalized (Fig. 1.9). Greenfield FDI in services increased from $419 to $481 billion, resulting from a surge in construction investment in a few countries, and as well FDI in the primary sector rose, driven by some large announcements (for example, the Tengiz project in Kazakistan).

In contrast, all manufacturing industries suffered a deterioration. The stock of greenfield FDI announced in the sector fell by 9%, from $320 to $292 billion.

1.2. EU MANUFACTURING TRENDS BY SECTOR AND COUNTRY

The European Union is traditionally one of the strongest regional areas in the world for the manufacturing industry. It is also fully integrated into the international trade of goods. The EU is an important market for non-EU countries and EU Member States export high volumes of goods elsewhere.

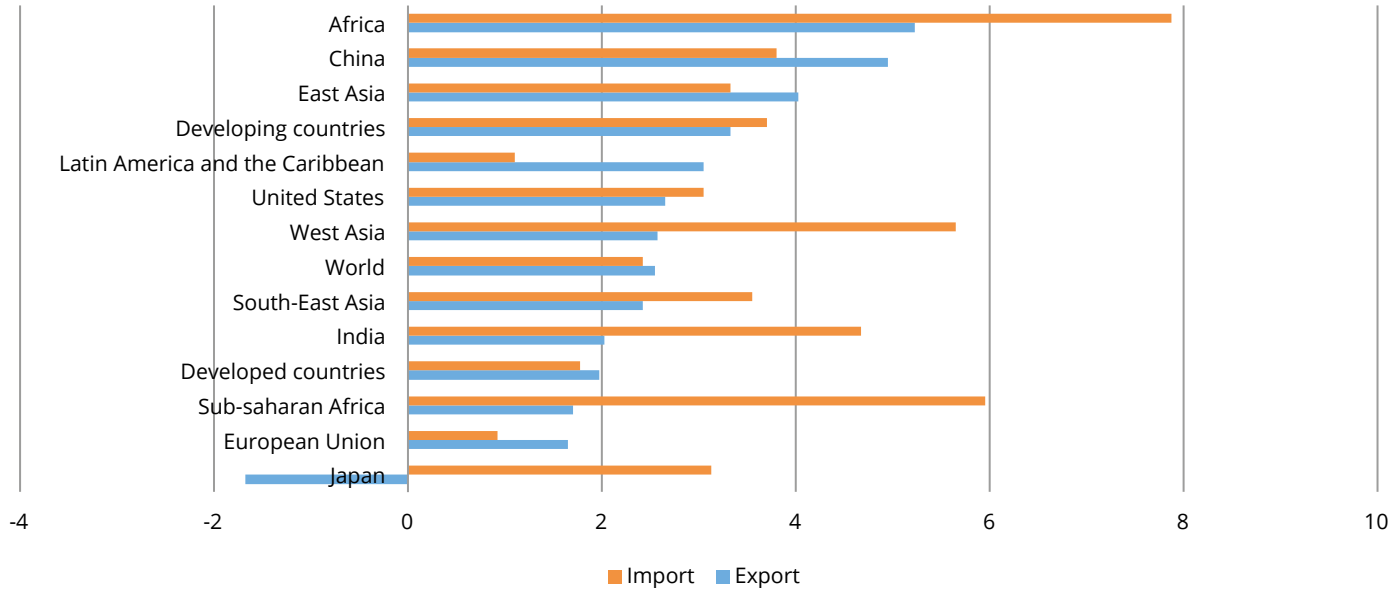
However, the manufacturing sector suffered from the economic crisis and is still recovering. Global exports grew at an average rate of 2.55% between 2012 and 2015 (Fig. 1. 10). The best performance was achieved by African countries, that exported on average 5.23% more in the period 2012-2015 than in the previous one. The Chinese export performance was also significant, with a growth rate of 4.95%, while India was notable did not exceed 2%.

In this context, with an average increase of 1.65%, the European Union underperformed even compared to the United States, whose exports increased by 2.65% between 2012 and 2015. Only Japan's performance was worse than Europe's, with exports falling by 1.68%. Nonetheless, concerning the European Union, the speed-up registered in 2015, pushing the yearly increase up to 3.2%, could represent an encouraging signal for the recovery of the EU export growth rate.

However, in the meantime the European Union sustained an even worse performance in its import growth rate, with only a 0.93% increase in the period 2012-2015. This can be interpreted as an alarm bell

Fig. 1.10 Export and import growth rates (%, 2012-2015)

Source: I-Com elaboration on UNCTAD data



regarding European domestic demand. All the other countries or regions taken into consideration exhibited import growth rates higher than Europe's (Fig. 1.10). Nevertheless, apart from the export growth rate, the European Union registered a recovery in 2015 (+3.6%), with an import growth rate much higher than the global average for the same year (+1.6%).

Signs of recovery in EU manufacturing, even if weak, can be confirmed if we look at the total manufacturing production index for EU countries (Fig. 1.11). In 2015-2016, only 3 countries, Portugal, Norway and Iceland, suffered a decline in total manufacturing production. On the other hand, the best performances in export growth occur in Slovenia (+7.7%), the Slovak Republic (+5.2%), Latvia (+4.8%), Denmark (+4.4%) and Poland (+4.1%). Even Greece, the country hit the hardest by the global financial crisis, succeeded in increasing its exports by 4% in the same period. In contrast on average, the Euro area shows a lower production growth rate at +1.5%. Similarly, the most developed countries in the EU present a lower percentage increase than the average in 2015-2016.

For example, Germany stands at 1.3%, Italy at 1.2%, France and the United Kingdom at 0.5%.

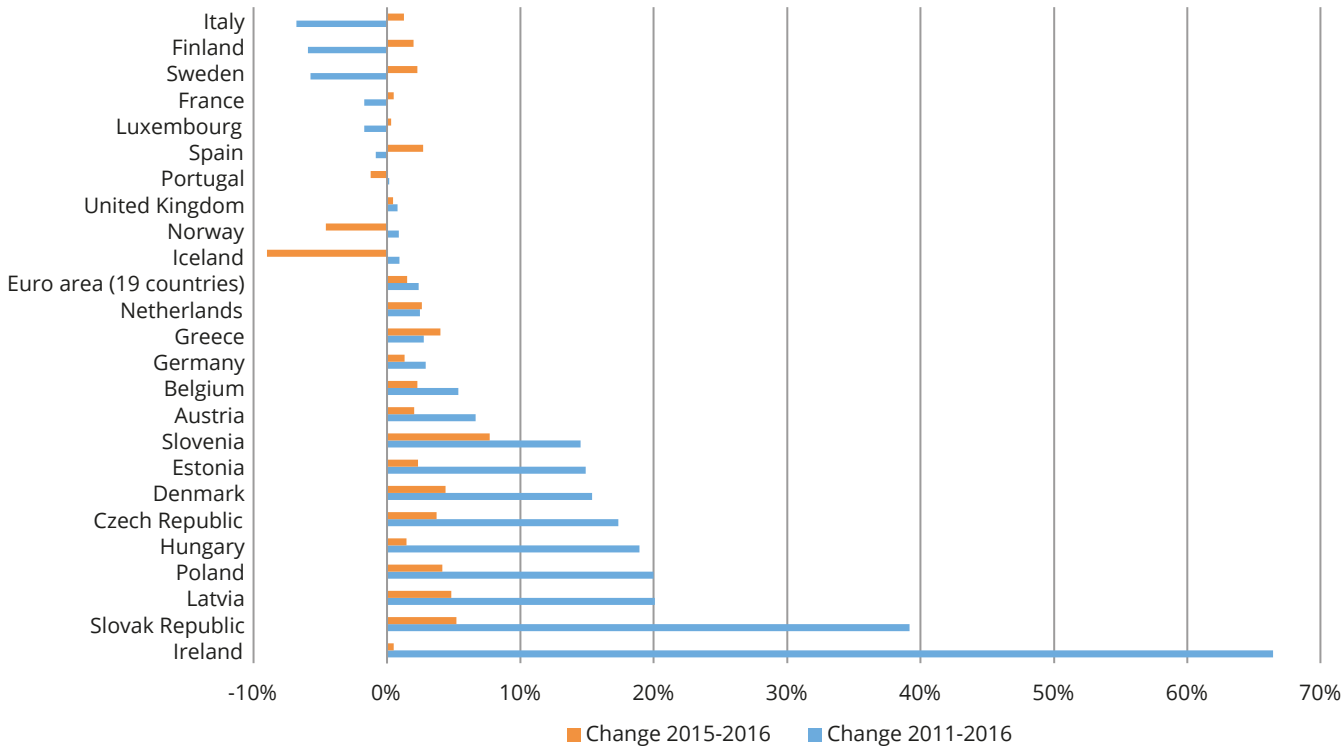
If we take into consideration a longer period, such as

that from 2011-2016, to see how European economies have coped with recovering from the financial crisis, the evidence appears mixed. Some countries appear to have been heavily hit by the economic downturn. In Italy, production in manufacturing diminished by 6.8% between 2011 and 2016. In the same period, also Finland (-5.9%), Sweden (-5.7%), France (-1.7%), Luxembourg (-1.7%) and Spain (-0.9%) showed a decreasing output in this sector. However, overall, the Euro zone recorded an average increase of 2.4%, Germany confirming the resilience of its economy with a growth rate of 2.9%. The countries with the best performance were Ireland (+66.4%, thanks to strong tax incentive policies), the Slovak Republic (+39.2%), Latvia (20.1%), Poland (20%) and Hungary (18.9%).

However, the European Union, in second position, still retains its role as a global power in the export of goods.

Fig. 1.11 Production in total manufacturing growth rates (%)

Source: I-Com elaboration on OECD data



In 2015, its exports amounted to €1.789 billion, less than China's (€2.056 billion), but higher than the United States (€1.548 billion)[7].

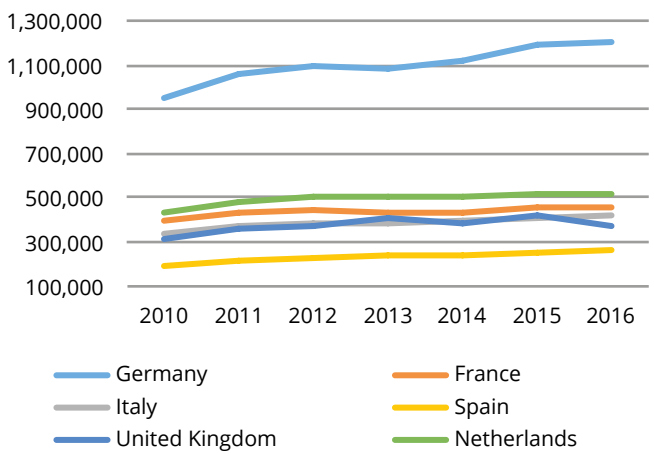
The EU held a world export share of exports of 15.5% in 2015[8], after China (17.8%, not including Hong Kong) and before the USA (13.4%). Japan and South Korea followed with 4.9% and 4.1%, respectively.

In 2015[9], the EU export/import ratio was 1, while the USA and India recorded a deficit at 0.7. Instead, China and Russia had a trade surplus, with a ratio of 1.4 and 1.9, respectively (Russia being heavily dependent on mining and energy).

We can also look at the EU Member States export trends in the period 2010-2016 (Fig. 1.12).

Fig. 1.12 Export in all products (€ bn, 2010-2016)

Source: I-Com elaboration on Eurostat data



Among the main countries, Spain shows the best performance (+35.9%), increasing exports from €192 billion to €261 billion, followed by Germany (+27.3%) and Italy (+23.6%).

Other countries experienced significant, but lower performances between 2010 and 2016. The Netherlands's exports rose by 19.2%, United Kingdom's by 18% and France's by 14.6%.

Moreover, if we focus only on 2016 compared to 2015, we may notice that United Kingdom suffered a relevant decrease of exports (-10.7%), and also France declined (-0.7%), while Spain (+2.5%), Italy (+1.2%), Germany (+1.1%) and the Netherlands (0.4%) showed a positive outcome.

To have a clearer view, it is important to also look at the level of exports by Member State (Fig. 1.13). In 2016, Germany was by far the leading country with €1.209 billion in total exports, followed by the Netherlands (€514 billion euros) and France (€452 billion), with Italy (€417 billion) and the United Kingdom (€370 billion) completing the top five. At the bottom of the ranking, we find some smaller economies, such as Estonia, Latvia, Malta and Cyprus, xporting approximately €10 billion or less.

Thanks to its significant stock of exports, Germany recorded a significant trade surplus, with €256 billion in 2016 (Fig.1.14), followed by the Netherlands (€59 billion) and Italy (€51 billion). Instead, several other developed EU countries, such as France and Spain (€65 and €20 billion, respectively) recorded deficits. However, it is the United Kingdom that registered the heaviest deficit within the EU (€204 billion). The UK trade deficit is largely due to huge product imports

7 Source: Eurostat
8 Eurostat
9 Eurostat

Fig. 1.13 Total product exports (€ bn, 2016)

Source: I-Com elaboration on Eurostat data

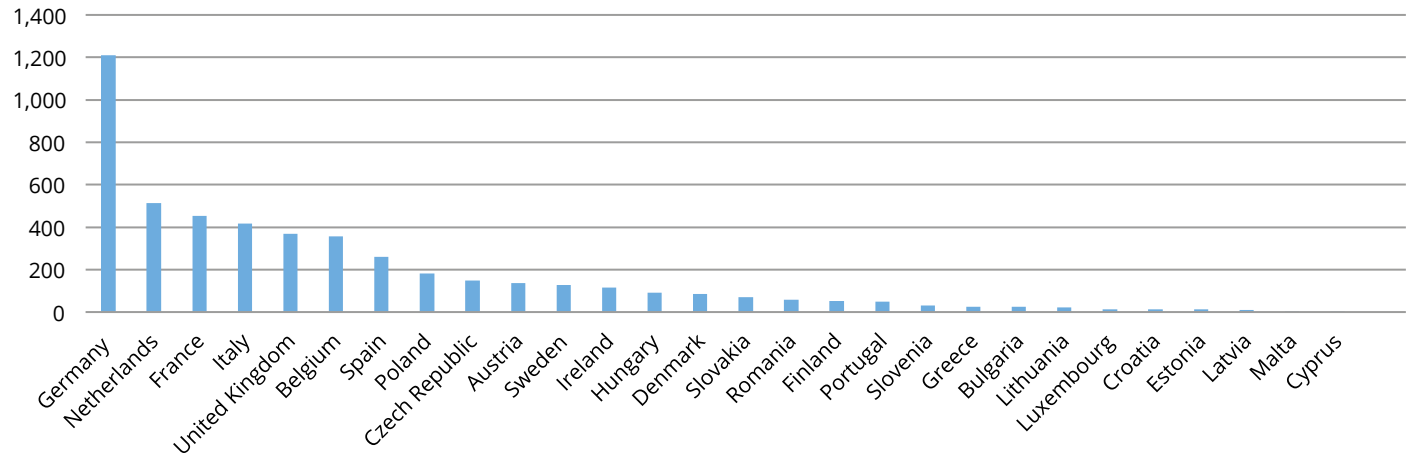
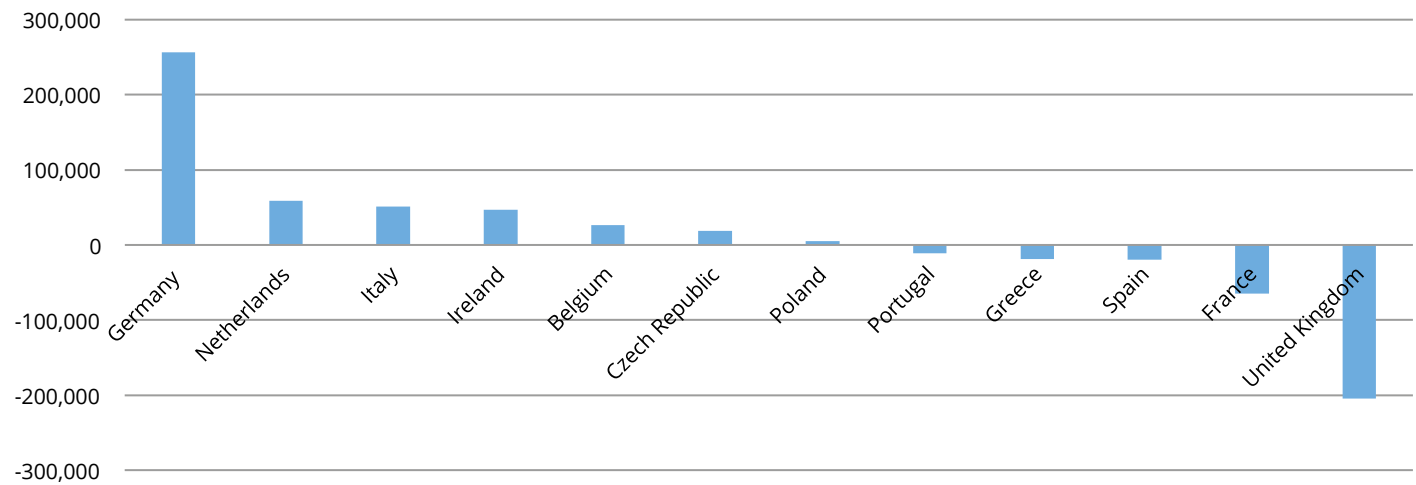


Fig. 1.14 Trade balance (€ million, 2016)

Source: I-Com elaboration on Eurostat data



in the following sectors: motor vehicles, trailers and semi-trailers and other transport equipment, chemicals, computer and electronics, machinery and equipment, food, electrical equipment, mining and quarrying.

Finally, we can see which are the leading export countries by product group, according to the SITC classification (Tab. 1.1). Taking into account the top five exporter countries by SITC product group, the countries that recur in the rankings are the Netherlands, Germany, France, Spain, Italy, Belgium, the United Kingdom and Ireland. Excluding Ireland, these are also the top 8 countries for exports in the EU[10]. If we look at the product group, the Netherlands is, by a small margin, the first exporter of food, drinks and tobacco and raw materials, as well as with the main share of the exports in mineral fuels, lubricants and related materials (26.7%). Germany comes second in the above-mentioned sectors, while being first in the remaining products – chemicals and related products, other manufactured goods, machinery and transport equipment, commodities and transactions not classified elsewhere in the SITC. In particular, Germany's performance in machinery and transport equipment is very significant. In fact, this country exports almost one third (31.5%) of the total European exports in the sector. This is a confirmation of the strength of the German mechanical industry. For

Tab. 1.1 Leading export countries, by SITC product groups (2016)

Source: I-Com elaboration on Eurostat data

Product by SITC	First exporter country and total export share	Second exporter country and total export share	Third exporter country and total export share	Fourth exporter country and total export share	Fifth exporter country and total export share
Food, drinks and tobacco	Netherlands (15.8%)	Germany (15%)	France (12.3%)	Spain (9.1%)	Italy (7.9%)
Raw materials	Netherlands (18.1%)	Germany (15.1%)	France (7.7%)	Spain (7.3%)	Belgium (6.7%)
Mineral fuels, lubricants and related materials	Netherlands (26.7%)	Belgium (11.3%)	United Kingdom (10.9%)	Germany (10.7%)	Spain (6.1%)
Chemicals and related products, n.e.s.	Germany (23.9%)	Belgium (13.1%)	Netherlands (10.6%)	France (10.4%)	Ireland (8.2%)
Other manufactured goods	Germany (22.3%)	Italy (12.1%)	France (8.4%)	Netherlands (8.3%)	Belgium (7.4%)
Machinery and transport equipment	Germany (31.5%)	France (9.5%)	Netherlands (8.8%)	Italy (8%)	United Kingdom (7.6%)
Commodities and transactions not classified elsewhere in the SITC	Germany (28.4%)	United Kingdom (21.1%)	Belgium (11.9%)	Italy (9%)	France (9%)

10 Source: Eurostat

machinery and transport equipment, France comes second at 9.5%, while Belgium is the second exporter both for mineral fuels, lubricants and related materials (11.3%), and chemicals and related products (13.1%). Italy has a good performance in "other manufactured goods sector", with a share of 12.1%.

1.3. THE INTAKE OF DIGITAL IN EU INDUSTRY: STATE OF THE ART

It is evident that the future of manufacturing is linked to the ability to integrate new digital technologies into its products and processes. The digitization of industries is creating new business models, boosting economic growth and productivity. Investments in digital goods and technologies are also increasing efficiency and sales and creating added value, and entrepreneurs are aware of this fact. According to the Global Manufacturing Outlook published by Forbes in 2016, to the question "In which of the following manufacturing technologies will you be devoting a significant amount of investment in R&D funds over the next 12 to 24 months?", between 30% and 39% of the manufacturers interviewed answered that they were planning to invest in additive manufacturing (3D Printing), robotics, artificial intelligence or cognitive computing, advanced material science and material bonding technologies (Tab. 1.2). Moreover, a percentage ranging from 32% to 44% of the sample said that they would possibly invest in the mentioned sectors, while a share ranging from 18% to 25% replied that they had already invested. Only a tiny percentage of respondents, between 4% and 12%, answered that they did not have any plan to invest at the present.

Tab. 1.2 In which of the following manufacturing technologies will you be devoting a significant amount of investment in R&D funds over the next 12 to 24 months?

Source: I-Com elaboration on Forbes data

	Yes, definitely	Possibly	No, because we have already invested	No, no plans at present
Additive manufacturing (3D printing)	31%	35%	25%	9%
Robotics	39%	32%	18%	11%
Artificial intelligence/ cognitive computing	30%	34%	25%	12%
Advanced material science	33%	43%	19%	5%
Material bonding technologies	33%	44%	19%	4%

Equally, to the question "In your best estimate, what percent of revenue did your organization spend in the last 2 years on R&D/innovation? What percent of revenue does it plan to spend over the next 2 years?"[11], 28% of the interviewed entrepreneurs answered that they estimate to invest between 6% and 10% of their revenue in R&D innovation. The percentage is greater than 10% for 21% of manufacturers (17% in the past

11 Source: Global Manufacturing Outlook, Forbes, 2016

two years). Therefore, the share of investments in R&D is increasing.

EU Member States are committed to attracting digital investments. In Germany alone, more than €70 billion were invested in ICT in 2015[12]. Many of the European countries are in leading positions for attractiveness, also thanks to favorable tax measures adopted in the last years. Concerning tax policies, Pwc, the University of Mannheim and the Centre for European Economic Research (ZEW) analyzed the tax attractiveness of locations for digital business across different countries in the world[13]. The result of the analysis is summarized in the *2017 Digital Tax Index*, which calculates the effective tax burden for basic types of investments in digital business, compared with tax burdens for traditional business, considering other relevant location factors such as infrastructure, employees and the degree of technology utilization. If we consider direct business taxation, Ireland, Italy and Hungary represent the most attractive locations (Tab. 1.3). Instead, Germany appears to be one of the less attractive countries for digital ventures.

Tab. 1.3 2017 Digital Tax Index

Source: I-Com elaboration on Pwc, University of Mannheim and ZEW data
Note: Δ = difference between digital and traditional business taxation

Country	Rank	Effective Average Tax Rate	Δ in ranking position	Δ in percentage points
Ireland	1	-10.32%	3	-24.44
Italy	2	-8.84%	20	-32.43
Hungary	3	-6.85%	11	-26.18
Latvia	4	0.33%	1	-13.94
Lithuania	5	0.44%	-2	-13.18
Belgium	6	2.28%	22	-26.07
Croatia	7	5.19%	2	-11.28
Romania	8	6.62%	-2	-8.11
Czech Republic	9	7.48%	1	-9.18
Norway	10	8.02%	11	-15.27
Switzerland (Zurich)	11	8.39%	1	-10.25
Cyprus	12	8.73%	-10	-4.38
Slovenia	13	9.51%	-6	-5.96
Bulgaria	14	9.52%	-13	0.52
Luxembourg	15	10.76%	9	-14.76
United Kingdom	16	11.11%	2	-10.44
Portugal	17	11.63%	8	-14.99
France	18	12.39%	15	-25.96
Poland	19	12.63%	-8	-4.86
Spain	20	12.85%	9	-17.43
Malta	21	13.12%	9	-19.12
Netherlands	22	13.61%	-3	-8.93
Denmark	23	14.81%	-6	-5.23
Slovakia	24	15.09%	-8	-4.48
Austria	25	15.16%	-5	-7.93
Finland	26	15.86%	-13	-3.04
Canada (Ontario)	27	16.05%	-4	-9.07
Estonia	28	16.27%	-20	0.57
Greece	29	16.73%	-3	-10.84
Sweden	30	16.93%	-15	-2.5
Germany	31	22.81%	-4	-5.41
USA (California)	32	22.82%	0	-13.7
Japan	33	25.46%	-2	-8.79
AVERAGE		10.20%		-11.73

12 Digital Tax Index 2017: Locational Tax Attractiveness for Digital Business Model, PWC, University of Mannheim and ZEW, 2017
13 Digital Tax Index 2017: Locational Tax Attractiveness for Digital Business Model, PWC, University of Mannheim and ZEW, 2017

The three leading countries, Ireland, Italy and Hungary, post negative effective tax rates at -10.32%, -8.84% and -6.85%, respectively. In these countries, digital investments are essentially subsidized. Negative effective burdens are due to the application of R&D incentives and Intellectual Property Box regimes, which make investments in digital more profitable after rather than before taxation. Thanks to these rates, these three countries hold the first three positions in the global attractiveness ranking for digital investments. However, there is a strong difference between Ireland, Italy and Hungary. Indeed, Ireland is traditionally a low-tax country (compared to the ranking for traditional investments, it edges up three places – see the third column of the table), so it is not surprising that it results as highly attractive. Instead, Hungary, and especially Italy, with their higher tax levels, have been able to reduce the effective burden for digital investments and to improve their attractiveness by using tax incentives. Therefore, they edge up 20 and 11 positions, respectively, compared to the ranking for traditional investments. Many EU countries (12) fall below the average digital tax rate, while Germany, the US and Japan are found at the bottom of the list. The extremely low level of attractiveness of the latter is caused by high tax rates or minor tax incentives or a complete lack of special regimes. These three countries show effective tax rates higher than 22%.

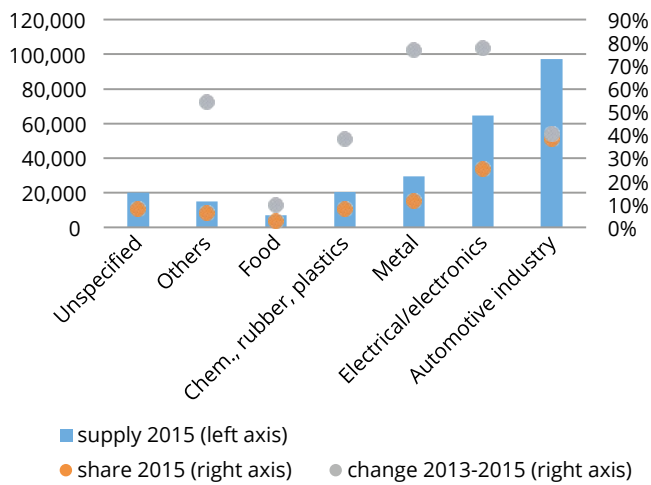
On average, digital business models are taxed at a rate of 10.2%, 11.7 percentage points less than the traditional business average tax rate, thanks to an assumed higher share of costs that do not require capitalization in investment structures (for example, software developed in-house and intangible assets) and favorable depreciation rules for digital capital goods as well as special tax incentives for research, development and innovation.

Nevertheless, in a context where the international big players are making huge investments in digitalizing their manufacturing sector, the European Union has still a large room for improvement.

This can be seen, for example, in the use of multipurpose industrial robots in production. The worldwide annual supply of industrial robots increased by 214% between 2003 and 2015 (from 81,000 to 254,000 units)[14]. The main driver of the growth in 2015 was general industry with an increase of 33% compared to 2014. The electronic industry (+41%), the metal industry (+39%), and the

Fig. 1.15 Estimated worldwide annual supply of industrial robots at year-end, by industry (2013-2015)

Source: I-Com elaboration on World Robotics 2016 data



14 Source: World Robotics 2016

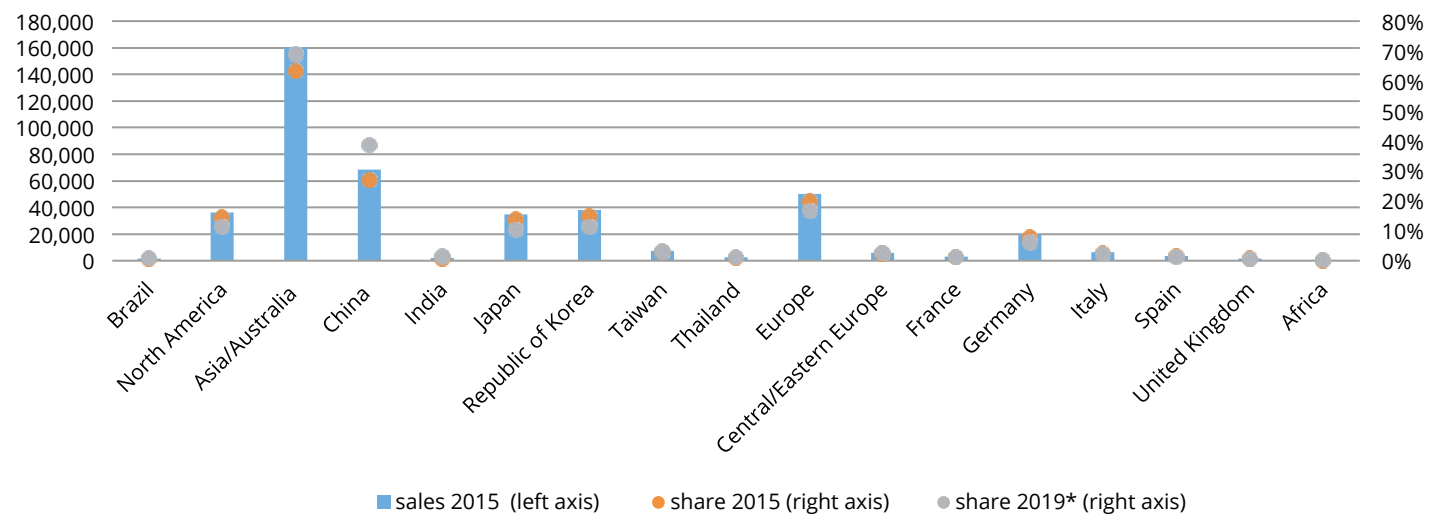
chemical, plastics and rubber industries (+16%) were the main drivers of this growth (Fig. 1.15). While for the automotive industry, robot sales in this sector only moderately increased in 2015 after five years of continual positive trends. However, the automotive industry is still the most important customer of industrial robots with a share of 38.5% of the total and sales increasing by 40% from 2013. Sales to the electrical/electronics industry (including computers and equipment, radio, TV and communication devices, medical equipment, precision and optical instruments) increased by 77.5% from 2013 to 2015, reaching 25.4% of the total supply.

Out of 254,000 robot units, 63.3% of the sales were in Asia and Australia (Fig. 1.16) and China alone accounted for 27% of the shipments of industrial robots in 2015, followed by the Republic of Korea (15.1%) and Japan (13.8%). While North America held only 14.4% of the market, with the EU19.7% representing the second largest regional market after Asia. Industrial robot sales in Europe increased by 10% to 50,100 units in 2015, a new sales peak. The countries that contributed the most to the European results were Germany (7.9%), Italy (2.6%) and France (1.2%).

However, the industrial robot market is highly concentrated globally. In 2015, the five main markets (China, Republic of Korea, Japan, the United States and Germany) made up 75% of the total sales volume. However, in 2015 China alone outdid Europe's total sales

Fig. 1.16 Estimated yearly shipments of multipurpose industrial robots in selected countries (No. of units)

Source: I-Com elaboration on IFR - national robot associations data
*Forecast



(68,800 units compared to 50,100 units) and the Asiatic robotics is expected to surge very quickly.

Where Europe is concerned, the German performance should be highlighted, representing the fifth largest robot market in the world. In the period 2010-2015, the annual sales of industrial robots rose by an average of 7% (CAGR) and in 2015 a new record was reached at 20,105 units. Nowadays, sales remain very high, despite a very high robot density (301 robot units per 10,000 employees)[15].

Moreover, Italy is the second largest robot market in Europe after Germany. In the global ranking, it was 7th in 2015 (as well as in 2014). Italian robot sales reached a new record in 2015 (6,700 units), increasing by 7% and recovering from the 2010-2013 downturn. France also registered an increase (even if smaller at 3%), but it is the Spanish performance which sets it apart, at least from the other Western European countries. Between 2014 and 2015, industrial robot sales increased by 63% to about 3,800 units. In 2015, robot sales also rose considerably in the Czech Republic and Poland. Instead, the United Kingdom revealed a negative trend, with sales slipping back to 1,645 units in 2015 from 2,094 units in 2014.

The worldwide annual supply of industrial robots is estimated to rise by 63% from 2015 to 2019 (from 254,000 units to 414,000 units). The share of Chinese robots is expected to increase from 27% to 38.6%, while North America and the EU will reduce their quotas from 14.4% to 11.1% and from 19.7% and 16.6%, respectively. Germany is expected to decrease its global share to 6%, Italy to 2.2% and France to 1.1%.

Overall, global competition is requiring an ongoing modernization of production facilities and China is affirming its leading position in continued innovation in robotics and automation. It is now up to Europe to pick up the challenge.

1.4. THE BENEFITS OF DIGITALIZATION FOR INDUSTRY

An overall methodology to measure the impact of digitization is still to be developed and it will be an important step, fundamental to support investment decisions and policy making. However, benefits of the increasing applications of digital technologies appear evident, not only economically, but also socially and politically.

Above all, digitalization boosts economic growth. Strategy& found that countries at the most advanced stage of digitization derive 20% more in economic benefits than those at the initial stage[16]. It has been pointed out that in over 150 countries an increase in digitization of 10% results in a 0.5% to 0.62% gain in per capita GDP[17]. The economic impact of digitization grows as countries accelerate to more advanced technological stages. Indeed, late digital economies benefit from a 0.5% increase in GDP per capita for every 10% growth in digitization, while, for the same increase in digitization,

15 Source: World Robotics 2016

16 Strategy&, "Maximizing the impact of digitization", 2012.
17 vd. supra

the advanced digital economies present a 0.62% gain in GDP per capita.

As well, the growing impact of technologies contributes to creating new jobs. An increase in digitization by 10% results in a decrease in the unemployment rate by 0.84%[18]. IT constitutes a critical finding both for developed economies, that have suffered from labour demand stagnation since the outbreak of the financial crisis, and for emerging markets, which need to create millions of new jobs in the next decades in order to ensure employment for the booming population of young people. Moreover, a 10% increase in digitization produces a 6% increase in the country's score on the Global Innovation Index[19]. This evidence shows a strong correlation between the country's improvement in digitization and its innovation rate.

As far as industry is concerned, companies investing in digitalization increase their chances of achieving better business performance, boosting their sales and their ability to penetrate foreign markets. In doing so, they increase their profits and investment. Specifically, the following benefits from digitalization for companies should be highlighted:

- opportunities for higher profits
- production of new products and services
- competitive advantages
- ability to achieve a global position
- more production flexibility
- faster response to demand changes
- ability to answer customer needs
- better cost optimization
- integration of the supply chain
- reduction in human error.

McKinsey identified 8 main value drivers of Industry 4.0[20]. In particular, they estimate: 1. a productivity increase from 3% to 5% through IoTs, real-time yield optimization and smart energy consumption; 2. a 20% to 50% reduction in time to market thanks to concurrent engineering and rapid experimentation and simulation; 3. an increase in accuracy forecasting supply and demand to 85% thanks to data-driven demand predictions; 4. a reduction in quality costs of10% to 20% due to statistical and advanced process control and digital quality management; 5. a decrease inventory costs from 20% to 50% thanks to in-situ 3D printing and real-time supply chain optimization and batch size; 6. an increase in productivity of technical professions through automation of knowledge work, human-robot collaboration and remote monitoring and control; 7. a reduction in total machine down-time thanks to machine flexibility, routing flexibility and remote control; 8. a reduction in maintenance costs of 10% to 40% through predictive and remote maintenance and virtually guided self-service.

Therefore, digitization is deeply changing how industry works. Technological disruption is transforming how industry carries out production and its operations, goes to market and interacts with customers, creating

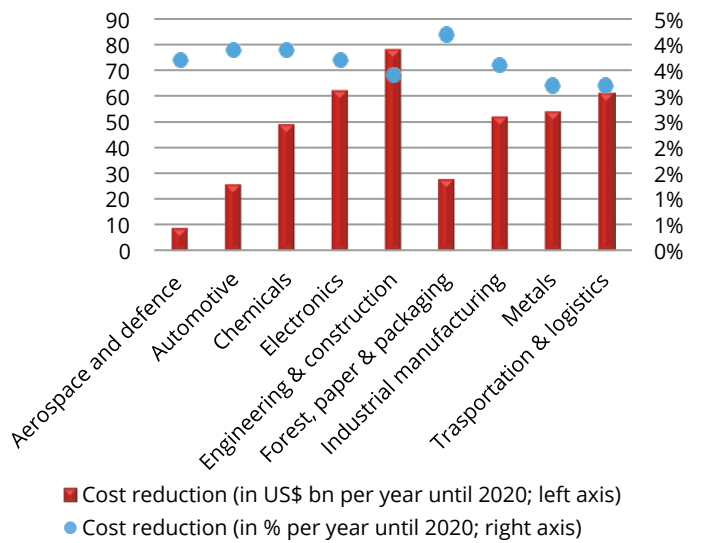
18 vd. supra
19 vd. supra

20 McKinsey Digital, "Industry 4.0: How to navigate digitization of the manufacturing sector," 2015.

new opportunities for value creation. From a company perspective, the reduction in costs is quite significant. Industries that invest in digitalization expect to reduce their operational costs by 3.6% on an average and to improve efficiency by 4.1% annually[21]. These estimates vary depending on the industrial sector in which the company operates (Fig.1.17). In fact, some sectors expect a cost reduction that is higher than the average (-3.6%): forest, paper and packaging (-4.2%), automotive (-3.9%), chemicals (-3.9%), aerospace, defence and security (-3.7%), and electronics (-3.7%). If we consider the cost reduction in US$ billion, engineering and construction (-78 US$ billion), electronics (-62 US US$ billion) and transportation and logistics (-61 US$ billion) are the industrial sectors that show wider margins for cost reductions.

Fig. 1.17 Cost reduction expected by industrial sector after digitization investments

Source: I-Com elaboration on Pwc data (2016 Global Industry 4.0 Survey)



These surveys also point out a competitive edge for the *first movers*. Indeed, the companies that have already made early investments in digitization and therefore are already at an advanced level of technology integration in their operations are more successful in combining high revenue growth with significant increases in cost reduction. These enterprises are likely to acquire gains in efficiency almost three times more than their competitors[22].

With regards to customer services, the Pwc study highlights that 72% of the companies that invested in Industry 4.0 succeeded in improving customer relations and customer intelligence along the product life cycle[23]. This was achieved by implementing actions such as using data analytics to meet customer requirements and improve operational performance; building a customer-focused supply chain; driving customer-centric marketing and channel access; customizing products all the way down to a lot size of 1; basing product/service development on customer specifications; introducing innovation in customer service.

Therefore, it is not surprising that the nine industries that are mentioned above are committed to making substantial investments in technology integration in

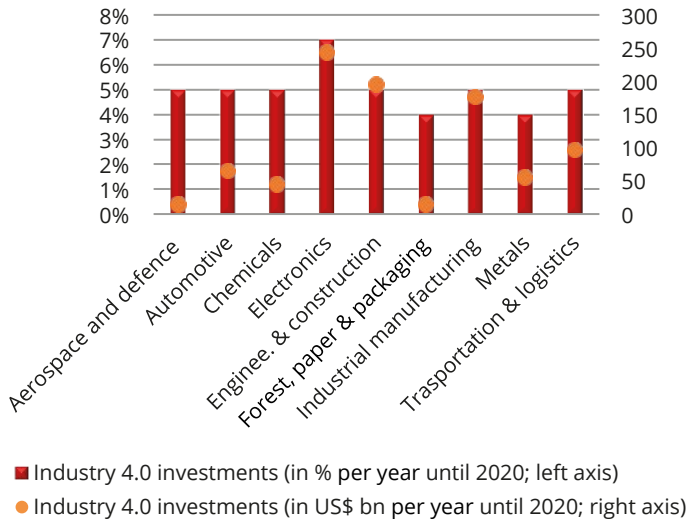
21 Pwc, "Industry 4.0: Building the digital enterprise. 2016 Global Industry 4.0 Survey", 2016.

22 vd. supra

23 Pwc, "Industry 4.0: Building the digital enterprise. 2016 Global Industry 4.0 Survey", 2016.

Fig. 1.18 Planned Industry 4.0 investments by industrial sector

Source: I-Com elaboration on Pwc data (2016 Global Industry 4.0 Survey)



the coming years. On average, they plan to invest 5% of their annual revenue for a total of 907 US$ billion in investments. The percentage of investments on annual revenues (Fig.1.18) is higher for the electronics sector (7% vs. an average of 5%), while, if we look at the total amount of investments, the industrial sectors which are expected to invest more are electronics (243 US$ billion), engineering and construction (195 US$ billion) and industrial manufacturing (177 US$ billion).

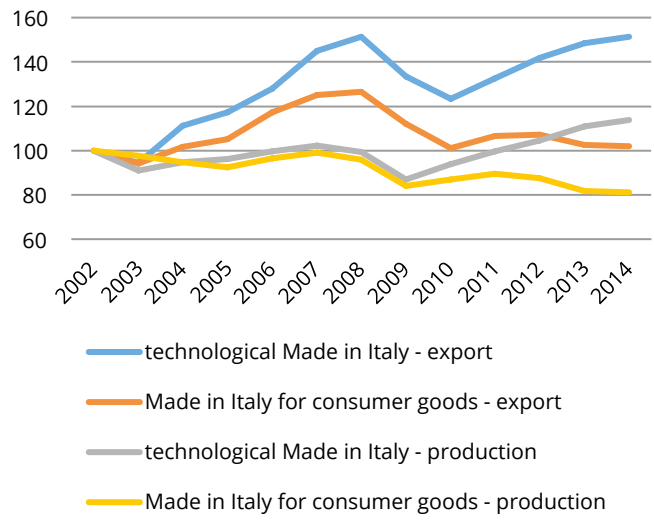
Most companies expect a short timescale to realize a positive Return on Investment (ROI). 55% believing that investments in Industry 4.0 technology will pay back within two years and only 8% expecting to wait more than five years for investments to pay for themselves[24].

We can look at some immediate examples from recent experience in Italy, taking into account the "Made in Italy" companies, which design, produce and package their products completely in Italy. We can distinguish between "Made in Italy for consumer goods" – Italian companies producing goods of common use – and "technological Made in Italy"[25] – Italian companies producing goods with technological added value.

From an analysis conducted by Fondazione Nord Est and Prometeia, it is evident that high-tech Made in Italy shows

Fig. 1.19 Export and production of *Made in Italy for consumer goods and technological Made in Italy* (2002=100)

Source: I-Com elaboration on Prometeia data

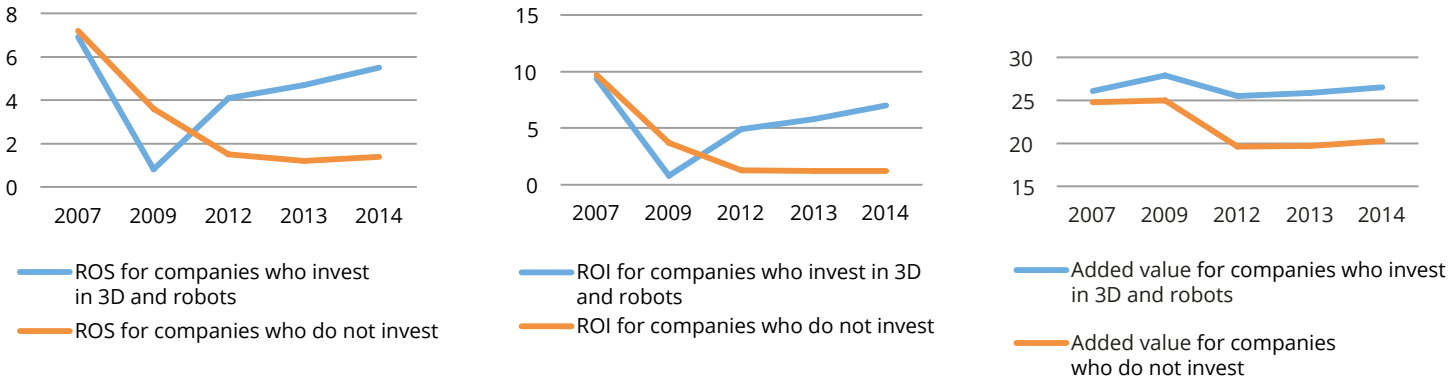


24 Pwc, "Industry 4.0: Building the digital enterprise. 2016 Global Industry 4.0 Survey", 2016.

25 Fondazione Nord Est and Prometeia, "Make in Italy. *Il 1° rapporto sull'impatto delle tecnologie digitali nel sistema manifatturiero italiano*", 2015.

Fig. 1.20 ROS, ROI and Added Value for Italian companies that invest or not in 3D and robots

Source: I-Com elaboration on Prometeia data



a better trend in production and exports (Fig. 1.19).

With reference to production, choosing 2002 as the base year, a diverging trend can be observed between the two types of Made in Italy. In fact, after 2002, Made in Italy for consumer goods started to decline and after the onset of the economic crisis fell even further, hitting a low in 2014 (81.1 in 2014 compared to 100 in 2002). Instead, technological Made in Italy showed a fluctuating trend after 2002, but recovered quickly from the economic crisis and reached a peak in 2014 (113.8 in 2014 compared to 100 in 2002). Even with regard to exports, we can highlight the same diverging trends. While Made in Italy for consumer goods recorded almost the same level of exports as in 2002 (102.1 in 2014 and 100 in 2002), technological Made in Italy exports were more than 50 points higher than twenty years previously (151.3 in 2014 compared to 100 in 2002). Therefore, investments in technology seem to bear fruit even if not so important for production and export growth.

Moreover, companies investing in new manufacturing technologies also seem to increase their profitability indices[26]. We are referring once again to Italian data. Overall, Industry 4.0 companies have higher *Return On Sales, Return On Investment* and *Added Value* compared to those companies that do not innovate their facilities (Fig. 1.20). ROS e ROI show a quite similar trend. In the short term, companies that do not invest in technologies have a higher return, but, in the long term, investments in technologies yield the best returns. In 2014, technology-driven companies presented a Return On Sales of 5.5% and a Return On Investment of 7%, while traditional companies displayed a ROS of 1.4% and a ROI of 1.2%. Added value displays an even more pronounced

26 Fondazione Nord Est and Prometeia, "Make in Italy. *Il 1° rapporto sull'impatto delle tecnologie digitali nel sistema manifatturiero italiano*", 2015.

trend. Added value for companies not investing in 3D technologies or robots had gradually been deteriorating (24.8% in 2007 and 20.3% in 2014), while, on the contrary, added value for technology-driven companies had been hit by the crisis, but quickly recovered (26.1% in 2007 and 26.5% in 2014).

PART 2

KEY DRIVERS AND PREPAREDNESS FOR CONNECTED INDUSTRY IN THE EU

2. KEY DRIVERS AND PREPAREDNESS FOR CONNECTED INDUSTRY IN THE EU

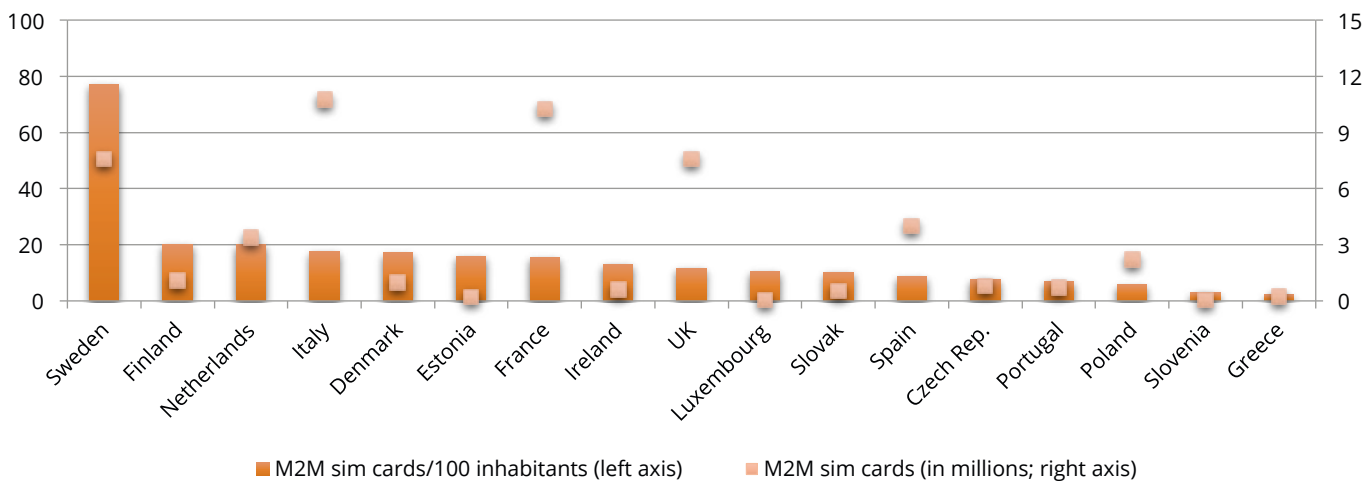
2.1. THE POTENTIAL FOR AN EFFECTIVE IOT'S PENETRATION IN THE MANUFACTURING INDUSTRY

The Internet of Things (IoT) describes the coordination of multiple machines, devices and appliances connected to the Internet through multiple networks. These include everyday objects such as smartphones, tablets and other consumer electronics, and machines such as vehicles, monitors and sensors equipped with Machine-to-Machine (M2M) connectivity allowing them to send and receive data. M2M describes the use of applications that are enabled by the communication between two or more machines. M2M technology thus connects machines, devices and appliances wirelessly via a variety of communication channels, including IP and SMS, to deliver services with limited direct human intervention. Today, in every EU country, M2M connections are quite widespread, ranging from 60,000 M2M sim cards in Estonia to nearly 11 million in Italy (Fig. 2.1). However, the Swedish figure is particularly striking as Sweden numbers 77 M2M sim cards per 100 inhabitants, a much higher level than for most other countries, immediately followed by Finland, with about 20 M2M sim cards per 100 inhabitants.

ICT has fast become an integral part of enterprise functioning and its extensive and intensive use,

Fig. 2.1 M2M-embedded mobile cellular subscriptions (2016)

Source: I-Com elaboration on OECD data



combined with new ways of accessing and using the Internet efficiently, characterizes what we refer to as the e-business integration.

These driving forces are decisive in the way enterprises run their business, organize internal communications, share information with business partners and communicate with customers.

In the following, the widespread important e-business integration technologies are analyzed – cloud computing services, radio-frequency technologies, enterprise-resource planning (ERP), customer-relationship management (CRM), and supply-chain management (SCM) solutions, and Big Data analytics (BDA) tools.

2.1.1. The adoption of IoT-linked technologies

Instead of building their own IT infrastructure which would include hardware and involve developing and maintaining software applications and databases, enterprises can access computing resources hosted by third parties on the Internet (the "cloud").

In technological terms, cloud computing is a model for providing enterprises with ubiquitous, flexible, on demand access over the Internet to a shared pool of configurable computing resources, including servers, databases, software applications, storage capacity and computing power.

Cloud computing can be seen as the technological evolution of server-based computing. The cloud function is an enormous networked server. Consequently, enterprises can use the services by accessing the Internet using devices ranging from relatively low-cost desktop computers to any number of various portable devices.

Cloud computing services should be delivered from service providers and, for ICT usage and e-commerce, an enterprise survey revealed the following mandatory characteristics:

- on-demand self-service: users may request computing resources without human interaction with the service provider;
- elasticity of provision: capabilities may be easily scaled up or down, e.g. in response to changes in the number of users or required storage capacity, so that enterprises can meet demand peaks without having to invest in infrastructure that will otherwise remain idle or underutilized;
- payable services (pay-per-user, pay-per-use or pre-paid).

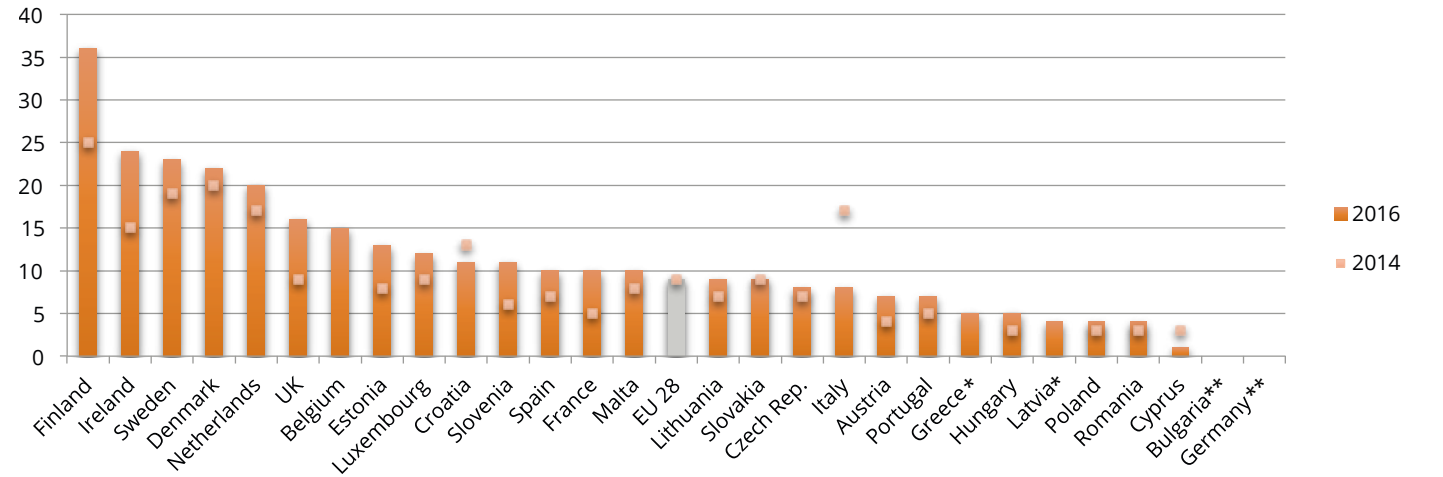
In principle, the service providers may deliver ICT-related services from shared servers (public cloud) or from a cloud infrastructure provided for the exclusive use of a particular enterprise (private cloud).

The most advanced cloud computing services include hosting of the enterprise's database, accounting software applications, CRM software and computing power.

In 2016, only 9% of EU manufacturing companies had purchased at least one of such services, with only Northern countries showing greater interest (Fig. 2.2). In Finland, 36% of manufacturing companies had already purchased a cloud computing service of medium-high sophistication (11 p.p. more than only two years before). In countries like Ireland, Sweden, Denmark and the Netherlands, at least one in five companies makes use of this, whereas

Fig. 2.2 Manufactuirng enterprises purchasing cloud computing services of medium-high sophistication (in %)

Source: I-Com elaboration on Eurostat data
* 2014 figure not available
** 2014 and 2016 figures not available



in all the other countries the degree of awareness among manufacturing companies is still quite low. In certain countries, the percentage of enterprises using high-level cloud computing services has even decreased.

The use of radio-frequency identification technologies is slightly more frequent across European manufacturing companies, 13% in 2014, a share that has tripled in the last 3 years (Fig. 2.3). These technologies include tags or transponders that can be applied to or incorporated into a product or object and transmit data via radio waves, making possible person identification, tracking of supply chain and inventory or after-sales product identification. There is a certain disparity across Europe. In certain countries (Austria, Germany, Finland), more or less one in four manufacturing companies has been using such technologies as of 2014, instead, in countries like Cyprus and Poland, only 5-6% of manufacturing companies recognize the importance of such solutions.

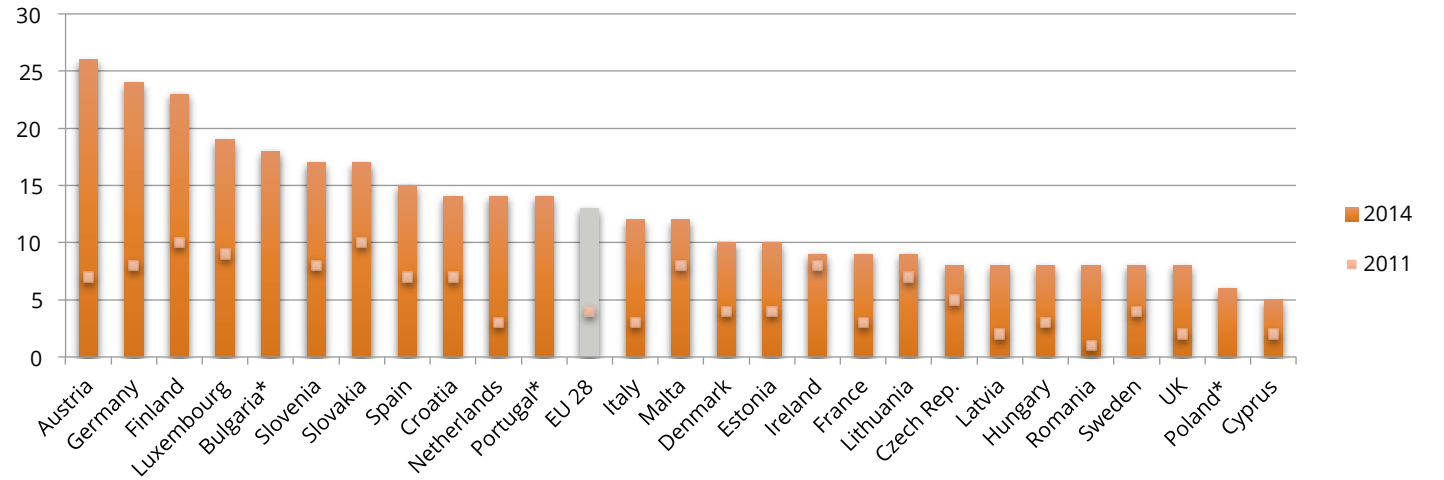
An enterprises' internal e-business integration refers to sharing information electronically and automatically between different business functions within an enterprise as opposed to external integration, where other business partners are involved. Internal integration allows companies to streamline and boost their efficiency.

Integration is implemented in various forms. One of them is data linking between various software applications, using a common database. The use of a single modular software application, enterprise resource planning (ERP), is another commonly-used alternative.

ERP software applications aim at facilitating the flow of

Fig. 2.3 Manufacturing enterprises using Radio Frequency identification (RFID) technologies (in %)

Source: I-Com elaboration on Eurostat data
* 2011 figure not available

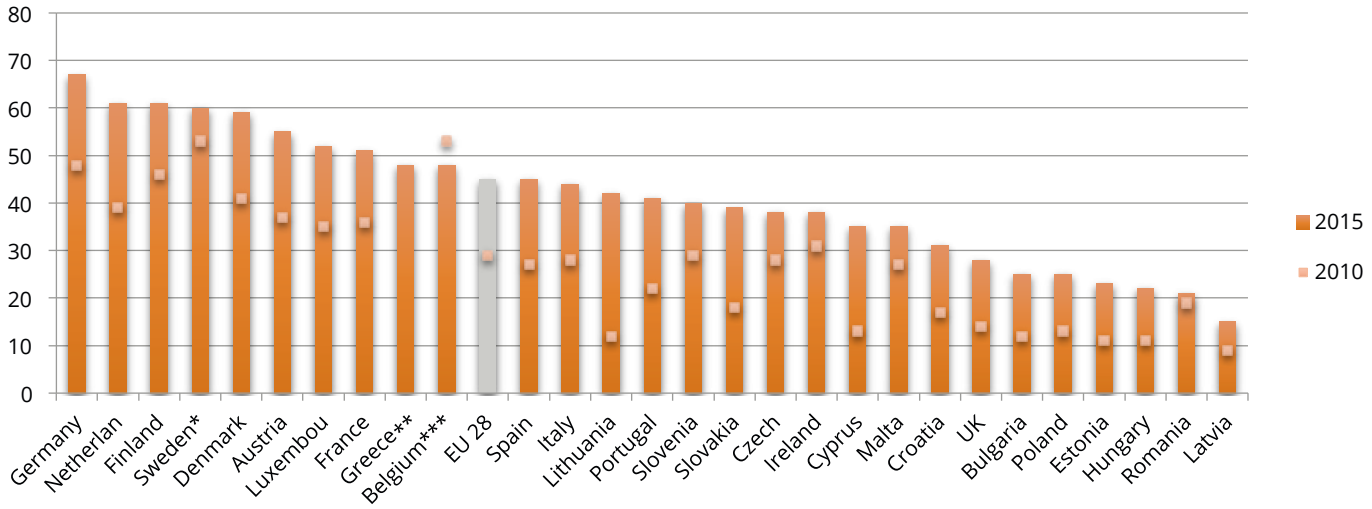


information and potentially the integration of internal and external management information across several functions of an enterprise. A characteristic of ERP is that it is delivered in "modules" that typically integrate processes relevant to planning, purchasing, marketing, sales, customer relations, finance and human resources. The percentage of EU manufacturing enterprises that used ERP software applications reached 45% in 2015, an increase of 16 p.p. compared to 2010 (higher than the average of all enterprises, i.e. 36%), with countries such as Germany (67%), the Netherlands and Finland (both 61%) leading the pack (Fig. 2.4). Eastern countries lag behind, as is the case of Latvia (15%), Romania (21%), Hungary (22%), Estonia (23%), Poland and Bulgaria (25%). Thanks to external integration, enterprises are able to streamline their marketing efforts and target their customers to maximize business potential. For this specific purpose, they use software applications to manage information about their customers, via customer relationship management (CRM) applications.

It is believed that the adoption of CRM improves marketing and sales performance by improving customer service and customer relations. For instance, improvements derive from providing user-friendly mechanisms for receiving complaints, identifying potential problems before they occur and, generally speaking, by facilitating communication with the customer and by anticipating customer preferences. These technology-enabled improvements lead to long-term customer satisfaction and can ensure increased customer loyalty, decreasing

Fig. 2.4 Manufacturing enterprises that have ERP software packages to share information between different functional areas (in %)

Source: I-Com elaboration on Eurostat data
* The figure is updated to 2014
** 2010 figure not available
*** The figure is updated to 2012



marketing costs and increasing sales. As shown in Figure 2.5, 33% of EU manufacturing enterprises used operational CRM software applications to capture, store and transfer available information about the enterprise's customers to other business functions.

Furthermore, a CRM software application can be used to analyze customer information to identify patterns of customer preferences and behavior (analytical CRM). This information is essentially used for marketing purposes, such as sales promotions that are effective in creating interest in a product or market penetration optimization through the use of alternative distribution channels.

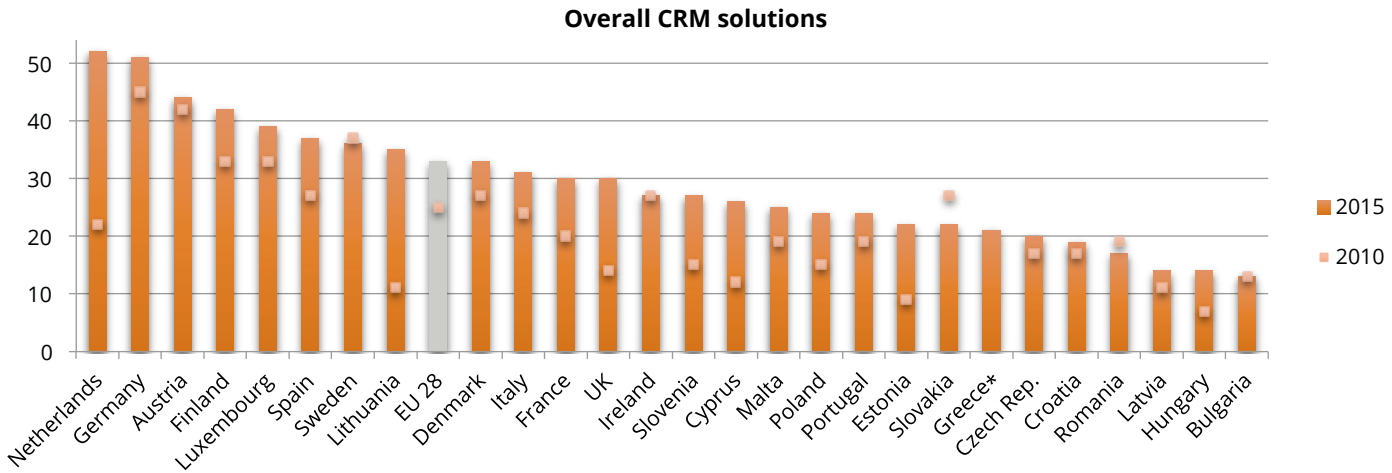
In 2015, 20% of EU manufacturing enterprises used CRM for such sophisticated analysis. Overall, adoption levels of analytical CRM are much lower than those of operational CRM.

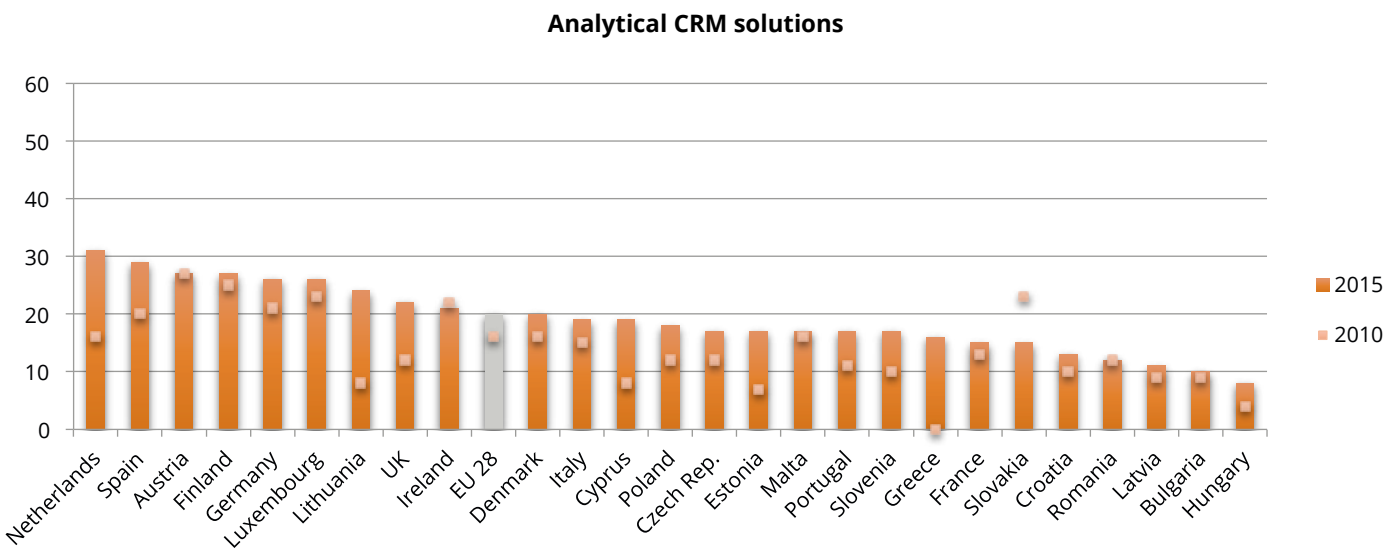
Compared with 2010, the use of CRM increased for both types of CRM regardless of enterprise size. In general, for many countries, further progress can still be expected as regards adopting CRM, because of both the potential benefits that customer-centric marketing practices may bring to enterprises and the integration of CRM with social media, expected to further boost the use of CRM applications.

Supply chain management (SCM) includes all activities involving the exchange of information between an enterprise and its suppliers and customers. This information may concern, for example, inventory levels,

Fig. 2.5 Manufacturing enterprises using CRM solutions (in %)

Source: I-Com elaboration on Eurostat data
* 2010 figure not available





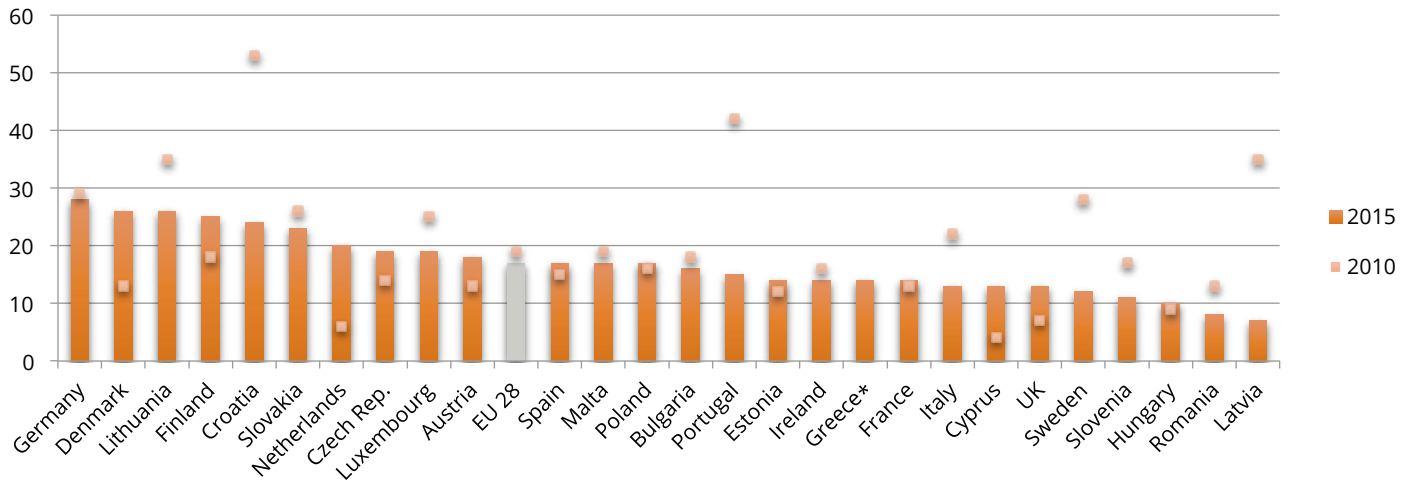
production plans and demand and supply forecasts or delivery times. Accordingly, the use of SCM software applications aims to effectively coordinate the availability and delivery of products to final consumers, in the right quantity, at the right time, into the right hands and at optimal cost. SCM actively involves all resources – business functions – concerned with planning and forecasting, purchasing, product assembly, logistics, sales and customer service. Depending on the industry served, SCM and ERP software applications may overlap to a certain extent. However, the former tend to focus more on financial information and material flows along the whole value chain of suppliers, manufacturers, service providers, distributors and customers.

The extent to which SCM information is shared across manufacturing enterprises varies among EU Member States, ranging from 7% in Latvia to 28% in Germany (Fig. 2.6). On average, only 17% of EU manufacturing companies used such business integration systems in 2015, less than five years before (19%), a decrease that is particularly significant in certain countries – Croatia, Latvia, Portugal and Sweden.

The production of huge amounts of data – as a consequence of more and more connections among devices – make it necessary for companies to be able to analyze this data so as to make it valuable. Analytics refers to the application of statistics and other mathematical tools to business data in order to assess and improve practices. In manufacturing, operations managers can use advanced analytics to go in-depth into historical process data, identify patterns

Fig. 2.6 Manufacturing enterprises whose business processes are automatically linked to those of their suppliers and/or customers (SCM; in %)

Source: I-Com elaboration on Eurostat data
* 2010 figure not available



and relationships among discrete process steps and inputs, and then optimize the factors that prove to have the greatest effect on yield. Many global manufacturers in a range of industries and geographies now have an abundance of real-time shop-floor data and the capability to conduct such sophisticated statistical assessments. They are taking previously isolated data sets, aggregating and analyzing them to come up with important insights. Manufacturers taking advantage of Big Data analytics can thus reduce process flaws, saving time and money.

As of 2016, only 7% of EU manufacturing companies analyzed Big Data from any data source (Fig. 2.7). The Netherlands, Malta, Finland, the UK, Luxembourg and Lithuania are at the forefront of Big Data Analytics (BDA), with more than 1 in 10 companies using BDA techniques. Overall, the level of IoT deployment across Europe and in the big five countries still remains disappointing. Whereas most common integration systems – such as ERP, CRM and SCM systems – are quite widespread across manufacturing companies, much less common is the use of RFID systems, cloud computing services of a medium-high sophistication level or BDA tools. On average, only 13%, 9% and 7% of European manufacturing companies are currently employing RFID, high-level cloud computing

Fig. 2.7 Manufacturing enterprises analyzing big data from any data source (2016; in %)

Source: I-Com elaboration on Eurostat data

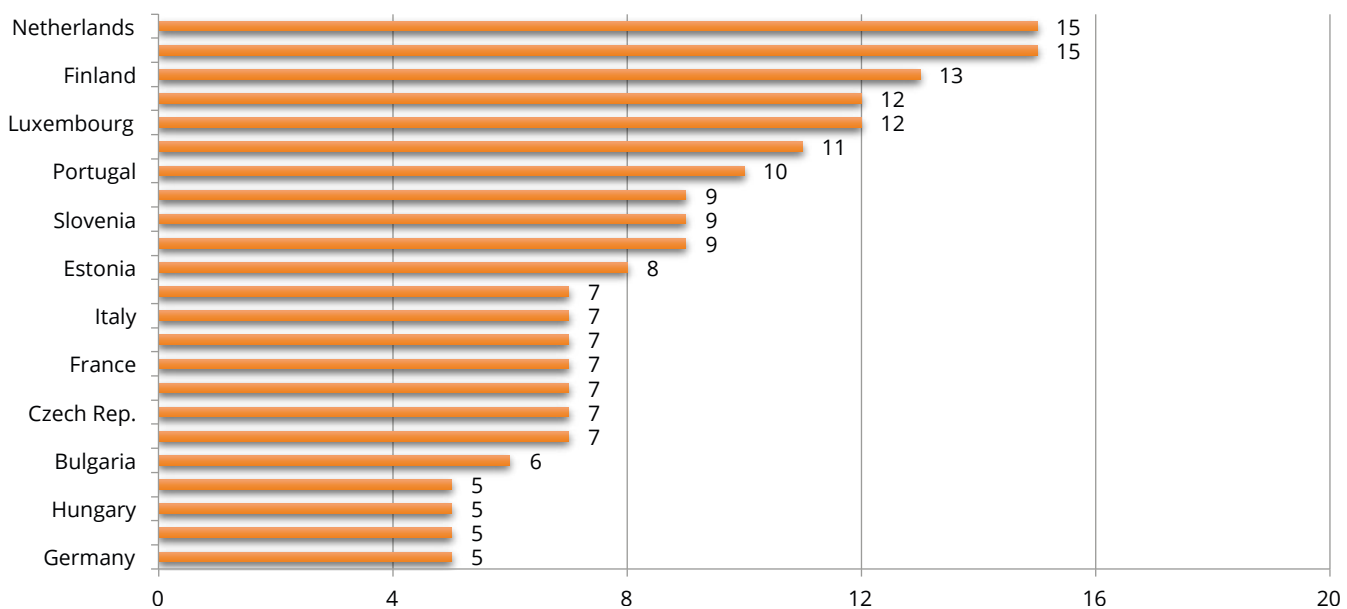
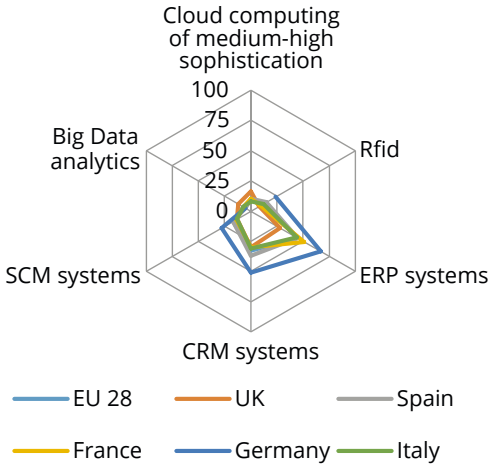


Fig. 2.8 IoT deployment in the manufacturing industry (2016)

Source: I-Com elaboration on Eurostat data



and BDA solutions, respectively (Fig. 2.8). Germany is at the forefront in Europe, although there still remains much to be done even there.

2.1.2. The ultra-broadband coverage and 5G deployment

Behind the spread of these technologies, however, there is the need for extensive and fast connectivity. For the fixed ultra-broadband network, in 2017, 76% of the EU population was on average covered (+14 p.p. over 2014), with Malta, Belgium and the Netherlands topping the ranking with almost 100% coverage (Fig. 2.9). The performance of larger countries – such as Germany, Spain, Italy and France – is more lackluster.

This is quite disappointing, especially if we consider the

Fig. 2.9 NGA Coverage, by country (population %)

Source: I-Com elaboration on Eurostat data
* 2017 figure not available

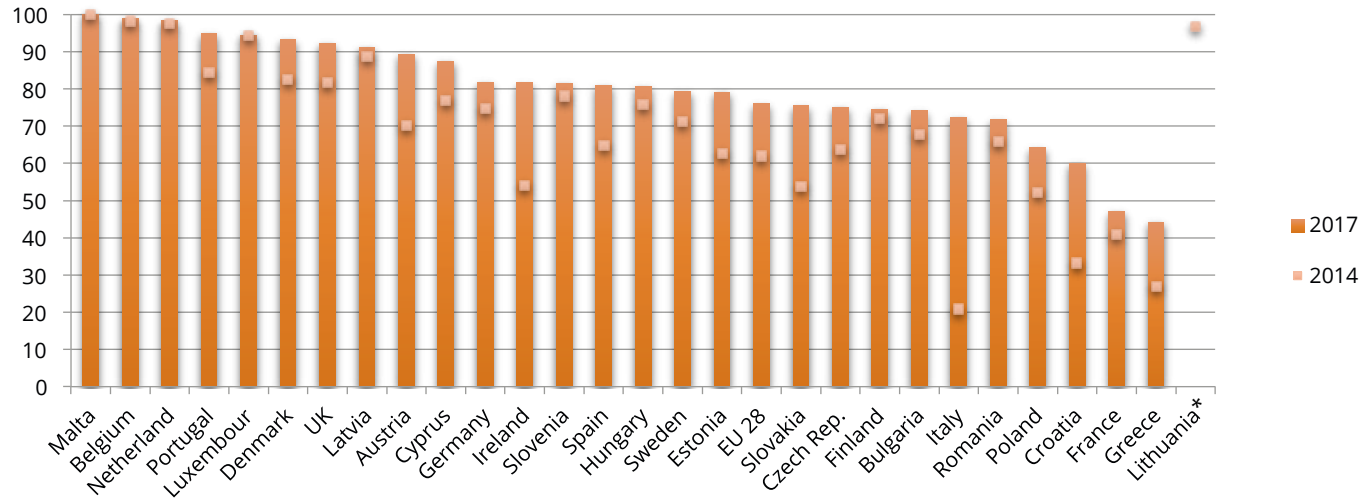
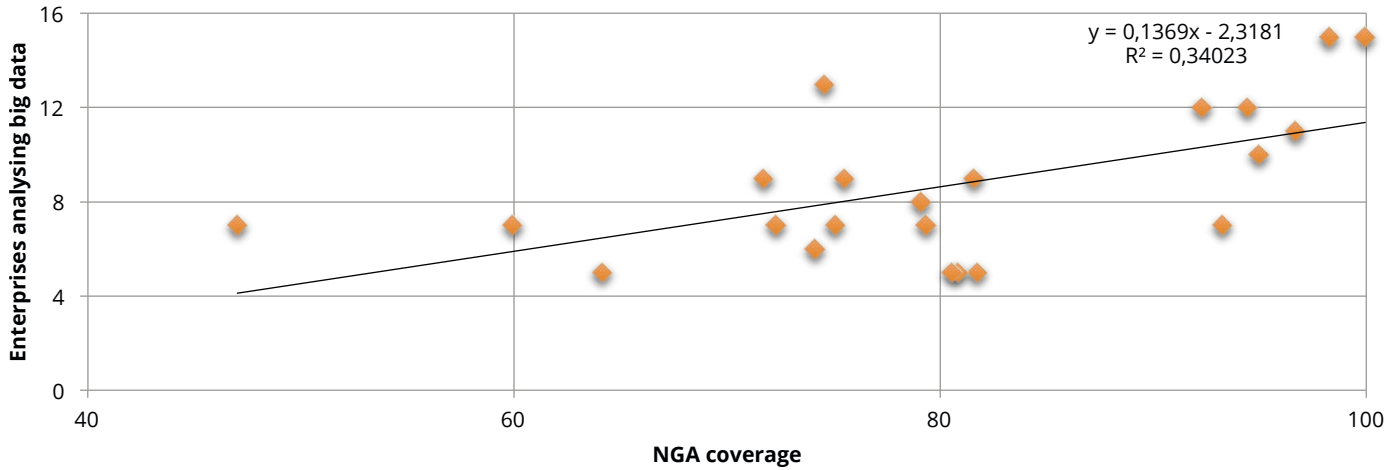


Fig. 2.10 Relationship between NGA coverage and BDA across EU manufacturing companies

Source: I-Com elaboration on Eurostat data



linkage existing between connectivity and the ability of companies to analyze data, which is becoming over time – as argued before – one major source of business value. As Figure 2.10 shows, 10 percentage points (p.p.) more in NGA coverage approximately yields a 1.5 p.p. increase in the share of companies analyzing Big Data (even if we have to consider that such a correlation doesn't imply a causation).

5G deployment in Europe: vertical sectors and focus on 5G implementation in industry

We are living in a society where everything will be connected, video and data volumes will increase and technologies will face new challenges ensuring high performances. In this revolutionary contest, 5G is the new generation of radio systems and network architecture that will revolutionize citizen/consumer lives and business productive systems.

5G is, indeed, the next chapter of telecom networks designed to meet a more advanced and more complex set of performance requirements, being able to support more users, more devices, more services and new use cases through more efficiency and speed.

In particular, a wide range of benefits stemming from 5G can be identified: 1) data rates up to 100 times faster (more than 10 Gbps); 2) network latency lowered by a factor of five; 3) mobile data volumes 1,000 times greater than today; 4) battery life of remote cellular devices stretched to 10 years or more; 5) increase in the number of devices connected to the network (1 mill. per 1 km^2); 6) possibility of use of several bands from 400 MHz to 100 GHz.

Therefore, 5G technology will allow the development of new services – among them, IoT is one of the most important – bringing progress, welfare, jobs and new opportunities for businesses but also for citizens.

The paper *"5G empowering vertical industries"*[1] underlines opportunities connected to 5G development in sectors such as transport, healthcare, energy and media and entertainment, showing that, in general, the digitization of factories will be a key issue for the 2020s. With reference to the transport sector, Automated driving, Share My View, Bird's Eye View, Digitalization of Transport and Logistics and Information Society on the road are the main use cases identified in the automotive industry. 5G technology will ensure performances able to support these cases and many new applications, such as tele-operated driving – where a disabled individual could be driven with the help of a remote driver in areas where highly automatic driving is not possible – generating new opportunities for disabled people and enhancing safety for frail and elderly people during complex traffic situations. In a context where industry will produce advanced driver assistance systems and complete autonomous driving cars – which will guarantee less fatal accidents, less traffic congestion, less congested cities and new important business opportunities – the performance of 5G (above all in terms of latency and data transfer) will be essential.

Where the health sector is concerned, 5G will allow assisted self-management capabilities, ensuring the empowerment of less qualified personnel to conduct routine tasks on the behalf of higher qualified professionals, a massive utilization of robots by surgeons (by cutting latencies and allowing the remote use of these robots from everywhere) and personalized medicine, contributing also to cost cutting. The "European green paper on m-health" (2014) underlines a potential reduction in healthcare costs, through m-health, by 15% and possible benefits on the effectiveness and efficiency of the delivery of care.

The energy sector will also benefit from the opportunities related to 5G implementation. Grid access, Grid backhaul and Grid backbone are the main factors identified for the energy sector. Considering that the physical infrastructure will need to support a two-way energy flow originating from the distributed energy resources, which in turn implies new needs for communication technologies, intelligence, business models and market structure, 5G will be crucial in order to achieve this goal.

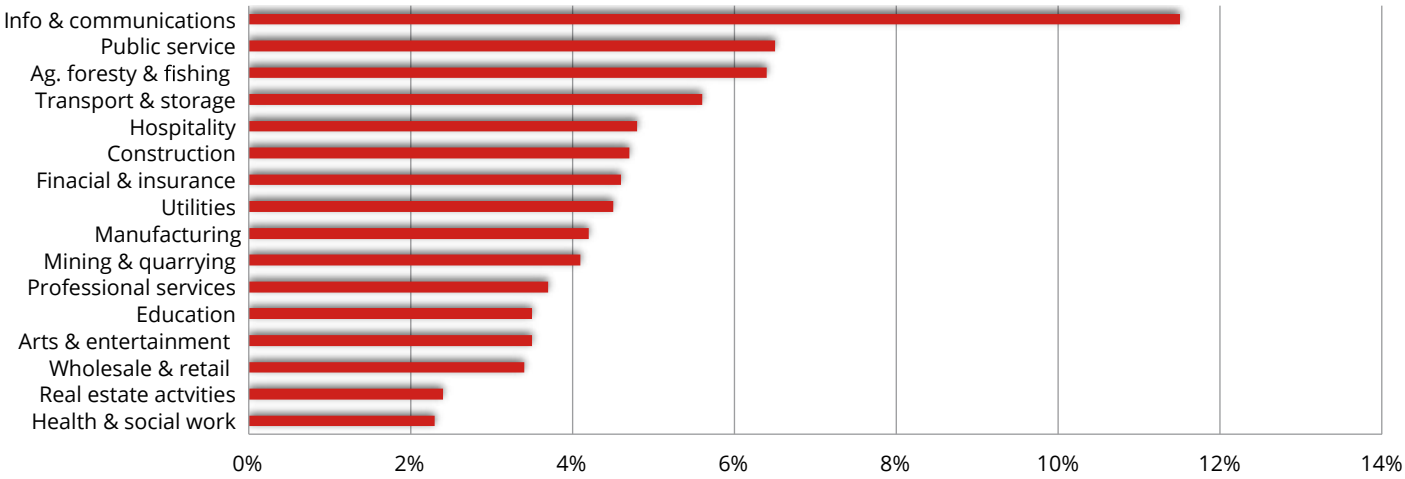
Finally, within the media and entertainment sector, 5G, integrating different network technologies – including unicast, multicast and broadcast – and capabilities, will enable at least six main families of M&E use cases in the 2020s. Specifically, these will include Ultra High Fidelity Media, On-site Live Event Experience, User/Machine Generated Content, Immersive and Integrated Media, Cooperative Media Production and Collaborative Gaming.

According to the IHS 2017 estimates, 5G will enable $12,300 billion in global economic activity in 2035 (2016 US$), equal to 4.6% of global real output for that year. In

1 5G-PPP, 5G Empowering vertical industries, February 2016, available at https://5g-ppp.eu/wp-content/uploads/2016/02/BROCHURE_5PPP_BAT2_PL.pdf

Fig. 2.11 Percentage of 5G-enabled expected output on total sector production in 2035

Source: I-Com elaboration on IHS forecasts



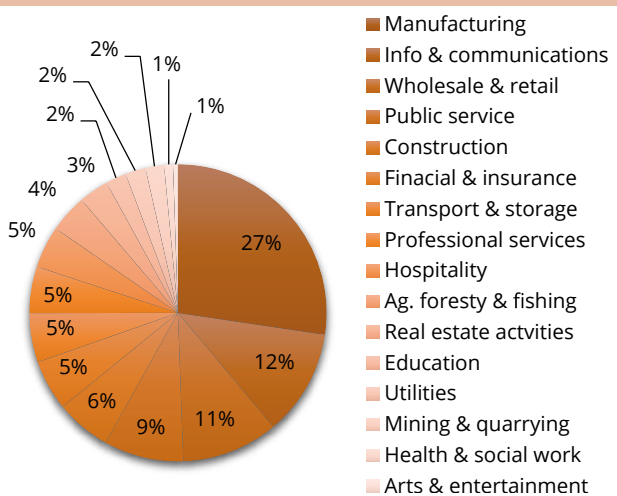
percentage terms, the impact of 5G-enabled output varies from 11.5% in the information and communications sector to a minimum of 2.3% in the health and social services sector (Fig. 2.11).

In 2035, manufacturing, at $3,364 billion, is expected to achieve the largest share of 5G-enabled economic activity (Fig. 2.12).

5G will be a very important technology for Industry 4.0 deployment. Industry 4.0 is the theorizing of a manufacturing paradigm based on the concept of "Cyber Physical System" (CPS), characterized by IT systems with computational and communication capabilities that can interact with the physical systems in which they operate. In particular, there are five technology areas considered strategic for the implementation of Industry 4.0:

Fig. 2.12 IoT deployment in the manufacturing industry (2016)

Source: I-Com elaboration on Eurostat data



1) Collaborative Robotics; 2) "Digital Factory"; 3) Advanced control and supervision of the production process; 4) Internet of Things and Big Data; and 5) Cyber Security.
In this new context planning, detection and reaction activities are completely innovated.
The ability to connect systems, but also businesses and citizens/consumers, to the network through a more operational way is a basic requirement.
In this context, 5G features are an extraordinary opportunity for industry. New automated technologies – industrial robots and autonomous driving systems for example -require a quick response from the system and the increase of connected devices – IoT development – need a high performance from communications network. The new generation of "mobile" connections must ensure a speed of 100 to 1000 times faster than 4G and low latency, allowing the efficient connection of a very high number of devices. This will be one of the most important drivers for the future of the industrial sector.

5G implementation: technological and regulatory issues. Initiatives in EU Member States

In this changing context, European institutions, led by the European Commission, are aware of the opportunities arising from the spread of digital technologies.
In considering the obstacles to be overcome to fully exploit the opportunities associated with the digital revolution in Europe, in March 2015, the Commission developed a strategy to create a Digital Single Market. The Digital Single Market Strategy is built on three pillars: 1) better access for consumers and businesses to digital goods and services across Europe; 2) creating the right conditions and a level playing field for digital networks and innovative services to flourish; 3) maximizing the growth potential of the digital economy.
In view of the importance of telecommunication network deployment, the "5G Manifesto for timely deployment of 5G in Europe" (July 2016), endorsed by several leading businesses, states that standards and coordination regarding European stakeholders for pre-commercial trials are very important for 5G development, proposing a two-phase trial roadmap – one before 2018 and the other during 2018. The first phase specifically requests the setting up of technology trials run by independent trial consortia in various countries – involving also vertical industries – independent of standardization status, to demonstrate and validate new 5G capabilities; the second phase, instead, is focused on the conclusion of an agreement on trial specifications (use-cases, interfaces, scenarios, agreement to transfer use-cases across trial networks) among European stakeholders valid for pan-European trials to demonstrate wider interoperability and support for vertical use-cases in order to attract global public attention.
On September 14, 2016, the European Commission published the Communication "5G for Europe an Action Plan" and the working document "5G Global Developments" which accompanied the first document, presenting a short summary of 5G developments worldwide and of the main issues which impact on the anticipated deployment of 5G networks. In the Action Plan, the Commission outlined several key elements such as the importance of aligning

roadmaps and priorities for a coordinated 5G deployment across all Member States. Indeed, 5G deployment demands substantial investments and a coordinated approach which involves a harmonization of standards and global consensus on the choice of technologies, spectrum bands and a shared roadmap.

To encourage a coordination at EU level, the Commission has identified the following eight actions:

1) the promotion of preliminary trials from 2017 onwards and pre-commercial trials with a clear cross-border dimension from 2018, encouraging the adoption by Member States of national 5G deployment roadmaps and the identification of at least one major city to be "5G enabled" by the end of 2020;
2) the definition – in accordance with Member States – by the end of 2016 of a list of pioneer spectrum bands for the initial launch of 5G services;
3) the adoption of an agreement on the full set of spectrum bands (below and above 6GHz) to be harmonized for deployment of commercial 5G networks in Europe;
4) the establishment of roll-out and quality objectives for monitoring the progress of key fibers and cell deployment scenarios identifying actionable best practices to facilitate – also incrementing administrative conditions – denser cell deployment. The planned 5G networks will serve up to one million connected devices per square kilometer and the resulting traffic increase per network access point will require increasingly smaller cells to deliver the planned connectivity performance and an increase in the density of antennae deployed;
5) the promotion by the end of 2019 of the availability of the initial global 5G standard, the standardization of radio access and core network challenges and the conclusion of cross-industry partnerships;
6) the planning of technological experiments and their creation as early as in 2017 and the presentation of detailed roadmaps by March 2017 for the implementation of advanced pre-commercial trials.
7) the encouraging of Member States to consider the usage of 5G infrastructures to improve the performance of communication services used for public safety and security;
8) the identification of assumptions and modalities for a venture financing facility.

5G deployment is a priority for Europe and for the world, in general. Several 5G industrial public private partnerships were launched between 2013 and 2015, involving leading operators, vendors, universities, and research institutes in the field of mobile communications – in particular, the IMT- 2020 (5G) Promotion Group in China (2013), the 5G Forum in the Republic of Korea (2013), the 5G Mobile Communication Promotion Forum (5G MF) in Japan (2014) and in the USA (2015).

Considering 5G deployment as a policy priority, many EU Member States are setting up initiatives to promote research and investments on 5G networks.

In Autumn 2016, a National Productivity Investment Fund (NPIF) was created in the **United Kingdom** to meet investment and innovation requirements. Between 2017 and 2022, the NPIF will provide GBP 23 billion in additional

spending in the following key sectors – transport, communications, R&D and housing. The government will invest GBP 740 million in fiber broadband and 5G network trials by 2020-2021. On March 7th, 2017, the DCMS (Department for Digital, Culture, Media & Sport) published a report on the 5G strategy for the UK where the Government announced GBP 270 million in major disruptive technologies including robotics, biotech and autonomous cars, a new national 5G Innovation Network to trial and demonstrate 5G applications and an initial investment of £16 million for a cutting edge facility with the technology to run the trials, delivered through cooperation between leading 5G research institutions during 2017/18. It will deliver an end-to-end 5G trial in early 2018 and support a number of testbed spokes from 2018/19 while funding for future trials will be awarded on a competitive basis.

Germany is also launching important initiatives to promote 5G deployment. In September 2016, the Federal Ministry of Transport and Digital Infrastructure launched a 5G strategy for Germany specifically aiming at frequencies' release by 2018, the beginning of first tests on 800, 1500, 1800, 2600 MHz frequency bands and then 700 MHz and 3.4-3.8 GHz frequencies, the governmental and regional support to 5G R&D, the creation of a 5G forum, the construction of a 5G-city in Germany where large-scale demos are to take place by 2020 and the acceleration of a 5G commercial launch to ensure that by 2025 trains and the 20 biggest cities will be covered by 5G.

In December 2016, the German regulatory authority, the Bundesnetzagentur, lauched a public consultation, aiming at identifying and providing suitable spectrum for the introduction of 5G. All interested companies were invited to set out their scenarios of use for the respective frequency bands by 1 March 2017.

On 27 June 2017, the Bundesnetzagentur published key elements for the provision of the spectrum assigned to 5G, addressing the suitable bands (in particular, 2 GHz, due to expire next, and 3.6 GHz) and issuing a call to interested companies for notification of their forecast requirements in the frequency band at 2 GHz and 3400 – 3700 MHz. After notifications will be submitted by 30 September 2017, the German Regulator will be able to take a decision on the needed provision of spectrum, based on the identified demand. In this way, auctions will be carried out (probably in 2018) only if and in the measure the consultation will show that spectrum is insufficient to tackle expected demand. New innovative services such as Industry 4.0 are explicitly mentioned as possible main uses of 5G.

In **France**, the government launched in 2013 a program called "Nouvelle France Industrielle" to support new developments and opportunities in 34 growth sectors, including several telecom and technology-related areas, such as the Internet of Things or connected devices. The program gathers industrial players, public institutions, competition committees, operators, and research organizations and is focused on very high speed fixed and mobile broadband (fiber broadband and 5G are key elements), regulation, IoT, security of radio networks, employment/education, SMEs and start-up economic

development. Instead, the "Sovereignty Telecoms" is a specific plan, within the government program, for the telecom sector aiming at standardizing 5G technology, deploying a European network for the Internet of Things using a mix of French and European players and creating a label that will identify connected devices and processes.

In **Spain**, Telefonica signed a public-private partnership for the 5G development for the joint development of 5G products, services and technologies. Telefonica created the first 5G Spanish research lab, 5TONIC, which aims to create a global open environment where members from industry and academia work together in specific research and innovation projects related to 5G technologies with a view to boost technology and business innovative ventures. The laboratory will promote joint project development and entrepreneurial ventures, discussion fora, events and conference sites in an international environment.

Recently, **Italy** has taken the lead in 5G initiatives, by launching pre-commercial trials for innovative 5G networks and services in the 3.7-3.8 GHz spectrum portion. These trials will affect 5 Italian cities (the metropolitan area of Milan, Prato, L'Aquila, Bari and Matera), with the aim of experimenting the 5G network not only from an infrastructural point of view but also with regard to the services provided. Indeed, projects will involve not only communication carriers but also companies wishing to develop services enabled by 5G technology and universities and research entities.

After a public tender, detailed projects will be presented by the end of 2017 and run in the following 4 years, subject to a trimestral control system of trial results run by the Ministry of Economic Development.

Therefore, thanks to the recent government's initiative, Italy will have the chance to experience trials in 5 cities, while the European Commission in the Action Plan encouraged the identification of at least one major city to be "5G enabled" by the end of 2020.

Actually, it should be added that also Turin has independently identified a 5G trial in collaboration with TIM to be developed in the next years. By 2018, over 3,000 users (including devices) could take advantage of the 5G network installed in Turin's downtown.

2.2. THE CONSEQUENCES AND OPEN ISSUES OF IOT DEPLOYMENT IN THE EU

Industrial production processes are changing, just as industrial jobs. One key point is that real-time data analytics enables timely error corrections to minimize rework, thus leading to an improvement in quality and a decrease in costs – estimated at 10-20%.

Despite the important benefits associated with the IoT, it is also important to understand the main concerns arising from it. These can be summarized into three categories and illustrated in the following three sections.

2.2.1. Skills, skill gap and the impact on the labor market

ICT's extensive and intensive use, together with new ways of accessing and using the internet efficiently, has created an unprecedented demand for skilled ICT

specialists. In today's companies – operating in any sector – specialized ICT skills are essential to both the effective use of ICT in business processes (e-business) and commercial transactions that are carried out electronically (e-commerce).

In 2016, one in five EU enterprises employed ICT specialists (20%), the highest proportion being observed, not surprisingly, among enterprises in information and communication industries (74%). In other sectors, the percentage of enterprises employing ICT specialists was much lower and ranged from 9% in construction to 34% in professional activities. ICT specialist employment in the manufacturing industry is just slightly higher than the average (21%) (Fig. 2.13).

Ireland, Austria, Luxembourg and the Netherlands signal the largest employment of ICT specialists within the manufacturing industry – and largely greater than in other sectors – with percentages reaching 30% in the Netherlands and 42% in Ireland (Fig. 2.14). In Eastern countries the employment of ICT specialists is much less spread, with thepercentage of manufacturing companies employing them quite stable – below 15%.

29% of EU enterprises recruiting or trying to recruit ICT specialists reported having difficulty filling those vacancies (Fig. 2.15), with several countries showing a much higher degree of hardship – such as Austria or Slovenia, where more than one in two companies searching for an ICT specialist found a serious shortage of people with such skills.

More than one in two EU manufacturing enterprises

Fig. 2.13 Enterprises that employ ICT specialists, by vertical sector (2016; in %)

Source: I-Com elaboration on Eurostat data

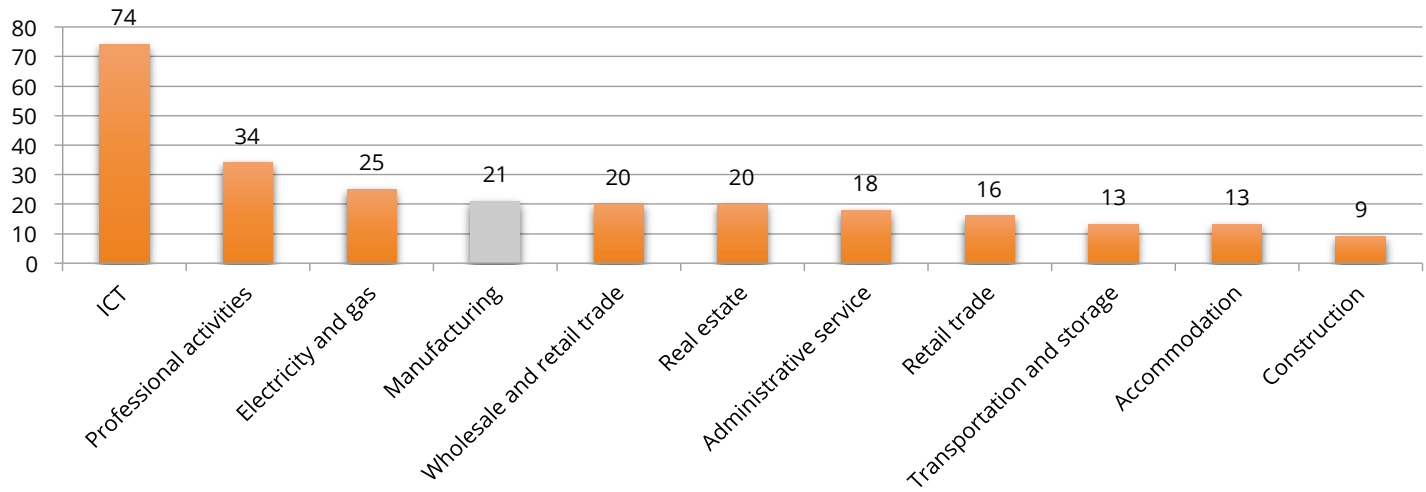
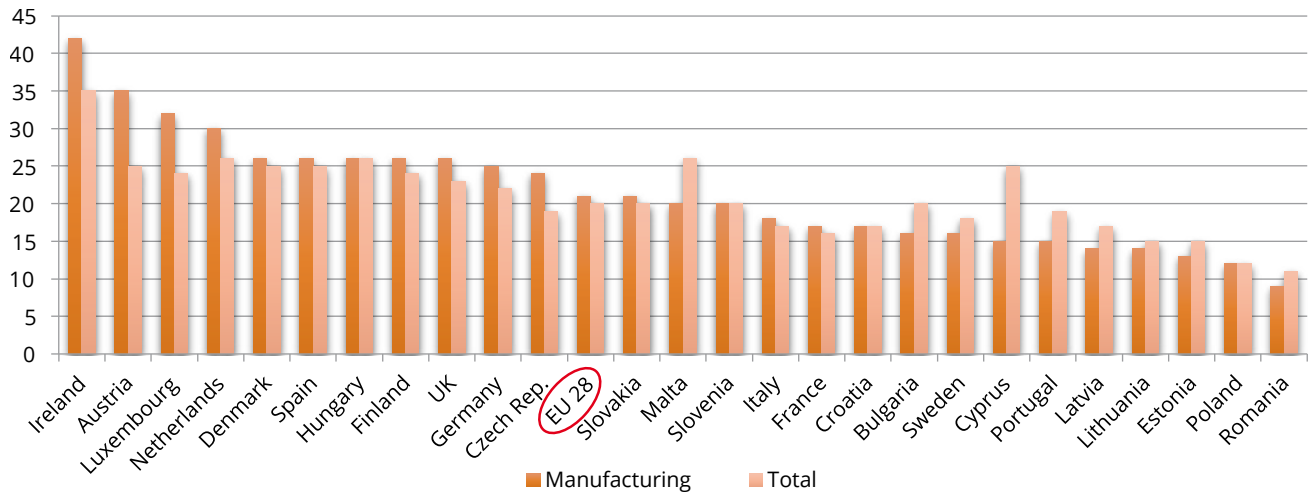


Fig. 2.14 Enterprises that employ ICT specialists, by country (2016; in %)

Source: I-Com elaboration on Eurostat data



outsource their ICT functions for:

- maintenance of ICT infrastructure (servers, computers, printers, networks);
- support for office software;
- development/support of business management software/systems (e.g. ERP, CRM, HR, databases);
- development/support of web solutions (e.g. websites, e-commerce solutions);
- security and data protection (e.g. security testing, security software).

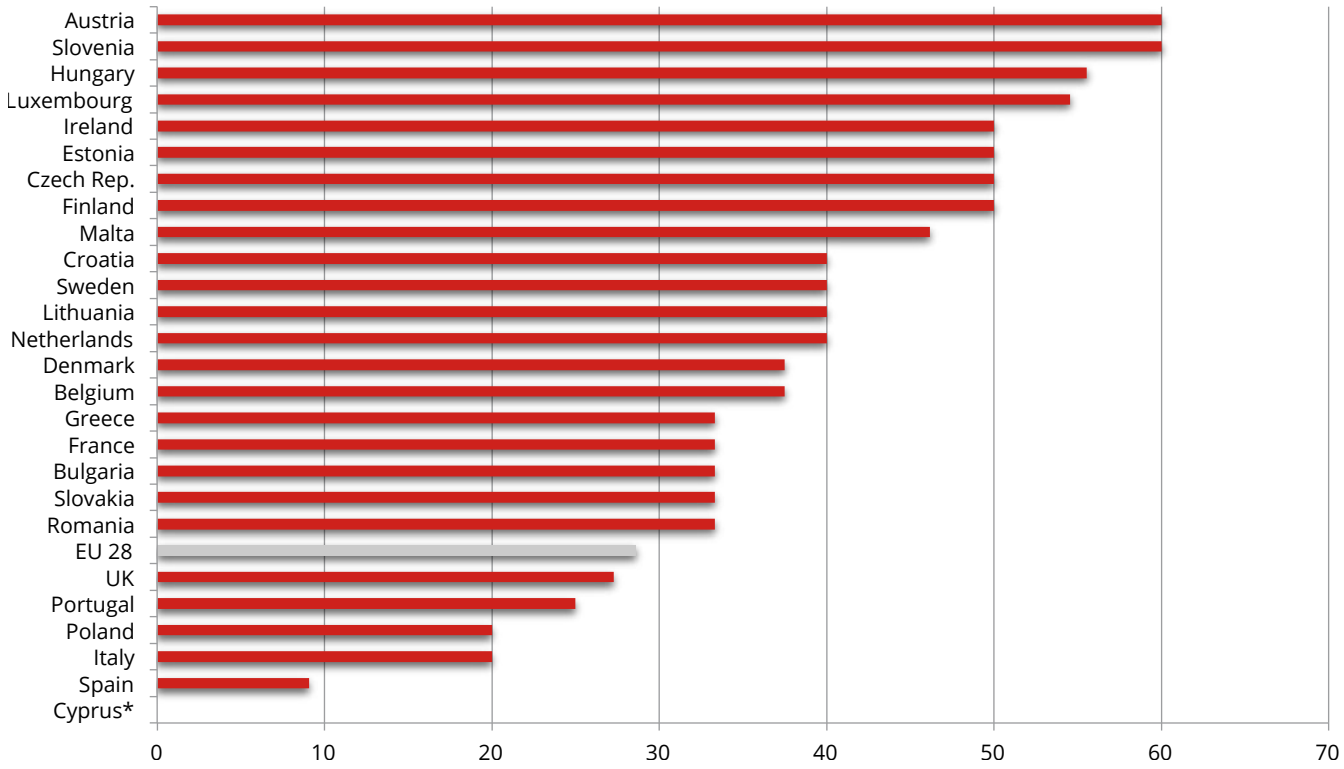
Only 18% mainly perform ICT functions internally. This trend is substantially common to every EU country (Fig. 2.14), although in certain countries, e.g. Luxembourg, one in three manufacturing companies performs ICT functions in source.

When broken down by the type of operation for which the ICT skills were employed, the data showed that in 2016 EU enterprises reported the highest share of outsourcing for maintenance of ICT infrastructure (60%), closely followed by functions related to security and data protection (55%), development of web solutions and support for web solutions (51% each) (Fig. 2.15). Only for one function, namely the support for office software (such as word processors or spreadsheets, dedicated to producing documents, presentations, worksheets, graphs, charts, etc.), the share of enterprises that mainly used their own employees (44%) is higher compared to those that mainly used external suppliers (41%).

As stated previously, in order to use and exploit the progressively increasing amount of data which is being

Fig. 2.15 Enterprises with hard-to-fill vacancies for jobs requiring ICT specialist skills (2016, in %)

Source: I-Com elaboration on Eurostat data
*Figure not available



produced, data analytics professionals are needed.

Data workers are, thus, defined as workers who collect, store, manage and analyze data as their primary (or as a relevant part of their) activity. They are proficient in the use of structured and unstructured data – elaborating it to support analysis and decision-making processes – and are able to work with a huge amount of data and are familiar with emerging database technologies.

Data workers in the EU28 numbered over 6 million in 2016. The UK and Germany led with about 1.2 million data workers each (Fig. 2.18). Six Member States (the UK, Germany, France, Italy, Poland, and Spain – the "Big Six") accounted for 72% of the total number of data workers in 2016, while the remaining 28% of EU data workers were distributed across the other 22 Member States. It is worth noting that, of the Big Six, only Italy registered a decrease

Fig. 2.16 ICT functions in manufacturing, by country (2016; in %)

Source: I-Com elaboration on Eurostat data

Fig. 2.17 ICT functions performed in enterprises at EU level (2016; in %)

Source: I-Com elaboration on Eurostat data

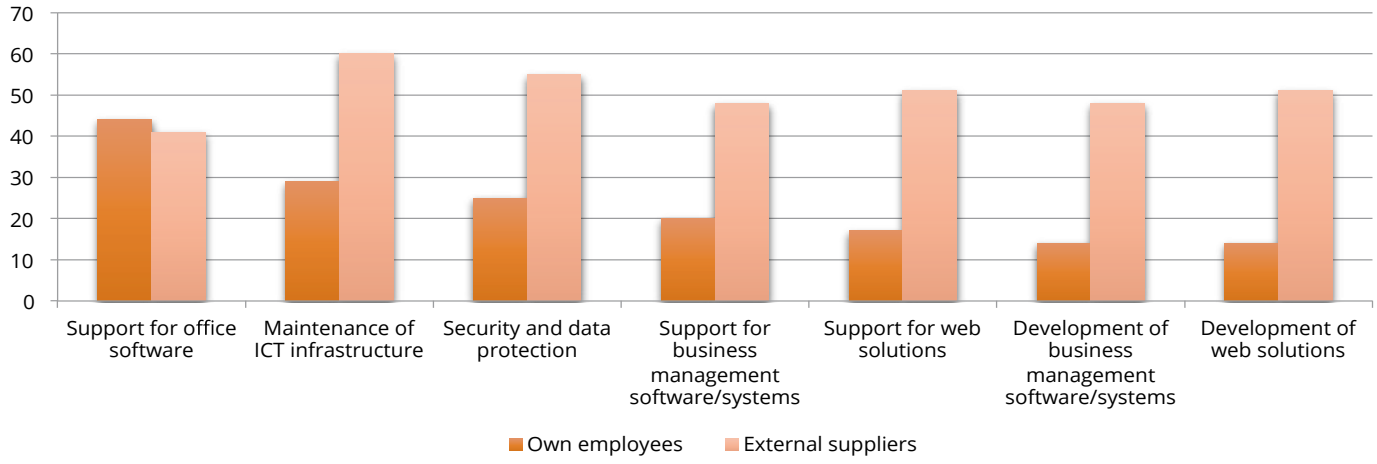
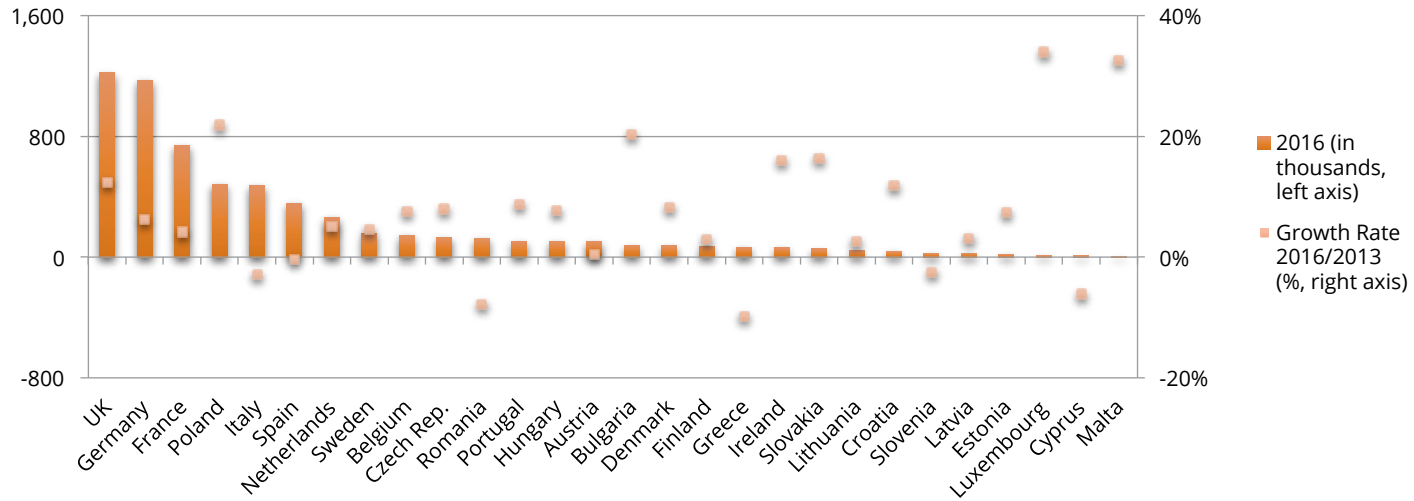


Fig. 2.18 Data workers, by EU Member State (2016)

Source: I-Com elaboration on data European Data Market Monitoring Tool, IDC (2016)

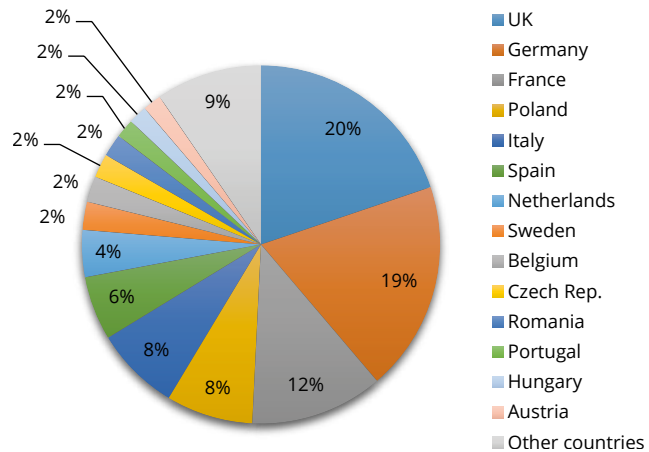


in the number of data workers throughout the last three-year period. The number of data workers depends on the data market trend but also on other factors such as ICT stock and productivity. This explains why some countries, such as Poland, for example, number more data workers than Spain, although its data market is lower than the Spanish data market. This depends on the fact that in Spain ICT stock is much higher. In other words, ICT inputs increase the data worker productivity so that the workers needed are less than the data workers needed by a country with a lower ICT stock.

The percentage of data workers out of total employment is stable for the EU28. This varies significantly by country, ranging from 6.5% in Luxembourg to 2% in Romania with an average of data workers out of total employment

Fig. 2.19 Distribution of data workers across the EU28 (2016)

Source: I-Com elaboration on data European Data Market Monitoring Tool, IDC (2016)



around 3%. Two countries among the Big Six, Italy and Spain, lag behind the European average (2.3%). This relates partly to their ICT spending, and significantly to their industry structure where SMEs are very important, and where small business data products and services may be less accessible than they are for larger companies. In terms of employment share, the discrepancy between large and small countries tends to lose importance while structural factors – both country and industry specific – appear to be more significant.

According to forecasts up to 2020, the countries where the number of data workers are expected to increase the most are Sweden (+21.1% yearly), Luxembourg (+16.6%), the Netherlands (+16.2%) and Malta (+16.1%), on a far

Fig. 2.20 Share of data workers out of total employment, by Member State (2016)

Source: I-Com elaboration on data European Data Market Monitoring Tool, IDC (2016)

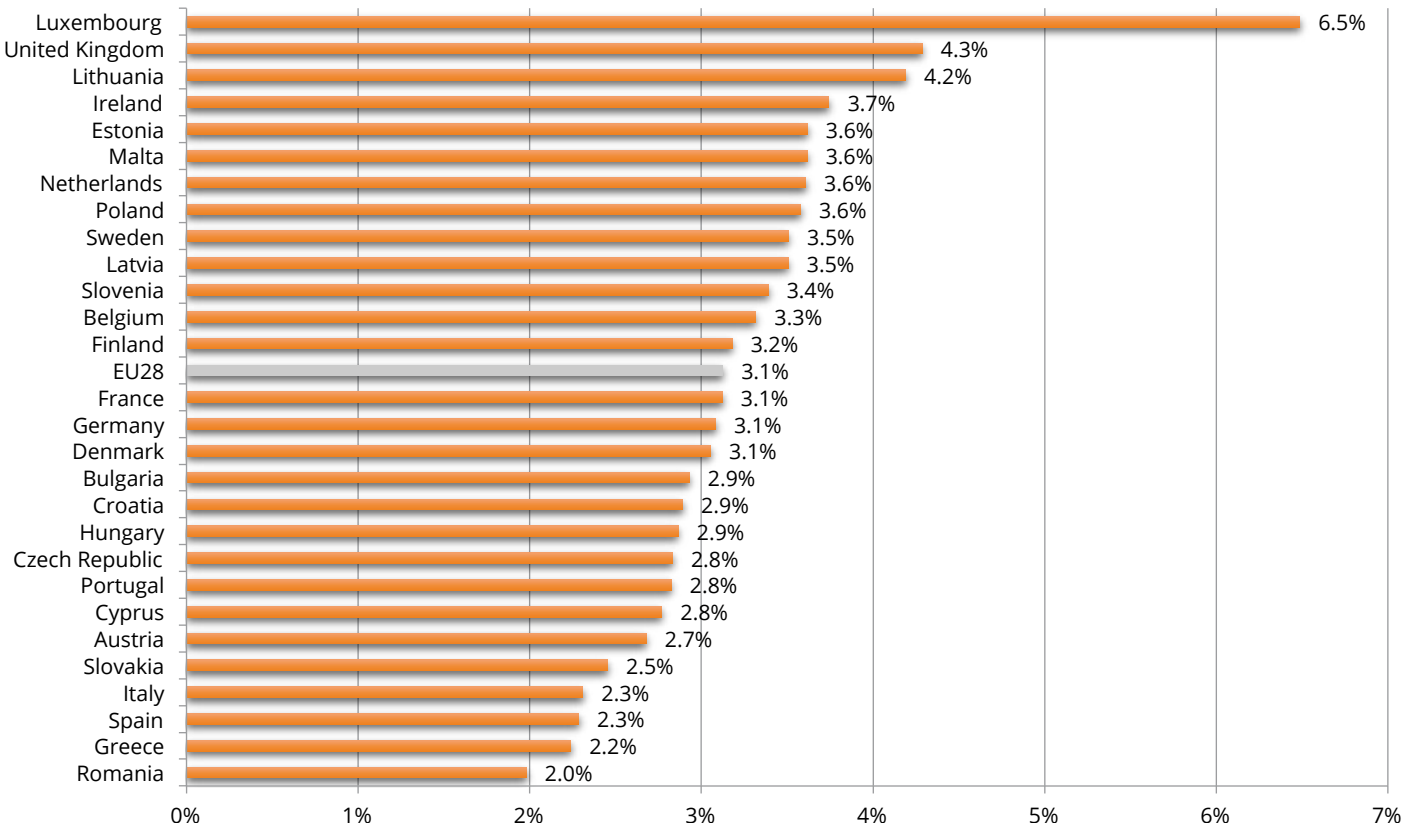
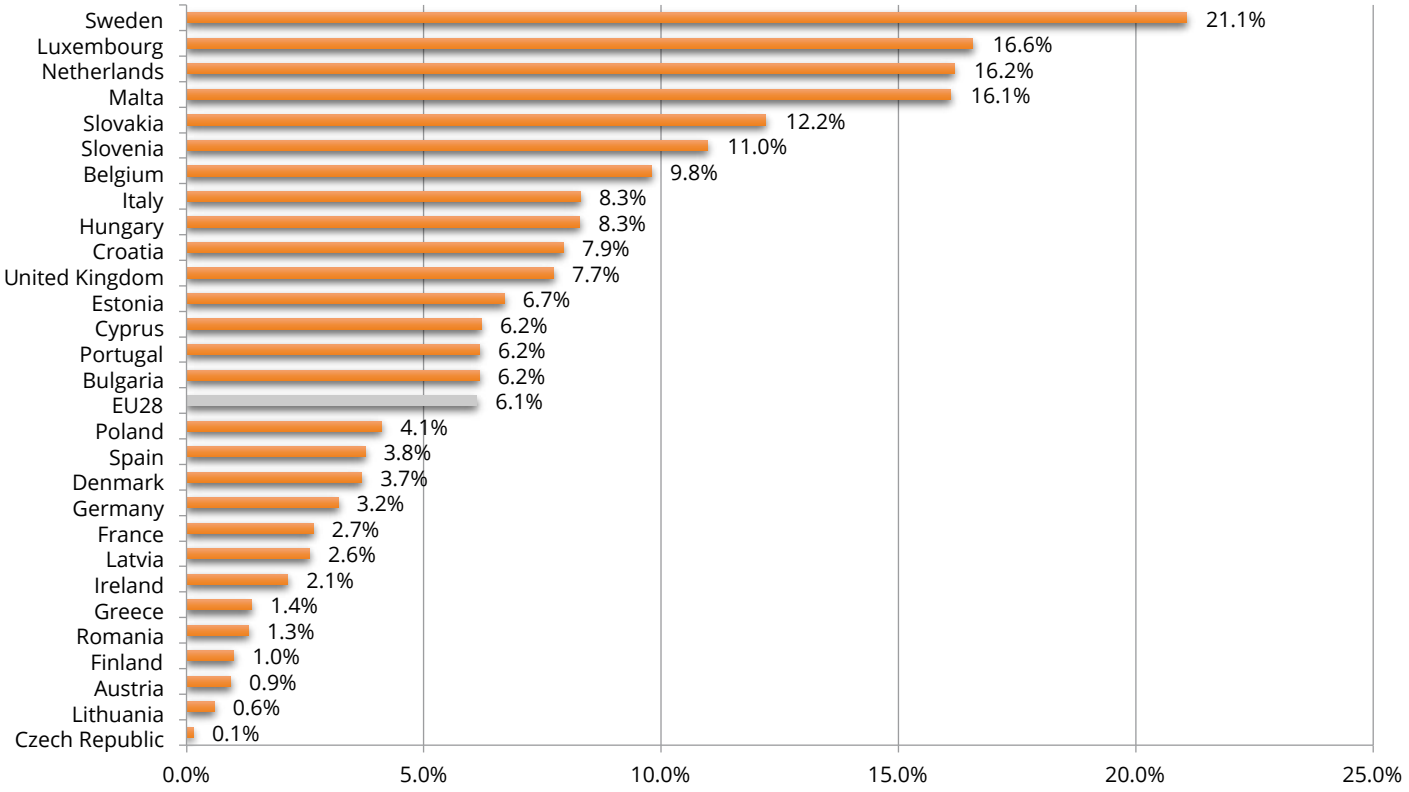


Fig. 2.21 Average annual growth in the number of data workers, by Member State (forecasts, 2016-2020)

Source: I-Com elaboration on data European Data Market Monitoring Tool, IDC (2016)



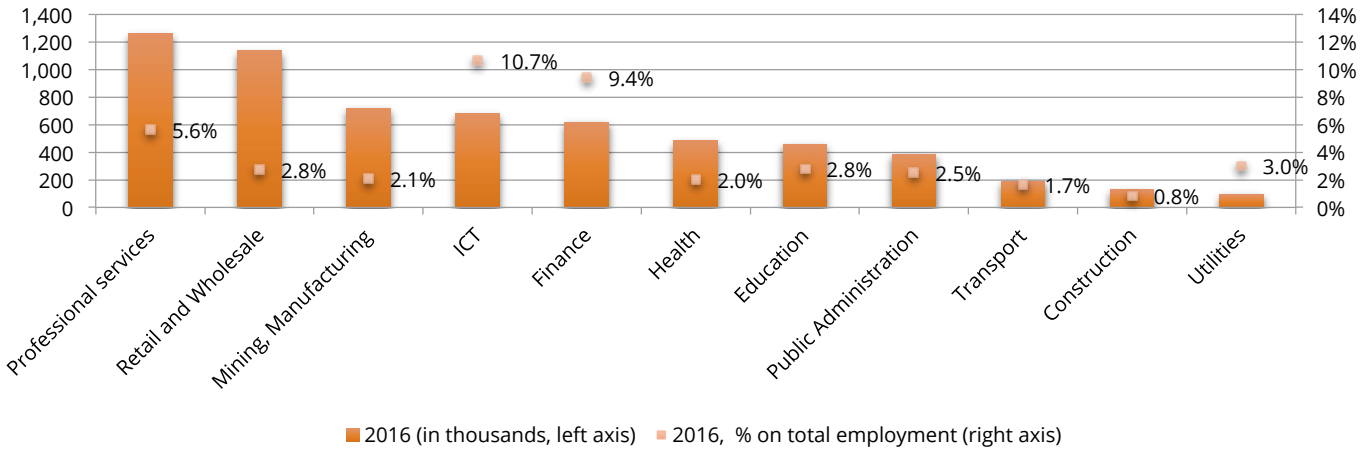
larger scale than for the EU average (3.1%) (Fig. 2.21). The manufacturing industry is the third industry as to the employment of data workers – with a total number of about 718,000 workers in 2016 (Fig. 2.22). Nevertheless, the share of data workers out of total employment is still too low in the manufacturing industry (2.1%, compared with 10.7% in ICT or 9.4% in finance, which are typically the most highly digitalized sectors).

In terms of the intensity of data workers – meant as the average number of data workers calculated out of the total number of data user companies[2] – in certain sectors this is definitely above the average – retail and wholesale

2 Data users are organizations that generate, exploit collect and analyze digital data intensively and use what they learn to improve their business. They represent the demand side of the data market.

Fig. 2.22 Data workers, by vertical sector (2016)

Source: I-Com elaboration on data European Data Market Monitoring Tool, IDC (2016)



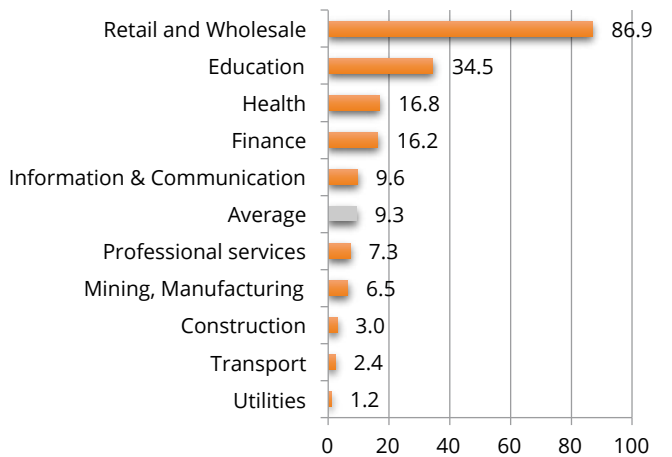
(86.9) and education (34.5).

The immediate consequence of such changes is the need for specific skills, that are currently largely unavailable. Skills are a pathway to employability and prosperity. They are a pull factor for investment and a catalyst in the virtuous circle of job creation and growth. However, skills gaps and mismatches are very obvious. Many people work in jobs that do not match their talents.

At the same time, 40% of European employers have difficulty finding people with the skills they need to grow and innovate. According to current data and estimates for the future, there is (and there will be) a substantial skill gap. According to IDC, in 2016, the gap between total demand and supply of data workers was 420,000 unfilled data worker positions in the EU (corresponding to 6.2%

Fig. 2.23 Intensity of data workers*, by vertical sector (2016)

Source: I-Com elaboration on data European Data Market Monitoring Tool, IDC (2016)
*Average number of data workers per user company



of total demand) and this is expected to rise to 769,000 (9.8% of total demand) by 2020 (Fig. 2.24). Poland shows the highest gap in 2016 (almost 15%), however, in the scenario to 2020, the UK's skills gap is expected to more than double – from 5.5% to 13.8% – thus becoming the country that will suffer the most from the shortage of the necessary data skills.

Germany, France and the UK – the leading data markets – show a mid-size gap in the scenario to 2020, because the positive dynamics of supply do not keep up with the strong growth of demand. However, whereas Germany should remain stable around 4.5% and France should even edge down to 2.7%, in the UK the number of unfilled positions is expected to climb to 13.8% (more than twice the present level) (Fig. 2.25). Poland, starting from a percentage data skills gap higher than in other countries in 2016, will reduce it, according to forecasts, still remaining above the EU average (12.9% vs. 9.8%) and only lower than the UK.

Only in Spain the skills gap is expected to decline, from 8.7% in 2016 to only 0.4% in 2020. This is partly due to a moderate growth of demand – due, in turn, to the high unemployment and dysfunctional labor market characterizing the country – but also to the substantial growth trend of students and graduates in Science, Technologies, Engineering and Mathematics (STEM graduates), that will result in a skill supply increase by about 11% in the four-year period. However, the forecasted demand to 2020 of Big Data analysts – a specific category of highly qualified data workers with

Fig. 2.24 Data workers' skills gap

Source: I-Com elaboration on data European Data Market Monitoring Tool, IDC (2016)

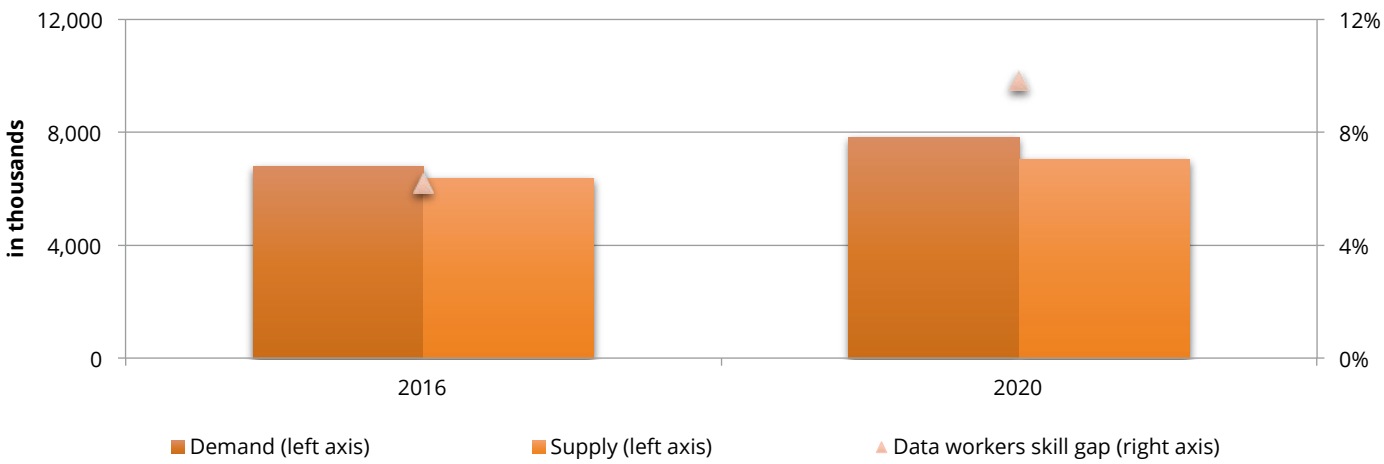
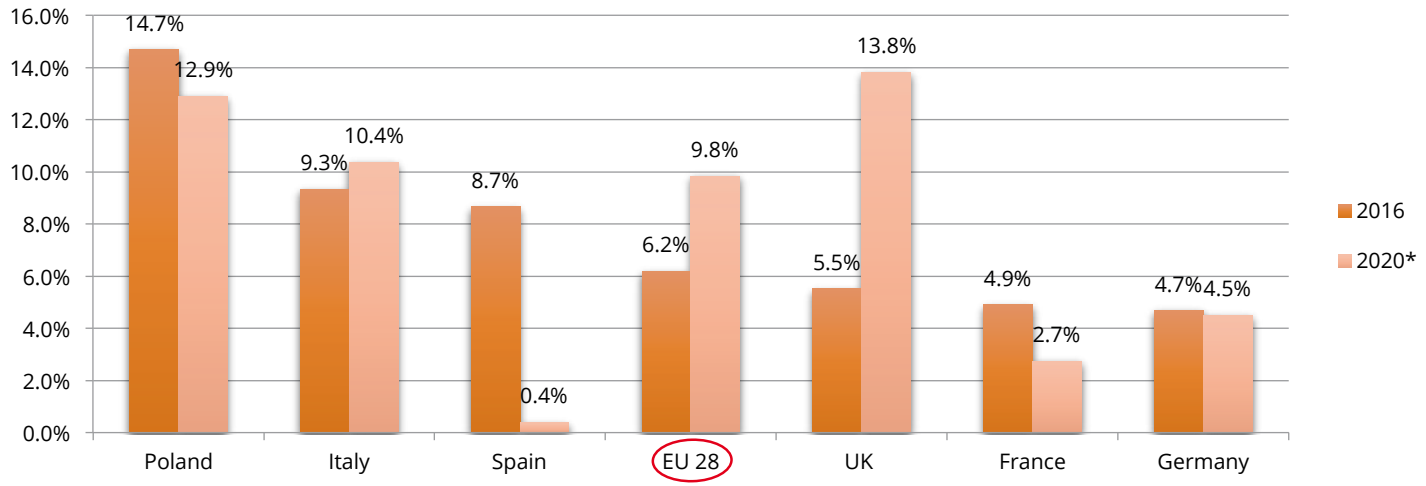


Fig. 2.25 Data workers' skills gap in selected countries

Source: I-Com elaboration on data European Data Market Monitoring Tool, IDC (2016)
*Forecasts



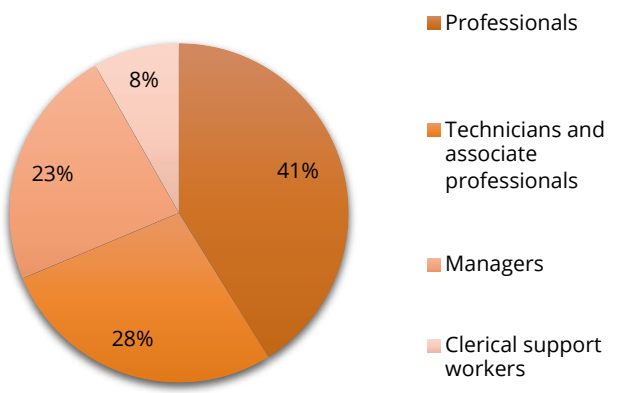
sophisticated technical skills – is expected to rise much faster than the demand for data workers, at a CAGR of 14.3%. This would lead to a potential supply-demand gap of 66,000 unfilled positions only for Big Data analysts, corresponding to approximately 17% of their demand. This appears to confirm the concern among Big Data stakeholders regarding the potential lack of Big Data skills and the need for Europe to catch up in training and education for these skills.

This gap needs to be urgently addressed both by policy actions and by the industry. While competence for the content of teaching and the organization of education and training systems lies within Member States, a concerted effort is required to achieve meaningful, sustainable results.

Last year, the European Commission proposed to establish a framework to coordinate national and EU-level initiatives and relevant policy actions including, among others, regulatory conditions and adaptation of the workforce, involving up-skilling. Advances in automation, robotics and smart systems are increasingly transforming the nature of work, not only for repetitive tasks but also for sophisticated tasks in administrative, legal or supervisory functions. In terms of the occupational mix, most data workers are professionals, technicians, or professional associates (69% total) (Fig. 2.26), but there is also a significant number in the manager occupation category (23%),

Fig. 2.26 Data workers, by occupation category (2014)

Source: I-Com elaboration on data European Data Market Monitoring Tool, IDC (2016)



largely focusing on data in order to drive their decisional processes.

Thus, work in a digitized economy will also involve new skills and abilities including more creativity, communication and adaptability. It will require a massive upskilling of the workforce at all levels, and such hurdles will call for a collective public and private effort. Reducing the mismatch between the skills available and those demanded for the digital transformation of the economy has been a key EU-level priority over the past decade. For instance, a 2008 communication entitled 'New skills for new jobs' emphasized the increasing need for digital skills. Furthermore, the 2010 Digital Agenda recognized the need for indicators to measure the extent of digital competence in the EU. This was implemented through the development of the Digital Competence Framework, enabling citizens to evaluate their digital skills, and the Digital Economy and Society Index, summarizing important indicators for Europe's digital performance and tracking the evolution of EU Member States in the area of digital competitiveness.

Starting in 2013, the Commission initiated the Grand Coalition for digital jobs as a trans-European, multi-stakeholder initiative to increase the provision of digital skills through stakeholder pledges offering ICT training, apprenticeships, placements, actions to facilitate mobility and/or carrying out awareness raising activities to encourage young people to study and pursue careers in ICT. The initiative has also led to the development of 13 national and local coalitions. Local Coalitions are the reflection of the Digital Skills and Jobs Coalition at regional or national level in a country. They bring together ICT and ICT-using companies, education and training providers, non-profit organizations, local, regional and national public administrations, public and private employment services and social partners. Partners of the National or Local Coalitions take action to bring digital skills and competences to all levels of education and training. They support teachers and educators and promote active involvement of business and other organizations. The members join forces in areas such as increasing industry-led training, certifying skills, improving school and university curricula, and raising awareness of ICT careers, especially among young people and women. Outcomes expected by 2020

can be summarized as follows:

1) training 1 million young people for vacant digital jobs through internships, apprenticeships and short-term training programs;
2) supporting the upskilling and retraining of the workforce and, in particular, taking concrete measures to support small and medium enterprises (SMEs) facing specific challenges in attracting and retaining digital talent as well as retraining their workforce;
3) modernizing education and training to provide all students and teachers with the opportunity to use digital tools and materials and to develop and upgrade their digital skills;
4) making use of available funding to support digital skills and carry out awareness-raising about the importance of digital skills for employability, competitiveness and participation in society.

On 6 June 2016, a Communication was drafted by the European Commission establishing a New Skills Agenda for Europe, that focuses on the need to work together to strengthen human capital, employability and competitiveness. The Communication outlines 10 key initiatives and sets out a joint agenda for the EU, the Member States and stakeholders at all levels. The goal is to reach a shared vision and commitment to work together on improving the quality and relevance of skills formation, in order to keep pace with the rapidly changing skills requirements of the labor market, equip all with a minimum set of basic skills and make qualifications easier to understand, helping workers and learners to move around more easily within the EU. The goal is also to raise political awareness of the critical importance of skills for European job and growth prospects. To help Member States design and implement reforms as well as understand how to best use the opportunities offered by existing funding programs, the Commission, in cooperation with OECD, will assist Member States in developing national skills strategies and action plans based on a whole-government approach.

More specifically, the ten actions proposed by the Commission include:

1) a Skills Guarantee, providing a skills assessment – enabling low-qualified adults to identify their existing skills and their upskilling needs – a learning offer responding to the specific needs of individuals and of local labor markets and opportunities to have their own skills validated and recognized;
2) a revision of the Key Competence Framework, in order to develop a shared understanding of key competences and further foster their introduction in education and training curricula, with a special focus on promoting entrepreneurial and innovation-oriented mindsets, by encouraging also practical entrepreneurial experiences;
3) making Vocational Education and Training (VET) a first choice by enhancing opportunities for VET learners to undertake a work-based learning experience and promoting greater visibility of good labor market outcomes of VET;
4) the launch of a Digital Skills and Jobs Coalition,

building on the positive results of the Grand Coalition for Digital Jobs, aimed at ensuring that individuals and the labor force in Europe be equipped with adequate digital skills and at supporting cooperation among education, employment and industry stakeholders. In addition, all Member States have been asked to develop national digital skills strategies by mid-2017 and to set up national coalitions to support their implementation. To support the development of national strategies, a group made up of Member State experts has put together a menu of challenges to be addressed and potential actions that could form part of a digital skills strategy – the so-called "shared concept";

5) a revision of the European Qualifications Framework for a better understanding of qualifications and to make better use of all available skills in the European labor market;
6) the launch of a Skills Profile Tool Kit for Third Country Nationals to support early identification and profiling of skills and qualifications of asylum seekers, refugees and other migrants, as well as making available online language learning for newly arrived migrants;
7) a revision of the Europass Framework, offering people better and easier-to-use tools to present their skills and get useful real-time information on skills' needs and trends which can help with career and learning choices;
8) the sharing of best practice regarding effective ways of tackling the problem of brain drain;
9) the launch of a Blueprint for Sectoral Cooperation on Skills to improve skills intelligence and address skills shortages in specific economic sectors, by setting up sectoral skills partnerships at a EU level, in order to help mobilize and coordinate key players, encourage private investment and promote more strategic use of relevant EU and national funding programs;
10) an initiative on tertiary graduate tracking to support Member States in improving information on how graduates progress in the labor market.

Despite favorable developments in the digital literacy of citizens, the digital gap needs to be narrowed further. Improving skills supply can be done by encouraging people to offer their skills in the labor market and by retaining skilled people in the labor market. Putting skills to effective use, by creating better matches between skills offered and demanded and increasing the demand for high-level skills, can also contribute to improving the situation. Economic prosperity and social cohesion can, indeed, be enhanced by strengthening skills systems in three areas:

1) developing relevant skills by encouraging and enabling people to acquire the right skills throughout life, fostering international mobility of skilled people to fill skills gaps, and promoting cross-border skills policies;
2) activating skills supply by encouraging people to offer their skills to the labor market and retaining skilled people in the labor market;
3) putting skills to effective use by creating a better

match between people's skills and the requirements of their job and increasing the demand for high-level skills.

In this respect, some best practices already exist at a national level in the EU[3].

2.2.2. Standards and interoperability

A standard is a voluntary formal agreement on doing something in the same way, repeatedly. It can be developed for products, processes, management and services. More specifically, standards are defined by the International Organization for Standardization (ISO) as "documents, established by consensus and approved by a recognized body, that provide for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context".

Why we need standards

Standards are essential to ensure the exchange of data between machines, systems and software within a networked value chain, as a product moves into and through the 'smart factory' towards completion, as well as to allow robots to be integrated into a manufacturing process through simple 'plug-and-play' techniques. If data and communication protocols are proprietary or only recognized nationally, only the equipment of one company or group of companies will be compatible. Thus, competition and trade can be expected to suffer and costs rise.

On the other hand, independent, commonly agreed, international standard communication protocols, data formats and interfaces can ensure interoperability across different sectors and different countries, encourage the wide adoption of Industry 4.0 technologies, and ensure open markets worldwide for European manufacturers and products.

A 2014 study by the European Commission emphasized the need for anticipating standards requirements and accelerating their development in Europe[4]. The benefits of standards for the European industry are tremendous (Fig. 2.27). Standards lead to cost reduction or cost savings derived mainly from economies of scale, the possibility to anticipate technical requirements, the reduction of transaction costs and the possibility to access standardized components.

According to the World Bank[5], one of the most important economic benefits of standards is that they increase productive and innovative efficiency. They allow suppliers to achieve lower per-unit costs by producing large homogeneous batches. In addition, producers gain skills and experience by focusing on fewer product variations. Another benefit is improved market access as a result of increased competitiveness due to increased

3 For more detailed information, see: http://www.europarl.europa.eu/RegData/etudes/IDAN/2017/595889/EPRS_IDA(2017)595889_EN.pdf

4 Joint Research Centre, How will standards facilitate new production systems in the context of EU innovation and competitiveness in 2025?, 2014

5 Quality Systems and Standards for a Competitive Edge (drafted by J. Luis Guasch, Jean-Louis Racine, Isabel Sánchez and Makhtar Diop), The International Bank for Reconstruction and Development/ The World Bank, 2007

efficiency, reduced trading costs, simplified contractual agreements (the characteristics and functionalities of the product are clear as a result of the standards) and increased quality. Standards also lead to better relations with suppliers and clients derived from increased safety for consumers, increased trust, reduced liability risk and wider choice of suppliers for the same reasons mentioned above. Minimum safety standards are the most straightforward example of standards used to solve imperfect information problems. European standards have an immense value for the competitiveness of the enterprises working in the fields of transport, machinery, electro-technical products and other manufacturing industries, as well as in the field of telecommunications.

Well-designed and timely European standards can support innovation in a number of ways. Existing standards can codify and spread the state of the art in various technologies. They can also facilitate the introduction of innovative products by providing interoperability between new and existing products, services and processes, for example in the field of eco-design, smart grids, energy efficiency of buildings, nanotechnologies, security and eMobility. In some instances, innovations can more easily gain market acceptance if they comply with existing standards for safety, quality and performance.

Interoperability standards can underpin a technological platform on which other innovation can take place, especially for services (for example, using LTE mobile services as a platform for mobile commerce solutions or public cloud computing platforms for eGovernment applications). Finally, standards can help bridge the gap between research and marketable products or services. A standard can codify the results of publicly funded research, thus making them available as a basis for further innovation.

THE BENEFITS OF STANDARDS

Source: ETSI

- **Safety and reliability** – Adherence to standards helps ensure safety, reliability and environmental care. As a result, users perceive standardized products and services as more dependable – this in turn raises user confidence, increasing sales and the take-up of new technologies.
- **Support of government policies and legislation** – Standards are frequently referenced by regulators and legislators for protecting user and business interests, and to support government policies. Standards play a central role in the European Union's policy for a Single Market.
- **Interoperability** – the ability of devices to work together relies on products and services complying with standards.
- **Business benefits** – standardization provides a solid foundation upon which to develop new technologies and to enhance existing practices. Specifically, standards:

  - » open up **market access**
  - » provide **economies of scale**
  - » encourage innovation
  - » increase **awareness** of technical developments and initiatives
- **Consumer choice** – standards provide the foundations for new features and options, thus contributing to the enhancement of our daily lives. Mass production based on standards provides a greater variety of accessible products to consumers.

What the world would be like without standards:

- Products might not work as expected
- They may be of inferior quality
- They may be incompatible with other equipment – in fact they may not even connect with them
- In extreme cases, non-standardized products may be dangerous
- Customers would be restricted to one manufacturer or supplier
- Manufacturers would be obliged to invent their own individual solutions to even the simplest needs, with limited opportunity to compete with others.

Standards success stories

A good example of the power of standardization is the GSM mobile communication technology and its successors (3G, 4G...), truly global phenomena, in which the European Standardization body ETSI has played a leading role. Although GSM was originally envisaged as a solution only for Europe, these technologies have been deployed worldwide. As a result, travelers today can communicate and use familiar services in every corner of the world – all thanks to standardization. ETSI can boast many other similar success stories including, for example, Smart Cards, DECT, TETRA, Short Range Radio, medical implants, electronic signatures.

In 2010, the International Standardization Organization (ISO) and its members initiated the undertaking of case studies, encompassing more than 20 countries and some 15 different industries, with the aim of giving a rounded view of how tangible benefits can be achieved with the use of standards. The results were then recapped as follows[6]:

- standards are used to streamline business functions by reducing the time required for performing specific activities. The full number of case studies brought a figure of 0.15% – 5% gross profit increase in annual sales revenues;
- the innovation of new business processes was

6 ISO, What's the bottom line?, May 2012

responsible for companies expanding their supplier network or introducing and managing new product lines. Standards also helped mitigate the risk to companies which brought new products to the international market;

- finally, the third way company benefits are measured is by studying the development of new products and creation of new markets (domestic and export). In some cases, profit was measured at 33% of the annual revenue, positioning companies as market leaders.

At a national level, a study of the German Standardization Organization DNI on the contribution of standards to national economic growth[7] has shown that the economic benefits of standardization represented about 1% of GDP in Germany, where standards made a greater contribution to economic growth than patents or licenses. Export-oriented sectors of German industry used standards to open up new markets and facilitate technological change. In France, according to estimates, standardization directly contributed to the growth of the national economy of up to 0.81%, or almost 25% of GDP growth. In the United Kingdom, standards made an annual contribution of GBP 2.5 billion to the economy, and 13% of the growth in labor productivity was attributed to standards. Standards were identified as enablers of innovation and facilitators of technological change. The economic return on investment for standards made sound business sense at both macro- and micro-economic levels.

7 DNI, The Economic Benefits of Standardization

European standardization bodies

European standardization is a consensus-building process that involves many players. As the development of standards is mainly initiated by market needs, industry plays an important role. European standards are then developed through one of the three European Standards Organizations – the European Committee for Standardization (CEN), the European Committee for Electro-technical Standardization (CENELEC), and the European Telecommunications Standards Institute (ETSI). Standards developed by the aforementioned bodies are called Harmonized Standards, and are created following a request from the European Commission to one of these organizations. Manufacturers, other economic operators, or conformity assessment bodies can use harmonized standards to demonstrate that products, services, or processes comply with relevant EU legislation. The references of harmonized standards must be published in the Official Journal of the European Union.

The European Standardization Organizations are officially recognized by Regulation (EU) No 1025/2012[8] as providers

8 The Regulation provides a legal basis to use European standards for products and services, identify ICT technical specifications, and finance the European standardization process. It also sets an obligation for European Standardization Organizations and National Standardization Bodies on transparency and participation. The key points of the European standardization process are: Transparency and stakeholder participation: the work program of the European standardization organizations and national standardization bodies must be transparent and publicly available. Standardization processes shall be inclusive and allow the participation of all relevant stakeholders; European standards and other deliverables in support of Union legislation and policies; Identification of ICT technical specifications; Financing European standardization. This establishes the legal basis for the financial support provided by the EU to the European standardization system.

of European standards. CEN, CENELEC, and ETSI have been working with the European Commission since 1984, when a cooperation agreement was signed. Revised in 2003, it lays down general guidelines for cooperation.

CEN

The European Committee for Standardization (CEN) brings together the National Standardization Bodies of 33 European countries. It provides a platform for the development of European Standards (ENs) and other technical documents on various types of products, materials, services, and processes. These include air and space, chemicals, construction and more.

CENELEC

The European Committee for Electro-technical Standardization (CENELEC) is responsible for standardization in the electro-technical engineering field. Voluntary standards prepared by CENELEC help facilitate trade between countries, access new markets, cut compliance costs, and support the development of the EU Single Market. CENELEC also creates market access at international level through its close collaboration with the International Electro-technical Commission (IEC).

ETSI

The European Telecommunications Standards Institute (ETSI) produces globally-applicable standards for information and communications technology (ICT). These standards also include fixed, mobile, radio, converged, broadcast, and internet technologies. ETSI's purpose is to produce and maintain the technical standards required by its members.

In the case of ETSI, industry can become directly involved in the process of standards development, while industry can only access CEN and CENELEC through the National Standards Bodies (NSBs). The European Union recognizes 37 national standardization bodies[9], which are subject to requirements laid down in Regulation (EU) No 1025/2012:

- Article 3 Transparency of work programs of standardization bodies
- Article 4 Transparency of standards
- Article 6 Access of SMEs to standards
- Article 15 and 17 regarding union financing

The European strategy for standardization

The digitization of European industry and services represents an important opportunity for the growth of European businesses and society, as well as an important milestone in achieving a Digital Single Market. Industry in Europe has held a longstanding leading position in factory automation and intelligent manufacturing technologies. Currently, the digitization of industry and services and the application of cognitive technologies is establishing connections across sectors, as well as throughout the value chain, from innovator to manufacturer and from provider to consumer. This is a catalyst for innovation and technology integration throughout the value chain. Regulation (EU) No 1025/2012 establishes a legal basis for European product and service standards, identifying ICT technical specifications, and financing of European

9 List available at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014XC0927%2807%29

standardization practices. It also sets an obligation for European Standardization Organizations (CEN, CENELEC, ETSI) and National Standardization Bodies to comply with transparency and participation. Articles 15 to 19 of the regulation lay down the legal basis of the EU financial support for the European standardization system, the total amount available – approximately €20 mill. annually – being constant over the last years.

The EC package on "Digitizing of European Industry", as well as several initiatives at Member State level and within industry federations recognizes that standardization has an important role to play, helping European industry secure its leadership in manufacturing and service provision by adopting the best available digital technologies. As the Communication states, "an effective standardization environment for digital technologies is crucial for Digitizing European Industry, and is key to the Digital Single Market. ICT standards allow devices and services to connect seamlessly across borders and technologies. In the future, billions of connected devices – including appliances, industrial equipment, and sensors – will depend on such seamless communication, regardless of manufacturer, technical details, or country of origin."

The Communication of the European Commission: ICT Standardization Priorities for the Digital Single Market

The proposal for a 2017 Work Program for European standardization identifies services and ICT sectors as priority areas for future standard-setting, given their cross-cutting role in the economy.

In April 2016, the Commission had already proposed concrete measures to speed up the ICT standard setting process by focusing on five priority areas: 5G; cloud computing; Internet of Things; data technologies; and cybersecurity (Fig. 2.26). Action in these areas can accelerate digitization and immediately impact competitiveness in domains such as eHealth, intelligent transport systems and connected/automated vehicles, smart homes and cities, and advanced manufacturing[10].

In June 2016 the Commission presented its standardization package, where it set out its vision for a single and efficient standardization policy that adapts to the changing environment, supports multiple policies and brings benefits to companies, consumers and workers alike. The package included the Communication European standards for the 21st century. Here the Commission recommends a renewed focus on the services sector[11]. While services account for 70% of the EU economy, service standards only account for around 2% of all European standards. The fragmentation of standards acts as a barrier to the cross-border provision of services. Complementing other initiatives under the Single Market Strategy to facilitate cross-border provision of services, the Commission proposes to prioritize and promote the targeted development of voluntary European service standards. Examples of service standards include terminology used in hotels and other tourism accommodation. The package also includes the

10 Communication of the European Commission, ICT Standardization Priorities for the Digital Single Market, COM (2016) 176, 19.04.2016

11 Communication of the European Commission *European standards for the 21st century*, COM (2016) 358 final 01.06.2016

Tab. 3.1 European Commission's ICT standardization priority areas

Source: European Commission

CLOUD COMPUTING	
Cloud computing supports new digital services by providing the massive data storage and computational power needed for the digitization of European industry and science. Proprietary solutions, purely national approaches and standards that limit interoperability can severely hamper the potential of the Digital Single Market	The Commission will: - intend to support funding the development and use of the ICT standards needed to further improve the interoperability and portability of the cloud, also making more use of open source elements by better integrating open source communities by the end of 2016
	- facilitate the adoption of cloud computing services by supporting the finalization of international standards on service level agreements, by mid-2017. This will ensure transparency and quality for end users, especially SMEs
	- request ESOs to update the mapping of cloud standards and guidelines for end users (especially SMEs and the public sector), in collaboration with international SDOs, cloud providers and end users, by mid-2017
INTERNET OF THINGS	
The IoT technology connects more objects to the internet – including household equipment, wearable electronics, vehicles and sensors. The number of such connected devices is expected to exceed 20 billion by 2020. The IoT also has the potential to help address many societal challenges including climate change, energy efficiency and ageing. However, the IoT landscape is currently fragmented because there are so many proprietary or semi-closed solutions alongside a plethora of existing standards	The Commission will: - foster an interoperable environment for the Internet of Things, working with ESOs and international SDOs. The Commission will assess if further steps are needed to tackle identified interoperability failures, and if necessary, consider using legal measures to recommend appropriate standards
	- promote an interoperable IoT numbering space that transcends geographical limits, and an open system for object identification and authentication
	- explore options and guiding principles, including developing standards, for trust, privacy and end-to-end security, e.g. through a 'trusted IoT label'
	- promote the uptake of IoT standards in public procurement to avoid lock-in, notably in the area of smart city services, transport and utilities, including water and energy
5G COMMUNICATION NETWORKS	
5G networks enable seamless global communication between different kind of 'nodes', connecting data, vehicles and other objects, smart sensors or voice. 5G is expected to become the essential global infrastructure for communication and critically depends on standards to ensure interoperability and security, privacy and data protection	The Commission will: - foster the emergence of global industry standards under EU leadership for key 5G technologies (radio access network, core network) and network architectures notably through the exploitation of the 5G public-private partnership results at the level of key EU and international standardization bodies
	- ensure that 5G standards are compatible with innovative use cases of vertical industries, notably through broader participation of industries with sector-specific needs, in 5G standardization organizations

CYBERSECURITY	
Cybersecurity provides the bedrock of trust and reliability on which the Digital Single Market will be built. As the number of connected objects grows, and communication channels multiply, European citizens and businesses will expect a very high quality of security standards to be built-in to any new technology or service. Incorporating security-by-design principles is essential to mainstreaming cybersecurity considerations into all emerging ICT standards and reference architectures	The Commission will: - invite ESOs, other SDOs and relevant stakeholders to draw up practical guidelines aimed to ensure that security and seamless secure authentication are considered from the outset in the development of ICT standards. The Commission will consider adopting a Recommendation by end 2017 regarding the integration of cyber security requirements including data protection-by-design and data protection-by-default. - invite ESOs and other SDOs and relevant stakeholders to develop standards by the end of 2018 that support global interoperability and seamless trustworthy authentication across objects, devices and natural and legal persons based on comparable trust models - over the next three years, support the development of standards-based cybersecurity risk management guidelines for organizations and of corresponding audit guidelines for authorities or regulators with oversight responsibilities
DATA TECHNOLOGY	
Data is the fuel of the digital economy. Open standards, as well as initiatives such as Open Data Portal, can help overcome barriers to data sharing between technologies, scientific disciplines and countries. Future data infrastructures will require standards not only for security and privacy, but also for metadata, data preservation, semantics, data values, and others.	The Commission will: - increase R&D&I investment specifically for data interoperability and standards as of 2016. This will cover areas such as (i) cross-sectorial data integration; (ii) better interoperability of data and associated metadata. This will also be used to contribute to global standardization in the field of data. - bring the European data community together to identify missing standards and design options for a big data reference architecture, taking into account existing international approaches, by 2018. - support, as of 2016, together with stakeholders and relevant global initiatives26, data and software infrastructure services for access and long-term preservation of scientific data.

ESO: European Standardization Organization, SDO: Standard Development Organization

Annual Union Work Program for 2017, setting out the priorities in European standardization for the following year, and a Joint Initiative on Standardization – a dialogue process bringing together the relevant stakeholders (industry, institutions, consumers, union etc.). The partnership will develop concrete actions to better prioritize, speed up and streamline standardization work by the end of 2019.

The Joint Initiative on Standardization

To reinforce the partnership between the European institutions and the European standardization community, the European Commission announced in its Single Market Strategy the launch of a Joint Initiative on Standardization, bringing together public and private institutions and organizations in a collaborative dialogue. The initiative is driven by stakeholders (EU and EFTA Member States, standardization organizations and bodies, European industry and industry associations, SMEs, and societal stakeholders), with the European Commission playing a mainly coordinating role and building consensus.

These partners will commit to modernizing, prioritizing, and speeding up the timely delivery of standards by the

end of 2019. The JIS will better align standard setting priorities with research and innovation impetus, with support from the EU research and innovation program Horizon 2020. The JIS will also promote the use of European standards at international level.

Signatories to the initiative have agreed on a joint vision on standardization based on mutually-agreed underlying principles. To begin the process for improving the European standardization system, a Steering Group is drafting a set of actions, accompanied by pilot projects, based on three cluster domains identified as priorities:

- Awareness, Education and Understanding of the European Standardization System i.e. increasing the relevant use of standards and participation at all levels;
- Coordination, Cooperation, Transparency and Inclusiveness, i.e. ensuring adequate, high-quality, user-friendly and timely European standards;
- Competitiveness and International dimension, i.e. standards supporting European competitiveness in global markets.

All actions will address provisions under the Joint Initiative, as expressed in the Single Market Strategy of 2015 – prioritization, modernization and the appropriate speed for timely standards.

However, it should be taken into account that the Joint Initiative on Standardization is not legally binding.

The New European Interoperability Framework

The new European Interoperability Framework (EIF) was established with a European Commission Communication adopted on 23 March 2017[12]. The framework gives specific guidance on how to set up interoperable digital public services.

It offers public administrations 47 concrete recommendations on how to improve the governance of their interoperability activities, establish cross-organizational relationships, streamline processes supporting end-to-end digital services, and ensure that both existing and new legislation do not compromise interoperability efforts.

The new framework puts more emphasis on how interoperability principles and models should be applied in practice. The number of recommendations has increased from 25 to 47. The updated recommendations on interoperability have been made more specific to facilitate their implementation, with a stronger focus on openness and information management, data portability, interoperability governance, and integrated service delivery.

All EU countries are currently digitizing their public administrations. By following the recommendations provided by the new EIF, EU countries will follow a common approach while making their public services available online, integrating them end-to-end, managing their information sources, or dealing with security and data protection rules.

This will ensure that services are accessible, not only within their national borders, but also across countries and policy areas. In other words, they will apply

12 Communication of the European Commission, *European Interoperability Framework*, COM (2017)134, 23.03.2017

interoperability in practice. Thus, public administrations can save time, reduce costs, increase transparency, and improve the quality of services that they offer to citizens and businesses.

The EIF is accompanied by the Interoperability Action Plan, which outlines priorities that should support the implementation of the EIF from 2016 to 2020.

The Interoperability Action Plan is made up of five focus areas – addressing issues related to the identification of mechanisms to govern interoperability, collaboration between organizations, engagement of stakeholders, and raising awareness of the benefits of interoperability. It also covers the development, improvement and promotion of key interoperability enablers, while considering the needs and priorities of end users.

The European Commission will govern and coordinate the implementation and monitoring of the framework, using key performance indicators and measurable targets.

EU countries are expected to complement EU's actions, identified in the Interoperability Action Plan, with national actions, thus ensuring coherence. This is essential for the successful application of interoperability in the public sector within the EU. The Commission will evaluate the implementation of the new EIF by the end of 2019.

2.2.3. Cybersecurity: how companies are addressing the cyber risks

The Internet of Things is a major target of cyberattacks, as it will increase the attack surface for manufacturers. As advanced as manufacturing is becoming – with interconnected systems and data running factories, production and the entire supply chain – cybersecurity should be a concern for every manufacturer. For instance, the more shop floors adopt intelligent machines, the more those machines will contain data worth stealing. Cybersecurity incidents could disrupt the supply chain of manufacturing companies, causing serious repercussions, both economically and qualitatively. Today, many business models are built on the uninterrupted availability of the Internet and the smooth functioning of information systems. Cybersecurity incidents, either intentional or accidental, could disrupt the supply of essential services we take for granted, such as water or electricity. Threats can arise from different origins, including criminal, terrorist or state-sponsored attacks as well as natural disasters and unintentional mistakes.

By completing the Digital Single Market, the EU could boost its economy by almost €415 billion per year and create hundreds of thousands of new jobs[13]. But for new connected technologies to take off, Europeans need to develop trust and confidence. The digital world should then be protected from incidents, malicious activities and misuse.

ICT-related security incidents affect the ICT system of an enterprise and may cause different problems. The main security risks that need to be addressed by a ICT security policy are:

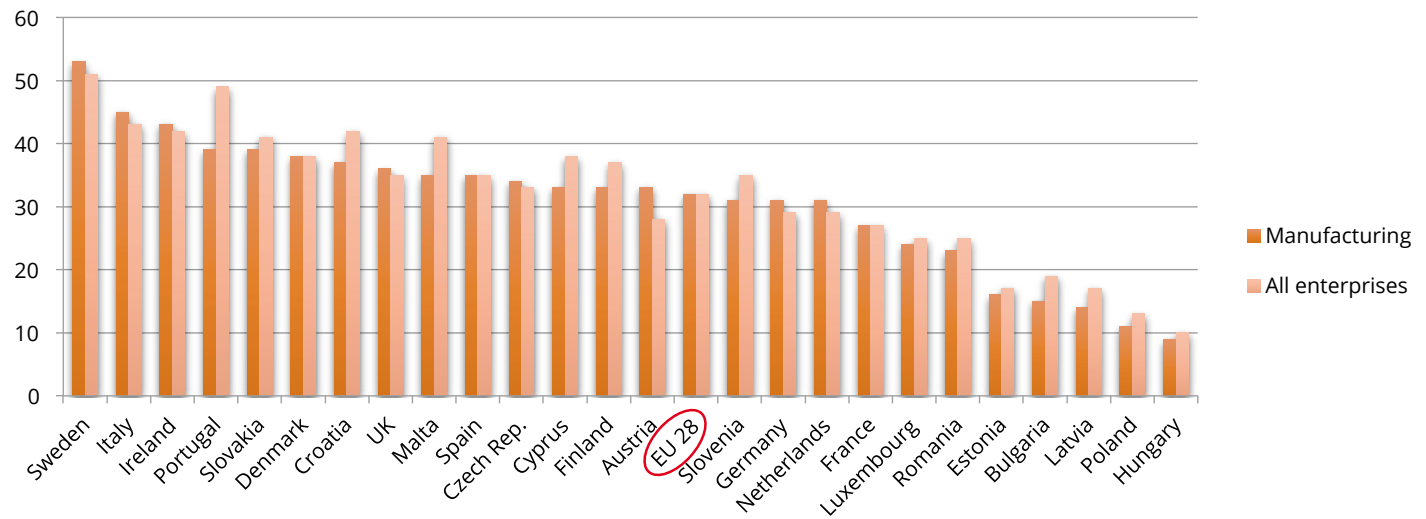
13 European Commission (2017), "EU cybersecurity initiatives working towards a more secure online environment".

- destruction or corruption of data due to hardware or software failures, referring to issues of data integrity of such failures, e.g. server or hard disk crashes due to hardware failures or server crashes due to software failures, e.g. erroneous updates;
- unavailability of ICT services due to external attacks, concerning external attempts to render an information system resource unavailable to its intended users. One aim of these attacks is to prevent an Internet site or service from functioning efficiently, e.g. websites of banks, credit card payment gateways;
- disclosure of confidential data due to intrusion, pharming, phishing attacks, that is an attempt to get confidential information on persons, staff or clients, intellectual property or other confidential information:
  - *Intrusion* is an attempt to bypass security controls on an information system by viruses, worms, Trojan horses, etc.
  - *Phishing* is a criminally fraudulent attempt to acquire sensitive information such as usernames, passwords and credit card details by masquerading as a trustworthy entity in an electronic communication.
  - *Pharming* is an attack which redirects the traffic of a website to another bogus website in order to acquire sensitive information.

The existence of an ICT security policy in an enterprise

Fig. 2.27 Share of manufacturing companies with a ICT security policy (2015; in %)

Source: I-Com elaboration on Eurostat data



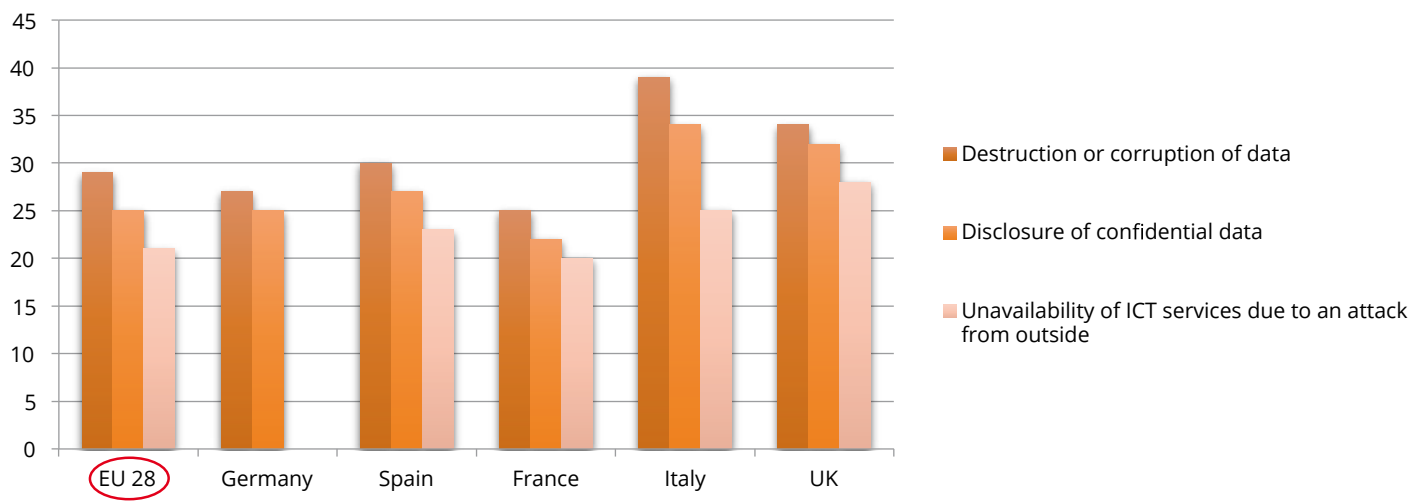
means that the enterprise is aware of the importance of its ICT systems and the relevant potential risks. Moreover, the existence of an ICT security policy would imply an enterprise's strategy to safeguard data and ICT systems as well as mandatory obligations for all employees.

According to Eurostat data, 32% of all EU enterprises have a formally defined ICT security policy (Fig. 2.27), with manufacturing companies alone holding the same percentage. Sweden, Italy and Ireland appear to be the countries with the greatest awareness of the importance of having a security policy, especially in the manufacturing industry, where the share of companies aware of the importance of having a well-defined security policy is even higher than in other sectors. This is true also for other countries, such as Austria, the UK, the Czech Republic, Germany and the Netherlands, whereas, in all other countries, manufacturing companies are, on average, less aware than in other sectors.

More than one Swedish manufacturing company out of two already had a security policy in place as of 2015. As well, 45% of Italian manufacturing companies had defined a security policy, primarily to address the risk of destruction or corruption of data and disclosure of confidential data, as it also the case for other countries (Fig. 2.28). The risk that EU companies seem to be relatively less worried about – only 21% of manufacturing companies – is that of unavailability of ICT services due to an attack from outside (e.g. Denial of Service attack).

Fig. 2.28 Share of manufacturing companies with a ICT security policy (2015; in %)

Source: I-Com elaboration on Eurostat data



Three main regulatory issues are currently at stake:

1) the need to increase cybersecurity capabilities, reaching the same level of development in all EU Member States, and ensuring that exchanges of information and cooperation are efficient, also at cross-border level;
2) aiming at making the EU a strong player in cybersecurity: Europe needs to be more ambitious in nurturing its competitive advantage in the field of cybersecurity to ensure that European citizens, enterprises (including SMEs), public administrations have access to the latest digital security technology, which is interoperable, competitive, trustworthy and respects fundamental rights including the right to privacy. This should also help take advantage of the booming global cybersecurity market. To achieve this, Europe needs to overcome the current cybersecurity market fragmentation and foster the European cybersecurity industry;
3) the need for mainstreaming cybersecurity in EU policies, by embedding it in the future EU policy initiatives from the start, in particular with regard to new technologies and emerging sectors such as connected cars, smart grids and, more in general, the Internet of Things (IoT).

Both governments and the private sector have a significant role to play here. For this reason, the Commission is working with all relevant players to strengthen cybersecurity. Since the adoption of the EU cybersecurity Strategy in 2013, the European Commission has stepped up its efforts to better protect Europeans online. It has adopted a set of legislative proposals, specifically on network and information security, earmarked more than €600 mill. in EU investment for research and innovation in cybersecurity projects during the 2014-2020 period, and fostered cooperation within the EU and with global partners.

Moreover, the EU cybersecurity Strategy launched in 2013 established 5 priorities: increasing cyber resilience; drastically reducing cybercrime; developing EU cyber defense policy; developing the industrial and technological resources for cybersecurity; establishing a coherent international cyberspace policy for the EU.

Following on from this strategy, several initiatives emerged from both the European Commission and the European Parliament.

A European Agenda on Security was launched by the European Commission in 2015, setting 3 priorities – terrorism, organized crime and cybercrime – and proposing, with regard to the latter, the following actions:

- placing renewed emphasis on the implementation of existing policies on cybersecurity, attacks against information systems, and combating child sexual exploitation;
- reviewing and possibly extending legislation on combatting fraud and counterfeiting of non-cash means of payments taking into account the newer forms of crime and counterfeiting of financial instruments;
- reviewing obstacles to criminal investigations on cybercrime, notably on issues of competent jurisdiction and rules on access to evidence and information;

- enhancing cyber capacity building action under external assistance instruments.

On 6 July 2016, within the Digital Single Market Strategy, a public-private partnership (PPP) on cybersecurity was signed by the Commission and the European Cyber Security Organization (ECSO), an industry-led association, which includes a wide variety of stakeholders such as large companies, SMEs and start-ups, research centers, universities, end-users, operators, clusters and association as well as public authorities. The partnership is supported by EU funds from the Horizon 2020 Research and Innovation Framework Program (H2020) with a total investment of up to €450 million until 2020.

The goal of the partnership is to stimulate European competitiveness and help overcome cybersecurity market fragmentation through innovation and trust-building between Member States and industrial actors as well as helping align the demand and supply sectors for cybersecurity products and solutions, by:

- gathering industrial and public resources to deliver innovation against a jointly-agreed strategic research and innovation roadmap;
- focusing on targeted technical priorities defined jointly with industry;
- maximizing the impact of available funds;
- providing visibility to European research and innovation excellence in cybersecurity.

Finally, in July 2016, the Commission also adopted a Communication on Strengthening Europe's Cyber Resilience System and Fostering a Competitive and Innovative Cybersecurity Industry, including measures aimed at:

- stepping up cooperation across Europe, by encouraging Member States to make the most of the cooperation mechanisms under the Network and Information Systems (NIS) Directive and to improve how they work together to prepare for a large-scale cyber incident – i.e. working more on education, training and cybersecurity exercises;
- supporting the emerging single market for cybersecurity products and services in the EU (e.g. through the introduction of a certification framework and a labelling scheme), scaling up cybersecurity investment in Europe and supporting SMEs active in the market;
- establishing a contractual public-private partnership (PPP) with industry, to nurture cybersecurity industrial capabilities and innovation in the EU.

The European Parliament, on the other hand, adopted three measures in the last three-year period.

The first measure was the Regulation on electronic identification authentication and signature (EIDAS), entering into force on 17 September 2014 and applicable starting from July 2016, in the field of electronic identification and trust services for electronic transactions in the internal market. It provides a predictable regulatory environment to enable secure and seamless electronic interactions between businesses, citizens and public authorities. More specifically, it ensures that people and businesses can use their own national electronic identification schemes (eIDs) to access public services in other EU countries where eIDs

are available and creates a European internal market for eTS – namely electronic signatures, electronic seals, time stamps, electronic delivery services and website authentication – by ensuring that they will work across borders and have the same legal status as traditional paper-based processes. It is only by providing certainty on the legal validity of all these services that businesses and citizens will use the digital interactions as their natural way of interaction.

This regulation provides for a predictable legal framework for people, companies (in particular SMEs) and public administrations to safely access services and carry out transactions online and across borders. Indeed, rolling out eIDAS means higher security and more convenience for any online activity such submitting tax declarations, enrolling in a foreign university, remotely opening a bank account, setting up a business in another Member State, authenticating Internet payments, bidding on online calls for tenders, and so on.

In early 2016, the Parliament reformed the legal framework as regards data protection and issued the General Data Protection Regulation (GDPR), the aim being to protect all EU citizens from privacy and data breaches in an increasingly data-driven world that has become vastly different from when the 1995 Directive was first established. Although the key principles of data privacy still hold true to the previous Directive, many changes have been proposed to the regulatory policies. These concern several issues:

1. *increased territorial scope*, by extending jurisdiction of the GDPR to all companies processing the personal data of data subjects residing in the Union, regardless of the company's location and regardless of whether the processing of personal data takes place in the EU or not;
2. *penalties*, up to 4% of annual global turnover or €20 million, whichever is greater;
3. *consent*, where conditions have been strengthened and companies will no longer be able to use long illegible terms and conditions full of legalese, as the request for consent must be given in an intelligible and easily accessible form – with the purpose for data processing attached to that consent – using clear and plain language; in addition, it must be as easy to withdraw consent as it is to give it;
4. *breach notification*, that becomes mandatory, within 72 hours, in all Member States where a data breach is likely to "result in a risk for the rights and freedoms of individuals";
5. *right to access*, i.e. the right for data subjects to obtain from the data controller confirmation as to whether or not their personal data is being processed, where and for what purpose. Furthermore, the controller shall provide a copy of the personal data, free of charge, in an electronic format, which dramatically increases data transparency and empowerment of data subjects;
6. *right to be forgotten*, entitling the data subject to have the data controller erase his/her personal data, cease further dissemination of the data, and potentially have third parties halt processing of the data. The conditions for erasure, as outlined in article 17, include data no longer relevant to original purposes

for processing, or data subjects withdrawing consent;

7. *data portability*, i.e. the right for a data subject to receive personal data concerning them, which they have previously provided in a 'commonly use and machine readable format' and have the right to transmit that data to another controller;
8. *privacy by design*, calling for the inclusion of data protection from the onset of the designing of systems, rather than as an addition;
9. *Data Protection Officers*, who are mandatory only for those controllers and processors whose core activities consist of processing operations which require regular and systematic monitoring of data subjects on a large scale or of special categories of data. The introduction of this professional figure avoids controllers notifying their data processing activities with each local Data Protection Authorities (DPAs), with only internal record keeping requirements.

Finally, on 6 July 2016, the Directive on security of network and information systems (NIS) was adopted. It provides legal measures to boost the overall level of cybersecurity in the EU by ensuring:

- Member States preparedness by requiring them to be appropriately equipped, e.g. via a Computer Security Incident Response Team (CSIRT) and a competent national NIS authority;
- cooperation among all Member States, by setting up a cooperation group, in order to support and facilitate strategic cooperation and the exchange of information among Member States. They will also need to set a CSIRT Network, in order to promote swift and effective operational cooperation on specific cybersecurity incidents and sharing information about risks;
- a culture of security across sectors which is vital for our economy and society and moreover relies heavily on ICTs, such as energy, transport, water, banking, financial market infrastructures, healthcare and digital infrastructure. Businesses in these sectors that are identified by the Member States as operators of essential services will have to take appropriate security measures and to notify serious incidents to the relevant national authority. Also key digital service providers (search engines, cloud computing services and online marketplaces) will have to comply with the security and notification requirements under the new Directive.

2.3. I-COM INDUSTRY 4.0 INDEX 2017 ON THE LEVEL OF PREPAREDNESS ACROSS EU COUNTRIES

A synthetic index was elaborated in order to give an idea of the level of preparedness for Industry 4.0 in the EU countries. The I-Com index is based on thirteen variables that are closely related to the topic of the fourth industrial revolution.

In particular, the variables are listed below and refer to the adoption of technology, infrastructure and skills:

1. manufacturing enterprises that share internally electronic information with an ERP;
2. manufacturing enterprises using Radio Frequency Identification (RFID) technologies;

3. manufacturing enterprise buying Cloud Computing services of medium-high sophistication;
4. manufacturing enterprises using software solutions like Customer Relationship Management (CRM);
5. manufacturing enterprises whose business processes are automatically linked to those of their suppliers and/ or customers (SCM);
6. manufacturing enterprises analyzing big data from any data source;
7. fixed Ultra-broad coverage of the population;
8. 4G coverage of the population;
9. share of ICT specialists out of total employment;
10. share of data workers out of total employment
11. share of enterprises providing training to their personnel to develop/upgrade their ICT skills;
12. share of STEM graduates
13. share of manufacturing companies with a ICT security policy as of 2015.

It is worth noting that the variables referring to the adoption of technology (from 1 to 6) are specific to the manufacturing industry, whereas – because of the limited availability of public data – the remaining variables are more general and refer either to the total population (infrastructural data) or to the total of enterprises (skills data), except for the last variable concerning cyber security. For this reason, a greater weight was assigned to the adoption of technology – 0.5, equally split among the six variables within this category – and 0.25 each to the other two categories. Then, for each country, a compound average of the variable figures was calculated. The values obtained were finally normalized relative to the best performer country, so as to establish a ranking from 0 to 100.

Finland tops the ranking, with a score of 100 – thanks primarily to the adoption of certain technologies (cloud computing services and Big Data analysis tools) and the relatively high level of employment of both ICT specialists and data workers – showing to be the country at forefront of the fourth industrial revolution. The Netherlands, Germany and Denmark immediately follow (Fig. 2.29). In all of these countries, employment of both ICT specialists and data workers is relatively more widespread. In addition, a large part of companies adopt IoT-linked technologies. In particular, in Germany, the ERP, CRM and SCM tools as well as the RFID systems are widespread across manufacturing companies, whereas Denmark is stronger on the infrastructural side. Germany also stands out for the high level of STEM graduates (34%), only lower than in the UK (35%).

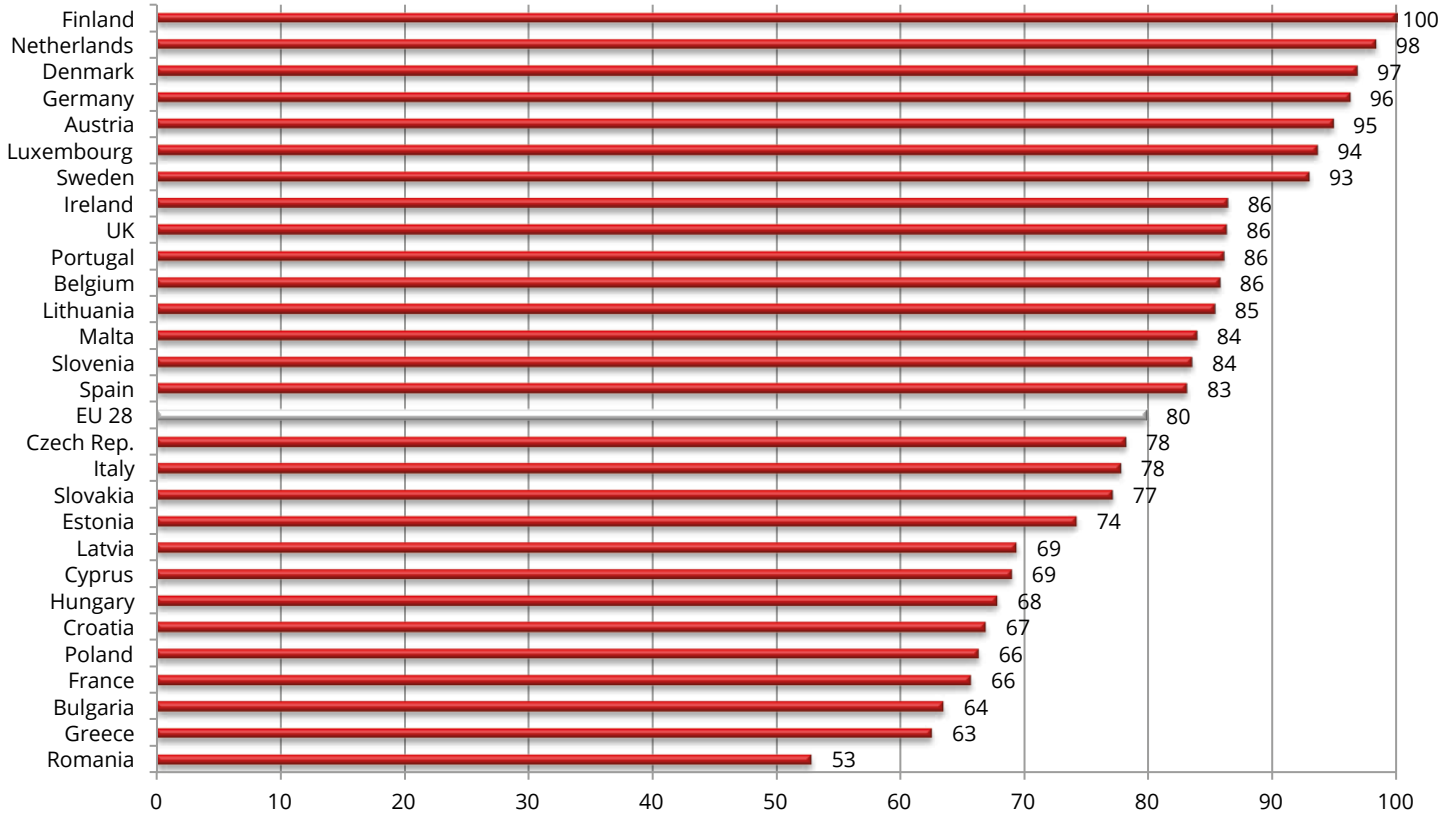
Instead, most Eastern countries show unfavorable conditions to the development of Industry 4.0. A great variability exists within the EU as to the level of preparedness to Industry 4.0, if we look at the score of Romania (53) suggesting a level of development of IoT and Industry 4.0 concepts lower than the best performing Finland by almost 50%. This country lags behind especially with regard to infrastructural development – especially the mobile network – and the adoption of business integration technologies.

Italy and France – two of the Big Five countries, with an important economic role played by the manufacturing industry – are positioned closer to the worst performing countries. More specifically, Italy ranks 17th, with a

score of 77.8 points, slightly less than the European average. Nevertheless, regarding the adoption of IoT-linked technologies, Italy shows a performance that is line with the EU average. It must, instead, still reduce the gap with the rest of Europe relative to fixed network infrastructure, even if some steps have been taken recently. A similar situation occurs in France, with even greater problems as regards infrastructures – both mobile and fixed – where France substantially lags behind, thus ranking 25th, above only Bulgaria, Greece and Romania. Skills remain, however, the most critical aspect – in these countries like in any other – and also the most difficult to be significantly improved in the short term.

Fig. 2.29 I-Com Industry 4.0 Index 2017 on the level of preparedness across EU countries

Source: I-Com elaboration on data Eurostat and European Data Market Monitoring Tool, IDC (2016)



PART 3

POLICIES AT EU AND NATIONAL LEVEL

3. POLICIES AT EU AND NATIONAL LEVEL

3.1. EU POLICY FRAMEWORK: DIGITIZING EUROPEAN INDUSTRY

Industry is one of the pillars of the European economy – the manufacturing sector in the EU accounts for 2 million enterprises, 33 million jobs and 60% of productivity growth. The new-generation information technologies such as the Internet of Things, cloud computing, big data and data analytics, robotics and 3D printing open up new horizons for industry to become more adventurous, more efficient, to improve processes and develop innovative products and services. Recent studies estimate that product and service digitization can add more than €110 billion of annual revenue in Europe in the next five years[1] European industry is strong in digital sectors such as electronics for automotive, security and energy markets, telecom equipment, business software, and laser and sensor technologies. As well, Europe hosts important research and technology institutes. However, high-tech sectors face severe competition from other parts of the world and many traditional sectors and small and medium enterprises (SMEs) are lagging behind. There are also large disparities in digitalization between regions.

On 19 April 2016, the European Commission launched the first industry-related initiative of the Digital Single Market package to address these challenges. Building on and complementing the various national initiatives for digitizing industry, such as *Industrie 4.0* in Germany, *Smart Industry* in the Netherlands and *l'Industrie du future* in France, the Commission wants to use its policy tools, financial support, coordination and legislative powers to trigger further public and private investments in all industrial sectors and create the framework conditions for the digital industrial revolution.

Digital industry in Europe can build on a number of assets, notably the size of the EU market that should attract further investments as it develops into a digital single market. It also has clear strengths in professional (e.g. B2B) and sectoral markets such as embedded and business software, telecom equipment, robotics, automation, laser and sensor technology as well as electronics for automotive, security, healthcare and energy markets. However, Europe needs to markedly improve its attractiveness for investments in the production of digital products.

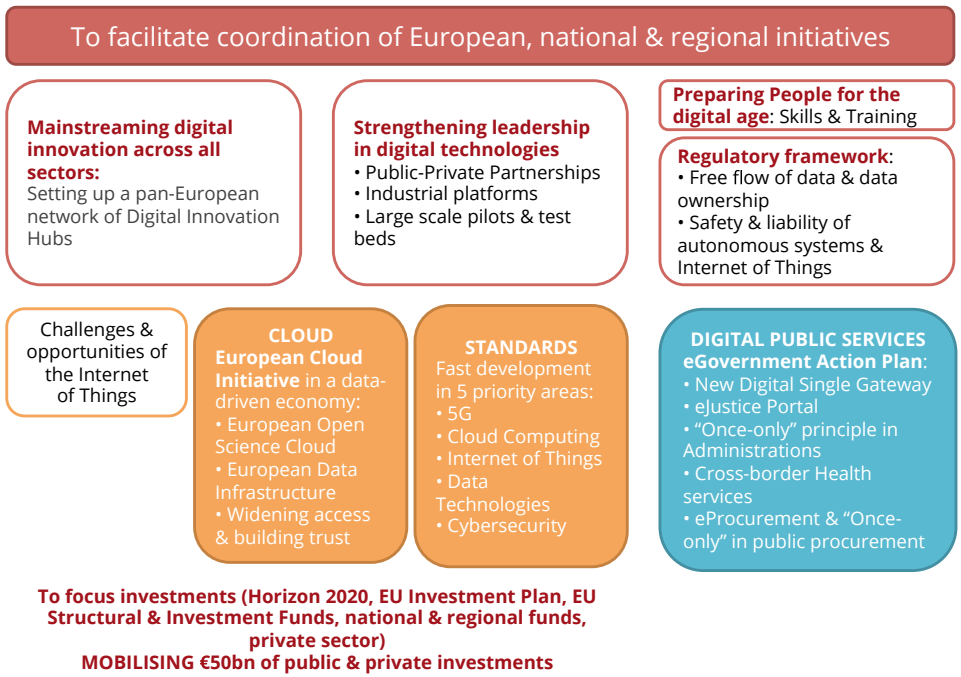
Therefore, the purpose of the Commission's Communication on Digitizing European Industry[2] is to reinforce EU's competitiveness in digital technologies and to ensure that every enterprise in Europe, in whichever sector, wherever situated, and no matter of what size, can fully benefit from digital innovations (Fig. 3.1).

1 PwC, Opportunities and Challenges of the Industrial Internet (2015), and Boston Consulting Group: the future of productivity and growth in manufacturing industries (2015)

2 Digitizing European Industry Reaping the full benefits of a Digital Single Market, COM (2016) 180 final

Fig. 3.1 Goals of the European Commission initiative on Digitizing European Industry

Source: European Commission



Facilitated by a dynamic framework for coordination and experience sharing between public and private initiatives at EU, national and regional level, the proposed actions are expected to mobilize close to €50 billion in public and private investment[3] in the next 5 years, explore and adapt when needed the legislative framework and reinforce coordination of efforts on skills and quality jobs in the digital age.

3 Based on the planned activities in H2020, COSME and national public and private efforts amounting to about €35 billion, up to €5 billion for regional investment on innovation hubs, €10billion for co-investment in first production capacities

A framework for co-ordination of initiatives for digitizing industry

With more than 30 national and regional initiatives for digitizing industry underway across Europe, there is a need to address standardization and examine the regulatory fitness of legislation at EU level to ensure the development of a single market. As well, there is also a substantial value in sharing best practices in areas such as skills and jobs for the digital change.

In 2016, the Commission, together with Member States and industry, set up a governance framework to:

facilitate the coordination of EU and national initiatives on digitalization; mobilize stakeholders, and resources across the value chain, on actions to achieve a Digital Single Market, building upon existing multi-stakeholders dialogues; and exchange best practices.

The Commission committed to hold twice a year a high-level Roundtable of representatives of Member State initiatives, industry leaders, and social partners ensuring a continuous EU-wide dialogue, with preparatory activities developed, when needed, in specific working groups addressing both sector-specific and cross-sector issues. A yearly European stakeholder forum will provide for a wider consultation and outreach involving stakeholders from the full digital value chains. The Commission will regularly report on the progress of the actions.

The mid-term review of the Digital Single Market strategy[4] accounted for the European industry oriented actions.

Co-investing in boosting Europe's digital innovation capacities

Fostering private investment in digital innovation in all EU industrial sectors is a major challenge to be addressed at regional, national and EU levels. As seen with the European Fund for Strategic Investment[5], the EU as a whole can mobilize resources for investment, when needed, that no individual Member State could do on its own and with a leverage effect on private investments that is far beyond the reach of many Member States. The Communication on the European Cloud Initiative, issued on the same day as the Digitizing European Industry, shows how such a collective effort in partnership with Member States and industry can boost Europe's innovation capacity across scientific disciplines and industrial sectors[6].

The European Commission aims at increasing digital innovations in all sectors, by financing Digital Innovation Hubs across Europe.

EU actions supporting such competence centers have shown not only an increase in competitiveness of existing industries, notably for SMEs, but also additional business creation in new digitized products and services, increasing investment appeal. Some successful competence centers include the micro-tech cluster in Southern Germany where institutes such as Fraunhofer and university labs play an essential role, or the Grenoble digital innovation eco-system around French institutes such as CEA and INRIA.

There is space for more competence centers based in technical universities or research organizations to become DIHs providing companies, especially SMEs, with facilities for digital innovation. Apart from transferring leading-edge technology to companies, they would also give advice on potential sources of funding/finance, provide space for experimentation and help workers find training.

4 COM (2017) 228 final, 10.05.2017

5 The European Fund for Strategic Investment (EFSI) is one of the three pillars of the Investment Plan for Europe and aims to overcome current market failures by addressing market gaps and mobilizing private investment. It helps to finance strategic investments in key areas such as infrastructure, research and innovation, education, renewable energy and energy efficiency, as well as risk finance for small and medium-sized enterprises (SMEs).

6 European Cloud Initiative - Building a competitive data and knowledge economy in Europe COM (2016) 178 final, 19.04.2016

The Commission plans to focus €500 million in investments from Horizon 2020 on digital innovation hubs on:

- networking and collaboration of digital competence centers and cluster partnerships;
- supporting cross-border collaboration of innovative experimentation activities;
- sharing of best practices and developing, by end of 2016, a catalogue of competences;
- mobilizing regions with no Digital Innovation Hub to join and invest;
- wider use of public procurement of innovations to improve efficiency and quality of public sector.

The Commission encourages Member States and regions to invest in DIH and provide incentives for industry to embrace digital innovations and foster synergies with other key enabling technologies.

The large investments needed in high performance computing facilities and data infrastructures for science and engineering can be addressed by pooling public and private resources in Europe. Similarly, more coordination of the large but fragmented R&D&I efforts in other key digital technology fields is essential. This can be achieved by strengthening the coordination role of the Public Private Partnerships (PPPs) so that they become real aggregation frameworks and ecosystems for digital industrial innovation. PPPs can act as drivers for implementing EU-wide digital industrial strategies, ensuring closer links between R&D&I and standardization efforts and fostering the use of all available financial tools. This is the case for the work started towards a 5G Action Plan calling for coordinated investment in the next generation mobile architecture, in order to deliver on industry's connectivity needs.

Overall, more than €20 billion are already earmarked to be invested in the next 5 years in the digital-sector PPPs by the industry and the EU in support of strategic R&I agendas[7].

Moreover, the Commission plans to launch a set of initiatives supporting the building of future digital industrial platforms[8]. One group of platform building initiatives aims at combining digital technologies, notably IoT, big data and cloud, autonomous systems and artificial-intelligence, and 3D printing, into integration platforms addressing cross-sector challenges. A second group addresses the integration of converging digital innovations into sectoral platforms and full solutions, such as The Connected Smart Factory and Connected and automated driving.

Therefore, the European Commission, in co-operation with Member States, will focus investments on PPPs and strongly encourage the use of the opportunities offered by the EU Investment Plan and European Structural and Investment Funds.

7 This includes around €5 billion already foreseen as EU support to PPPs in H2020 and the €15 billion private investment committed by industry to these PPPs.

8 Platforms are to be understood as multi-sided market gateways creating value by enabling interactions between several groups of economic actors. Among others, platform building requires the development of reference architecture and its gradual implementation, testing and validation in evolving ecosystems that trigger broad value creation. Examples of existing industrial platforms include AUTOSAR (www.autosar.org) in the automotive sector, ISOBUS (www.aef-online.org) in the agricultural machinery sector. On-going industrial platform initiatives include RAMI (www.plattform-i40.de), Industrial Data Space (www.fraunhofer.de). Digitizing European Industry Reaping the full benefits of a Digital Single Market.

In the Digital Single Market, billions of connected devices – including phones, computers and sensors – should communicate safely and seamlessly, regardless of their manufacturer, technical details or country of origin. An effective standardization environment for digital technologies is crucial for Digitizing European Industry. The Commission proposes concrete measures to speed up the standard setting process by:

- focusing on five priority areas, when asking industry and standardization bodies to work on standards. These areas are 5G, cloud computing, internet of things, data technologies and cybersecurity;
- co-financing the testing and experimentation of technologies to accelerate standards setting including relevant public-private partnerships. This will ensure timely delivery of standards to spur innovation and business growth.

This faster, more focused approach should also speed up the development and take-up of technologies such as smart grids, mobile health services, connected vehicles and other sectors. The same day it released its Digitizing European Industry Communication, the European Commission issued a Communication on Priority ICT Standards for the Digital Single Market, which, as already explained in Chapter 2, contains a series of measures aimed at streamlining standard setting for ICT technologies[9]. Following this Communication, the European Commission launched the EU standardization package.

This approach is in line with the already mentioned broader Joint Initiative on Standardization, signed on the 13th June 2016 by the European Commission and other stakeholders (EU and EFTA Member States, standardization organizations and bodies, European industry and industry associations, SMEs, and societal stakeholders).

Another Commission priority involves providing the appropriate regulatory framework conditions, that is adopting future-proof legislation that will support the free flow of data and clarify ownership of data generated by sensors and smart devices. The Commission will also review rules on safety and liability of autonomous systems. Other areas of Commission interest are the legal frameworks for autonomous systems and IoT applications, in particular safety and liability rules and the legal conditions to allow large scale testing in real life environments. The Commission also intends to work on the safety of apps and other non-embedded software not covered by sectoral legislation, assessing a possible need for further action at EU level.

One last, but crucial priority of the Commission is to ensure the preparedness of the human capital for the digital transformation thanks to an upgrading of the required skills.

Together with all stakeholders, such as Member States, industry, social partners and education and training providers, the Commission will address these challenges as part of the dialogue with social partners on the impact of digitization on work; reinforce the role of industry

9 Communication on Priority ICT Standards for the Digital Single Market, COM (2016) 176 final, 19.04.2016.

and research organizations in the Grand Coalition[10] and stimulate further commitment from industry to take action; improve the understanding of skills requirements for new technologies, including within H2020, and promote the development of digital skills and stimulate partnerships for skills within the framework of the New Skills Agenda for Europe; and engage Digital Innovation Hubs (DIH) in skills for mid-caps and SMEs.

An action plan to modernize digital public services completes the EU initiatives for Industry 4.0, in order to create a better environment to live, work and invest[11]. The Commission has put forward 20 measures to be launched by the end of 2017. Among the most notable actions:

- setting up a digital single gateway enabling users to obtain all information, assistance and problem-solving services needed to operate efficiently across borders;
- linking all business registries and insolvency registers and connecting them to the e-justice portal, which will become a one-stop shop;
- setting up a pilot project with administrations that will apply the "once-only" principle for businesses across borders. This means companies will only need to provide paperwork to public authorities in one EU country, even if they operate in other EU Member States;
- helping EU Member States develop cross-border e-health services such as e-prescriptions and patient summaries;
- accelerating the transition to e-procurement, e-signatures and implementation of the "once-only" principle in public procurement.

Overall, the Digitizing European Industry plans should mobilize up to €50 billion in public and private investments in support of the digitization of industry.

- €37 billion investment to boost digital innovation;
- €5.5 billion national and regional investments in digital innovation hubs;
- €6.3 billion for the first production lines of next-generation electronic components;
- €6.7 billion for the European Cloud Initiative;
- several initiatives are currently in place at a national level across the EU (Fig. 3.2).

Fig. 3.2 List of Industry 4.0 national initiatives active in May 2017

Source: European Commission

10 Starting in 2013, the Commission initiated the Grand Coalition for digital jobs as a trans-European, multi-stakeholder initiative to increase the provision of digital skills through stakeholder pledges offering ICT training, apprenticeships, placements, actions to facilitate mobility and/or carrying out awareness raising activities to encourage young people to study and pursue careers in ICT. https://ec.europa.eu/digital-single-market/en/grand-coalition-digital-jobs.

11 EU eGovernment Action Plan 2016-2020 Accelerating the digital transformation of government COM (2016) 179 final, 19.04.2016

3.2. FRANCE: L'INDUSTRIE DU FUTURE

The digital revolution and new manufacturing technologies represent a golden opportunity for companies to modernize, innovate and manufacture.

To help this become a reality, starting in 2013 President Hollande launched the New Industrial France initiative in order to assist French companies move upmarket and position themselves in the markets of the future. The government defined nine key priorities, the goal of which was to provide tangible responses to major economic and social issues. They are meant to provide solutions to challenges in areas such as:

- the medicine of the future;
- eco-mobility;
- new resources;
- sustainable cities;
- transport of tomorrow;
- the data economy;
- smart objects;
- digital trust and;
- smart food production.

In April 2015, the government supplemented this initiative with the Alliance for the Industry of the Future, which focuses on the modernization of France's production tools. So far nearly €2 billion have been provided in public support to one thousand innovative projects (Fig. 3.3).

The Industry of the Future project was launched by the President of the Republic on 14 April 2015. It is a cross-cutting initiative aimed at encouraging all companies to modernize their production base and use digital technologies to transform their business models in a world where digital tools are breaking down barriers between industry and services. The industry of the future project is built on five pillars:

1. *developing cutting-edge technologies* such as Additive Manufacturing, The Virtual Plant and the Internet of Things and Augmented Reality. Within the «Programme d'investissements de l'avenir» (Invest for the Future program), €305 million in subsidies and repayable loans and €425 million from the SPI (industrial project companies) fund partly finance this action. In October 2015, a first call for proposals for Industry of the Future technologies was launched with a €100 million in funding. In early 2016 4 projects, representing a total funding budget of €48.5 million, selected for in-depth assessment.
2. *helping companies adapt to the new paradigm*, through personalized support offered by regional platforms. Based on a shared database, awareness-raising campaigns are expected to reach 15,000 companies and the proposed goal is to support 2,000 of them within the first two years. Some 200 to 300 experts have been trained to certify innovative projects at the national level.

   The government announced two exceptional measures to support companies keen to modernize their production base: €2.5 billion in tax incentives for companies investing in their production base in the period 2015/2016, and €2.1 billion in loans earmarked by Bpifrance for SMEs and mid-tier firms until 2017. The higher depreciation allowance was extended

for one year and expanded to include certain digital goods. This tax incentive, which covers up to 13% of the value of investments made between 15 April 2015 and 14 April 2017, is intended to support companies seeking to modernize their business models.

The Industry of the Future loans are soft, unsecured loans granted to SMEs with a two-year deferred repayment. They have a significant leverage effect on private-sector financing, and can be used to finance innovative and high-powered investment in production capacities. The first tranche of loans was granted to 851 "Industry of the Future" projects, for a total of €719 million and a new tranche of €1 billion was introduced in the fall of 2016.

These additional development loans supplement the €1.2 billion already made available to companies investing in Industry of the Future projects (digitization, robotics, energy efficiency, etc.).

3. *Employee training*

   Training goes hand-in-hand with the heightened presence of digital technology and robotics in industry, which are vital to creating jobs in France and ensuring that businesses in many sectors remain competitive. In March 2016, the Learning about Industry project ("Osons l'Industrie") was launched aimed at creating a web portal to provide students and their families with information about professions, trainings and recruitment possibilities in Industry of the Future-related sectors, in connection with businesses. The project was selected for financing as part of the Invest for the Future Program.

4. *Promoting the Industry of the Future*

   This pillar consists of launching emblematic projects on a national or even European scale. During the Industry Week 2016, throughout France 2,550 authorized events spotlighted French industry.

   So far, 26 companies have been awarded with the title of authorized Industry of the Future flagship sites. These are companies that have developed innovative projects for their production management, specifically through digitization. The goal of accrediting emblematic Industry of the Future projects is to provide visibility for innovative French technical solutions and to share best practices among national and international ecosystems, including manufacturers in the same sector (particularly SMEs), as well as those from other sectors, technology integrators and suppliers, funding sources, public authorities and the academic world.

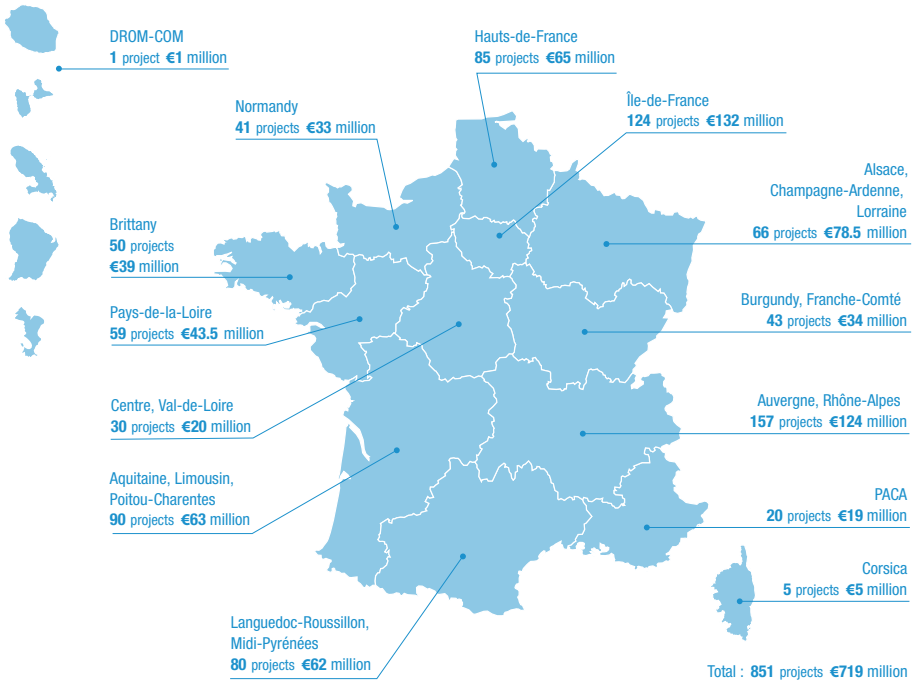
5. *Reinforcement of European and international cooperation*, focusing on technological cooperation with Germany.

   Most industrialized countries have launched government-sponsored programs to promote new technologies in industry. The goal of the French "Industry for the Future" initiative is to connect with these various projects in order to initiate and support joint technological and training efforts with other countries.

   Additionally, the aim is to create strategic alliances in the area of standardization, with an eye to better representing French interests within European and global initiatives

Fig. 3.3 France - Regional breakdown of Industry of the Future loans

Source: French Ministry for Economy



The *Alliance Industrie du Futur* (Industry of the Future Alliance) is responsible for the operational implementation of France's Industry of the Future project. The Alliance organizes and coordinates national initiatives, projects and efforts fulfilling the goals of the initiative, relying on dedicated working groups.

The Alliance is responsible for fostering operational partnerships (employer associations, clusters, sectors, chambers of commerce and industry, etc.).

To support industrial SMEs on the ground, the Alliance's actions are spread throughout France's regions by teams made up of Alliance members, local authorities, the Directorates for Enterprises, Competition Policy, Consumer Affairs, Labor and Employment and clusters.

The "Invest for the Future" program

Launched in 2016, the third investment program for the future (PIA 3) will supply €10 billion in funds earmarked for education and research, and also business innovation.

Of the €10 billion, €5.9 billion will finance education, research and development and the program will

contribute to the implementation of a "digital plan" in schools, by financing the launch of new experiments (Table 3.1).

On the "innovation and business development" component, PIA 3 will continue to support actions with a €4.1 billion fund in the following domains:

- innovative projects carried out by SMEs / start-ups and research laboratories;
- structuring of industrial sectors, specifically supporting strategies defined in the *Nouvelle France Industrielle*, as well as agriculture and agro-food. In this framework, PIA 3 will provide an additional allocation to the *Société de Projets Industriels* (SPI) fund, which will share the risk of a first industrialization of new products developed by companies;
- modernization of SME production processes within the framework of the Industry of the Future (automation, 3D printing, internet of objects);
- training of the workforce in these new solutions.

Apart from financing technological innovation, support for SMEs is recognized concerning two challenges – the breakdown of economic models and the speed of development.

Tab. 3.1 Breakdown of Investments for the Future Programme (€mln)

Source: French Government data processed by I-Com

Support the development of education and research	
Support educational innovation	750
Amplify research programs	750
Integrate research and education	1,000
Diversify university management	400
Highlight research	
Promote innovative regions	2,350
Help in the capitalization of innovation	650
Speed up the modernization of enterprises	
Support innovation	1,550
Accompany the Industry of the Future	450
Speed up the growth of SMEs	2,100
Total investments	**10,000**

3.3. GERMANY: *INDUSTRIE 4.0*

Industrie 4.0 is a strategic plan backed by the federal government and with the involvement of the main firms in the industrial and technology sectors. *Industrie 4.0* was one of the future projects adopted in the "Action Plan High-tech Strategy 2020" by the German Federal Government in 2010. This encouraged the business associations of BITKOM, VDMA and ZVEI to establish the *Plattform Industrie 4.0* in 2013. Many players from the private sector, business associations, unions, research organizations and political institutions also later joined

(Fig. 3.4). Today, a total of over 300 participants from 159 organizations are active in the Platform.

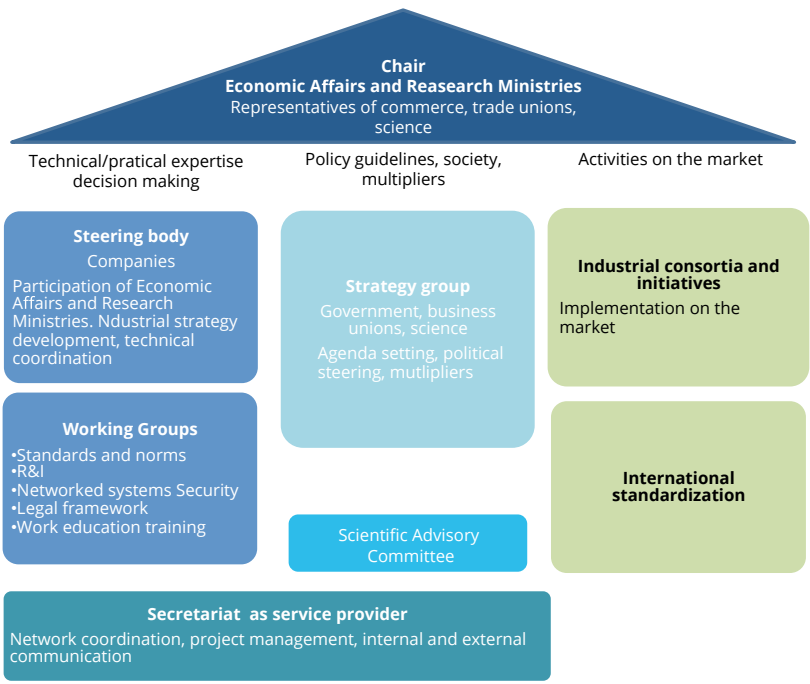
The main objective of the Platform is the development of technologies, standards, business and organizational models and their practical implementation, to secure and develop Germany's top international position in industrial manufacturing. The Platform aims to promote digital structural change and to provide the consistent and reliable framework necessary for this. The Platform's goal is, therefore, to develop a consistent overall understanding of *Industrie 4.0* through dialogue with businesses, trade unions, science and government, drawing up relevant recommendations for action and demonstrating with example applications how industrial manufacturing can be successfulldigitized.

The central office of the Platform organizes and coordinates all *Plattform Industrie 4.0* activities, informs on the progress made by the cooperation and serves as a main point of contact for businesses, politics and the media.

The platform sees itself as a network that brings stakeholders together, discusses the various issues with them, monitors processes, raises awareness of issues,

Fig. 3.4 Germany - Structure of *Plattform Industrie 4.0*

Source: Plattform Industrie 4.0



and mobilizes businesses – all to ensure that Industrie 4.0 "Made in Germany" will be a success (Fig. 3.5). The work of the platform is therefore concentrated in four areas:

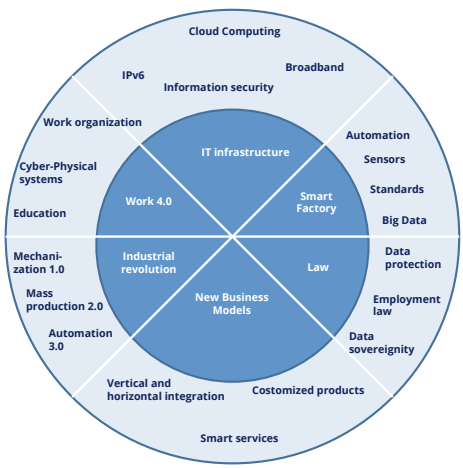
1. *Making content recommendations*
   The underlying idea is that Germany maintain its status as one of the most modern industrial nations, continuing to develop dynamically. Based on the knowledge obtained through research and practical experience, the platform's working groups identify where action is needed and make recommendations for implementing suitable framework conditions. This makes it easier for businesses to integrate the new Industrie 4.0 approaches and technological developments into their business practices.
2. *Mobilizing businesses, particularly SMEs*
   Around a third of businesses in Germany are currently involved in Industrie 4.0 and the idea is to encourage even more businesses to become involved. On the basis of these use cases, businesses can become informed about the different topics and tackle them concretely. It also encourages the trialing and implementing of such scenarios themselves.
3. *Providing single-source support*
   There are numerous programs and projects in Germany in the area of Industrie 4.0. *Plattform Industrie 4.0* provides interested individuals with quick access to information about these, for example, information on funding programs. The platform is, therefore, the central contact point for interested individuals within and outside of Germany. Synergies are thereby being created and the work duplication avoided.
4. *Promoting international networking*
   Plattform Industrie 4.0 maintains close ties with initiatives in Japan, the USA, France, and China and is systematically expanding these relations. The platform also participates in national and international events and in national and international networks.

The platform has formed five working groups of representatives from business, science, associations, trade unions and federal ministries, which correspond to the following activity areas:

- Working group 1: Reference architecture, standards and norms
- Working group 2: Research and innovation
- Working group 3: Security of networked systems
- Working group 4: Legal framework
- Working group 5: Work, education and training

Fig. 3.5 Germany – What *Industrie 4.0* is

Source: Plattform Industrie 4.0



Services for SMEs

Plattform Industrie 4.0 website features an Online Map which displays around 250 examples of *Industrie 4.0* applications. These examples help enterprises find out which *Industrie 4.0* applications may be used in their own company. In addition to this, the map shows a number of places where companies can test new developments under real-life conditions. Finally, the map displays advisory services, provided, for example, by the chambers of industry and commerce or by initiatives based in a *Länder*.

Plattform Industrie 4.0 has developed an *Industrie 4.0* compass that helps companies find local support services. The compass lists more than 50 non-commercial support services that are available in Germany, providing basic information, information onpecific testing opportunities and information about how to implement a pilot project. In addition, *Plattform Industrie 4.0* has held many events, raising awareness among companies and also training them. These events have been organized in cooperation with the chambers of industry and commerce, associations and Länder-based initiatives. The series of events entitled *Industrie 4.0@Mittelstand* provides those people interested with information about key issues such as IT security, legal implications, progress on standardization, innovation transfer. These events also allow company representatives to directly network with one another.

A number of *Plattform Industrie 4.0* members, including companies and associations, have started a new initiative entitled 'Labs Network *Industrie 4.0*'. This initiative helps companies find suitable centers where they can test their *Industrie 4.0* solutions before making any major investment. The findings that result from the work undertaken in these testing environments also inform the efforts undertaken on standardization, the work done by the platform's working group on 'Reference Architecture, Standards and Standardization' and the Standardization Council 4.0.

Recommendations for action for policymakers and companies

Plattform Industrie 4.0 has five working groups, each of which focuses on a different subject: concepts and recommendations for action for the pre-competitive stage in a number of selected areas. These recommendations are aimed at both companies and policymakers:

- Working group 1 has developed a model that illustrates the basis for interaction among Industrie 4.0 components. The RAMI 4.0 reference architecture model is attracting attention internationally and it has been discussed by international standardization organizations such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC);
- Working group 2 has drawn up a research agenda where it identifies and ranks a number of issues where companies are to conduct more research and where providing dedicated funding program could prove to be worthwhile;
- Working group 3 has released a 'Guideline on IT security' which helps companies, particularly SMEs, to implement digitized manufacturing processes securely;

- Working group 4 deals with lawmakers adapting the legislative framework;
- Working group 5 addresses the issue of Training and Education for *Industrie 4.0* and looks at what new skills employees need to develop in the age of digitalization and *Industrie 4.0*. The recommendations provided by working group 5 are aimed at both policymakers and companies.

The platform's working groups develop recommendations for action on standards, research, IT security, legislation and training, thus providing input for companies, policymakers and civil society. All papers, concepts, guidelines and recommendations for action will be then published in the platform's online library.

National and international alliances

The platform engages in intensive dialogue with both national and international alliances in order to drive forward the debate on standardization and to position Germany as the leading market for *Industrie 4.0*. The platform is also part of the dialogue that takes place between Federal Government and Länder initiatives. At international level, the platform works with the Industrial Internet Consortium (USA), *Alliance Industrie du Futur* (France) and the Robot Revolution Initiative (Japan). In addition to this, Germany has signed a Memorandum of Understanding and adopted a joint action plan with China, and maintains regular dialogue with the EU and the G20 countries. It is currently working with its international partners to draw up an online overview of *Industrie 4.0* applications worldwide.

Telecommunications and New Media (BITKOM) and the research institution Fraunhofer IAO calculate that *Industrie 4.0* alone could push the gross added value of the German machine and plant manufacturing sector from €76.8 billion in 2013 to nearly €100 billion in 2025. The additional annual GVA growth of 2.21% could also be achieved in the chemical and electrical equipment branches. Meanwhile, vehicles, agriculture, and ICT could expect extra annual GVA growth of over 1%. Of course, such growth requires significant investments. BITKOM expects annual investments in *Industrie 4.0* in Germany to rise from €650 million in 2015 to around €2 billion by 2018 and over €2.6 billion by 2025.

Despite the high level of support from the government, *Industrie 4.0* remains an industrial and not a political initiative. However, the German government is keen for the country to maintain its leading edge. In September 2014, the federal cabinet adopted a new version of its High-Tech Strategy aimed at strengthening economic prosperity by providing coherent innovation policy. The strategy focuses on the transfer of scientific findings to accelerate marketable products, processes and services, and to improve the innovation environment. The initiative combines the resources of all government ministries, which are setting billions of euros aside annually for the development of cutting-edge technologies. *Industrie 4.0* is firmly anchored as one of the strategy's ten forward-looking projects.

3.4. ITALY: THE INDUSTRY 4.0 NATIONAL PLAN

The Italian government presented its "Italia 4.0" project on September 21, 2016.

The Plan provides a wide array of strategic and complementary measures promoting investment in innovation and competitiveness.

According to the government, the planned measures can be put in place automatically by every company, thus avoiding any evaluation procedures and the associated red tape and without any restrictions in terms of size, sector or location.

The "Industria 4.0" National Plan aims to help companies to improve their competitiveness by supporting investments, digitalization of industrial processes, improvement in worker productivity, as well as the development of new skills, new products and new processes.

The project focuses on four kind of measures. These are divided between strategic measures and complementary measures.

Strategic measures

Innovative investments

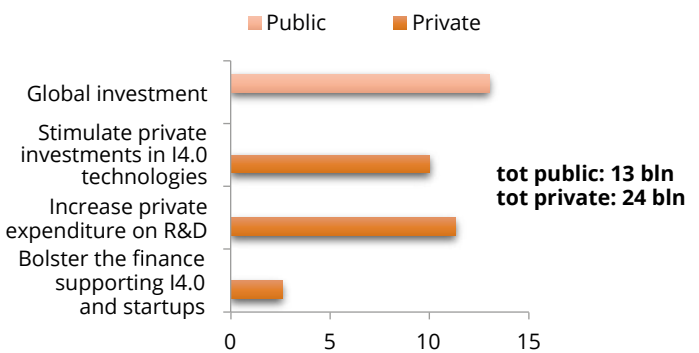
Regarding innovative investments, the government will invest €3.3 billion over four years, through: the extension of the 140% super-amortization plan; hyper-amortization on digital goods (between 200% and 160%) with the possible reduction of the timeframe from seven to five years; recapitalization of the SME Guarantee Fund for €900 million; €100 million in refinancing of the "New Sabatini Law" (for investment in machine tools), and a special section of the rotating business fund of the *Cassa Depositi e Prestiti*.

Until 2020, €2 billion will be used to fund tax credit for investment in R&D. As for venture capital, the project aims to attract €1.5 billion in private investments at an early stage.

The main goals are to stimulate private investments in I4.0 technology drivers, increasing private spending in R&D &I and expanding open innovation relations between mature companies and high-tech startups. Manufacturing will not be the only targeted industry, but also agro-food, bio-based economy and energy efficiency.

Fig. 3.6 Plan Industria 4.0 – Public and private efforts in innovative investments 2017-2020 (bn €)

Source: MISE data processed by I-Com



Skills and research

The Industry 4.0 plan includes a chapter on human capital. It sets ambitious targets, including a school plan on smart manufacturing aimed at involving 8 million students in primary and secondary schools in the national plan for digital education, and an additional 250,000 high school

students in a school-work exchange program.

The plan also includes universities, with €70 million on new 4.0 university classes training 200,000 students and 3,000 future managers.

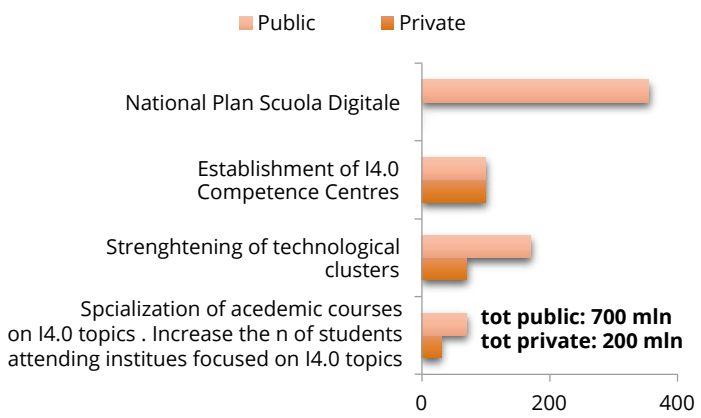
The project also aims to double the number of students of technical institutes, increasing the offer of highly specialized classes in the 4.0 industry.

To improve the exchange between university and businesses, the project will fund 900 specialized PhDs (including at least 100 on Big Data), as well as smart manufacturing clusters, and the creation of "competence centers" associated with the best universities – the Polytechnics of Milan, Turin, and Bari, Bologna University and the Sant' Anna School of Advanced Studies – where companies will train and test the new 4.0 technologies.

Moreover, selected Digital Innovation Hubs, located at Confindustria's and R.E.TE. Imprese Italia's branches will serve as contact points between companies, research institutions and public/private investors.

Fig. 3.7 Plan Industria 4.0 – Public and private efforts in skills and research 2017-2020, € mln

Source: MISE data processed by I-Com



Complementary measures

Enabling infrastructures

These measures aim to ensure adequate network infrastructures with the Ultra Broadband Plan and to define the IoT open standards and interoperability criteria.

The target has been set so that by 2020, at least 50% of Italian businesses will have access to ultra-broadband networks of 100 Mbps, while all businesses will have a network coverage of at least 30 Mbps. For this reason, the government intends to develop ultra-broadband networks.

The plan already exists and €6.7 billion in national and European funds have been approved. It will try to address the hurdle of the "grey" zones of the country, those overlapping the white areas "at risk of market failure", and where the State is investing €3 billion in areas where there is no viable business case for the private sector, and the black areas, where competition is possible and private companies are already operating.

According to estimates, 69% of businesses are located in "grey" areas ("marked by the presence of a single broadband network operator"). A public investment of €3.7 billion is expected to attract private funds through a series of initiatives that are awaiting European Commission approval. The plan includes vouchers to activate connectivity services, tax deduction on investments, easier access to credit, and giving private investors the ownership of the infrastructure. The draft plan includes initiatives for strengthening cybersecurity.

Public support tools

The Plan sets a bundle of complementary measures in order to:

- guarantee private investments;
- support large innovative investments;
- reinforce and support internationalization of Italian companies;
- strengthen productivity– salary taxation exchange through decentralized negotiation.

These goals will be attained with the reform and refinancing of Public Guarantee Fund for 2017 by €1 billion, as well as with support measures of large scale investments focused on I4.0. investment in digital sales chains ("Made in Italy Plan").

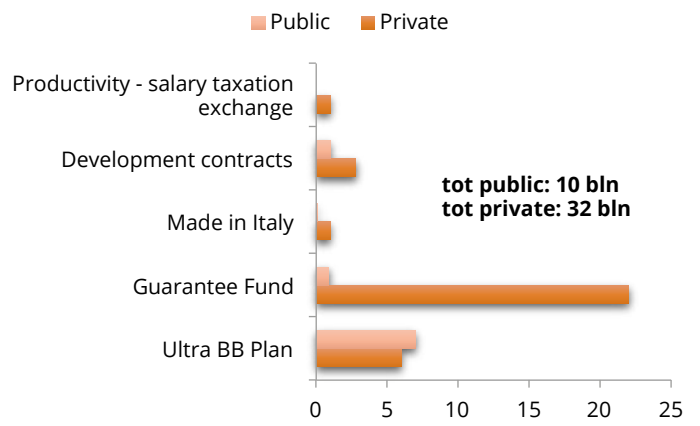
The plan is expected to attract €10 billion in additional industrial investment, and €7 billion for research and development through tax incentives, support for venture capital, ultra-broadband development, educational training in schools and universities, and state-of-the-art research centers.

According to government estimates, the public injection will multiply by 4.5 times private investment targeted to the industrial sector, expected to rise from €80 billion to €90 billion per year. Private spending in R&D innovation is also expected to increase from €13 million to €20 billion.

The "growth-friendly" project goes beyond the industrial sector, with the ambition to make Italy a leading G-7 player, also in forging alliances with other countries.

Fig. 3.8 Plan Industria 4.0 – Public and private efforts in complementary measures 2017-2020 (€ bn)

Source: MISE data processed by I-Com



3.5. UNITED KINGDOM: THE GREEN PAPER "BUILDING OUR INDUSTRIAL STRATEGY"

The UK has initiated a number of policies to foster innovation, but it was only in 2017 that it expressed its view on a global industrial strategy to meet the new challenges of the economic environment. In January 2017, the government issued a Green Paper "Building our Industrial Strategy", seeking comments from industry. Among the main goals, the government promises to tackle the UK's poor labor productivity, improve access to capital and cultivate "world-leading" sectors.

The strategy is built on 10 pillars:

1. *Science*
2. *Research and innovation*

   The UK invests 1.7% of GDP in private and public funds on R&D. This is below the OECD average of

2.4% and substantially below the leading backers of innovation – South Korea, Israel, Japan, Sweden, Finland and Denmark – which contribute over 3% of their GDP to this area. Furthermore, there are regional disparities in how the public sector and companies spend money on research and innovation. The UK plans to invest an additional £4.7 billion by 2020-21 in R&D funding. The Green Paper also focuses on the technologies which could be supported, including – smart and clean energy technologies (such as storage and demand response grid technologies); robotics and artificial intelligence (including connected and autonomous vehicles and drones); satellites and space technologies; leading edge healthcare and medicine; manufacturing processes and materials of the future; biotechnology and synthetic biology quantum technologies, and transformative digital technologies including supercomputing, advanced modelling, and 5G mobile networks.

3. *Developing skills*

   The UK hosts some of the world's top universities and a large percentage of its population are graduates, more than most of its competitors. However, technical education has been relatively neglected. Consequently, the UK suffers from a shortage of technical-level skills, and ranks 16th out of 20 OECD countries for the number of people with technical qualifications. England remains the only OECD country where literate and numerate 16 to 24-year olds are less than 55 to 64-year olds. The Green Paper opens a discussion on how the country can create a new system of technical education, including creating prestigious new Institutes of Technology to deliver higher-level technical education in all regions. The paper also advises on how to boost STEM skills (science-technology-engineering-mathematics) at all levels and ensure the number of16 year-old school leavers is reduced.

4. *Upgrading infrastructure*

   Though the UK has pioneered many types of infrastructures, from railways to mobile telecoms, the quality of its transport infrastructure has been rated as the second lowest among G7 countries. To upgrade the national infrastructures, the government announced a new National Productivity Investment Fund that will add £23 billion in high value investment from 2017-18 to 2021-22. This includes: £2.6 billion for improvements in transport projects to reduce journey times, and £740 million to support the rollout of fiber broadband connections and future 5G mobile technology. The government will also take action to support more private infrastructure investment. As well as taking strategic decisions on major projects such as Heathrow, Hinkley Point C and HS2, the government will extend support for infrastructure bonds and loans and create new opportunities for private involvement

5. *Supporting business growth and investment*

   According to OECD studies, the UK ranks third for start-ups, but 13th for the number of businesses that successfully scale up. One potential cause is an

under-supply of long-term funding – "patient capital" – and later stage venture capital for developing UK companies. Barriers to entrepreneurship and scale-up need to be identified and addressed in order for UK companies to be able to become a major global player. The Patient Capital Review, recently announced by the Prime Minister, will identify the most effective ways to improve the availability of patient capital for developing businesses

6. *Improving procurement*
   The public sector spends in procurement around £268 billion per year, equivalent to 14% of GDP. Used strategically, government procurement can encourage innovation, competition, and investment in skills. The Government is rolling out the "balanced scorecard" across all investment projects over £10 million, to ensure the impact of procurement on the growth of small businesses and UK supply chains, skills and apprenticeships are taken into account when considering the value for money of different bids.
7. *Encouraging trade and investment*
   The UK ranks as the number one location for inward investment in Europe, but not enough UK firms export, and trade has grown more slowly than in its G7 competitors over recent decades. The creation of the new Department for International Trade is an opportunity to upgrade support for investors and exporters. The government is working to support businesses through discussions on market access issues with third countries such as Canada, China, India, Mexico, Singapore and South Korea, which have already expressed interest in discussing future trading relations with the UK.
8. *Delivering affordable energy and clean growth*
   The government will set out a long-term roadmap in 2017 to minimize business energy costs. It will also review the opportunities for growth from the energy sector and the opportunities for the UK. To ensure that new energy technologies are developed locally – and the UK benefits from global investment in this area – the government has doubled support for energy innovation, and is already investing over £600 million to accelerate the transition to ultra-low emission vehicles. In autumn 2016, an additional funding of £270 million was announced.
9. *Cultivating world leading sectors (sectoral policies)*
   The government will work with sectors that organize themselves behind strong leadership to help deliver upgrades in productivity. This could involve addressing regulatory barriers, promoting competition and innovation, working together to increase exports and working together to commercialize research.
10. *Driving growth across the whole country;*
    Economic imbalances between different parts of Britain are larger than in competing countries. The government will use infrastructure investment to support local growth and the rebalancing of the economy. The creation of new funding like the Housing Infrastructure Fund and £1.1 billion in funding for local roads and public transport networks will enable infrastructure decisions to be matched more effectively with local economic plans. The government

will also use the additional R&D investment to back world-class research and innovation, supporting local economies across the country.

The outlined approach builds on what already exists in sectors such as automotive and aerospace, with individual firms taking the initiative to organize their sectors, backed by institutions or organizations which enable vital partnerships in R&D throughout the supply chain.

The Green Paper also establishes technologies where Britain has strengths in research and development which could be supported through the government's new *Industrial Strategy Challenge Fund.* This was created in April 2017 to provide funding and support to UK businesses and researchers, part of the government's £4.7 billion increase in R&D over the next 4 years. It was designed to ensure that research and innovation takes center stage in the government's Industrial Strategy. The key areas of investments are: healthcare and medicine (£197 million in 4 years), clean and flexible energy (£246 million), and robotics and artificial intelligence (£93 million); driverless cars (£38 million), manufacturing and future materials (£26 million); and satellite and space technology (£99 million).

To support delivery of the Industrial Strategy Challenge Fund, the government will invest £250 million over the next 4 years to continue to build the pipeline of high-skilled research talent, while Innovate UK, the government innovation agency, will be funding £10 million in a first wave of projects through the ISCF in each of the 6 areas with a number of smaller projects, starting in 2017 to 2018. Within its mandate, Innovate UK set up Catapult Centers, organizations to promote R&D through business-led collaboration between scientists, engineers and market opportunities.

The Green Paper does not mention Brexit. However, this is an issue that will need to be addressed. A survey, conducted by KPMG Consultancy in December 2016 and early January 2017, found that two thirds of manufacturing executives surveyed said that the uncertainty from Brexit would damage UK economic stability. Some companies are considering relocating aspects of their plant or operations to another country in order to boost productivity or reduce costs. There is also a slight but notable increase in consideration of moving elements of the supply chain away from the UK. While this might seem counter-intuitive at a time when the low pound value is encouraging greater investment into the UK, businesses with interconnected pan-European supply chains may be planning for the possibility that the UK exits the EU Customs Union without an EU-UK Free Trade Agreement in place. For such businesses, tariffs and non-tariff barriers, e.g. delays in border clearance, could prove costly[12].

Innovate UK

The Technology Strategy Board – established in 2004 within the former UK Department of Trade and Industry (DTI), before becoming an independent body in July 2007, fully adopted the name Innovate UK in 2014.

12 KPMG, Rethink manufacturing - Designing a UK industrial strategy for the age of Industry 4.0, February 2017

Innovate UK is a UK innovation agency, whose focus is on driving innovation across the UK, by investing in high-potential innovation projects in a number of priority areas, as well as by connecting businesses with each other and with research and by establishing the Catapult centers

Recently Innovate UK has restructured the organization into four sector groups:

- emerging and Enabling Technologies;
- health and Life Sciences;
- infrastructure Systems;
- manufacturing and Materials.

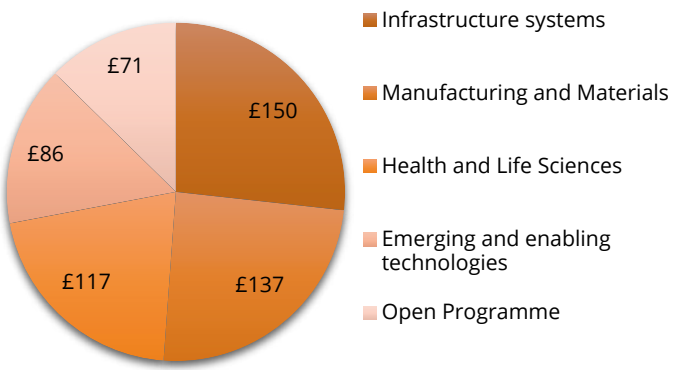
Underpinning the activity of the sector groups, Innovate UK has set out a 5-point plan that will drive its action to ensure productivity growth by:

- turning scientific excellence into economic impact and deliver results through innovation, in collaboration with the research community and government;
- accelerating UK economic growth by nurturing high-growth potential SMEs in key market sectors;
- building on innovation excellence throughout the UK, investing locally in areas of strength;
- developing Catapult centers within a national innovation network to provide access to cutting-edge technologies, encourage inward investment and enable technical advances in existing businesses;
- evolving its funding models.

Innovate UK's core budget for the financial year 2016/17 (April to March) was £561 million, divided among its different programs.

Fig. 3.9 Innovate UK: Spending breakdown 2016-2017 (£ mln)

Source: Innovate UK data processed by I-Com



The spending provides, in each sector group, a single innovation funding stream through which businesses compete for grants, contracts or, in future, other innovation finance products. This should result in a structure where competition is much broader in scope than previously, consistently focused on groups of interrelated sectors and run twice a year for each sector group.

Since 2007, Innovate UK has committed over £1.8 billion in innovation, matched by a similar amount in partner and business funding. It has supported more than 7,600 organizations with projects estimated to add more than £11.5 billion to the UK economy and create 55,000 extra new jobs.

Recently, the government has announced its intention to create Research UK, a new body incorporating the seven

research councils[13], looking at integrating Innovate UK into this new body.

Catapult centers

Catapult centers are organizations set up by Innovate UK to promote R&D through business-led collaboration between scientists, engineers and market opportunities. The Catapult Centers provide access to expert technical capabilities, equipment and other resources to help businesses to put into practice their innovative ideas.

Each Catapult center specializes in a different area of technology:

- cell and gene therapy;
- compound semiconductor applications;
- digital;
- energy systems;
- future cities;
- high value manufacturing (a network of another seven centers);
- medicine discovery;
- offshore renewable energy;
- precision medicine;
- satellite applications;
- transport systems.

Each Catapult center is expected to raise funds equally from three sources – business-funded R&D contracts; collaborative applied R&D projects from UK and Europe (H2020), funded jointly by the public and private sectors, also won competitively; and core UK public funding.

3.6. OUTSIDE THE EU: CHINA AND THE US

3.6.1. Made in China 2025

The Chinese government focused its efforts to modernize the industrial sector on "Made in China 2025" plan. China's State Council launched "Made in China 2025" in May 2015 as a national strategy to make China a leading manufacturing power, setting a time horizon initially of 2025 and then up to 2035 and 2049. The plan was drafted by the Ministry of Industry and Information Technology (MIIT) over two and a half years and gathers the inputs received from 150 experts from the China Academy of Engineering. The strategy contains principles, goals, specific tools and priority sectors. "Made in China 2025" aims at placing Chinese industry at the top of global production chains, by optimizing the structure of Chinese industry, introducing innovation-driven processes, nurturing human talent and promoting sustainable development. The plan sets three strategic priorities: 1) to further

13 Established in 2002 following a government review, the Research Councils UK (RCUK) is a Non-Departmental Government Body whose purpose is to manage a strategic partnership between seven individual research councils that coordinate and fund research in the arts, humanities, science and engineering. There are seven councils: The Arts and Humanities Research Council (AHRC); The Biotechnology and Biological Sciences Research Council (BBSRC); Engineering and Physical Sciences Research Council (EPSRC); Economic and Social Research Council (ESRC); Medical Research Council (MRC); Natural Environment Research Council (NERC); Science and Technology Facilities Council (STFC). In 2007, the government raised the status of the Technology Strategy Board, now Innovate UK, to become a research council for industry. This was due to a concern that the seven research councils, with their emphasis on academic excellence, were placing insufficient attention on innovation through the application of research findings.

promote the structural adjustment of the manufacturing industry; 2) to support the coordinated development of the service-oriented manufacturing and productive manufacturing; 3) to raise the level of development of the manufacturing industry in line with international standards. In order to achieve these goals, the strategy identifies various policy measures, such as: the deepening of the reform in system and mechanism, the creation of fair and competitive market environment, the enhancement of financial support policy, the expansion of the level of support in financial and taxation policies, the development of a multi-tier personnel training system, improvements in policy on small and medium-sized enterprises, the further opening up of China's manufacturing sector to foreign investments, the strengthening of the mechanisms for the organization and the implementation.

"Made in China 2025" also includes the development of finance and commercial finance to support priority sectors and the creation of a multidimensional capital market through domestic and international financial arrangements and for enterprises. Moreover, an increased public funding is expected to sustain the manufacturing industry in general and the intelligent manufacturing specifically as well as the utilization of public-private partnership and private sector funding in major manufacturing ventures.

Besides, the plan sets the goal of increasing the domestic content of core components and materials up to 40% by 2020 and 70% by 2025 and it highlights tools to support the upgrade of Chinese manufacturing, such as the creation of innovation centres (15 by 2020 and 40 by 2025) and the strengthening of market institutions, such as the promotion of a more effective use of intellectual property by the enterprises and the reinforcement of the intellectual property rights protection for SMEs. The State assures an overall framework to the strategy and identified 10 priority sectors: 1) New advanced information technology; 2) Automated machine tools & robotics; 3) Aerospace and aeronautical equipment; 4) Maritime equipment and high-tech shipping; 5) Modern rail transport equipment; 6) New-energy vehicles and equipment; 7) Power equipment; 8) Agricultural equipment; 9) New materials; and 10) Biopharma and advanced medical products.

Moreover, in addition to "Made in China 2025", it is worth noting that China's manufacturing heartland, Guangdong Province, released a region-specific "Plan for the development of Smart Grid Manufacturing (2015-2025). In the same way, it is likely that other regions will follow Guangdong's example launching their own programmes and boosting interregional competition for Chinese manufacturing.

3.6.2. Manufacturing USA

The US government has been keen on the potential of digital manufacturing for many years. In 2011, a public-private intervention scheme for industrial innovation was introduced, followed by the establishment of a Steering Committee, in 2013, with the task to encourage innovation, promote resources and skills and create favourable conditions to the development of industrial activities. Later, in 2014, the federal legislator introduced a specific

program, called Manufacturing USA – National Network for Manufacturing Program (NNMI), that is operated by the interagency Advanced Manufacturing National Program Office (AMNPO).

The office is staffed by representatives from federal agencies with manufacturing-related missions as well as fellows from manufacturing companies and universities and it works in partnership with the Department of Defense, the Department of Energy, NASA, the National Science Foundation, and the Departments of Education, Agriculture, and Labor.

Manufacturing USA aims at increasing the manufacturing industry's competitiveness, transforming innovative technologies into economically sustainable industrial applications, facilitating the access of companies to advanced technological infrastructures, on the one hand, and to financing sources, on the other hand, and creating new jobs.

To this purpose, Manufacturing USA brings together industry, academia and federal partners within a growing network of advanced manufacturing institutes in order to boost U.S. manufacturing competitiveness and sustain a sustainable national manufacturing R&D infrastructure. Therefore, a national network of centres for manufacturing innovation – relying on the National Institute for Standards – has been created, acting through the support of public funding as long as further private economic resources are proved to be available. This Institute is provided with specific allocations, that currently amounts to 5 million $ – supplied by the Department of Commerce – per each fiscal year from 2015 to 2024; an additional $250.000 fund is made available by the Ministry of Energy for researches and initiatives in this specific area. In short, some federal resources are put in place and relevant sectors are identified, but the bulk of investments comes from the business sector. By coordinating federal resources and programs, the AMNPO supports technology transfer in U.S. manufacturing industries and helps companies overcome technical, financial and organizational obstacles to scale up of new technologies and products.

Manufacturing USA currently has nine manufacturing innovation institutes established or announced, with six more planned by the end of 2017. These institutes are based on public-private partnerships and each of them has a distinct technology focus but all aim at securing the future of manufacturing in the United States through the enhancement of the industrial competitiveness, the increase of the economic growth and the strengthening of U.S. national security.

CONCLUSIONS AND POLICY RECOMMENDATIONS

The manufacturing sector is undergoing a profound transformation worldwide. It is a process of change that encompasses all aspects: – products, services, process logistics, market approach, customer care, etc. The integration of digital technologies in the industrial sector guarantees important opportunities for growth, creation of new professions and increases in production and export rates. Industry 4.0 is about to change the global competitive scenario. Some manufacturing sectors will disappear, others will emerge and succeed and, as well, many jobs will become obsolete and others will grow exponentially.

It is, therefore, necessary to be prepared to meet this industrial revolution. For Europe, it is essential to be able to stabilize and speed up economic recovery, which is still a risk.

Therefore, we would like to put forward the following policy recommendations:

1) Attracting FDI in digital manufacturing. As reported in this study, among EU Member States, there are countries that rank in the first positions globally for attractiveness for digital investments. However, other countries are less attractive for digital business models. EU institutions and Member States need to stimulate FDI in digital manufacturing and private investments in Industry 4.0 technology drivers, to increase private spending in R&D and to develop open innovation relations between mature companies and high-tech start-ups. The EU could sustain business growth and attractiveness of locations for digital investments thanks to favourable and common tax measures and adequate funding support, so as to reduce the tax burdens for companies investing in digital. Of course, FDI should be open also to those extra-UE countries that comply with principles of reciprocity.

2) Integrating robots and other digital technologies in manufacturing. The integration of digital technologies in manufacturing in Europe is rising, but it is also disappointing for many aspects, especially if we consider the fast progress in China and other Asiatic countries in this field. Therefore, it is fundamental to provide incentives and sustain the integration of robots and other digital technologies (additive manufacturing such as 3D printing, robotics, artificial intelligence, cognitive computing, advanced material science and material bonding technologies) in the productive processes. In this respect, government procurement plays an important role. Used strategically, public procurement can encourage innovation, competition and investment in skills and technologies. It is also important to help smaller companies to access digital technologies, with special initiatives targeting SMEs.

3) Upgrading technologies and infrastructures. The spread of technologies such as cloud computing, radio-frequency identification technologies, ERP, CRM and SCM systems, as well as of Big Data Analytics, show great disparity across Europe. In this study, we strongly argued about the advantages of adopting these technologies in terms of cost reduction and increases in efficiency. At the

same time, the spread of fast connectivity networks in EU is still limited and geographically unbalanced. This appears quite disappointing, above all, if we consider the positive linkage existing between connectivity and the ability of companies to access new technologies and opportunities, such as analyzing data, which is becoming one major source of business value. Therefore, promoting public and private investments in upgrading digital infrastructures all over the EU is a foremost need.

4) Investing in human capital. Digital transformation requires well prepared human capital. Advances in automation, robotics and smart systems are increasingly transforming the nature of work, not only for repetitive tasks but also for sophisticated tasks in administrative, legal or supervisory roles. So, a massive upskilling of the workforce at all levels is required. In fact, if the immediate consequence of changes in manufacturing could be a reduction of workforce, we are also observing a shortage of skilled workers. Paradoxically, the EU labor market is facing an unprecedented demand for skilled ICT specialists and EU enterprises recruiting or trying to recruit ICT specialists report facing hurdles in filling these vacancies. This skills gap needs to be urgently addressed both by policy actions and by industry and this action goes hand-in-hand with the attempt to address painful redundancies in the labor market. The revision of the content of teaching and of the organization of Vocational Education and Training systems is required. Moreover, there is a need to support the national and local coalitions for worker up-skilling and the review of the European Qualifications Framework and to reinforce a common framework for coordination between national and EU-level initiatives and relevant policy actions. At the same time, not only should this skills gap be addressed, but the number of manufacturing companies employing ICT workers should be increased. In fact, it is still quite limited, with several countries showing more difficulties than others in introducing ICT specialists into their workforce. In this scenario, there is an important role to play for competence centers, technical universities and research organizations. Their work in transferring leading-edge technology to companies, giving advice on potential sources of funding/finance, providing space for experimentation and helping workers to find training is central to improve workers' skills and digital capabilities and increase the pace of innovation.

5) Setting standards and guaranteeing interoperability. As argued in this study, common standards carry an immense value for the competitiveness of enterprises, especially for those working in sectors such as transport, machinery, electro-technical products and other manufacturing industries, as well as in the field of telecommunications. The economic benefits of standards are enormous. They increase productive and innovative efficiency and allow suppliers to achieve lower per-unit costs by producing large homogeneous batches. Moreover, they can also facilitate the introduction of innovative products by providing interoperability between new and existing products, services and processes. The fragmentation of standards

acts as a barrier to the cross-border sale of products and provision of services. Therefore, well designed and timely international standards can support innovation in several ways. Therefore, we need to anticipate standards requirements and accelerate their development in Europe, by following the proposal for a 2017 work program for European standardization that identifies the services and ICT sectors as priority areas for future standard-setting, given their cross-cutting role in the economy. Thus, it is important to support the three European Standards Organizations – the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), and the European Telecommunications Standards Institute (ETSI. It is also essential to ensure the best possible coordination between national standard entities from EU Member States

6) Defining cybersecurity systems and policies. The increase in the introduction of IoT in manufacturing introduces many issues relative to privacy and security data. Today many business models are built on the uninterrupted availability of the Internet and the smooth functioning of information systems. Therefore, cybersecurity incidents could disrupt the supply chain of manufacturing companies, causing serious repercussions from both an economic and a quality point of view. The existence of an ICT security policy in an enterprise means that the enterprise is aware of the importance of its ICT systems and the relevant potential risks. Nevertheless, the share of manufacturing companies with a ICT security policy in EU is still too low. Therefore, it is fundamental to increase cybersecurity capabilities, bringing them to the same level of development in all EU Member States and ensuring that information exchanges and cooperation are efficient, also at a cross-border level. The EU needs to become a strong player in cybersecurity, ensuring that all European citizens, enterprises (including SMEs), public administrations have access to the latest digital security technology, at the same time interoperable, competitive, trustworthy and complying with fundamental rights including the right to privacy. It is also important to support the emerging single market for cybersecurity products and services in the EU. In this field, both governments and the private sector have a significant role to play.

7) Fostering international cooperation and networking. Many European countries are setting industrial digitization at the top of their government agenda. However, it would be appropriate to coordinate all these efforts in order to provide an adequate scale. In this respect, events aimed at international networking, the sharing of best practices and multi-stakeholder dialogue could be useful and effective tools. At the same time, the EU should ask for reciprocity when allowing companies from other countries to access its market, in terms of ownership of companies holding strategic technologies in their portfolio and sales of goods and services in paramount sectors.Indeed, all these efforts should be aimed at allowing as many European companies as possible to thrive in an increasingly competitive world.

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