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INTERNET OF THINGS & 5G REVOLUTION

THE HIGHWAY FOR THE FUTURE OF EU SERVICES AND INDUSTRY: ENERGY, HEALTHCARE AND MANUFACTURING

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EXECUTIVE SUMMARY

The extraordinary spread of Internet and mobile devices is changing the context in which citizens/consumers and businesses traditionally operate, introducing new ways to communicate, make purchases and exchange information. Indeed, the massive digitization of services is transforming the network into a privileged place in which citizens/consumers interact and transact with businesses, providing big opportunities and new business models but also creating potential critical issues to be solved.

In this revolutionary context, deployment of the Internet of Things (IoT) represents an important opportunity for citizens and companies. Technological progress and the availability of sensors able to measure virtually everything are revolutionizing every industrial sector – introducing new and more efficient production models and encouraging research into new technologies, more sophisticated devices and telecommunication networks – and citizens' daily habits. Citizens may benefit, for example, from wearable devices able to monitor their own vital signs – and Public Administration can economize through remote monitoring -, taking control of their electric consumption and saving money, or using real-time traffic data to save on travelling time. This extraordinary growth of IP traffic – especially mobile traffic – requires a reflection about the need to ensure the availability of high-performance networks and an efficient spectrum management. In this context, 5G deployment is very important to meet the challenges of the future.

Full exploitation of digitization benefits is a clear priority for European institutions. Considering the obstacles to fully enjoy the opportunities associated with the digital revolution in Europe, in March 2015, the Commission developed a strategy to create a Digital Single Market based 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.

The second pillar, in particular, encompasses several important and ambitious initiatives: among them, the harmonization of spectrum management and the provision of incentives for investment in high-speed broadband are essential to encourage IoT and 5G deployment.

This paper, on the one hand, describes the development of the IoT, the opportunities for citizens/consumers and businesses in several sectors (energy, health and manufacturing in particular) and the actions identified by European Institutions to encourage this deployment; on the other hand, it analyzes the benefits associated with 5G's development, its performances and the European initiatives to encourage research and investments in this new technology.

1. IOT'S PENETRATION IN DIGITAL SOCIETY: EXPECTED BENEFITS IN EUROPE AND ACTIONS TO PROMOTE

The digital economy is developing rapidly worldwide. It now **contributes up to eight percent of the GDP of the G-20 major economies**, powering growth and creating jobs. **It is the single most important driver of innovation, competitiveness and growth, and it holds huge potential for European entrepreneurs and small and medium-sized enterprises (SMEs)**.

New digital trends such as cloud computing, mobile web services, smart grids, and social media, are radically changing the business landscape, enabling more than just technological innovation: they spur innovation in business models, business networking and the transfer of knowledge and access to international markets.

The huge potential of the digital economy is, however, underexploited in Europe, with 41% of enterprises being non-digital. In addition, although European Union as whole proves to be a net exporter of digital services, the situation among Europe's countries appears to be largely uneven, with some countries – amongst which Italy – being net importers.

About half of the EU citizens are digital-friendly in some common activities like shopping or banking: however, the degree of maturity of the use of the digital channel appears to be very high in Northern countries and UK, Germany and Netherlands, whereas, at present, most Southern and Eastern Member States hold down the European average. The rates of adoption of IoT-linked technologies by enterprises are, on average, still relatively low: enterprise resource planning systems are, so far, the most diffused technology, adopted by slightly more than one third of the European companies. Less disseminated are radio frequency identification technologies and cloud computing services of medium-high sophistication – where only 1 over 10 European companies make use of them – or the integration of systems with suppliers or customers, where the level of diffusion amongst companies is 17%. Even in this case, the Northern countries – together with Germany, Belgium and, in certain cases, France – take the lead.

Looking more in depth at the IoT diffusion across Europe, the **chapter 1** gives an idea of how the reality of the **IoT market** around the world is already underway. Based on IDC's estimates, at the end of 2013 there were 9.1 billion IoT units installed, which are expected to grow at a 17.5% CAGR to 2020, reaching 28.1 billion, a huge growth explained by the pervasiveness of wireless connectivity, ubiquitous access to the Internet regardless of location, IoT standard protocols, regional government support for efficient technologies and services and consumer familiarity with realities around connected cars and connected homes. At the same time, IoT technology and services revenues are expected to grow too, from 1.9 trillion dollars in 2013 to 7.1 trillion dollars in 2020, at a 20.4% CAGR, with Asia and Western Europe exhibiting the highest growth (+23.3% and +22.8%, respectively).

Within Europe, IoT revenues are expected to be concentrated in those countries and in those vertical sectors that have traditionally invested more in ICT, with manufacturing and financial sectors leading

the pack.

Europe is in an excellent position to become a global leader in the IoT. The advent of the IoT completely changes opportunities and threats for all companies, irrespective of their size. Opportunities include optimization across individual devices and enterprises, traceability of products, remote maintenance as well as new Internet-based product-accompanying services. Possible threats include additional network-based security risks for company IP, and an uneven playing field between traditional and OTT players.

For EU28, IoT means the opportunity to unlock up to 7 percentage points of GDP growth by 2025 through productivity improvement and value redistributed to end customers, **with a potential value for the EU28 economy reaching nearly 1 trillion euro.** However, much effort is needed to achieve such relevant benefits: aside from technology, new business models will be needed; common standards agreements have to be pursued across ecosystems for tech solutions to interoperate; and processes will have to be reengineered to generate efficiency gains. In other words, **a systemic perspective is essential**, and in this respect policy makers are required to make bold moves to create the conditions for the IoT to thrive.

The extraordinary importance of the IoT development – considering economic and occupational benefits for the EU – prompted the European Commission (already in 2014, but even before) to analyze **opportunities and critical issues connected to the deployment of IoT's**. In the document *"Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination"* (2014), entrusted by the European Commission DG CONNECT to IDC EMEA, IoT is described as a "disruptive innovation" because it radically changes business processes within and across sectors. This report foresaw an IoT market expansion in Europe with yearly growth rates larger than 20% in value between 2013 and 2020, an increase in the number of IoT connections within the EU28 from approximately 1.8 billion in 2013 (the base year) to almost 6 billion in 2020 and an increase of IoT revenues in the EU28 to more than €1,181 billion in 2020, including hardware, software and services.

Considering the importance of the IoT, the Commission highlighted the need to promote actions able to contribute to R&D investments, to stimulate the growth of the stakeholder community and the development of a strong IoT supply industry, to open the way for the user industry to adopt this disruptive innovation and to create the main framework conditions needed for the development of the market, including the provision of skills, the building of trust, the removal of regulatory barriers.

A working document of the Commission, *"Advancing the Internet of Things in Europe"* (April 2016), underlines the importance of IoT development for the EU and the need to launch initiatives and actions to guarantee **spectrum availability**, **network coverage** and the introduction of mechanisms for the **identification of physical and virtual/logical objects,** to facilitate the **flow and transfer of data, standardisation and interoperability** and the creation of an ecosystem

in which **IoT technologies** and their application are **trusted, accepted, wanted, accessible and usable.**
Such awareness of the importance of the IoT spurred the establishment in March 2015 of the Alliance for the Internet of Things (AIOTI), that is made up of European Commission and IoT industry players and which aims at giving EU the lead in the IoT field creating a dynamic European IoT ecosystem.
Horizon 2020, the European Union program created to promote the funding of research and innovation in Europe, in 2014-2020 also acknowledges the importance of the IoT. The fields of application of the projects, called "**IoT Focus Areas**", which benefit from funds (deadline notice 12 April 2016), were smart city, smart life, industry 4.0, infrastructure security, food security, automated guided vehicles, smart home, wearable technologies while a second call is scheduled in December 2016 (deadline April 2017) for the development of IoT advanced architectures, artificial intelligence and smart networks.

2. 5G DEVELOPMENT IN EUROPE

The extraordinary growth of mobile data traffic – favored by IoT deployment and the increasing importance of contents – underlines the need to promote research and investments to deploy higher performance technologies and, in particular, **5G implementation**.
Chapter 2 aims at describing 5G performance and analyzing the actions and the roadmap identified from European Institutions to encourage 5G deployment.
5G is the new generation of radio systems and network architecture that will revolutionize businesses and the lives of citizens/consumers, guaranteeing 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 for 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's; 4) **battery life** of remote cellular devices stretched to 10 years or more; 5) increase of the **number of devices** connected to the network (1 mln per 1 sq km); 6) possibility of **use of several bands** from 400 MHz to 100 GHz.
European institutions have already underlined the importance of 5G deployment. Indeed, on 17 December 2013, the European Commission signed a landmark agreement with the *"5G Infrastructure Association"* representing major industry players to establish a Public Private Partnership on 5G (5G PPP) and accelerate research developments in 5G technology and at the Mobile World Congress 2015, the Commission and 5G PPP presented Europe's vision of the 5G technologies and infrastructure. This document, in particular, stresses that 5G is a new network to be designed as a sustainable and scalable technology and analyzes the development prospects favored by technological evolution focusing on transport sector, healthcare, energy and media & entertainment, showing that, in general, the digitization of factories will be a key factor for the 2020s.
Subsequently, the *"5G Manifesto for timely deployment*

of 5G in Europe" (July 2016), subscribed by a coalition of Telcos and leading companies in sectors touched by 5G, highlighted that standards and coordination across European stakeholders for pre-commercial trials are very important for 5G development.

A **two-phase trial roadmap**, encompassing different use-cases, is being proposed: 1) **before 2018**: realization of technology trials run by independent trial consortia in various countries – involving also vertical industries – independent of the status of standardisation, to demonstrate and validate new 5G capabilities; 2) **around 2018**: 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 claim global public attention.

This document highlights the relevance importance of spectrum aspects of the Digital Single Market – namely, harmonisation and predictability of spectrum policy across Member States (including spectrum availability, licensing procedures and costs, licence terms, and liberalisation and renewal of existing spectrum) to promote investment into the mobile sector and in 5G and, in general, the need to encourage 5G deployment synchronised across Europe to achieve homogenous availability both in terms of location and time (by 2020).

The 5G Manifesto identifies the actions to promote 5G development and in particular: reduction and simplification of the rules on access to key infrastructure, deployment the removal of barriers, prevision of incentives for all players and, where access regulation remains, promotion – wherever possible – of long-term commercial agreements that enable competitive outcomes as an alternative to regulation. The same document underlines the importance of the creation of a level playing field with equivalent and proportionate privacy requirements to innovate in data-driven markets and the danger of restrictive Net Neutrality rules, in the context of 5G technologies, business applications and beyond.

Finally the EU Commission documents *"5G Global Developments"* and *"5G for Europe: an Action Plan"* (14.9.2016) lists the benefits for several economic and industrial sectors and eight actions to promote 5G deployment: 1) out lines promoting **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) identifying – according with Member States – by the end of 2016 a **list of pioneer spectrum bands** for the initial launch of 5G services; 3) adopting an **agreement around the full set of spectrum bands** (below and above 6GHz) to be harmonised for deployment of commercial 5G networks in Europe; 4) setting roll-out and quality objectives for the monitoring of the progress of key fibres and cell deployment scenarios identifying actionable best practice to facilitate – also incrementing administrative conditions – **denser cell deployment**; 5) promoting **by the end of 2019 the availability of**

the initial global 5G standard, the standardisation on radio access and core network challenges and the conclusion of cross-industry **partnerships**; 6) planning **technological experiments** to be realized as early as in 2017 and presenting **detailed roadmaps** by March 2017 for the implementation of advanced pre-commercial trials; 7) encouraging Member States to consider 5G infrastructure's usage to improve the performance of communication services used for **public safety** and **security**; 8) identifying assumptions and modalities for a **venture financing facility**.

Considering the importance of 5G development and EU investment in 5G research and standards, the European Commission has earmarked a public funding of 700 million euro through the Horizon 2020 Programme.

3. INDUSTRY 4.0

Chapter 3 deals with Industry 4.0, the fourth industrial revolution that is concerning all the economic sectors, but particularly the manufacturing sector.

European manufacturing, indeed, is largely losing ground on a global level: in 1990 the manufacturing added value produced in Western Europe was 35% of global added value; in 2014, this share collapsed to 23%, largely in favor of Asian countries. This is the most important reason why European Union cannot continue to ignore the challenge posed by the ongoing revolution.

The first part of the chapter illustrates how the industrial sectors are evolving thanks to the merging of the virtual and the physical worlds through cyber-physical systems and the resulting fusion of technical processes and business processes. **Digitalization is finding its way into horizontal as well as vertical value chains** to an equal extent. It thus optimizes and generates a huge flow of information and data.

The data market value in the manufacturing industry is then analyzed. It amounted to almost 12 billion euro in 2015 and is expected to grow by 54% to over 18 billion euro in 2020.

The manufacturing industry is also **the second vertical market including 111,000 data user companies**, expected to reach 123.450 units by 2020, a growth of 11%, approximately in line with the other sectors.

Subsequently, the chapter describes the main **implications of the industrial revolution** on manufacturing processes, outcomes and business models. Smart factories allow **increased flexibility in production and mass customization**, encouraging **innovation**, since prototypes or new products can be produced quickly without complicated retooling or the setup of new production lines. Industry 4.0 also improves the **speed and efficiency** with which a product can be produced, thanks to a reduction of redundancies, the minimization of **quality** losses and the increased flexibility discussed above, which altogether increases **productivity**.

Investments in IoT initiatives may also impact on the revenues of manufacturing companies. According to Tata Consultancy data, following the realization of IoT investments revenues grew on average by 29% between 2013 and 2014.

Finally, Industry 4.0 will cause changes in business models.

Rather than exclusively competing on costs, European companies can compete on the basis of innovation – meant as the ability to deliver a new product rapidly, on the ability to produce customer-driven customized designs (through configurable factories), or on quality (primarily associated with the reduction of faults due to automation and control). Some companies may finally take advantage of the data created as smart products are created and used, and adopt business models based on selling services other than products: this "servitisation" can help enterprises expand **business opportunities and further increase revenues**.

But **the ongoing digital transformation also has profound implications for employment** in the manufacturing sector, affecting everything from the size of the workforce, to required skill-sets, and the location of factories. Certainly, there will be job redundancies for low-skilled jobs, and the need to shift towards more high-skilled complex jobs that generally require a more intense focus on continuous learning and education. Although some jobs will be lost, the level of cooperation between humans and machines will increase significantly. By adopting Industry 4.0, manufacturers will be able to increase their competitiveness, which will enable them to expand their industrial workforce at the same time that productivity increases. The higher demand resulting from the growth of existing markets and the introduction of new products and services will allow manufacturers to create new jobs.

Two types of new roles arising from Industry 4.0 will be: robot coordinator, overseeing robots on the shop floor and respond to malfunctions or error signals, **and industrial data scientist**, extracting and preparing data, conducting advanced analytics and applying her findings to improve products or production.

Six European countries (UK, Germany, France, Italy, Poland, and Spain) account for 72% of the total data workers in 2015. Nevertheless, **the share of data workers on total employment is still too low in the manufacturing industry** (2%, compared with 10.4% of ICT or 9.2% in finance).

According to current data and estimates for the future, indeed, **there is (and there will be) a substantial skill gap**. According to IDC, in 2015, the gap between total demand and supply of data workers was equal to 396,000 unfilled data worker positions in EU (corresponding to 5.9% of total demand) and is expected to grow to 486,000 (6.6% of total demand). However, the forecast demand to 2020 of Big Data analysts – a specific category of highly qualified data workers with sophisticated technical skills – is expected to grow much faster than the demand for data workers, at a 14,3% CAGR. This would lead to a potential supply-demand gap of 66,000 unfilled positions for Big Data analysts, corresponding to approximately 17% of the overall demand.

It was also elaborated a synthetic index that gives an idea of the level of preparedness for Industry 4.0 in I-Com's EU countries. **The I-Com's Industry 4.0 Index is based on twelve variables that belong to three areas crucial for a quick and smooth adoption of the fourth industrial revolution by EU manufacturing companies: technology, infrastructure and skills.**

Each variable was weighted so as to assign equal weight to each of the three areas. Average values obtained for each country were normalized relative to the best performer country, so as to establish a ranking from 0 to 100.

The countries that have the best characteristics to implement the fourth industrial revolution are Sweden, Denmark, Germany, Belgium, Finland, and the Netherlands, which are ranked respectively in the top six. In these countries, the majority of companies adopts IoT technologies, has a good infrastructure development and a good level of skills, which are necessary for the use of technologies. On the contrary, the countries of Eastern Europe show on average unfavorable conditions to the development of Industry 4.0.

Italy, unfortunately, does not rank very well compared to most European countries (18th with a score of 79), although, with regard to the adoption of IoT technologies, it shows a good performance (especially on cloud computing and RFID technologies). It must, however, still reduce the gap with the rest of Europe – even if some positive results were achieved in the last period – concerning infrastructures. Skills remain, however, the most critical aspect and also the most difficult to be significantly improved in a short time.

Finally, the chapter presents two last sections, one describing which measures have been so far implemented or planned in US, Germany, France and United Kingdom, and the other one showing the state of the art in Italy, where a National Plan for Industry 4.0 has been recently presented (September 2016), with a wide set of policy instruments to be implemented starting from the next Budget Law (to be approved by the end of 2016).

4. ENERGY EFFICIENCY

Chapter 4 is dedicated to **Energy Efficiency,** due to its potential role on the path to decarbonization and the vast range of IoT applications.

Setting a target of 20% by 2020 (less than 1,086 Mtoe of final energy consumption or less than 1,483 Mtoe of primary energy consumption) represents the basis for moving forward to a reduction of at least 27% by 2030, having in mind a figure of 30%.

About one third of the progress towards the 2020 target will be due to the lower growth than expected during the financial crisis. Nevertheless, EU-28 is expected to **achieve energy savings of 18%-19% in 2020**, missing the 20% target by 1%-2%.

Final energy consumption decreased by 11% in the EU28 between 2005 and 2014, due to reductions in industry (15.4%), transport (5.7%) and household sectors (3.2%). On the opposite, the services sector was the only one to display an increase (+5.7%).

More than 40% share of the European energy end-use is consumed by the building sector, carried in the most part by gas, followed by electricity and oil. Household consumption per dwelling has been decreasing 1.5%/ year at EU level, thanks to the energy efficiency improvement for space heating and the diffusion of new electrical appliances (A++). About three-quarter of the building in Europe is comprised of residential buildings. In year 2014, the residential sector accounted for 24.8% of the total final energy consumption, a share larger than 60% of total final energy used by buildings.

The ongoing **digital revolution** is coming **to the power industry**. Renewables, distributed generation, and smart grids demand are triggering new business models and regulatory frameworks. The **competition** for customers is shifting **to the online channel**; the IoT promises new product and management options. **Governments** and **companies** should **share the** huge **effort**. On one hand, Governments should be ready to embrace the new trends and create the market conditions in order to make new technologies flourishing; on the other side, companies should completely reconsider their business model and the way they have been used to relate with customers.

There is a **new generation model**, different in terms of ownership of the assets and the integration of new distributed energy resources into the grids.

Currently, thanks to **technological progress**, the final consumer can produce, store and consume (or shift in time consumption) her own energy under fair conditions in order to save money, help the environment, and ensure security of supply. The **prosumer** could represent the first step towards the exchange of energy between users through digital platforms, in real time.

Through the development of **interconnected systems in everyday life** (e.g. smart grid, smart home, smart buildings), end customers have the chance to be empowered. Regulation should encourage the **use of new digital applications** (and of new innovative services), **ensuring the security of transmissions and adequate data protection**. Although still unattractive for most end users because of their costs or complexity, such digital applications and related services could bring many benefits to the system as a whole. In their long-term interaction, intelligent applications, smart grids and management platforms will lead to a new model of consumption, automatically and remotely managed.

In the energy sector, the IoT can enable a large variety of services. For example, thanks to smart meters, **consumers can have access to a huge quantity of information and companies should help them understand how to make their consumption more efficient**. The roll-out of smart meters in the EU is occurring more slowly than expected due to different results of CBAs across EU Member States, as well as concerns linked to the transmission of data security and privacy. The Third Energy Package sets a specific target for the electricity sector – 80% of consumers with a successful cost/benefit analysis by 2020 – but not for gas, for which “a reasonable period of time” is recommended. Forecasts predict that in Europe the market for Advance Metering Infrastructure (AMI) in 2020 will be approximately equal to $9.2 billion compared to the $28.6 billion global market.

Italy, after the first mass deployment started in 2001, will proceed with the **replacement of first-generation smart meters with those of the second (2G)** in the **electricity** sector and AEEGSI (the National Regulatory Authority) has also established a gas target as 50% of delivery points in 2018. Italy is also proceeding with trials of multiservice smart meters (power, gas, water and "other" services).

The large amount of variable generation and loads requires a greater system flexibility to prevent or solve grid congestion and balancing production/consumption at national level. The **digitalization** and the huge amount of available data **allow System Operators** (as TSOs and DSOs) **to achieve new levels of operational efficiency and modernize their communication, bringing huge opportunities to the system as well**.

Data management is different across countries. Some Member States have chosen a centralized data hub, with a common clearing platform managed by a regulated party (e.g. DSO, TSO or third party), others preferred a decentralized model. **One size fits all model is not applicable in all European countries**, while, instead, each Member State should define its own strategy considering its needs and characteristics. However, according to TSOs and DSOs vision, some common principles related to data management have to be set at European level.

5. DIGITAL HEALTHCARE

Chapter 5 is focused on the use of digital applications or mobile and wireless technologies applied to health and healthcare systems.

eHealth (digital Health) **and mHealth** (mobile Health) **solutions have a great potential to increase the efficiency of healthcare systems and to transform the face of health services delivery across the EU**. They offer many advantages to patients and healthcare providers and the use of ICT in healthcare also allows costs reductions and care process improvements.

The European Commission's **eHealth Action Plan 2012-2020** ("Innovative healthcare for the 21st century") defines eHealth as "*the use of ICT in health products, services and processes combined with organisational change in healthcare systems and new skills, in order to improve health of citizens, efficiency and productivity in healthcare delivery, and the economic and social value of health. eHealth covers the interaction between patients and health-service providers, institution-to-institution transmission of data, or peer-to-peer communication between patients and health professionals*".

According to I-Com's eHealth Index, which is based on four key indicators of the EU Commission (seeking online information about health; making an appointment with a practitioner via a website; general practitioners using electronic networks to transfer prescriptions to pharmacist; general practitioners exchanging medical patient data with other healthcare providers and professionals) and describes the level of eHealth in European countries**. According to the Index, the most advanced country is Denmark, followed by Finland, Netherlands, Estonia and Sweden**. These countries have in common a high level of digitalization in doctor's offices and a high number of patients who use mobile and internet technologies for searching health information and making appointments online with doctor.

mHealth (or mobile Health) is a component of eHealth and refers to medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices. It also includes applications (apps) such as lifestyle and wellbeing apps that may connect to medical devices or sensors (bracelets or watches) as well as personal guidance systems, health information and medication reminders provided by sms and telemedicine provided wirelessly.

The market for mobile apps has developed very rapidly in recent years to become a key driver of mHealth deployment facilitated by smartphone penetration.

According to recent estimations, the number of mHealth apps available to consumers now exceeds 165,000. Most of the apps are published in Google Play or Apple App Store. Each of the two main app stores offer almost 70,000 apps within the categories Health&Fitness and Medical. The demand for mHealth apps also is increasing every year. The 2015 was another fascinating year for mHealth: the total number of mHealth app downloads worldwide reached 3 billion from 165,000 app solutions on the market.

According to recent studies, **the IoT could save € 99 billion in healthcare costs in the EU and add € 93 billion to the GDP**. Moreover, the use of digital applications in healthcare could enable 11.2 million people with chronic diseases and 6.9 million people at risk of developing chronic conditions to extend their professional lives and improve their productivity.

However, there are some barriers, which hamper the development of eHealth and mHealth and that need to be addressed in order to reap the benefits of a fully mature and interoperable digital health system in Europe:

- lack of awareness of and confidence in eHealth and mHealth solutions among patients, citizens and healthcare professionals;
- lack of interoperability between eHealth solutions;
- an absence of adequate regulatory mechanism and lack of clarity on data protection legislation.
- lack of legal clarity for health and wellbeing mobile applications and the lack of transparency regarding the utilisation of data collected by such applications;
- lack of clarity on mHealth certification;
- lack of reimbursement schemes for eHealth services;
- high start-up costs involved in setting up eHealth systems;
- regional differences in accessing ICT services, limited access in deprived areas;
- lack of IT literacy.

The new eHealth Action Plan – in line with Europe 2020 Strategy and the Digital Agenda for Europe – aims at addressing and removing these barriers.

Therefore there is a need to define clear policies that encourage the development of eHealth and mHealth in the EU because the digital applications offer many opportunities to take on several of the challenges of health system (such as chronic disease and multi-morbidity, sustainability and efficiency of health systems, cross-border healthcare).

PART 1

IOT IMPACT ON SOCIETY AND SECTORS

1. IOT IMPACT ON SOCIETY AND SECTORS

1.1. DIGITAL SINGLE MARKET STRATEGY: KEY FEATURES OF THE IOT IN A SINGLE MARKET

Internet and digital technologies are revolutionizing our lives. The network is becoming the preferred way for citizens/consumers and businesses to interact, for information to be researched, for the purchase of goods and services, for the conclusion of transactions and for socialization. Indeed, all principal and traditional socio-economic activities are slowly migrating to this huge space. In this changing context, European Institutions, led by the European Commission, are aware of the opportunities connected to the diffusion of digital technologies.

In considering the obstacles 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.

To achieve the objectives envisaged for the first pillar, the Commission proposed the adoption of rules to simplify cross-border e-commerce and, in particular, the harmonization of contractual regulations and consumer protection, more efficient and affordable parcel delivery, elimination of unjustified geo-blocking, competition critical issues' individuation, adoption of a European copyright law, Satellite and Cable Directive's revision and the reduction of the administrative burden businesses face from different VAT regimes.

The second pillar encompasses a significant number of important and ambitious initiatives, with the overhaul of EU telecoms rules as a priority. This includes more effective spectrum coordination, the individuation of common EU-wide criteria for spectrum assignment at national level, and the creation of incentives for investment in high-speed broadband and of a level playing field for all market players (traditional and new ones). Other initiatives in this pillar include: audiovisual media framework's revision, the analysis of the role of online platforms in the market, the reinforcement of trust and security in digital services, the proposal of a partnership with the industry on cybersecurity in the area of technologies and solutions for online network security.

Finally, the third pillar includes actions to promote the free movement of data in the European, define priorities for standards and interoperability in areas critical to the Digital Single Market (such as e-health, transport planning or energy Union) and support an inclusive digital society where citizens have the right skills to seize the opportunities of the Internet (also through the adoption of a new e-government action plan).

In the same month, the European Commission together with IoT industry players launched the Alliance for the

Internet of Things (AIOTI) that promotes a European strategy for IoT in response to international initiatives such as Industrial Internet Consortium (IIC), to examine regulatory and legal obstacles to further take up of IoT. IoT, in fact, is a phenomena offering extraordinary opportunities for citizens/consumers and businesses.

Given the presence of potential obstacles, the Implementation of the DSM Strategy is fundamental to the development of the IoT. Among them, fragmentation in management and regulation of the spectrum in Member States and critical issues in terms of interoperability.

1.2. INTERNET OF THINGS: DEFINITION AND EXPECTED BENEFITS IN EUROPE FOR COMPANIES, CONSUMERS AND INSTITUTIONS. THE POSITION OF EUROPEAN INSTITUTIONS

The Internet of Things (IoT) has been defined in different ways but, generally speaking, it refers to a global, distributed network (or networks) of physical objects that are capable of sensing or acting on their environment, and able to communicate with each other, other machines or computers.

The IoT is a central theme in European institutions' documents. Already in 2014 – but even before – European Commission analyzed opportunities and critical issues connected to the development of the IoT. In the document *"Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination"* (2014), entrusted by the European Commission DG CONNECT to IDC EMEA, IoT is described as a "disruptive innovation" because it radically changes business processes within and across sectors. This report foresaw an IoT market's expansion in Europe with yearly growth rates over 20% between 2013 and 2020, an increase in the number of IoT connections within the EU28 from approximately 1.8 billion in 2013 (the base year) to almost 6 billion in 2020 and an increase of IoT revenues in the EU28 to more than €1,181 billion in 2020, including hardware, software and services. The paper identified the sectors which are successfully exploiting IoT technologies: smart manufacturing, smart homes (home security, energy applications and household appliances), smart transport, smart Government/smart environment, personal wellness applications and wearable devices (for generic and health-specific purposes), innovations connected to smart customer experience (digital signage, in-store digital offers and Near Field Communication payment solutions).

In its assessment of the IoT revolution, the Commission concluded that there was a need for policy action in Europe to contribute to R&D investments, stimulate the growth of the stakeholder community and the development of a strong IoT supply industry, open the way for the user industry to adopt this disruptive innovation, and create the main framework conditions needed for the development of the market, including the provision of skills, the building of trust and the removal of regulatory barriers. To meet these challenges, the Commission developed a comprehensive IoT and Cloud Research and Innovation Strategy for Europe articulated in some main pillars corresponding to clusters of challenges, and related areas of action. This Strategy was focused on the importance of investments in the development of technologies for the IoT, Cloud, and Big Data combination (able to manage complexity, provide scalability, guarantee usability and preserve privacy by design), on the development of supply capacity (building the EU industry competitiveness, improving IoT readiness, ensuring SMEs capability to enter the market), on the promotion of IoT's take up by user industries and finally on the creation of favorable framework conditions for the development of the IoT ecosystem (developing the necessary skills, building trust in the emerging IoT economy, removing the regulatory barriers, and encouraging international cooperation).

European Parliament also analyzed the importance and the future impact of IoT. In the document *"Internet of Things Opportunities and challenges"* (May 2015) the Parliament highlights the importance of IoT for Europe recalling Gartner Group's predictions that worldwide, by 2020, the IoT will connect 26 billion devices and IoT product and service suppliers will generate incremental revenues of more than US$300 billion and IDC's more optimistic previsions that the worldwide IoT market will grow from US$1.9 trillion in 2013 to US$7.1 trillion by 2020. This document also shows benefits for consumers, businesses and public authorities. In particular, the IoT allows consumers to receive more personalized product or service offers, travel more efficiently by avoiding traffic jams when their connected car suggests an alternative route, based on traffic reported by other vehicles, pay lower car insurance premiums based on verified safe driving practice, and to be healthier and safer thanks to wearable devices that provide feedback on health or that monitor the elderly in the home. Businesses can also benefit from the IoT for example by aligning offers with the expectations and needs of consumers, discovering new interests, becoming more efficient and introducing new business models. Finally, governments and public authorities can also benefit from the IoT for example by reducing health and long-term care costs through better remote support or improving road safety through the assessment of traffic and driving data.

It is also worth analyzing the Commission's staff working document *"Advancing the Internet of Things in Europe"* (April 2016) which accompanies the Communication *"Digitizing European Industry – Reaping the full benefits of a Digital Single Market"*. This working document, in particular, underlines the way in which the IoT represents the next major economic and societal innovation wave enabled by the Internet, able to make lives easier, safer, more efficient and more user-friendly. It also highlights the need for the European industrial future to seize the opportunities coming from the wider diffusion of digital innovation across sectors.

The same document identifies different actions divided into three pillars. The first pillar includes the initiatives designed to ensure that IoT devices and services are able to connect seamlessly and on a plug-and-play basis anywhere in the European Union, the second outlines the steps to ensure the presence of open platforms and the third, comprises initiatives to promote trust in the IoT through the provision of high standards for the protection of personal data and security. In fact, the development of the IoT faces different risks due to the presence of fragmentation and national barriers, fragmentation among different industries, lock-in in proprietary ecosystems through restraint interoperability and access to data and applications, the presence of users forced to compliance and data sharing and uncertainty about business models and standards able to produce information asymmetries and market failures.

The Commission highlights that one of the most important key enablers of the IoT is spectrum. In fact, additional speed and capacity for wireless data traffic is booming and forecasts about the increase in the number of connected devices suggest that the amount of available spectrum will have to be increased.

Another important component is the availability of communication networks as all devices should be able to plug and play wherever they are in the EU, considering also that the development of the IoT needs different types of connectivity. The availability of mechanisms for the identification of physical and virtual/logical objects, standardization and interoperability are other primary keys underlined by the European Commission. The development of the IoT also requires reflection about obstacles to the circulation and use of data and, in particular, the adoption of actions to clarify data ownership in relation to non-personal data, to reduce restrictions to data location and obstacles linked to data interoperability and reliability. The issues of data protection and liability are also central due to the fact that the IoT involves a plurality of actors – product manufacturers, sensor manufacturers, software producers, infrastructure providers, data analytics companies and other actors involved in the supply of different services, final users – and an accurate attribution of individual liabilities is very relevant. With reference to the data, in order to remove obstacles and encourage IoT's development, the Commission underlines the importance of analyzing existing different business models and contractual conditions under which access is given to data and data are transferred.

Intellectual Property Rights Licensing is also a central theme. Given that IoT's systems can naturally involve patented or protected technologies and it may be necessary to identify the relevant community of essential patent holders, issues such as the cost of the cumulated Intellectual Property needed to the development of IoT system, the methodology to calculate the value introduced by the patented technology and the regime regarding the settlements of disputes need to be factored in.

The importance of the IoT development is also recognized in Horizon 2020, the European Union program that promotes the funding of research and innovation in Europe in 2014-2020. The fields of application of the projects, namely "IoT Focus Areas", which benefit from funds (deadline notice 12 April 2016), were smart city, smart life, industry 4.0, infrastructure security, food security, automated guided vehicles, smart home, wearable technologies while a second call is scheduled in December 2016 (deadline April 2017) for the development of IoT advanced architectures, artificial intelligence and smart networks.

1.3. IOT'S PENETRATION IN DIGITAL SOCIETY

1.3.1. The digital economy in the EU

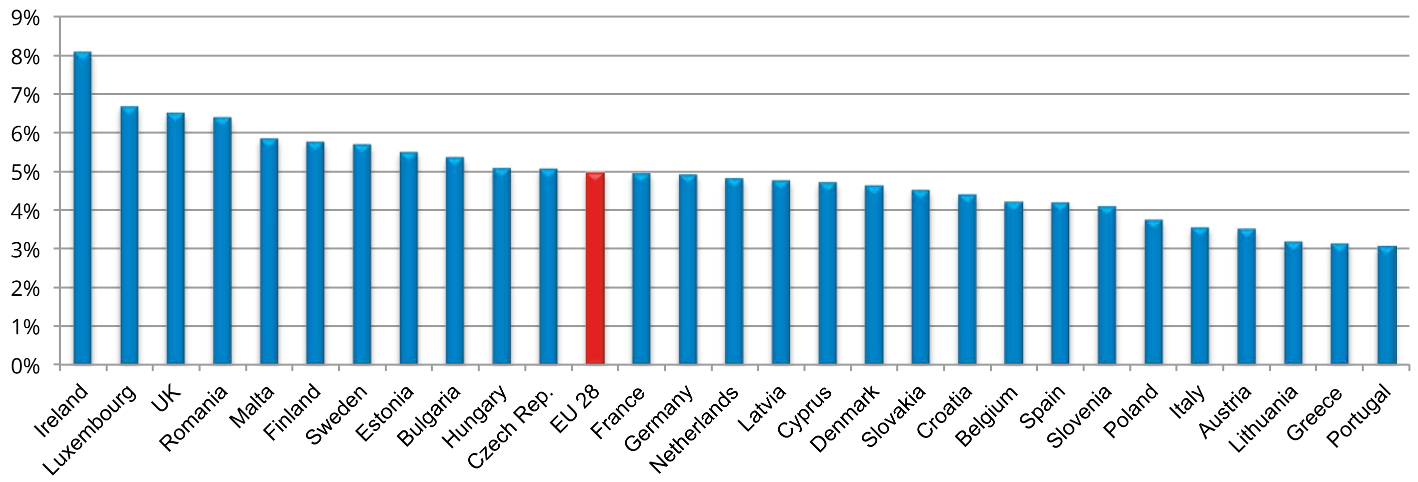
The digital economy is developing rapidly worldwide. It is the single most important driver of innovation, competitiveness and growth, and it holds huge potential for European entrepreneurs and small and medium-sized enterprises (SMEs). Unfortunately, only two percent of European enterprises are currently taking full advantage of new digital opportunities. How European businesses adopt digital technologies will be a key determinant of their future growth.

New digital trends such as cloud computing, mobile web services, smart grids, and social media, are radically changing the business landscape, reshaping the nature of work, the boundaries of enterprises and the responsibilities of business leaders. These trends enable more than just technological innovation. They spur innovation in business models, business networking and the transfer of knowledge and access to international markets.

The huge potential of the digital economy is underexploited in Europe, with 41% of enterprises being non-digital, and only two percent taking full advantage of digital opportunities. New digital opportunities create new business opportunities but other regions of the world are already ahead of the game. The digital economy now contributes up to eight percent of the GDP of the G-20 major economies, powering growth and creating jobs. Among EU countries, just Ireland shows such a value (Fig. 1.1), with a contribution of digital economy

Fig 1.1 Contribution of digital economy to GDP (2015)

Source: Eurostat



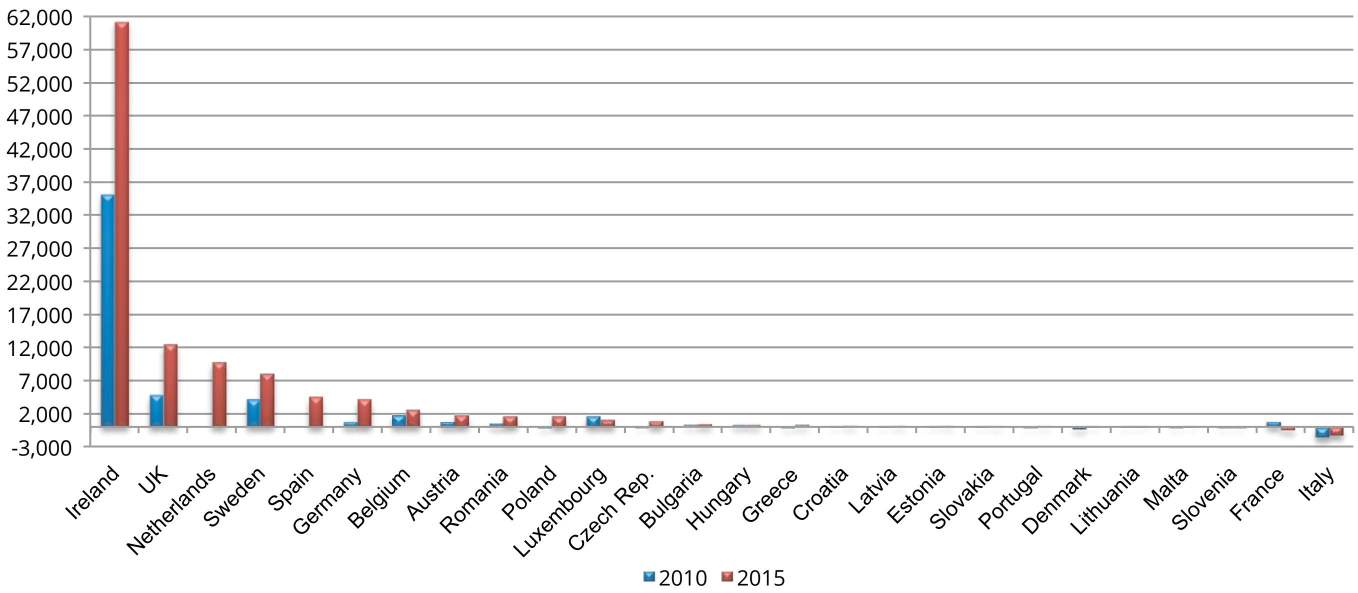
to GDP equal to 8.1%, followed by Luxembourg and UK (6.7% e 6.5%, respectively) and against a EU average of 5.0%. Italy only ranks 24th, with a weight of digital on the whole economy of just 3.6%, better than only Portugal, Greece, Lithuania and Austria.

Although European Union as a whole is a net exporter of digital services – with a net trade balance equal to over 114 billion dollars – the situation among EU countries appears to be largely uneven (Fig. 1.2): Ireland is a large net exporter of digital services – with a trade balance that has almost doubled in a five-year period and reaching, in 2015, a value of over 61 billion dollars – well above other countries like the UK, Netherlands and Sweden (12.4, 9.8 and 8 billion dollars of net exports, respectively) that follow in the ranking. There are only three EU countries which are reported as net importer of digital services: Italy is the largest, with a net import value of 1.3 billion dollars – a decrease of 17% relative to 2010. This is significantly more than France and Slovenia, the other two net importing countries.

In order to take into account the dimension and trade flows of each country, the normalized trade balance of digital services is computed as the ratio between the digital services' trade balance and total trade (Fig. 1.3).

Fig 1.2 Trade balance of digital services (US$ bn)

Source: UNCTAD

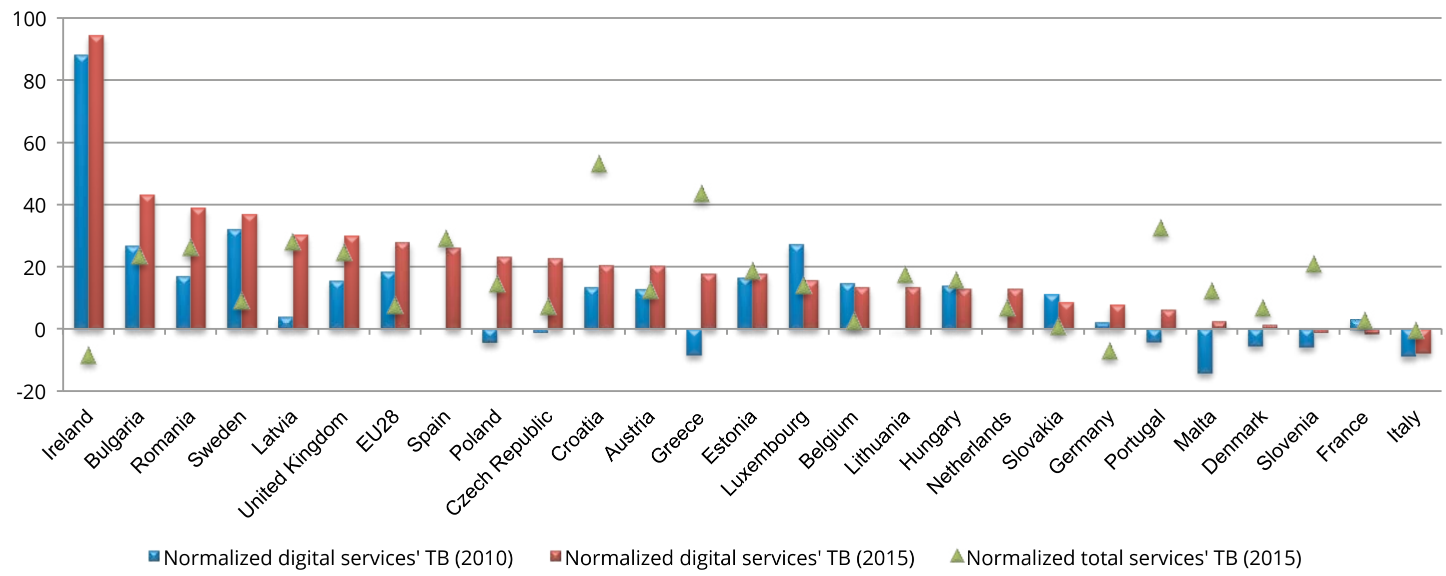


This indicator puts Italy once again in the last position across EU (-8) and what reveals to be interesting is the difference between countries like Ireland, Germany, Sweden and Belgium, which are either net importers of total services (like Ireland and Germany) or moderate net exporters (Sweden and Belgium) but register a large normalized trade balance in digital services. A similar trend is registered in some emerging countries from Eastern Europe – Bulgaria, Romania, Poland, Czech Republic and Slovakia – where the normalized trade balance in digital services has largely increased over time (in some cases from negative values) and is higher than the same indicator for total services, suggesting the large attention paid to digital themes. On the other side, there are countries like Croatia, Greece, Portugal and Slovenia, which, despite being large net exporters of total services, are, on the contrary, net importers or relatively smaller net exporters of digital services.

We examine, in the following pages, some indicators explaining the degree of penetration of the digital tools in EU Member States, both from the individuals' and the enterprises' perspective.

Fig 1.3 Normalized digital services' trade balance

Source: UNCTAD



1.3.2. Digital use by individuals

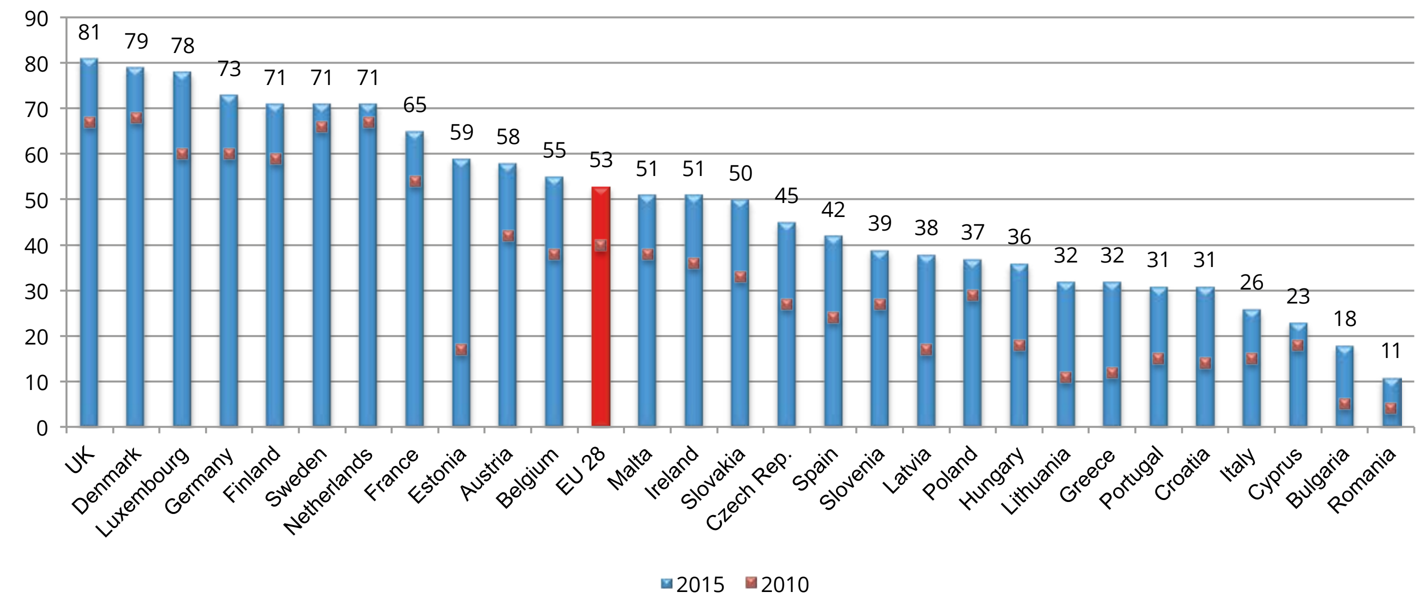
Looking at Figure 1.4 and 1.5, the degree of maturity of the use of the digital channel for some common activities like shopping and banking appears to be very high in Northern and Western countries, whereas Southern and Eastern Member States (with a few exceptions) perform below the EU28 average.

UK tops the e-commerce ranking, followed by Denmark and Luxembourg. Estonia was not only the first Eastern Europe Member State but also the best achiever in relative terms among EU countries between 2010 and 2015, with 59% of the population shopping online last year (while in 2010 only 17% of Estonians made purchases over the Internet). In Italy last year, only slightly more than 1 in 4 people made purchases online, roughly half of the EU average (53% of individuals) and less than one third compared to the best performing countries (Fig. 1.4).

The average share of individuals using the Internet for banking activities in the European Union (46%) is lower that the average share of individuals shopping online. However Finland, Denmark and Netherlands lead the Internet banking ranking (with respectively 86%, 85% and 85% of users), scoring higher than the best performing country (UK) in the e-commerce ranking. Internet

Fig 1.4 Individuals who buy online

Source: Eurostat



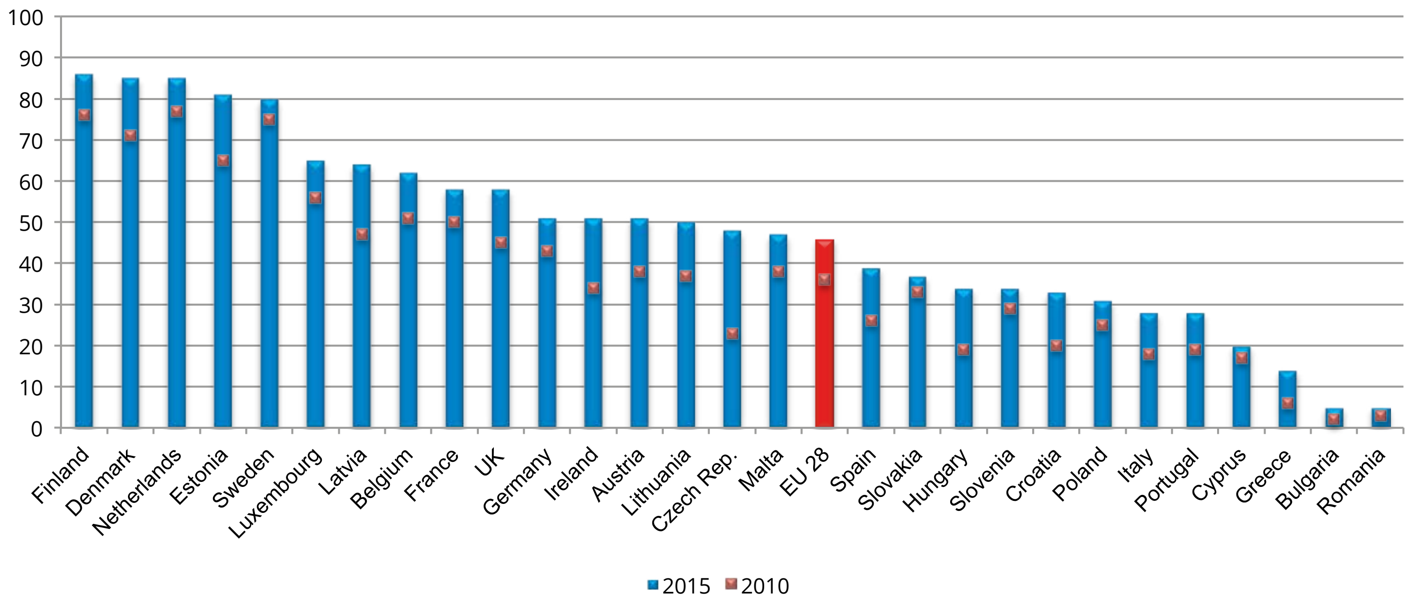
banking use is still very low in Bulgaria and Romania (where only 5% of individuals went online in 2015 for banking activities). In this case, Czech Republic is the best achiever in relative terms, rising from 23% in 2010 to 48% in 2015. Estonia is still one of the best performers with 81% of Internet banking users (Fig. 1.5).

1.3.3. Adoption of IoT-linked technologies by enterprises and households

Another – and maybe even more important – aspect is the adoption of IoT-linked technologies by enterprises. The share of EU companies using an *enterprise resource planning* (ERP) system – that is, a management system which integrate all the relevant company business processes and thanks to which information between different functional areas (e.g. accounting, planning, production, marketing) can be easily shared – has significantly increased in the last five-year period, reaching an average value of 36% (Fig. 1.6). Only in

Fig 1.5 Individuals using Internet banking (%)

Source: Eurostat



Germany and Belgium more than half of total companies have in use an ERP software package. Cyprus and Lithuania significantly improved their placement in the EU27 ranking between 2010 and 2015, respectively from 20th and 23rd to 7th and 9th. Latvia, Hungary and UK are the worst performers, with 17%, 16% and 16% respectively.

Less is frequent the usage by companies of *radio frequency identification* (RFID) technologies – that is, 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: 10% of EU enterprises use such a technology (Fig. 1.7), a share increased from only 4% in 2011. The most advanced country from this point of view is Finland, with 21% of enterprises adopting RFID technologies, before Austria and Bulgaria. Germany is 8th (14%), Italy is 16th (11%, slightly over the EU average), France is 22nd (7%) and UK is 26th (6%, preceding only Greece).

Only 11% of EU companies purchase cloud computing services of medium and high sophistication (hosting of the enterprise's database, accounting software applications, CRM software, computing power), with Finland, Denmark and Sweden leading the pack. In

Fig 1.6 Enterprises that share internally electronic information with an ERP (%)
** Data updated to 2014*

Source: Eurostat

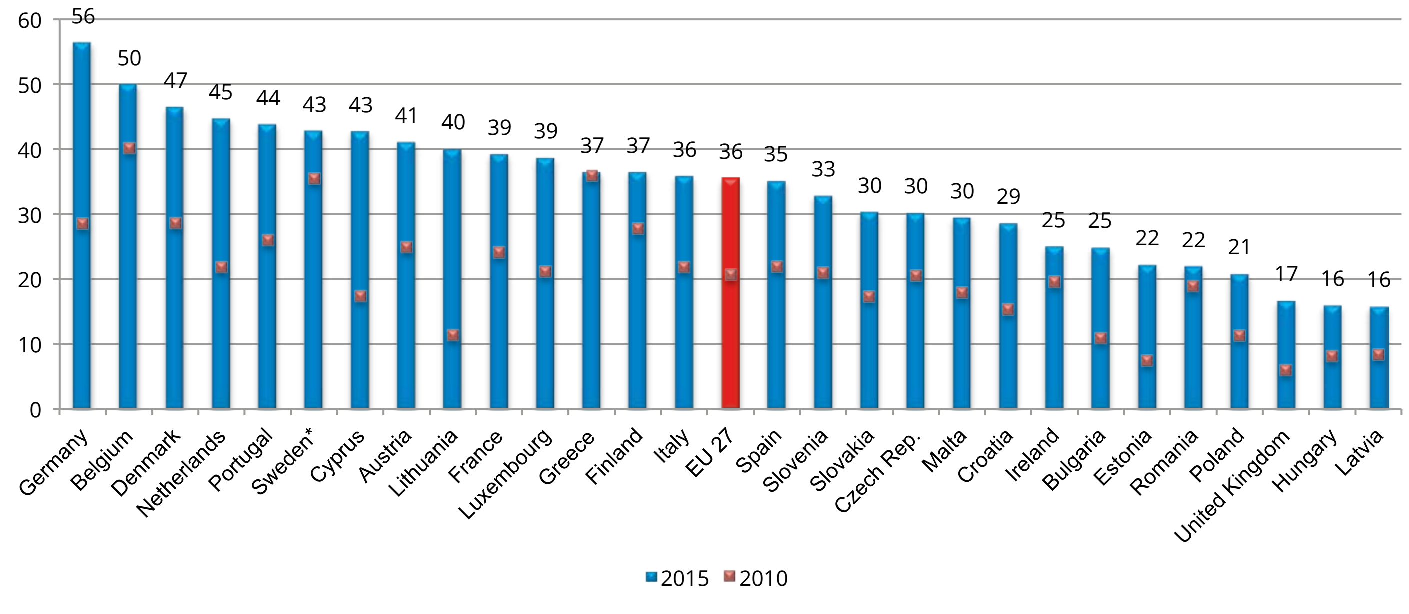
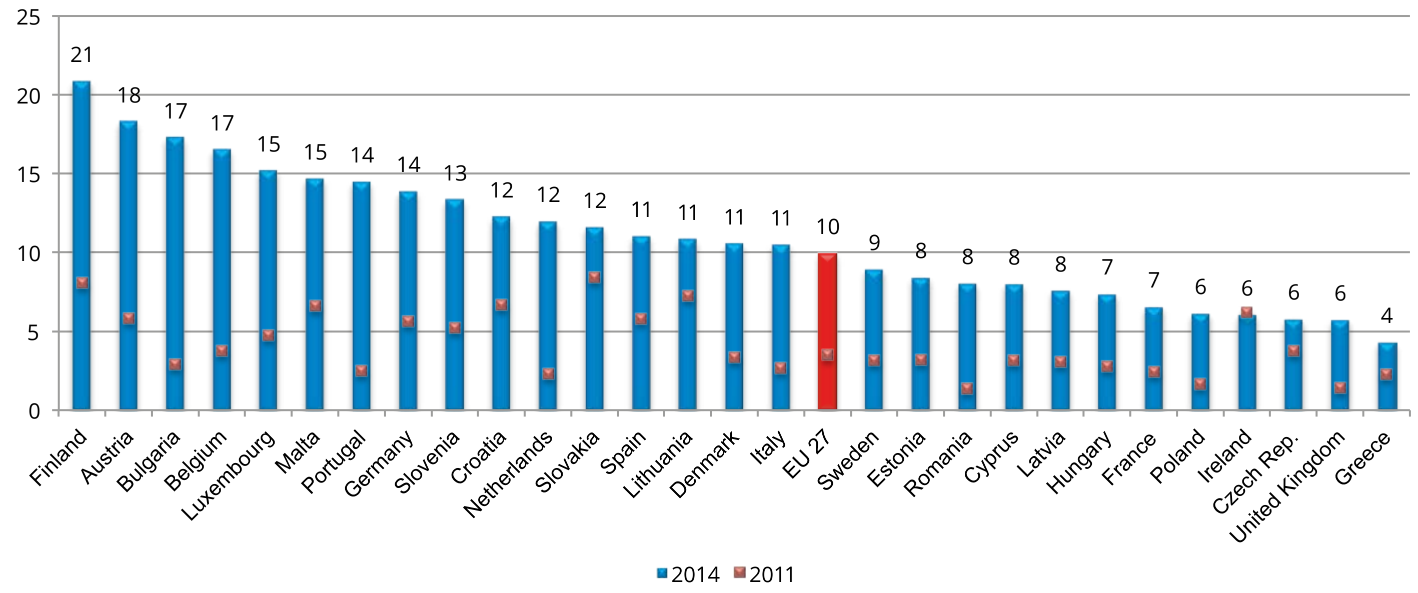


Fig 1.7 Enterprises using Radio Frequency Identification (RFID) technologies (%)

Source: Eurostat



this case, Italy seems to be quite advanced, with one company in five having purchased, in 2014, at least one of the available cloud computing services. At the opposite end, France and Germany are situated at the lower end of the ranking, with 8% and 6% respectively of companies buying cloud computing services (Fig. 1.8). Disappointing is the share of enterprises whose business processes are automatically linked to those of their suppliers and/or customers across Europe (on average, 17%). This figure has reduced in a significant number of countries over time. In Italy, for example, it has decreased from 22% to only 13% (Fig. 1.9). The adoption of systems integrated with suppliers/customers has consistently increased only in the Netherlands (+ 16 p.p.), Denmark (+13 p.p.) and Cyprus (+9 p.p.) and to a lesser extent in Czech Republic, UK, Estonia, Finland, Austria and Ireland. Moving from enterprises to households, France and Italy have the highest absolute number of M2M-embedded mobile cellular subscriptions (9.2 and 7.1 millions respectively), despite holding the fifth and seventh spots among the 17 countries analyzed (Fig. 1.10). Only Sweden stands out, with almost 6,5 million cards but an outstanding 67 cards per 100 inhabitants – a much higher percentage than in any other country.

Fig 1.8 Enterprises buying Cloud Computing services of medium-high sophistication (2014, %)

Source: Eurostat

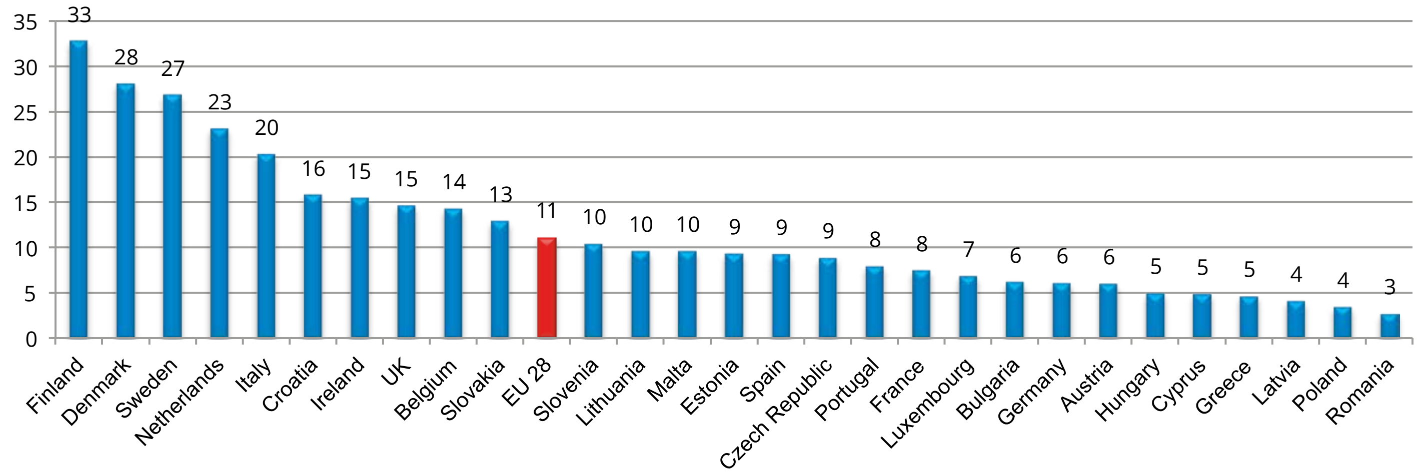


Fig 1.9 Integration with customers/suppliers and SCM (% of companies)

Source: Eurostat

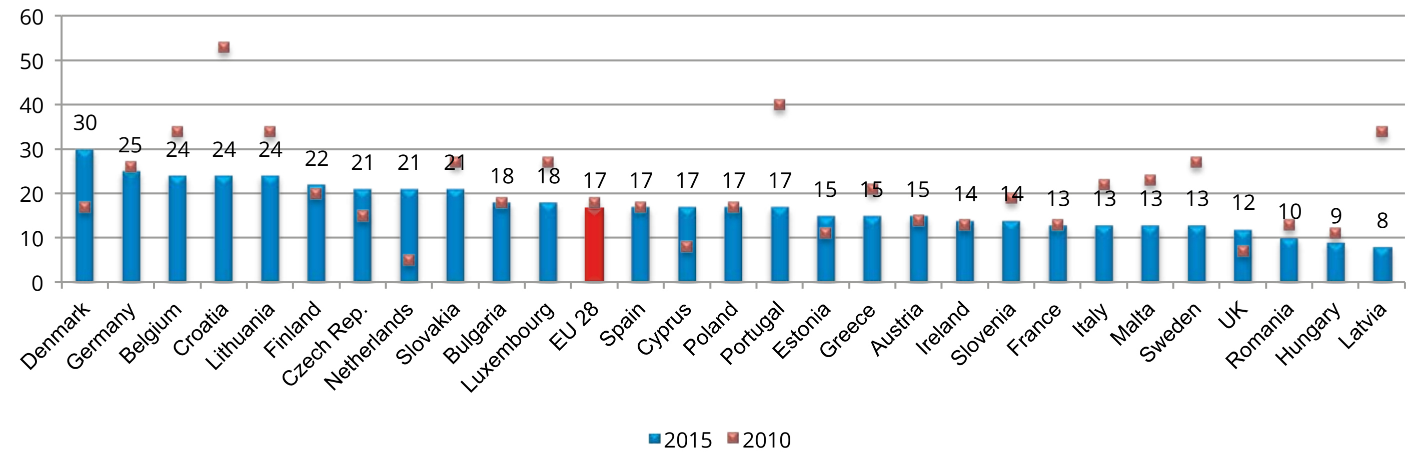
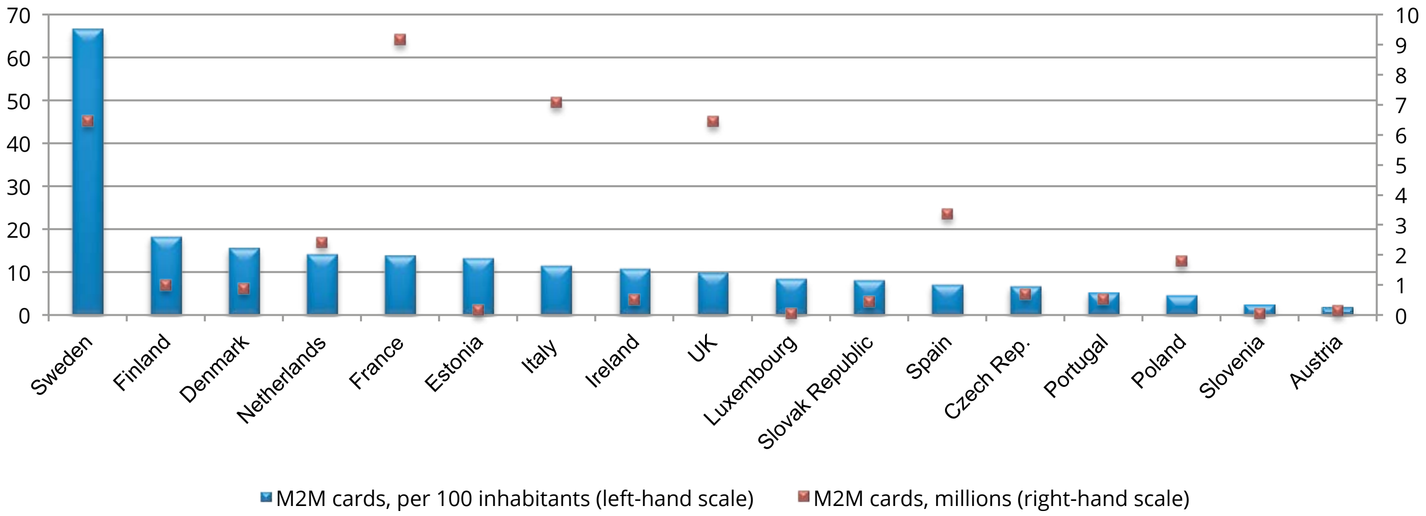


Fig 1.10 M2M-embedded mobile cellular subscriptions, June 2015

Source: OECD



Nevertheless, behind the diffusion of these technologies, there is the need for extensive and fast connectivity. With respect to the fixed ultra-broadband network, in 2015 70.9% of the EU population was covered on average (+22.8 p.p. over 2011). Malta, Belgium and Netherlands top the ranking with almost 100% coverage. The performance of larger countries performance is more lackluster. Out of 28 EU Member States, Germany was 13th (with a coverage equal to 81.3%), Spain 17th (76.6%), Poland 24th (60.7%), France 26th (44.8%) and Italy 27th (43.9%). Only the UK teemed with top performers (with a population coverage equal to 90.5%). The results from Cyprus also deserve to be highlighted – climbing from 0% to 84% in terms of fixed ultra-broadband coverage of the population within only 4 years.

Moving to the mobile sector, 4G coverage reached in 2015 85.9% of the EU population on average, with peaks of 99.6% in Netherlands (that had carried out a spectacular comeback given that in 2012 had no 4G in place), 99.2% in Sweden and 99.0% in Denmark. Larger countries were ranked slightly better in this case, in particular Germany (8th with a coverage of 94.0%) and Italy (13th with a coverage of 89.7%). 4 out of the leading 11 countries were from Eastern Europe, in the following order: Slovenia in 4th place, Hungary in 6th place, Czech Republic in 9th place and Lithuania in 11th place (Fig. 1.12).

Fig 1.11 Fixed Ultra-broadband coverage of the population (%)

Source: Eurostat

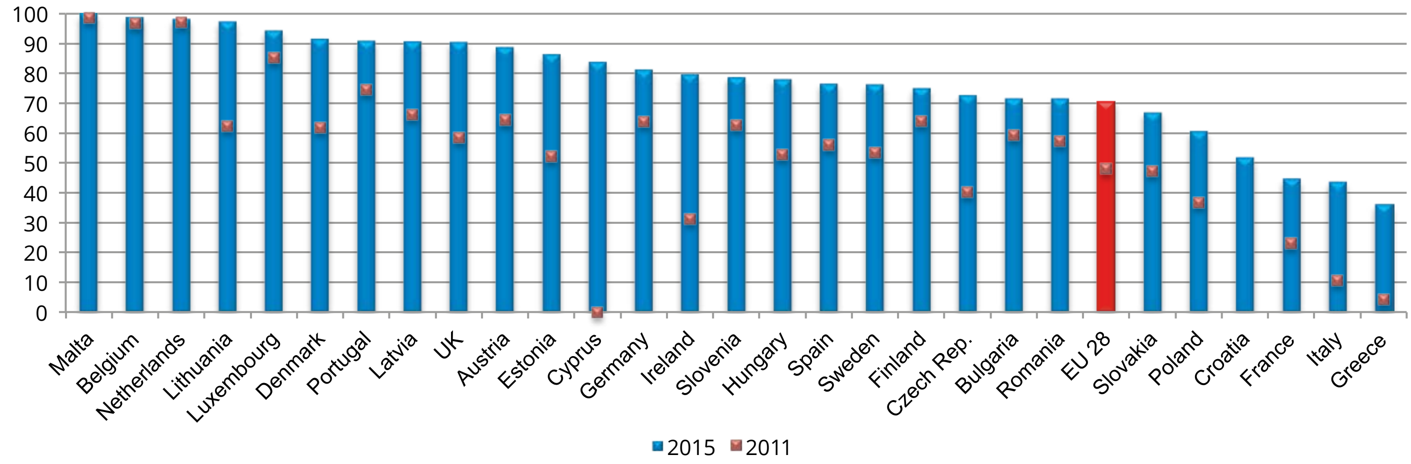
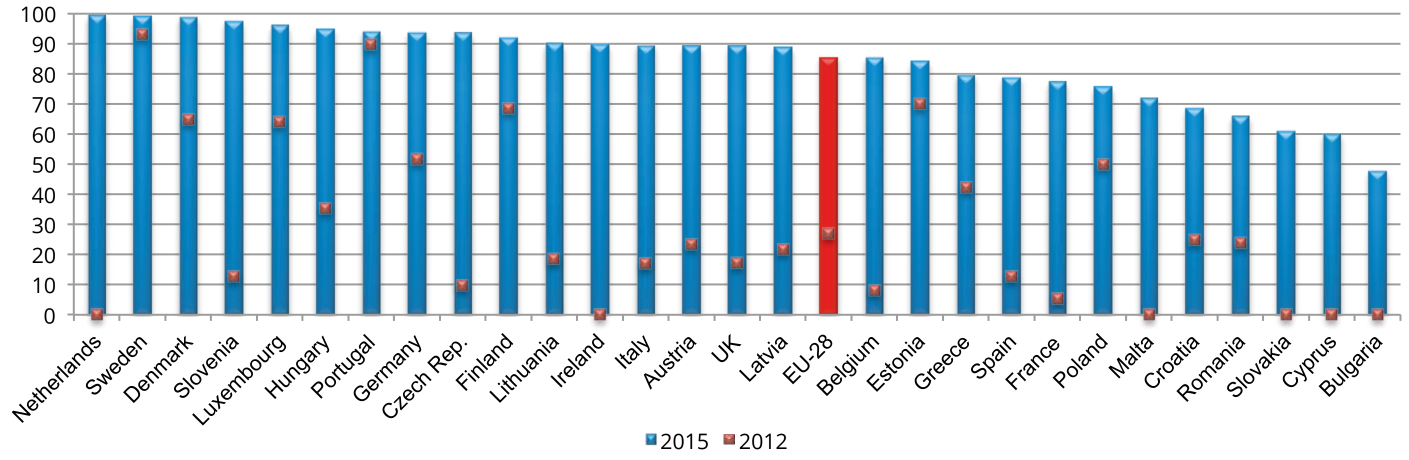


Fig 1.12 4G coverage of the population (%)

Source: Eurostat



1.4. IOT'S MARKET VALUE. THE GROWTH PERSPECTIVE OF IOT IN EUROPE AND IN THE WORLD

1.4.1. Worldwide market size and revenues and forecasts of the Internet oh Things

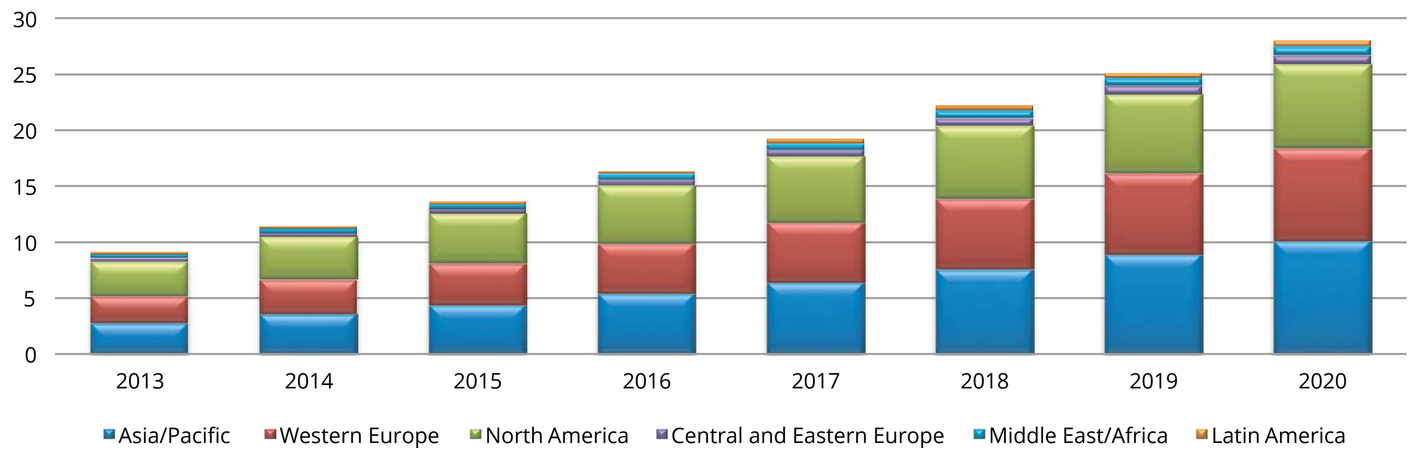
According to IDC – the premier global provider of market intelligence, advisory services, and events for the information technology, telecommunications and consumer technology markets – the reality of the IoT market around the world is underway: businesses are expanding their understanding of the efficiencies, business process transformations and revenue implications that IoT solutions can generate; consumers, on the other hand, are witnessing a number of innovative concepts coming to life that are changing the way they carry out their daily activities.

Based on IDC's estimates, at the end of 2013 there were 9.1 billion IoT units installed, which are expected to grow at a 17.5% CAGR to 2020, reaching 28.1 billion (Fig. 1.13). Such a huge growth is explained by the pervasiveness of wireless connectivity, ubiquitous access to the Internet regardless of location, IoT standard protocols, regional government support for efficient technologies and services and consumer familiarity with realities around connected cars and connected homes. The highest growth rates are attributed to the Asian-Pacific area (+20.1%) and Western Europe (+19.4%), with an installed base tripled in 7 years, in both cases.

Such growth will result in a redistribution of the IoT

Fig 1.13 Worldwide IoT Installed base, by region (US$ bn)

Source: IDC (2014)



icom institute for competitiveness

Fig 1.14 Distribution of IoT market, by region

Source: IDC (2014)

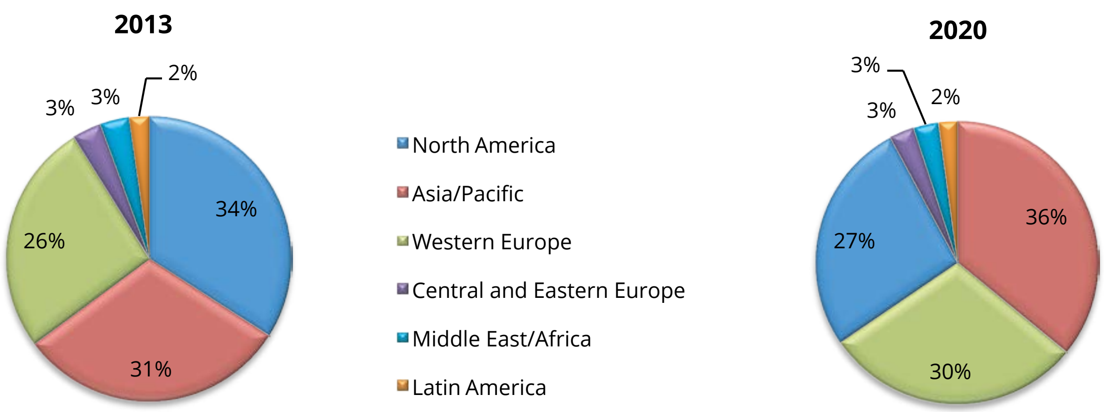


Fig 1.15 Worldwide IoT revenues, by region (US$ bn)

Source: IDC (2014)

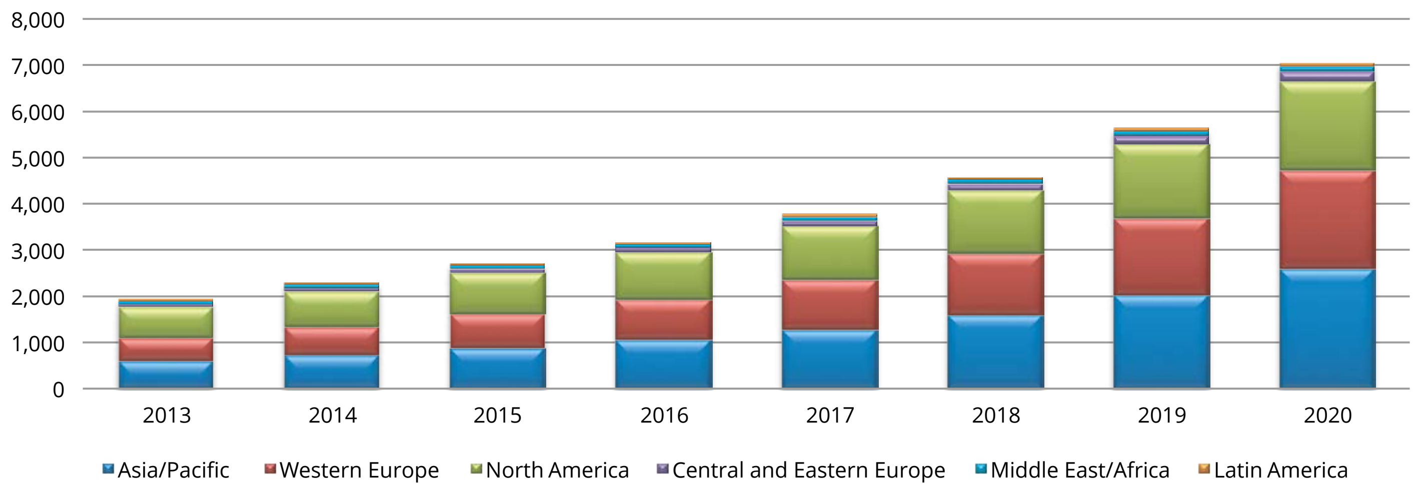
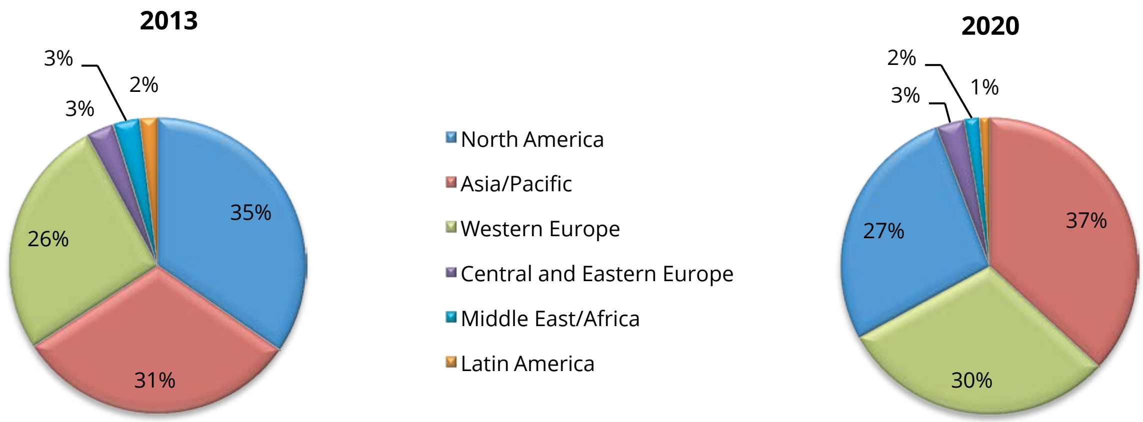


Fig 1.16 Distribution of IoT revenues, by region

Source: IDC (2014)



market among world regions, with Asia moving from second to first position with a share increased from 31% to 36% (Fig. 1.14), Western Europe becoming second with a share rising from 26% to 30%. According to forecasts, the US, on the other hand, will experience a large increase in installed base too (from 3.1 billion units to 7.5 billion), but will lose market share (27% in 2020 from 34% in 2013).

IoT technology and services revenues are expected to grow from 1.9 trillion dollars in 2013 to 7.1 trillion dollars in 2020, at a 20.4% CAGR (Fig. 1.15). Again, Asia and Western Europe should be the world regions with the highest growth (+23.3% and +22.8%, respectively), followed by Central and Eastern Europe (+20.8%)

In the same way as for market share, the uneven growth around the world imply a redistribution of future revenues, the 37% of which will be up to the Asian-Pacific countries in 2020 and slightly less than one third to Western European countries (Fig. 1.16). US will generate another 27% of total IoT revenues, whereas the rest of the world will remain marginal.

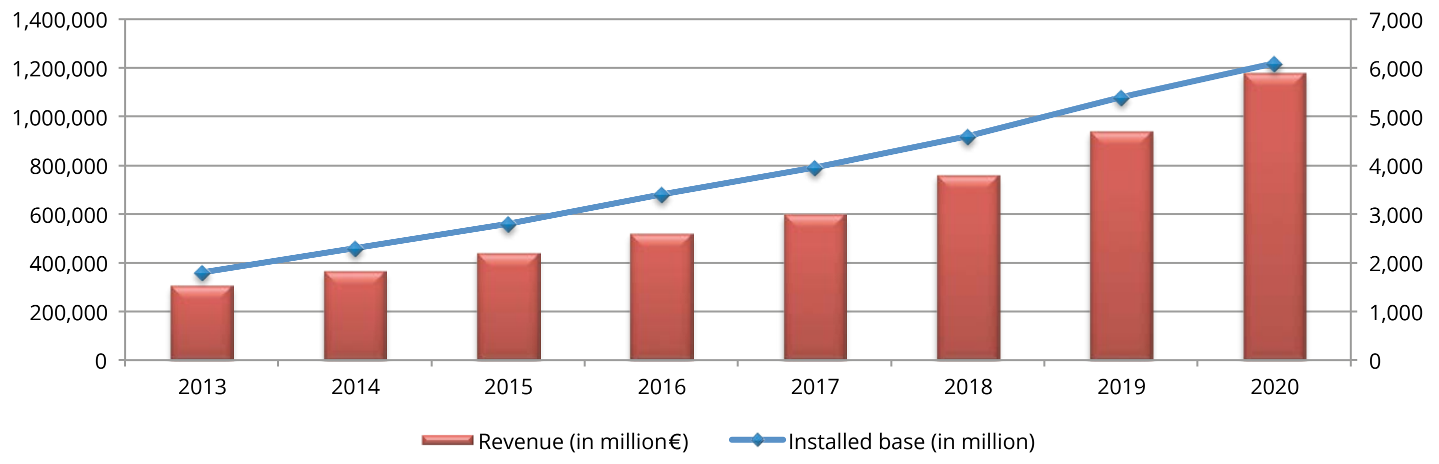
1.4.2. Market size and revenues forecasts for the EU

According to IDC's forecasts, the number of IoT connections within the EU28 will increase from approximately 1.8 billion in 2013 to almost 6 billion in 2020 (Figure 1.17). The main driver behind this is the increased connectivity within consumer goods (such as TVs, fridges etc.) combined with the widespread deployment of sensors (in manufacturing plant, bus shelters, attached to livestock, heartbeat monitors, remote medical devices). As a consequence of more things becoming connected, the installed base is expected to increase at a CAGR of 18.7% over the period. IoT revenues, at the same time, will increase from more than €307 billion in 2013 to more than €1,181 billion in 2020. As the installed base increases so revenues rise too, albeit with a slight time lag. Early in the 2013-2020 period, indeed, the increase in the installed base is more pronounced than the increase in revenue. This is partially explained by the fact that connectivity is the first stage in the journey towards an IoT world with application/ solution service revenues becoming more prominent later in the period. In addition, many early deployments will be relatively simple (e.g. checking a connected device is still working), whereas later in the period more sophisticated cases are expected to become the standard. As a consequence, after 2016, revenues increase at a faster rate than connections. Over the whole period the forecasted CAGR across the EU28 will be 21.2%.

Strong IoT growth is expected in both the installed base and revenues across all EU Member States. Although all countries in the EU will participate to the IoT revolution, those Member States that have traditionally invested more in ICT are expected to gain from the IoT revolution earlier than those that do not invest in ICT (Table 1.1). As a consequence, these countries (UK, Germany, and France) are forecast to take over half the IoT revenues in the EU, with the top 6 (the above plus Spain, Italy, and Netherlands) grabbing over 75% (Fig. 1.18). The highest

Fig 1.17 IoT installed base and revenues in EU28

Source: IDC (2014)



growth rate is anticipated to occur in Sweden with a foreseen CAGR equal to a skyrocketing 24.2% (because of advanced connectivity networks). However, this does not mean that those Member States where investment in ICT is low will permanently lose out: IoT will develop in all EU countries although in someone the impact will be less than in others and will probably occur later in the economic cycle.

IoT will impact all vertical sectors, and take-up in manufacturing; finance and the utilities sectors will grow faster than the EU average. All vertical sectors in the economy will participate in the IoT revolution (Table 1.2), but again those that have traditionally invested more in ICT, according to the forecasts, are more likely to enjoy more of the revenues and sooner, than those that have not. Nevertheless, it is probably too early to say at this

Table 1.1 Market size, by country (in million €)

Source: IDC (2014)

	2014	2020	Δ 2014-2020
UK	78,678	269,283	242%
Germany	71,114	243,642	243%
France	55,444	185,086	234%
Italy	32,087	97,927	205%
Spain	24,500	65,570	168%
Netherlands	18,584	57,922	212%
Sweden	13,436	50,199	274%
Belgium	9,353	28,328	203%
Poland	9,017	26,494	194%
The rest	53,778	157,152	192%
Total	365,992	1,181,603	223%

Fig 1.18 Market size, by country

Source: IDC (2014)

Table 1.2 Market size, by vertical market (in million €)

Source: IDC (2014)

	2014	2020	Δ 2014-2020
Manufacturing	87,805	286,539	226%
Finance	73,709	242,222	229%
Local & Central Government	49,742	153,707	209%
Retail & Wholesale	38,024	124,412	227%
Communications	37,388	119,975	221%
Business services	28,334	90,218	218%
Education & Health	22,060	66,925	203%
Utilities	10,630	39,668	273%
Transport	8,659	27,728	220%
Agriculture, construction and mining	7,331	23,193	216%

point which verticals will lead on IoT: there is also a view, indeed, that sectors where ICT investment has historically played a relatively minor role (e.g. Agriculture) will have most to gain from IoT and so growth will be more rapid than in the "usual suspects".

As already in 2014, manufacturing will represent the biggest IoT market in 2020 (24%), followed by the Finance sector (21%) and the Local & Central Government Sector (13%) (Fig. 1.19).

1.4.3. Importance of IoT for Europe and the need for a systemic perspective

IoT operates both at the level of the individual user and at the level of the invisible systems and processes that support and enable society, government and industry.

Fig 1.19 Market size, by vertical market (%)

Source: IDC (2014)

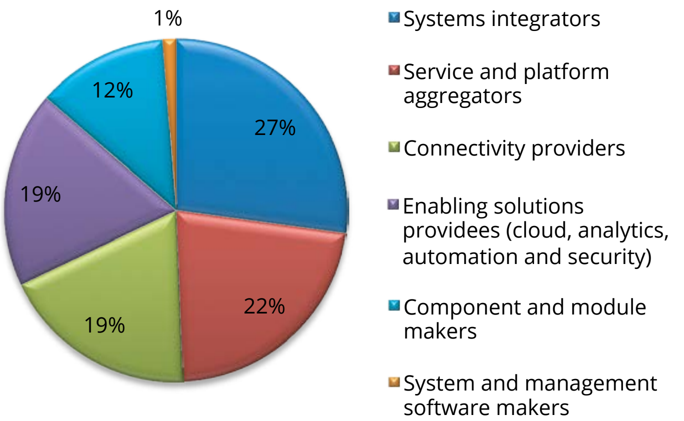
These processes include B2B, B2C, C2C (citizen to citizen), C2G (citizen to government) communications and transactions.

Europe is in an excellent position to become a global leader in IoT. The main strengths of European ICT are in business-to-business software and services (although with strong US competition), embedded systems (including automotive and aeronautics), and in particular in applying ICT in complex system level solutions in various industrial and societal domains. Leveraging traditional European industrial and social system strengths by augmenting solutions with ICT in e.g. Smart Grids, transportation and logistics, cyber-physical systems, eHealth, active & healthy aging, and digital inclusion is necessary for European industry and will strengthen Europe's position against the US and Asia. Over the past two decades, European companies, in particular SMEs in traditional engineering and production sectors, have endeavored to adapt their business models and human resources to the new requirements of embedded software and modern IT-based engineering tools. This process, which is far from completed, is now overlaid with the advent of the Internet of Things that some call the fourth industrial revolution ("Industry 4.0", or Smart Industry). This development completely changes the opportunities and threats for all these companies, irrespective of their size. Opportunities include optimization across individual devices and enterprises, traceability of products, remote maintenance as well as new Internet-based product-accompanying services. Threats include additional network-based security risks for company IP, and market entry of large players (often monopolistic) who enter industrial domains such as fashion, home automation or automotive from the Internet side. It will be crucial for European competitiveness and industrial future to strengthen the innovativeness and companies of not just the "pure" ICT industries but also software- and network-intensive "user industries" especially at the SME level.

Realizing the kinds of opportunities posed by IoT requires – according to ATKearney – the connection of more than 25 billion objects in the EU28 alone: this would represent an annual opportunity worth about 80 billion euro for six categories of IoT solutions providers, the largest part of which associated with systems integration and service and platform aggregation (Fig. 1.20).

Fig 1.20 Market size, by IoT solution (%)

Source: ATKearney (2016)



For EU28 IoT means the opportunity to unlock up to 7 percentage points of GDP growth by 2025 through productivity improvement and value redistributed to end customers, with a potential value reaching nearly 1 trillion euro. This potential will come mainly by three sources (Fig. 1.21):

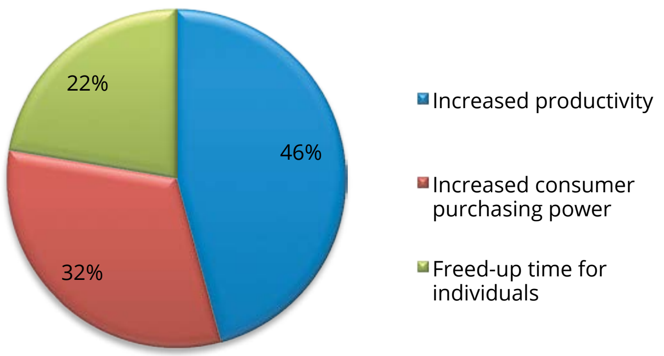
1. Increased productivity: analysis of real-time data and remotely controlling objects will help companies make better decisions and act earlier and at a lower cost to optimize and automate objects in ways unknown so far;
2. Increased consumer purchasing power, associated with significant energy savings for consumers and increased products' durability triggered by IoT-enabled objects;
3. Freed-up time for individuals, since connected objects will improve individuals' health and decrease their risk factors, which, combined with productivity gains, will provide people with more free time, a share of which will be spent on productive tasks, delivering further economic value.

The largest impacts, in terms of value generated by IoT applications on GDP, seem to be in the transport and healthcare sectors, accounting for over one half of the total value created by IoT (Fig. 1.22).

In particular, as for transportation, the proliferation of sensors and driving assistants, coordination between vehicles and road sensors and connection of vehicles to Internet marketplaces could dramatically reduce negative externalities affecting time and money spent, accidents, energy and vehicle utilization. Improvements

Fig 1.21 IoT's economic potential for EU28, by type of benefit

Source: ATKearney (2016)



associated with IoT solutions could reduce accidents by 30% through the use of telematics. There may also be a 10% reduction in the number of cars in circulation due to car sharing, private hire platforms and self-driving cars. Energy savings of up to 10%, amounting to about 245 billion euro, 39% of sectoral GDP, may also be seen.

IoT may have a strong impact on the healthcare sector by improving monitoring of chronic diseases (such as diabetes, asthma, high blood pressure) and supporting better patient compliance with medication regimens. IoT solutions are expected to save 10% in the cost of chronic diseases thanks to better monitoring of vital signs and better coordination of patient visits; reducing non-medication compliance by up to 80%; improving early detection of diseases, thanks to the proliferation and sophistication of low-cost consumer biometrics, by continuously measuring activity, vital signs and motion and reducing the cost for rehabilitative care up to 40%, thanks to remote hospitalization enabled by connected medical devices. The total impact would amount to 235 billion euro (17% of total GDP of the sector).

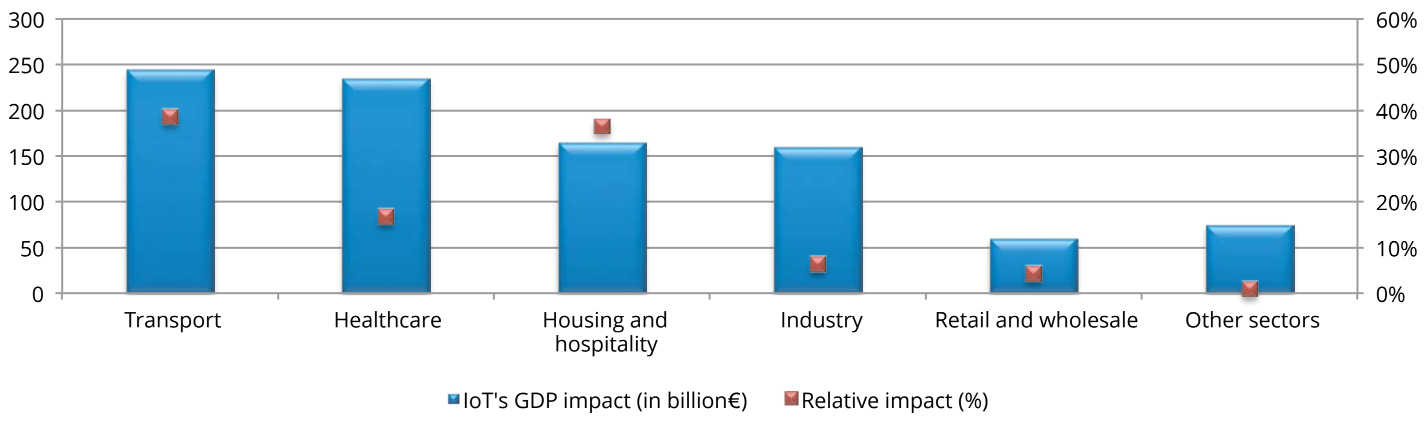
In the field of housing and hospitality, IoT solutions could save around 15% on energy costs – through better monitoring and the dynamic control of consumption of heating, cooling and energy-hungry appliances – and 20% of time spent by individuals on housekeeping tasks, thanks to the development of more autonomous and service-oriented white and brown goods, up to 165 billion euro (37% of total GDP).

In the industrial sector, IoT investments are associated with up to 5% in productivity gains thanks to better tracking of inventory, preventive machinery maintenance and improved positioning of objects in machines, as well as further savings on transport and handling due to better tracking and management of transportation fleets, pallets and items transported through tags and localization devices. This means a value generation of around 160 billion euro, equal to 6% of industrial GDP.

Finally, by 2025, the IoT should have a profound impact on the retail and wholesale sector, especially on logistics, inventory management and the shopping experience. In particular, reductions in logistics costs by 10%, shrinkage reduction and write-offs, and an increase in sales by at least 2% are foreseen thanks to goods tagging and connected store shelves enabling greater transparency in inventory tracking and, then, large availability. In addition, new sensing devices allows for a new shopping experience (self-service, automatic check-out), driving to further savings from lower cashier costs and increased sales.

Fig 1.22 IoT's impact on GDP, by sector (2025, € bn)

Source: ATKearney (2016)



The IoT could boost the European high-tech industry and profoundly improve competitiveness in most industry sectors. However, much effort is required to achieve such relevant benefits: aside from technology, new business models will be needed; common standards agreements will be needed across ecosystems for solutions to interoperate; and processes will have to be reengineered to generate efficiency gains.

In other words, a systemic perspective is essential, and in this respect policy makers are required to make bold moves to create the conditions for IoT to thrive.

With this in mind, the European Commission has outlined the five fields to keep an eye on:

1) Creating European winners

In hyper-scalable business, global natural monopolies will emerge in smaller and smaller pieces of innovation. Europe needs to ensure two things: 1) fair share of global winners and 2) ways to turn those successes in the jobs and economic growth for Europe. History shows that the winners can be both big companies as well as start-ups, but the competition is global. In other words Europe needs to offer the best conditions worldwide for competitive, innovative and market-ready IoT solutions.

2) Europe has to strengthen the IoT sector

Europe has to strengthen its core industries by supporting IoT technologies. Therefore, it needs a strong high-tech sector that is world-leading in IoT technology and supports the traditional European industry in the transition into the digital era, where everything is connected. This transition requires new types of organization, new business models, new services, new development methodologies, optimization of the whole digital engineering tool landscape for the whole production chain. Organizations, methodologies and business models have to be fundamentally scrutinized.

3) Standards and interoperability

IoT technological implementation should ideally rely on a commonly agreed basis e.g. via standardization. The international standards are needed to avoid regional fragmentation and allow worldwide use of products and solutions. Also the standardisation of a reference architecture model for IoT is needed to achieve the goal of compatibility and interoperability across industrial domains – without, however, compromising on security. This reference architecture model (like the ones proposed by European research project IoT-A, FI-WARE and Smart M3) will be the base for domain specific refinements and extensions addressing notably common open platform / backbone that supports the needed communication, data capturing services and can be shared by multiple providers of data-centered services / applications. For IoT standardization, it is of utmost importance to have relevant players from all industrial domains involved. IoT standards which are only defined from the viewpoint of a single domain (i.e. telecommunications or consumer domain) will not match the needs and requirements of other domains and lead to silo solutions which will contradict the IoT goal of compatibility and interoperability across industrial domains.

4) **Legal & regulatory framework as a key enabler of IoT innovation**_

This involves many notably legal and regulatory issues. The concept of single digital market in Europe is far from being realized. IoT applications and services can have many societal benefits, by making our society more effective, greener, healthier, safer, smarter, convenient etc, but they are often blocked by the legal and regulatory framework still in place in one or more EU Member States of EU. A balanced view between the benefits of new technological developments and associated risks and potential issues is needed. Trust, security and privacy are important aspects of IoT that have to be guaranteed in order to achieve wide acceptance in the society, as are consumer protection, autonomy, functioning competition and choice. A clear regulatory framework covering these aspects will provide guidance for standardization and solution development. The regulatory framework shall focus on requirements, liability and accountability and shall not select or prefer certain solutions and standards.

5) **Related developments dealing with big data, cloud and human agency**

These three aspects are closely related. To put it in a schematic form, sensors create data in massive amounts that need specific Big Data analytics to extract usable knowledge. Data can be made available easily and on a big scale using cloud technologies. Most of the data are generated by sensors or machines and will be processed by machines without human interaction. Therefore, it is important to take the humanistic, ethical and societal aspects into consideration.

PART 2

DIGITAL SINGLE MARKET AND 5G DEVELOPMENT

2. DIGITAL SINGLE MARKET AND 5G DEVELOPMENT

2.1. 5G'S TECHNOLOGICAL FEATURES: LATENCY, SPEED, NUMBER OF CONNECTED DEVICES

The extraordinary diffusion of Internet and mobile devices, the importance of contents and the prospects of development of the IoT call for a reflection on the need to promote technological progress and, in particular, 5G's implementation.

5G arrives downstream of a long process where the first generation of mobile technology was primarily about getting things together, the 2nd generation was focused on the introduction of speed increases and additional services (like SMS and support for data) and the 3G's implementation accelerated new services' development and the affirmation of mobile broadband. Today we're living in the 4G era where extraordinary data volumes flow, traditional services era surmounted by mobile broadband, cellular network technologies are being integrated and LTE networks provide advanced support for data and services.

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 citizens/consumers and businesses' lives. 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, it's possible to identify a wide range of benefits stemming from 5G:

- data rates up to 100 times faster (more than 10 Gbps);
- network latency lowered by a factor of five;
- mobile data volumes 1,000 times greater than today;
- battery life of remote cellular devices stretched to 10 years or more;
- increase of the number of devices connected to the network (1 mln per 1 sq. km);
- possibility of use of several bands from 400 MHz to 100 GHz.

These are important innovations and performances will enable new capabilities helping industries to offer new products and services increasing also productivity and efficiency; for example, ensuring a precise remote control, 5G will let us to develop remote surgery, machine's remote control and robotics, while it will encourage the diffusion of self-driving car, thanks to a shorter reaction time and a more stable signal. Finally, the increase of the number of devices connected to the network will encourage IoT's development creating new opportunities for businesses and citizens/consumers.

2.2. 5G IMPLEMENTATION: TECHNOLOGICAL AND REGULATORY ISSUES

Vertical industries and European institutions underline the importance of 5G deployment for the future of European Union. Indeed, 5G technology will allow the development of new services – among them IoT is one of the most important – that will enable the expansion of new services that will bring progress, welfare, jobs and new opportunities for businesses.

In light of this awareness, on 17 December 2013 the European Commission signed a landmark agreement with the "5G Infrastructure Association" representing major industry players to establish a Public Private Partnership on 5G (5G PPP) and accelerate research developments in 5G technology.

At the Mobile World Congress 2015, the Commission and 5G PPP presented Europe's vision of the 5G technologies and infrastructure. The document *"5G empowering vertical industries"*, in particular, summarizes the opportunities, the critical issues and the actions to be taken to encourage the development of 5G in Europe underlining that 5G network infrastructures will be a key asset to support the revolution connected to society's and industry's digitization. This paper analyzes the development prospects favored by technological evolution, focusing on transport sector, healthcare, energy and media & entertainment, showing that, in general, the digitization of factories will be a key issue for the 2020s. With reference to 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 on automotive industry. 5G technology will ensure performances able to support these cases and a lot of new applications which can be developed within them, 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, in an even longer perspective, complete autonomous driving cars – which will guarantee less fatal accidents, less traffic congestions, less congested cities and new important business opportunities – the performance of 5G (above all latency and data rates) will be essential.

With reference to the health sector – which will be analysed further in the fifth chapter – considering the main use cases identified on assets and interventions management, hospital, robotics, remote monitoring and smarter medication, 5G will be instrumental to these cases. For example by mobilizing efficiency reserves such as assisted self-management capabilities, it will ensure the empowerment of less qualified personnel to conduct routine tasks on the behalf of higher qualified professionals, the 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 cut costs of healthcare, through m-health, by 15% and possible benefits on the effectiveness and efficiency of the delivery of care).

The energy sector – analyzed in the fourth chapter – will also benefit from the opportunities related to the 5G's implementation. In fact, 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, "Smart Grids" will need to be introduced and 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, shall enable at least six main families of M&E use cases in the 2020s. In particular, 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.

After having highlighted the opportunities for different sectors, 5G PPP document underlines that, compared to the traditional ecosystem, 5G may create new grounds for cost sharing with innovative partnership models focused on synergies among network operators and vertical industries, favouring the emersion of new actors and allowing investors to hedge investments into smaller opportunities diversifying the telecoms investment portfolio. Therefore, considering that 5G will integrate different telecommunication technologies (e.g. mobile, fixed, satellite and optical), spectrum-regulatory frameworks (e.g. licensed and unlicensed) and enabling capabilities (e.g. IoT) for the benefit of vertical industries, the document highlights the importance of a cooperation among different standards organizations and vertical industries to optimize the 5G capabilities.

Subsequently, the *"5G Manifesto for timely deployment of 5G in Europe"* (July 2016), endorsed by several primary businesses, startes that standards and coordination across European stakeholders for pre-commercial trials are very important for 5G development and propose a two-phase trial roadmap, one before 2018 and the other one around 2018. In the first phase, in particular, it proposes the realization of technology trials run by independent trial consortia in various countries – involving also vertical industries – independent of the status of standardization, 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 claim global public attention.

This document makes some requests about spectrum management underlining the importance of harmonized licensing of 700MHz, 3.4-3.8GHz and higher-frequency bands (for 24GHz and beyond) by 2020, the necessity to eliminate restrictions in existing licenses and uses and, in general, the creation of a regulatory environment able to promote investments in connectivity by all players.

5G Manifesto identifies other actions to promote 5G development and in particular: reduction and simplification of the rules on access to key infrastructure, deployment barriers' removal, possibility for operators to mix and manage different technology generations, mobile or otherwise, that are enabling 5G mobile technology to serve their customers optimally and where access regulation remains, promotion – wherever possible – of long-term commercial agreements that enable competitive outcomes as an alternative to regulation. The same document underlines the importance of the creation of a level playing field with equivalent and proportionate privacy requirements to innovate in data-driven markets and the danger of restrictive Net Neutrality rules, in the context of 5G technologies, business applications and beyond. European operators will target launching 5G in at least one city in each of the 28 European Member States by 2020.

Recently, on September 14, 2016, European Commission presented *"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 of the main issues which impact the anticipated deployment of 5G networks.

The Commission's Action Plan begins with an awareness that we are living in a revolutionary period in which new technologies, devices and services are changing traditional activities. While these transformations have already started on the basis of existing networks, the Commission, adhering to industry guidelines, recognizes the need to develop 5G to reach their full potential in the coming years. Indeed, it is important to notice that 4G will continue to be developed and enhanced, and also to be deployed and that 5G is not conceived as a technology replacing 4G, but rather as a way to complement it with new service capabilities (just as 4G is complementary to 2G/3G).

The Commission strategy for the Digital Single Market and the Communication *"Connectivity for a Competitive Digital Single Market: Towards a European Gigabit Society"* underline the importance of very high capacity networks like 5G as a key asset for Europe to compete in the global market. Worldwide 5G revenues should reach the equivalent of €225 billion in 2025. The study on "Identification and Quantification of Key socio-economic data for the strategic planning of 5G introduction in Europe", however, highlights that the benefits of 5G introduction across four key industrial sectors may reach €114 billion/year.

The deployment of 5G is a priority at the global level. The working document reminds that several prominent 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), in America (2015).

The same working document shows 5G opportunities from a market perspective, recalling that an ABI research predicts that 5G revenues may reach US$250 billion in 2025, with North America, Asia-Pacific, and Western Europe being the top markets, based on revenues connected to "Machine to Machine" communications' development in addition to enhanced mobile broadband services and underlining the benefits for industrial sectors, summarized in Table 2.1.

The Commission has 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, identifying provisional spectrum bands available for 5G ahead of the 2019 World Radio Communication Conference (WRC-19) and then additional bands as quickly as possible, promoting early deployment in major urban areas and along major transport paths, accelerating pan-European multi-stakeholder trials to turn technological innovation into full business solutions, encouraging the implementation of an industry-led venture fund in support of 5G-based innovation and supporting the promotion of global standards.

In fact, 5G deployment demands substantial investments and a coordinated approach which involves an harmonization of standards and a global consensus about the choice of technologies, spectrum bands and a shared roadmap. Coordination among stakeholders is necessary to avoid 4G's critical issues in Europe: IDATE DigiWorld Yearbook 2016 & GSMA Report "The Mobile Economy in Europe 2015", indeed, highlights that in 2015 more than 75% of the US population had access to 4G/LTE versus only 28% of the EU population and that the delayed deployment of 4G networks in Europe has often been attributed to a lack of cross-border coordination in Europe.

To achieve these goals and encourage a coordination at EU level, the Commission identifies several actions (eight in particular), regarding:

1) the promotion of preliminary trials from 2017 onwards and pre-commercial trials with a clear cross-border

Table 2.1

Industrial sector benefits	Automotive (€ mn)	Healthcare (€ mn)	Transport (€ mn)	Utilities (€ mn)	Total (€ mn)
Strategic	13,800	1,100	5,100	775,000	19,770
Operational	1,800	4,150	3,200	2,700	11,850
Consumer	13,900	207,000		3,000	17,110
Third Party	13,700	72,000			13,770
Total	42,200	5,530	8,300	6,470	62,500

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 – according with Member States – by the end of 2016 of a list of pioneer spectrum bands for the initial launch of 5G services. In particular, this first set of such pioneer bands should include a mix of spectrum with different characteristics to address the versatile 5G requirements (so spectrum below 1 GHz – focusing on the 700 MHz band, available by 2020 (or in special cases and on request by 2022) as proposed by the Commission – spectrum between 1 GHz and 6 GHz, and spectrum above 6 GHz);

3) the adoption of an agreement around the full set of spectrum bands (below and above 6GHz) to be harmonized for deployment of commercial 5G networks in Europe. The identification of spectrum bands will allow Europe to align itself with other countries that have already identified spectrum ranges. The working document points out that: a) the Republic of Korea has already identified spectrum and assigned 3 blocks of 1 Ghz each to 3 operators at 28 GHz, planning the introduction of early 5G in 2018 for the Olympic Games in Pyun Cheong; b) Japan is afforming the will to introduce 5G in bands below 6 GHz in the context of the Tokyo Olympic Games in 2020, with the intention of designating 5G spectrum by the end of 2016; c) China has already selected the 3,4 -3,6 GHz band for early trials and is actualizing a 5G trial programme which will allow the realization of a complete 5G system before 2020; d) USA: in line with an approach to accelerate the pace of 5G introduction, the FCC released on 14 July 2016 the "Spectrum Frontier" rulemaking which identifies a set of applicable 5G frequency bands in the US and their conditions of use, planning 5G introduction by 2018;

4) the setting of roll-out and quality objectives for the monitoring of the progress of key fibres and cell deployment scenarios identifying actionable best practice to facilitate – also incrementing administrative conditions – denser cell deployment. The planned 5G networks, indeed, will serve up to one million connected devices per square kilometre (about a one thousand fold increase as compared to today) 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. It's also very important to guarantee an efficient connection of the small cells to the rest of the network – with high capacity backhaul communications since the aggregated volume of data that will transit through these small cells will reach several gigabits per second – and, to this end, to coordinate investments in cellular base stations and fibre infrastructures reducing, at the same time, the cost of installing access points (through a simplification of the deployment conditions for dense cellular networks, the removal of deployment barriers for the installation of small cells (for example the variety of specific limits on electromagnetic field (EMF) emissions and of the

methods required to aggregate them);

5) the promotion by the end of 2019 of the availability of the initial global 5G standard, the standardisation on radio access and core network challenges and the conclusion of cross-industry partnerships;
6) the planning of technological experiments and their realization as early as in 2017 and the presentation of detailed roadmaps by March 2017 for the implementation of advanced pre-commercial trials. To encourage uptake and demand the Commission underlines the need to ensure that hardware, terminals and devices based on 5G connectivity are available in due time before 2020;
7) the encouragement of Member States to consider the usage of 5G infrastructures to improve the performance of communication services used for public safety and security. It's very important that public services spur the emergence of innovative services, contributing to a critical mass of investment and addressing issues of importance for society;
8) the identification of assumptions and modalities for a venture financing facility.

Considering the importance of 5G development and EU investment in 5G research and standards, the European Commission has earmarked a public fund of 700 million euro through Horizon 2020.

PART 3 INDUSTRY 4.0

3. INDUSTRY 4.0

3.1. THE DATA-DRIVEN EVOLUTION OF THE MANUFACTURING INDUSTRY AND THE DIGITAL TRANSFORMATION OF SUPPLY CHAINS

Europe is experiencing a deep competitiveness shortfall with respect to developing economies, where the share of the manufacturing industry more than doubled between 1990 and 2014, with enormous growth seen particularly in Asia, moving from 9% to 40% of global manufacturing added value (Fig. 3.1). Such development occurred at a disadvantage to Western Europe in particular, with its share in terms of global added value decreasing by 12 percentage points.

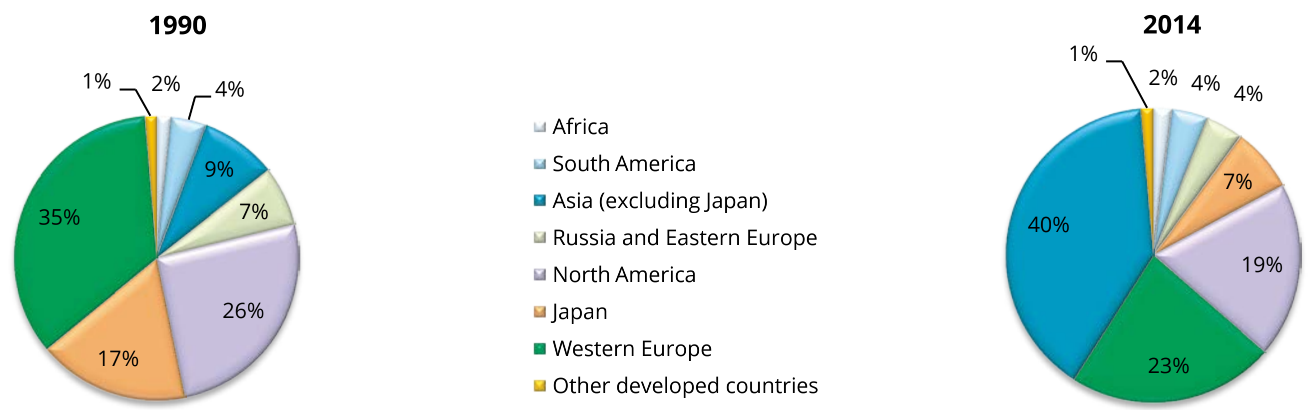
The role of industry, however, remains essential to the European economy.

In such a framework, the ongoing digital transformation completely transforms the way companies can compete, by not only changing the existing internal processes but also allowing for the development of completely different and innovative business models, thus providing new opportunities of value creation, and potentially generating an important competitive advantage.

Industry 4.0 can be defined as *"the comprehensive transformation of the whole sphere of industrial production through the merging of digital technology and the internet with conventional industry"*. In short, everything in and around a manufacturing operation (suppliers, the plant, distributors, even the product itself) is digitally connected, providing a highly integrated value chain.

Fig 3.1 Added value of the manufacturing sector, by Region

Source: UNCTAD



Industry 4.0 depends on a number of new and innovative technological developments:

- the application of information and communication technology (ICT) to digitize information and integrate systems at all stages of product creation and use (including logistics and supply), both inside companies and across company boundaries;
- cyber-physical systems that use ICTs to monitor and control physical processes and systems. These may involve embedded sensors, intelligent robots that can configure themselves to suit the immediate product to be created, or additive manufacturing (3D printing) devices;
- network communications including wireless and internet technologies that serve to link machines, work products, systems and people, both within the manufacturing plant, and with suppliers and distributors;
- simulation, modelling and virtualization in the design of products and the establishment of manufacturing processes;
- collection of vast quantities of data, and their analysis and exploitation, either immediately on the factory floor, or through big data analysis and cloud computing;
- greater ICT-based support for human workers, including robots, augmented reality and intelligent tools.

The merging of the virtual and the physical worlds through cyber-physical systems and the resulting fusion of technical processes and business processes is leading the way to a new industrial age best defined by the INDUSTRIE 4.0 project's "smart factory" concept.

The deployment of cyber-physical systems in production systems gives birth to the "smart factory." Smart factory products, resources and processes are characterized by cyber-physical systems, providing significant real-time quality, time, resource, and cost advantages in comparison with classic production systems. The smart factory is designed according to sustainable and service-oriented business practices. These insist upon adaptability, flexibility, self-adaptability and learning characteristics, fault tolerance, and risk management.

High levels of automation come as standard in the smart factory: this is made possible by a flexible network of cyber-physical system-based production systems that, to a large extent, automatically oversee production processes. Flexible production systems which are able to respond in almost real-time conditions allow in-house production processes to be radically optimized. Production advantages are not limited solely to one-off production conditions, but can also be optimized according to a global network of adaptive and self-organizing production units belonging to more than one operator.

This represents a production revolution in terms of both innovation and cost and time savings as well as the creation of a "bottom-up" production value creation model whose networking capacity creates new and more market opportunities. Smart factory production brings with it numerous advantages over conventional manufacture and production.

These include:

- CPS-optimized production processes: smart factory "units" are able to determine and identify their field(s) of activity, configuration options and production conditions as well as communicate independently and wirelessly with other units;

- optimized individual customer product manufacturing via intelligent compilation of ideal production system;
- resource efficient production;
- tailored adjustments to the human workforce so that the machine adapts to the human work cycle.

All supply chain and warehouse management processes such as demand management, order fulfillment, manufacturing flow management and return management can be tracked in real time to ensure the highest efficiency at each step. The production line, and the operations related to its maintenance, can also benefit from IoT-based wireless inspection tools allowing for real-time control of performance, durability, and safety of the products they produce. Manufacturing Operations is therefore the number one field in smart manufacturing today in Europe, followed by Production & Asset Management, which uses IoT to monitor and maintain assets (e.g. industrial manufacturing devices) that are part of the production value chain with the end goal of improving process efficiency for manufacturers.

Digitization is finding its way into horizontal as well as vertical value chains to an equal extent.

The digitization of the horizontal value chain integrates and optimizes the flow of information and goods from the customer through their own company to the supplier and back. This process involves the integration and proactive controlling of all company internal departments (e.g. purchasing, manufacturing, logistics and planning). It also includes all the external value chain partners that are needed to satisfy customer requirements and fulfil requested services.

Vertical digitization, on the other hand, is associated with securing a consistent flow of information and data from Sales through Product development to Manufacturing and Logistics. Quality and flexibility can be increased and costs reduced by the optimal connection of manufacturing systems, the prevention of system failures and better analytical abilities.

For example, a leading manufacturer of electronics components can achieve a very advanced level of digitization in some plants, by implementing various processes and value chain optimizations, including:

- vertical availability and integration of all development, manufacturing and supply chain data;
- effective data management and improved data analysis in real time;
- individual IP addresses for all components and systems in the plant;
- automation of all important process steps in a one-piece flow;
- continuous measurement and optimization of all process steps and parameters.

This would produce notable increases in performance at the plant level and significantly reduce error rates in manufacturing.

The level of digitization of the value chains will rise rapidly in the future in all the sectors: according to a survey conducted by PwC, whereas in 2014 just 22% of companies showed a high degree of digitization, within five years more than 4 in 5 companies will be highly digitized, with higher shares in automotive, manufacturing and electronics sectors (Fig. 3.2). The largest investments in digitization will come from the largest companies, 92% of which will be highly digitized in 2019 (31% in 2014) (Fig. 3.3).

Fig 3.2 Degree of digitization, by industry sector (% of enterprises)

Source: PwC (2014)

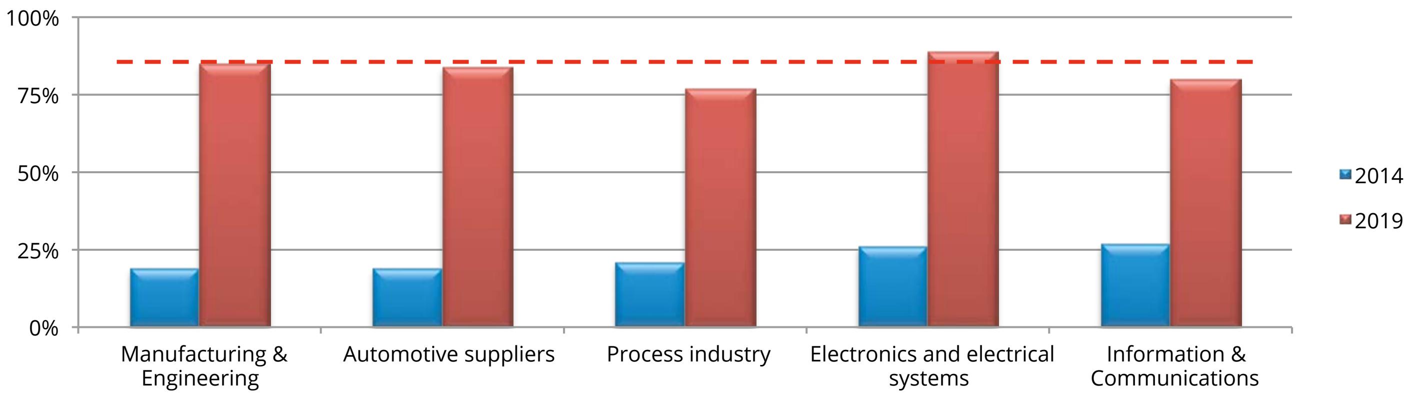
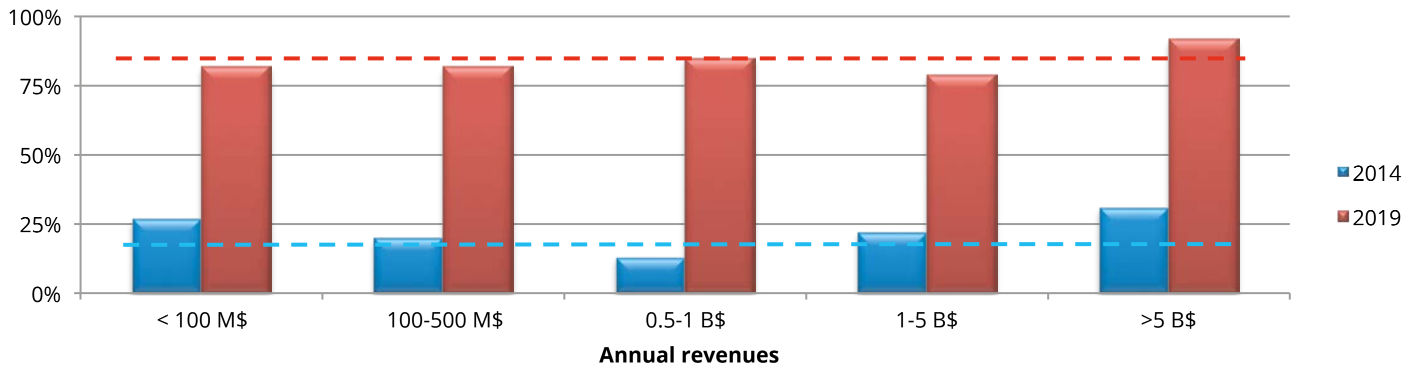


Fig 3.3 Degree of digitization, by company size (% of enterprises)

Source: PwC (2014)



3.2. THE DATA MARKET VALUE IN THE MANUFACTURING SECTOR

A large part of Industry 4.0 paradigm deals with the proliferation of huge data flows and the ability of manufacturing companies to use them.

The top industries in terms of EU28 data market size are represented by the manufacturing sector and the finance industry that, together, account for 41% of total data market value (Fig. 3.4).

The data market value in the manufacturing industry amounted to almost 12 billion euro in 2015 and is expected to grow by 54% to over 18 billion euro in 2020 (Fig. 3.5). Larger growth rates are exhibited by vertical markets that still hold a relatively smaller size of the overall data market. This proves that data-related technologies are rapidly finding new ground in previously unchartered areas and are growing fast in sectors like healthcare activities or public administration.

In terms of spending on data market relative to the total

Fig 3.4 Data market value in the EU, by industry (2015)

Source: European Data Market Monitoring Tool

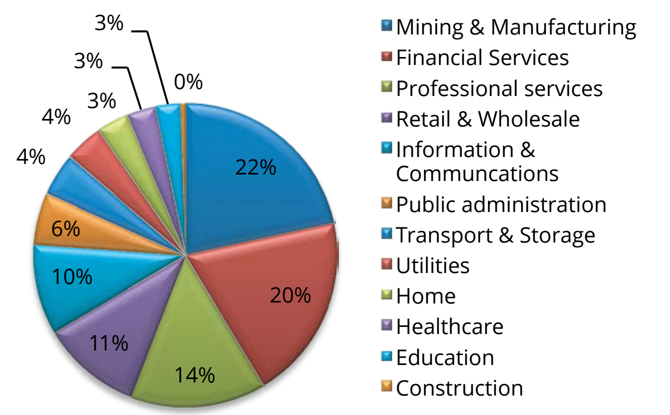
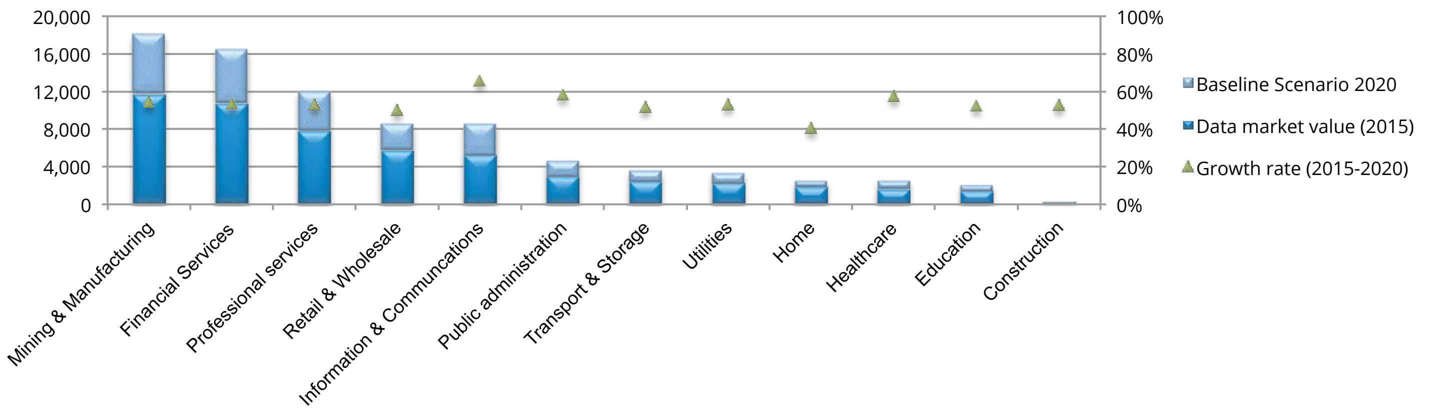


Fig 3.5 Data market value in the EU, by industry (2015 vs. 2020, € bn)

Source: European Data Market Monitoring Tool



sectoral spending on ICT, it is (maybe not surprisingly) the ICT industry that spends the most on data market – 18% of total ICT spending, more than twice the manufacturing industry, that just spent about 7% of the total ICT spending in 2014 (Fig. 3.6).

Finally, the manufacturing industry is the second vertical

Fig 3.6 Share of data market spending on total ICT spending

Source: European Data Market Monitoring Tool

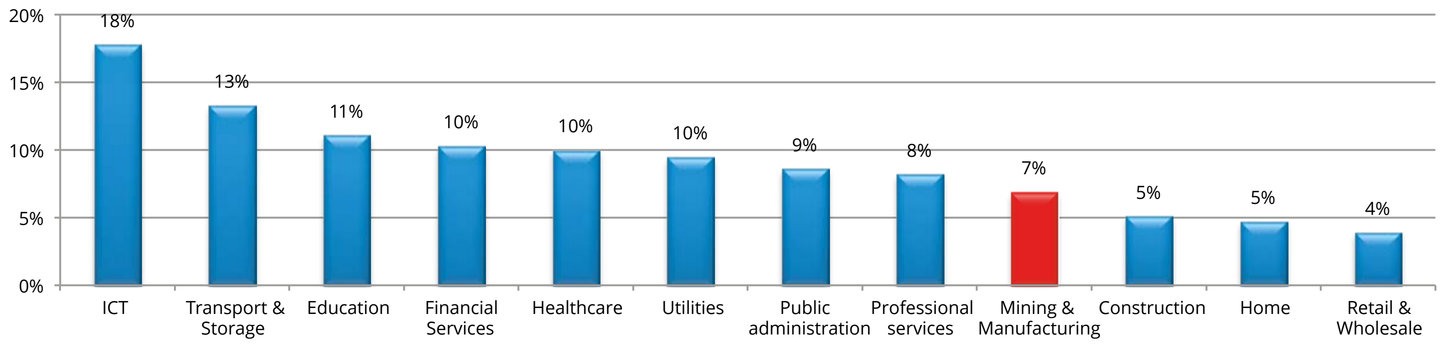
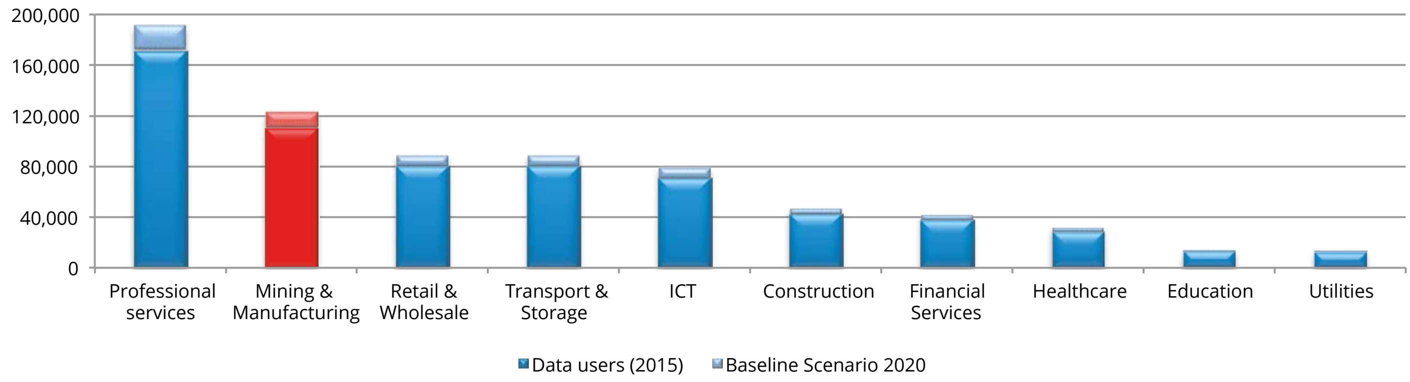


Fig 3.7 Data users (2015 vs. 2020)

Source: European Data Market Monitoring Tool



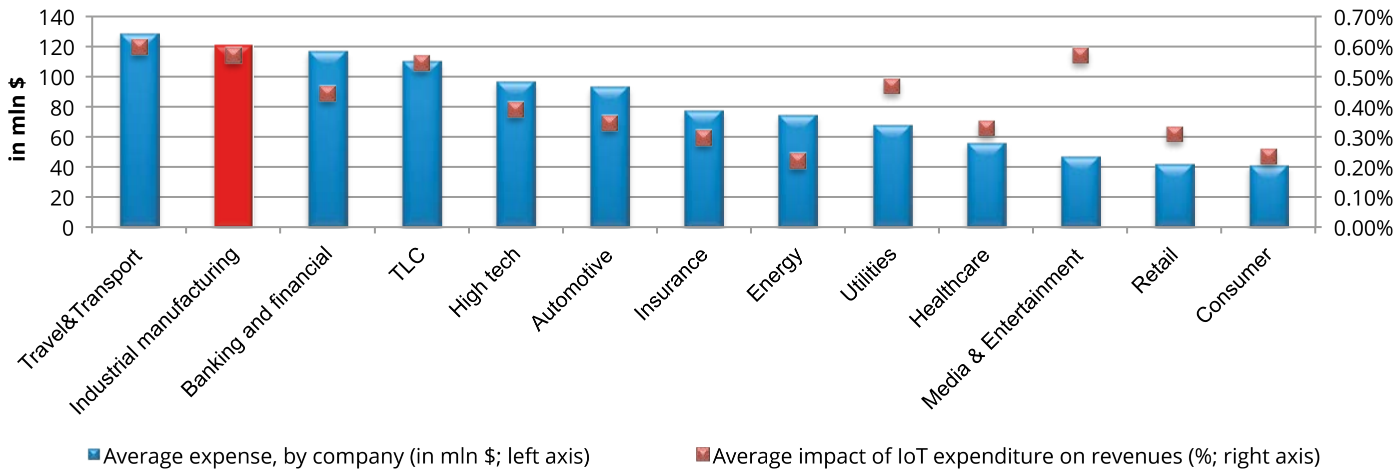
market in terms of data users – about 111,000 – however 35% less than the professional services market. Data users are expected to grow too, reaching 123,450 units by 2020, a growth of 11%, approximately in line with other sectors (Fig. 3.7).

3.3. INVESTMENTS ON IOT INITIATIVES IN INDUSTRIAL MANUFACTURING

According to a Tata Consultancy survey submitted to big companies located all over the world[1], enterprises that spend the most on IoT initiatives are those in the travel and transport sector, with an average per company of almost US$ 130 million (Fig. 3.8), immediately followed by the industrial manufacturing sector, equal to US$ 121 million (about 0.6% of total revenue, the highest impact after travel and transport) and expected to grow to over US$ 136 million in 2018 (+12.4%) (Fig. 3.9).

Fig 3.8 Average investment on IoT initiatives, by sector (2015, US$ mln)

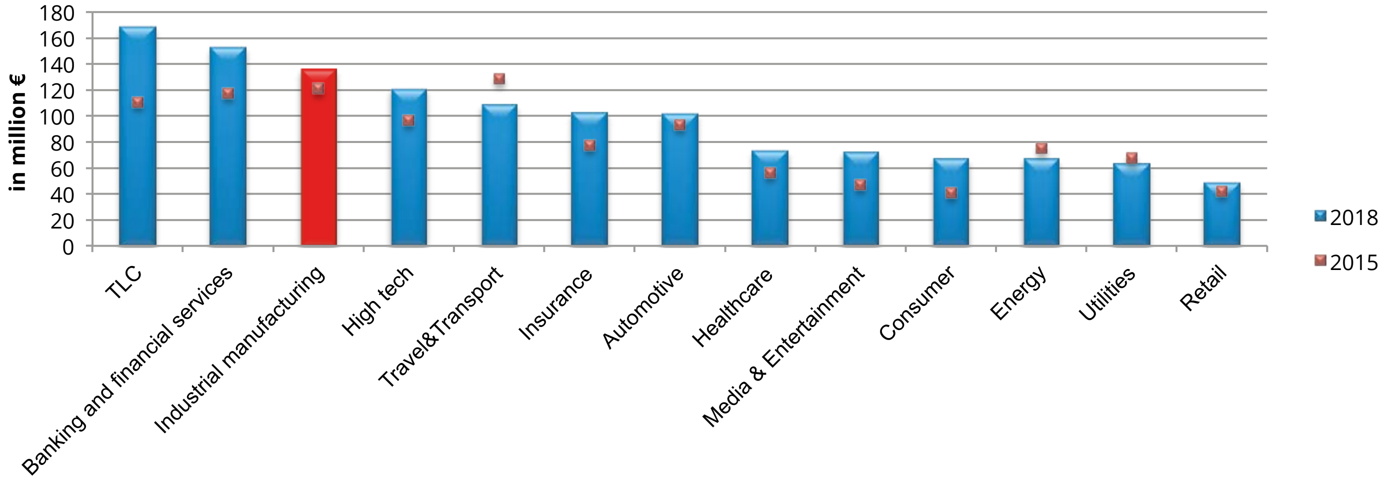
Source: Tata Consultancy (2015)



1 The majority of the 795 survey participants were in North America (44%) and Europe (31%); some 15% were in Asia-Pacific and 9% were in Latin America.

Fig 3.9 Average investment on IoT initiatives, by sector (2018 vs. 2015, US$ mln)

Source: Tata Consultancy (2015)



3.4. THE BENEFITS OF DIGITAL TRANSFORMATION

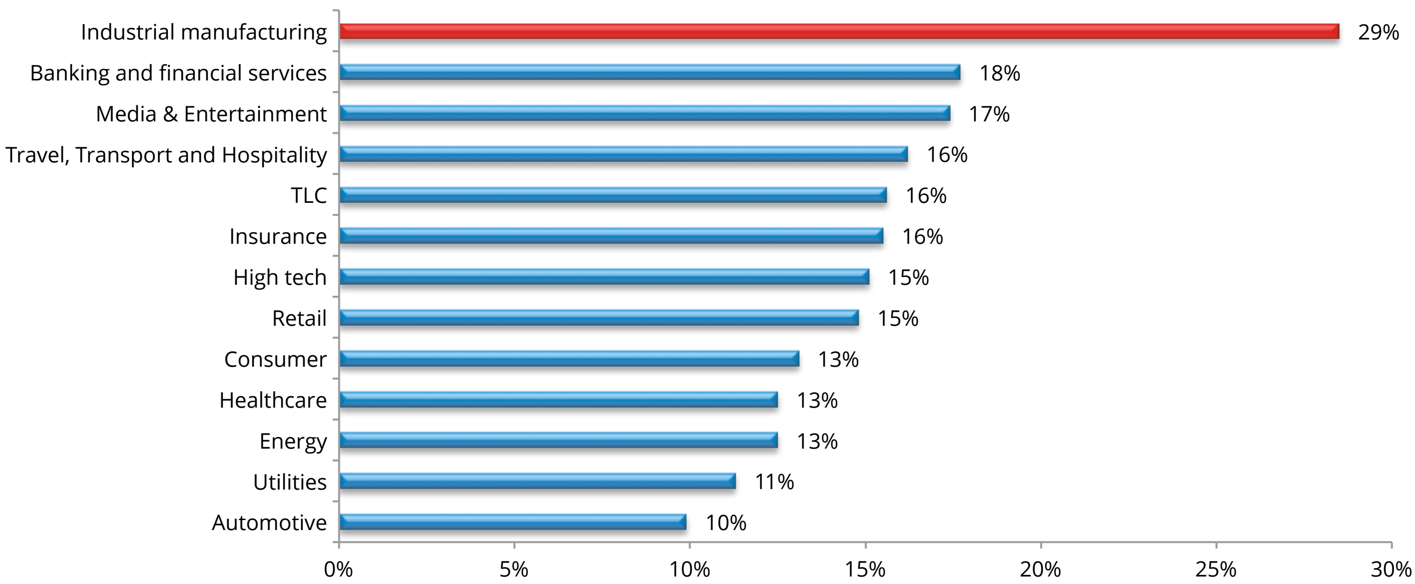
Digitalized manufacturing will result in a wide range of changes to manufacturing processes, outcomes and business models. Smart factories allow increased flexibility in production. Automation of the production process, the transmission of data about a product as it passes through the manufacturing chain, and the use of configurable robots mean that a variety of different products can be produced in the same production facility. This mass customization will allow the production of small lots – even a unique item if needed – due to the ability to rapidly configure machines to adapt to customers' products without complicated retooling or the setup of new production lines.

The speed and efficiency with which a product can be produced will also improve. Digital designs and the virtual modelling of manufacturing process can reduce the time between the design of a product and its delivery. At the same time, further improvements may result from focusing on core areas in the individual value chain, from reduction of redundancies, from minimizing quality losses and from the increased flexibility discussed above. More specifically, increased transparency improves the utilization of machines and systems; digitization and greater connectivity in process organization may permit areas of work to be rationalized and may yield gains in productivity. In addition, the smart analysis and integrated use of data for controlling purposes also reduces the rejection rate in production, as well as data-driven supply chains can speed up the manufacturing process by an estimated 120% in terms of time needed to deliver orders and by 70% in time to get products to market.

Integrating product development with digital and physical production has been associated with large improvements in product quality and significantly reduced error rates. Data from sensors can be used to monitor every piece produced rather than using sampling to detect errors, and error-correcting machinery can adjust production processes in real time. This data can also be collected and analyzed using 'big data' techniques to identify and solve small but ongoing problems. The rise in quality plays an important role in reducing costs and hence increasing competitiveness: the top 100 European manufacturers could save an estimated 160 billion euro in the costs of reworking defective products if they could eliminate all defects. Productivity can also increase through various Industry 4.0 effects. By using advanced

Fig 3.10 IoT investments' impact on revenues in manufacturing (2014, average growth for companies that invested in IoT year on year)

Source: Tata Consultancy (2015)



analytics in predictive maintenance programmes, manufacturing companies can avoid machine failures on the factory floor and cut downtime by an estimated 50% and increase production by 20%. Some companies will be able to set up 'lights out' factories where automated robots continue production without light or heat after staff has gone home.

Investing on IoT initiatives may impact significantly a manufacturing company's revenues: in the industrial manufacturing industry, according to Tata Consultancy data, revenues grew on average by 29% between 2013 and 2014, thanks to IoT investments (Figure 3.10).

Another important aspect concerns customers, who are equipped with new technologies and able to be more involved in the processes of product design – potentially even supplying their own modified designs which can then be quickly and cheaply produced -, creation, testing, distribution, purchasing and post-sales assistance.

The location of some manufacturing operations may also be close to the customer: if manufacturing is largely automated, it does not need to be "off-shored" or located in distant countries with low labor (but high transport) costs. European companies may then decide to re-shore – that is, to bring some manufacturing capacity back to Europe – or to establish new plants in Europe rather than abroad.

Industry 4.0 will also cause changes in business models. Rather than exclusively competing on costs, European companies can compete on the basis of innovation – meant as the ability to deliver a new product rapidly –, on the ability to produce customer-driven customized designs (through configurable factories), or on quality (primarily associated with the reduction of faults due to automation and control). Some companies may take advantage of the data created as smart products are created and used, and adopt business models based on selling services other then products. This "servitisation" can help to expand business opportunities and further increase revenues. But this also requires closer cooperation with value chain partners, which can indeed primarily improve the satisfaction of customer needs in this context of new, digital business models, but also shorten time-to-market and increase innovation speed as well as an efficient division of labor, combined with more flexibility. New business models can only be developed when several companies contribute their respective complementary competencies, allowing for quick and efficient solutions to changing customer needs.

3.5. THE IMPACT ON THE JOB MARKET

The digital transformation all the world is experiencing has profound implications for manufacturing employment, affecting everything from the size of the workforce, the skill sets required, and where factories are located. Some human manufacturing tasks, such as heavy lifting, precision positioning, and visual quality control, will most certainly be transferred to or supported by robots, which are not only more efficient and effective than humans, but can communicate seamlessly with one another. Human workers will have to learn to work side-by-side and in conjunction with robots. Advanced automation will increase workers' acceptance of safe and collaborative machines with human-like physiognomies working close to them. This, along with wearables, augmented reality, and other technologies, will change the nature of traditional blue-collar work, which will become both more complex and sophisticated, but also increasingly supported by technology. It is hard to predict whether Industry 4.0 will call for more or less skilled workers, but it is clear that the requirements will be very different, with a greater focus on flexibility and adaptability, and potentially less on expertise and craftsmanship.

There will be certainly job redundancies for low-skilled jobs and the need to shift towards more high-skilled complex jobs that require a generally more intense focus on continuous learning and education. At the same time, less demand for centralized management capacities, further automation of indirect processes and more demand for decentralized integrative and cross functional management capabilities should be expected leading to the consequence that planning and control jobs would gain more importance. In addition, a growing importance of teamwork, interdisciplinary cooperation and partner networks is expected, along with an increase in flexibility of individual work life, attention towards social media risks and IT and programming capability requirements for all levels.

The adoption rate of technological advancements will lead to significant productivity gains, thereby reducing the number of employees required to achieve a given level of output. Although some jobs will be lost, the level of cooperation between humans and machines will increase significantly. By adopting Industry 4.0, indeed, manufacturers will be able to increase their competitiveness, which will enable them to expand their industrial workforce at the same time that productivity increases. The higher demand resulting from the growth of existing markets and the introduction of new products and services will allow manufacturers to create new jobs. According to the results from a study of the Boston Consulting Group on the evolution of the German industrial workforce from 2015 through 2025, the additional growth of 1% per year would lead to an increase of approximately 960,000 jobs. This job gains will result from demand for an additional 210,000 highly skilled workers in IT, analytics and R&D roles, as well as the creation of approximately 760,000 new jobs resulting from the types of revenue growth opportunities cited above. At the same time, an increased use of robotics and computerization would reduce the number of jobs in assembly and production by approximately 610,000 units, implying however a net increase of 350,000 jobs (+5% relative to today's workforce of approximately 7 million people).

Robot-assisted production will cause the largest net decrease in jobs in the relevant manufacturing industries, because the efficiencies it creates will allow manufacturers to significantly reduce the number of jobs on the shop floor. At the same time, though, robotics, as well as predictive maintenance and augmented reality, will also allow manufacturers to deploy new business models that promote job creation.

Industry 4.0 will foster significant changes in how industrial workers perform their jobs, and entirely new job families will be created while others will become obsolete. Although the extent to which Industry 4.0 will replace human labor largely remains a matter of debate, it is widely accepted that manufacturers will increasingly use robotics and other advancements to assist workers. An operator will then be able to carry out the same types of responsibilities at several machines. The monitoring of machine performance and product quality will be aided by quality control queries provided by an automated system. Consequently, the operator will require less machine- and product-specific training but will need enhanced capabilities for utilizing digital devices and software and accessing a digital knowledge repository.

The two most relevant types of new roles arising from Industry 4.0 will probably be:

Robot coordinator. This role will be created to oversee robots on the shop floor and respond to malfunctions or error signals, carrying out both routine and emergency maintenance tasks. In many cases, manufacturers will be able to retrain machine operators to take on this role, reducing the need for new hires.

Industrial data scientist. These specialists will extract and prepare data, conduct advanced analytics and apply their findings to improve products or production. At the same time, they must understand both manufacturing processes and IT systems and possess strong root-cause-analysis skills to identify correlations and draw conclusions. Programming skills will also be required and individuals in this role will need the flexibility to address topics continuously or respond to specific requests.

With respect to the latter position, there is large need for widening data-related skills. In order to add value to data, indeed, an important mix of skills – including soft skills – is needed: not only mathematical and statistical skills are necessary but also domain and business knowledge. It is very difficult to have all these skills in one person; this means that teams dealing with data are a very important and diversified production factor, but it can be difficult to combine the necessary skills in order to have such a valuable team, especially for small and medium enterprises.

The main job of data workers with core skills (analytical and computational skills) is to create new products/services and processes, and to provide support for decision-making through data analytics. They generate products, features, and value-adding services. Data scientists are a category of data workers: they should also have a deep knowledge of their businesses; the most difficult skills to find include advanced analytics and predictive analysis skills, complex event processing skills, rule management skills, business intelligence tools, and data integration skills. Most data scientists have advanced computer science degrees, or advanced degrees in fields such as physics, biology, or social sciences that require a lot of computer work, and almost all have strong computational skills.

In the EU, data workers are distributed in nearly all sectors, but the first three (Professional services, Wholesale & Retail and Mining & Manufacturing) cover 50% of the total (Fig. 3.11). However, in terms of the share on total employment (Fig. 3.12), ICT and Finance lead, with professional services in the 3rd place. Sectors with the lowest concentration of data workers are Construction, Transport and Healthcare. ICT and Finance represent the industries with the highest level of IT spending and the highest propensity to exploit data. The strong

Fig 3.11 Data workers in the EU, by sector (2015, in '000s)

Source: European Data Market Monitoring Tool (2016)

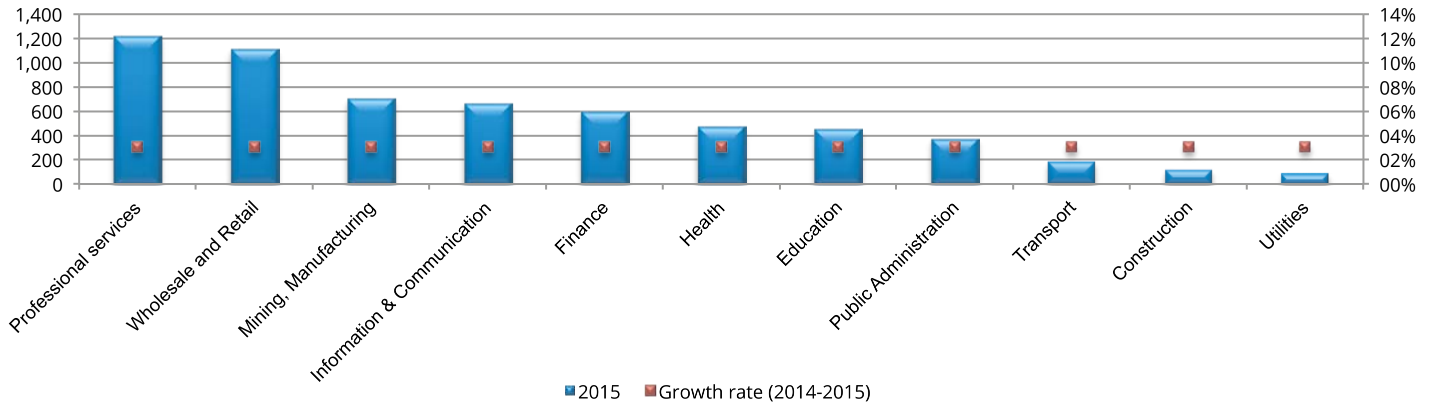
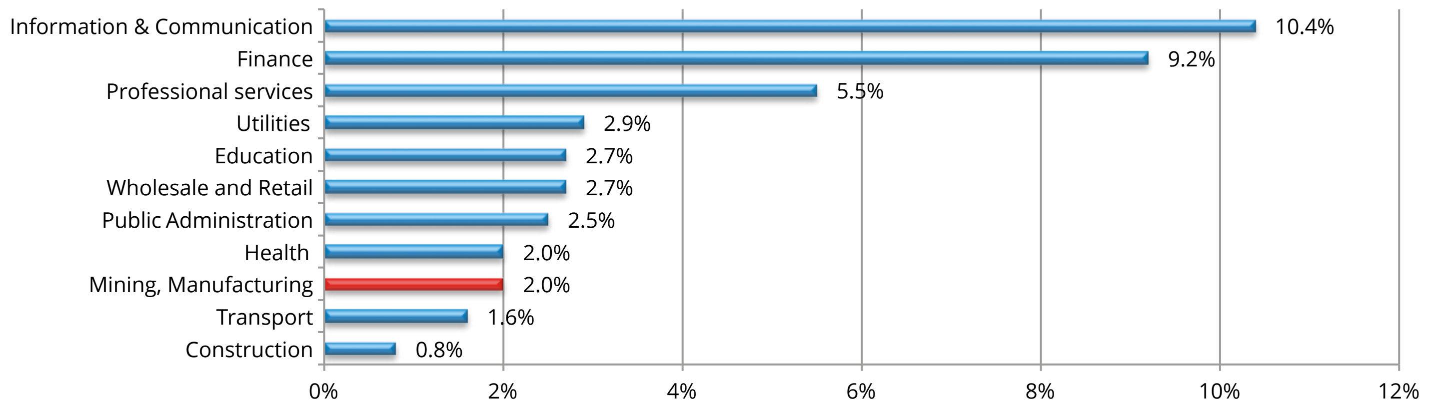


Fig 3.12 Share of data workers on total employment in the EU, by sector (2015)

Source: European Data Market Monitoring Tool (2016)



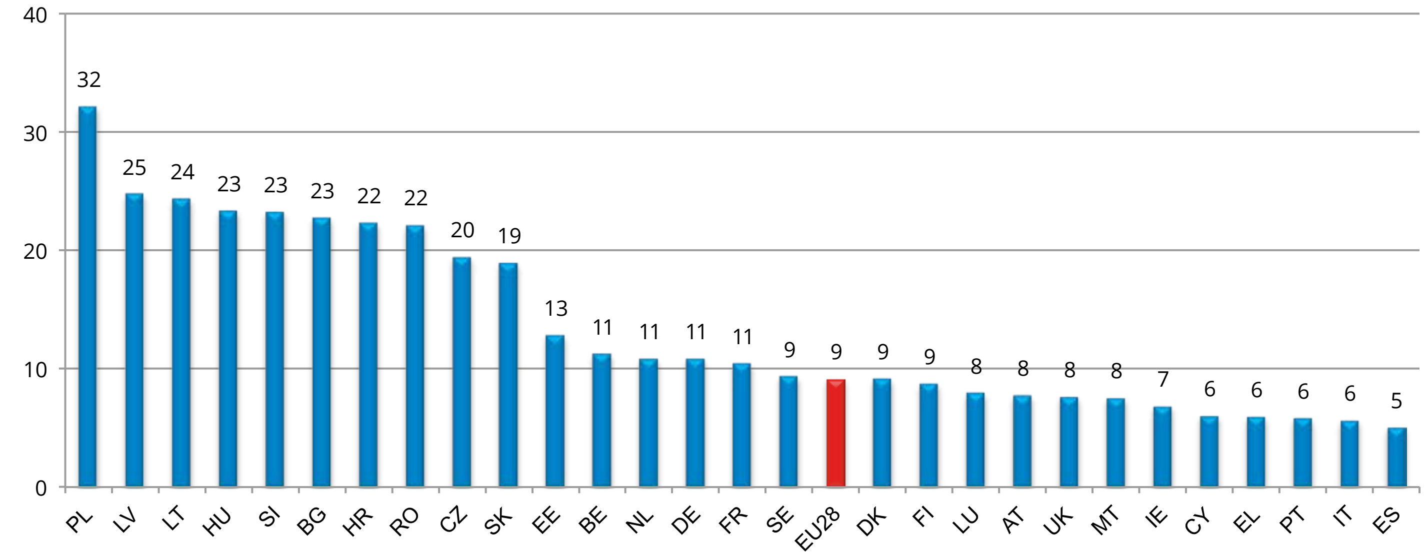
presence of data workers in professional services and retail show the increasing diffusion and relevance of data-driven services in these sectors, particularly for marketing and customer services. These industries are also undergoing a deep digital transformation process, using digital technologies to re-invent products and services, forced by competition and disruptive innovator start-ups. Manufacturing is evolving towards digital transformation but the presence of data workers is still too low (2%).

Looking at the intensity of data workers – measured as the average number of data workers calculated on the total number of data user companies – some countries appear to be definitely above the average: within this group we find all the Eastern European countries, where the number of data workers (per user company) goes from 13 for Estonia to 25 for Latvia or 32 for Poland (Fig. 3.13). Such a high figure can be at least partly explained by the fact that these countries count a very limited number of data users – overall they represent 4% of the total users in Europe – mainly restricted to large companies where the average number of data workers is by nature higher.

The more pervasive a technology becomes, the lower the intensity share of workers is, especially if the country has a high number of SMEs.

Fig 3.13 Intensity of data workers (2015)

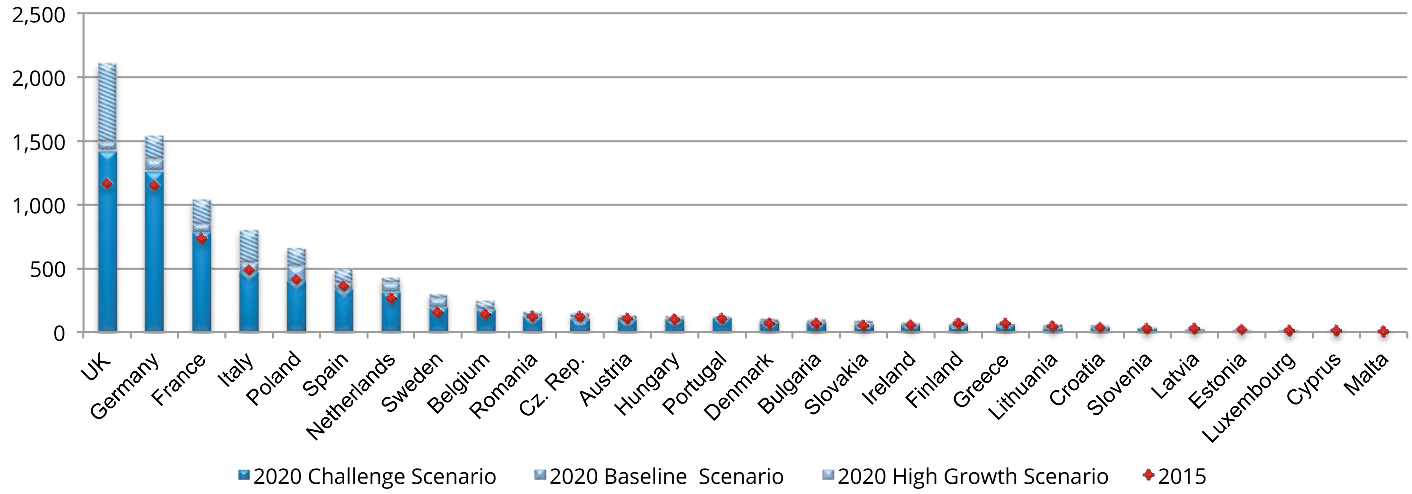
Source: European Data Market Monitoring Tool (2016)



In the other countries, the intensity of data workers per user shows a limited variability, from 11 of Belgium to 5 of Spain. Across Europe, 8 countries (Belgium, Netherlands, Germany, France, Austria, Finland, Denmark, and Sweden) presents an intensity of data workers per user, which is close to the EU average (9,2). Some of these countries also have the highest number of data users, meaning that the use of data and, therefore, of data workers is widespread.
For countries such as Italy, Spain, Portugal, and Greece, located well below the EU average, a large incidence of SMEs may affect the result.
According to current forecasts, the number of EU data workers will grow to 2020 at a minimum CAGR of 2%, which could become, in the best scenario, 9.2%.
The distribution of data workers by country remains heavily influenced by the overall size and employment of each country, with the 6 major EU Member States accounting for over 70% of the total number in all the three scenarios[2] (Fig. 3.14).

Fig 3.14 Data workers forecast

Source: European Data Market Monitoring Tool (2016)



2 The baseline Scenario is defined by a continuation of the 2015 positive moderate growth trend of the European economy, creating favorable conditions for investments in digital innovation in general and data technologies in particular.
The Challenge Scenario is characterized by the combination of a less positive macroeconomic context than in the Baseline Scenario, less favorable framework conditions and slower diffusion of digital innovation, which will push the data market into a low growth development path.
In the High Growth Scenario, Europe's economic growth in the next years will be similar to the Baseline's, but will be characterized by a stronger driving role of digital innovation, with higher overall ICT investments as a share of GDP.

The forecast growth rates are, however, also affected by the perspectives of economic growth and unemployment rates, with southern European countries such as Greece, Portugal, and Spain showing an increase in demand for data workers in the three scenarios lower than the EU average. In Italy the increase is higher than the average (66% vs. 55%) only in the High Growth scenario. Italy has currently a high unemployment level but not as high as in the other southern countries.

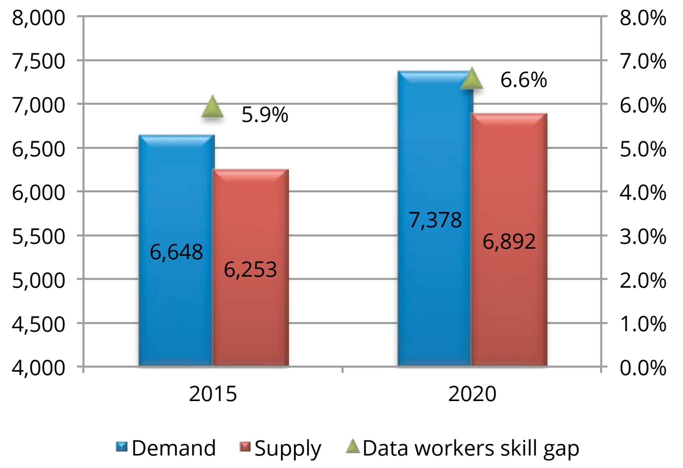
Under the High Growth scenario, around ten countries are expected to have an average growth of the data workers slightly over the EU average. In these countries tech investments will grow faster than in the rest of Europe; they include the Central and Eastern Europe Countries, but also Sweden, UK, Netherlands, Belgium.

The other factor explaining the demand of data workers in the medium to long term is the trend in the total factor productivity. The countries with a less advanced technology may start investing significantly in data technology, which could explain a higher demand for data workers; countries with an advanced technology may have lower productivity gains (diminishing marginal returns) which may explain as well a high demand of data workers.

According to current data and estimates for the future, there is (and there will be) a substantial skill gap. According to IDC, in 2015, the gap between total demand and supply of data workers was equal to 396,000 unfilled data worker positions in the EU (corresponding to 5.9% of total demand) and is expected to grow to 486,000 (6.6% of total demand) (Fig. 3.15).

Fig 3.15 Data workers skill gap in EU28 (in thousands)

Source: European Data Market Monitoring Tool (2016)

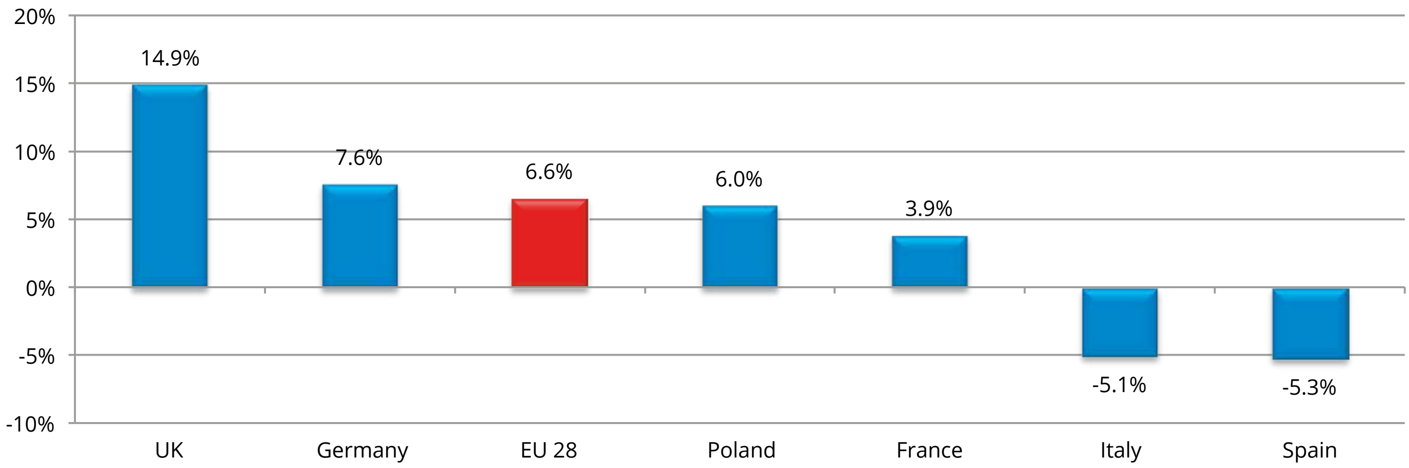


Germany, France and UK – leading data markets – show a mid-size gap in the scenario to 2020, because the positive dynamics of supply do not keep up with the strong growth of demand. Poland, starting from a data skills gap lower than in other countries in 2015, will move according to forecasts to a mid-size gap, even higher than France (6.0% vs. 3.9%). On the contrary, Italy and Spain are characterized by high unemployment and dysfunctional labor markets and, as a result, they show a moderate growth of demand which, combined to a supply growth on a par with the average EU growth, results in a small oversupply (-5.1% and -5.3%, respectively) (Fig. 3.16).

However, the forecast demand to 2020 of Big Data analysts – a specific category of highly qualified data workers with sophisticated technical skills – is expected

Fig 3.16 Data workers skill gap in the main EU28 countries (2020)

Source: European Data Market Monitoring Tool (2016)



to grow much faster than the demand for data workers, with 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 demand for them.

This gap needs to be urgently addressed by policy actors and by the industry.

3.6. I-COM INDUSTRY 4.0 INDEX ON LEVEL OF PREPAREDNESS IN EU COUNTRIES

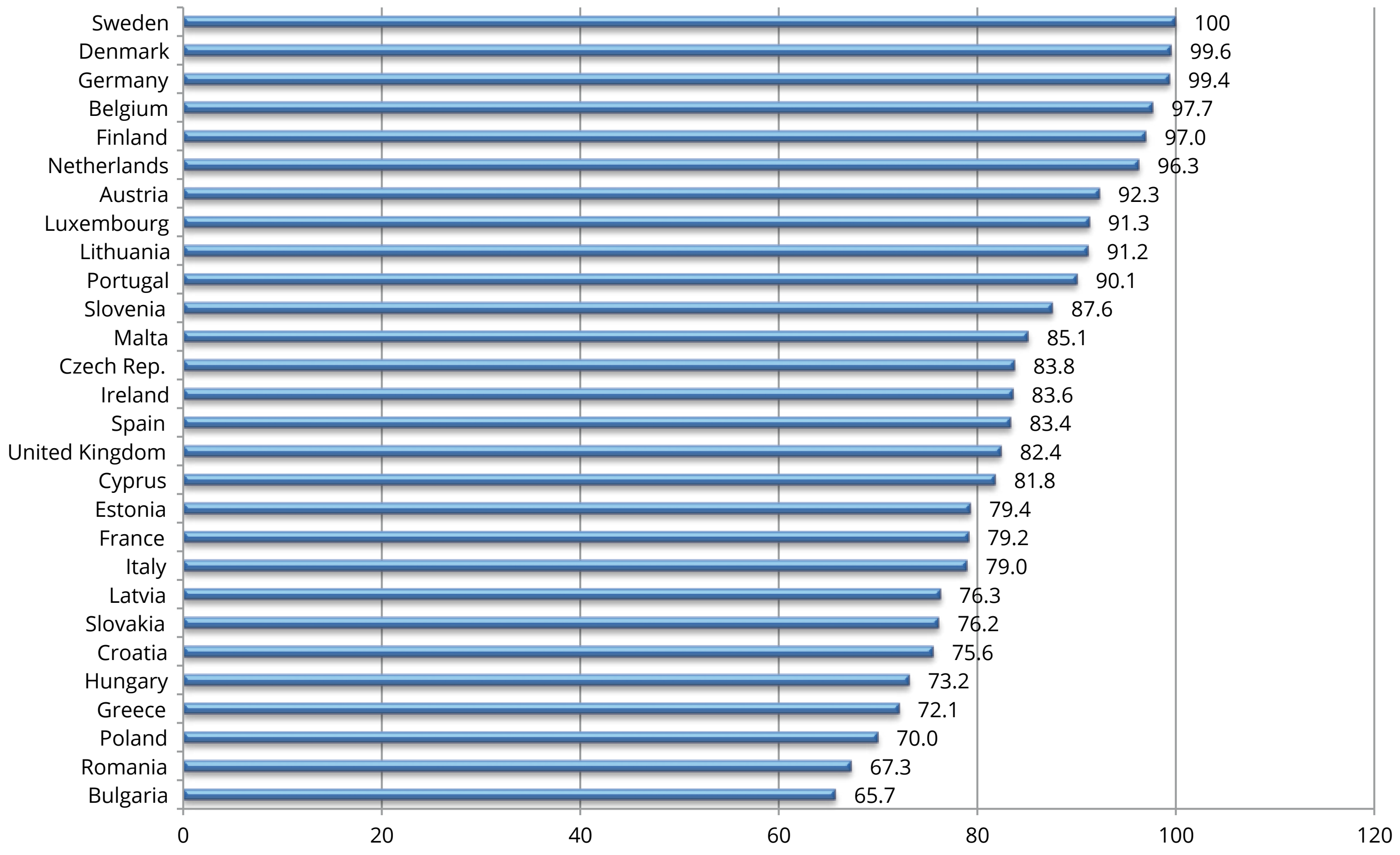
It was also elaborated a synthetic index that gives an idea of the level of preparedness for Industry 4.0 in EU countries. The I-Com index is based on twelve variables that are closely related to the topic of the fourth industrial revolution. In particular, the variables – listed below – refer to the adoption of technology, infrastructure and skills:

1. enterprises that share internally electronic information with an ERP;
2. enterprises using Radio Frequency Identification (RFDI) technologies;
3. enterprise buying Cloud Computing services of medium-high sophistication;

4. enterprises whose business processes are automatically linked to those of their suppliers and/or customers;
5. M2M cards;
6. enterprises with broadband access (fixed or mobile);
7. fixed Ultra-broand coverage of the population;
8. 4G coverage of the population;
9. share of data workers on total employment;
10. share of ICT specialist on total employment;
11. enterprise provided training to their personnel to develop/upgrade their ICT skills;
12. graduates in Science and Engineering.

Fig 3.17 I-Com Index on Level of preparedness for Industry 4.0 in European countries

Source: I-Com elaborations on Eurostat and OECD data



Each variable was weighted so as to assign equal weight to the adoption of the technologies, infrastructure and skills. Then, for each country, an average of the variables was calculated. The values obtained were normalized relative to the best performer country, so as to establish a ranking from 0 to 100.

The countries that have the best characteristics to implement the fourth industrial revolution are Sweden, Denmark, Germany, Belgium, Finland and Netherlands, which are ranked in the top six (Fig. 3.17). In these countries, the majority of companies adopts IoT technologies, has a good infrastructure development and a good level of skills, which are necessary for the use of technologies. On the contrary, most Eastern Europe countries show unfavorable conditions to the development of Industry 4.0.

Italy, unfortunately, does not rank very well, compared to the most European countries (18th with a score of 79), although, relative to the adoption of IoT technologies, it shows a good performance (especially with regard to cloud computing and RFID technologies). It must, however, still reduce the gap with the rest of Europe – even if some positive results were achieved in the last period – relative to infrastructures. Skills remain, however, the most critical aspect and also the most difficult to be significantly improved in a short time.

3.7. NATIONAL POLICIES IN KEY EU COUNTRIES AND US

United States

In 2011, a public-private intervention scheme for industrial innovation has been introduced, followed by the establishment of a Steering Committee, in 2013, with the task to encourage innovation, promote resources and skills and create favorable conditions to the development of industrial activities. In 2014, the federal legislator has introduced a specific program, called National Network for Manufacturing Program (NNMI), aimed 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, a national network of centers 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 amount until US$ 5 million – supplied by the Department of Commerce – per each fiscal year from 2015 to 2024; an additional US$ 250.000 fund is made available by the Ministry of Energy for researches and initiatives in this specific area.

Briefly, some federal resources are put in place and relevant sectors are identified, but the bulk of investments come from the business sector.

Germany

In 2011, a government strategy in the field of high technology – the so-called Hightech-Strategies – has been introduced, the first national strategy, at the European level, dealing with themes of advanced digital manufacturing.

This represents an action plan sponsored by the federal government but involving many large industrial and technological players. Indeed, in 2013, the three industrial associations BITKOM, VDMA and ZVEI – altogether representing over 6.000 companies – signed a cooperation agreement for the development of Industry 4.0, as a part of the Industrie 4.0 Platform, a project announced at the Hannover Exhibition in 2013 and led by the Economy and Energy Minister and the Education and Research Minister. The Platform is composed of a Directorate of the Platform – that defines objectives, strategy, employment and financial endowment – a Strategic Committee – with an advisory role to the Directorate – and an Executive Committee – that coordinates and direct the activities of five working groups (Architectures and standards; Research and Innovation; Security and connection systems; Regulatory conditions; Job and training).

So far the German government has provided a public funding of about 1 billion euro, in the form of fiscal incentives for investments in technological start-ups and funding of business projects and applied research projects.

France

In 2015, the government launched a project called "Industrie du Futur", aimed at pushing companies to modernize their industrial equipment and transform their business models through digitalization. Basically, the policy initiative is based on five pillars:

1. development of technological supply, supporting structural projects of companies in sectors where France could take, in 3/5 years, a European or global lead (such as the production of 3D printers);
2. support to the companies, especially SMEs, even through fiscal incentives to companies investing in their own equipment and subsidized loans for SMEs and mid-tier companies;
3. employees' training, by introducing a university chair specifically on the project Industrie du Futur;
4. strengthening of European and international cooperation, through a partnership with Germany, on the one hand, and the publication of a French standardization strategy of the project Industrie du Futur;
5. promotion of Industrie du Futur, through the creation of a common logo and the launch of pilot projects aimed at sharing the best practices and develop a unified communications.

So far the French government has allocated a public funding of about 10 billion euro, in the form of fiscal incentives for private investments, subsidized loans, tax credit for research and funding of projects 4.0.

United Kingdom

The UK has initiated a number of policies to make manufacturing more responsive, more sustainable, more open to new markets and more dependent on skilled workers.

Best known are the high-value manufacturing centers, called "Catapult centers", that help companies access research and expertise in specialized areas such as advanced manufacturing and process innovation. The High Value Manufacturing Catapult (HVMC) is based on seven research centers[3], each with a specific focus on an area of manufacturing. These centers are designed to enable companies to access equipment, expertise and information needed to develop and commercialize ideas and innovations and have received more than £200 million of government funding since 2011.

In addition, in 2012, the government provided £170 million in funds to established or new suppliers through an Advanced Manufacturing Supply Chain Initiative fund – in order to help expand already operating suppliers and to encourage the development new suppliers – and £50 million to continue the Manufacturing Advisory Service from 2011-12 to 2013-14 (recently with a particular emphasis on SMEs), whose purpose is to help manufacturing companies improve their productivity and competitiveness by offering them professional advice and expert support.

Finally, the Regional Growth Fund seeks to stimulate private sector investment by providing support for projects that offer significant opportunities for growth and employment. The fund is contestable with bidders competing for funds in different rounds. By March 2014, the Fund had allocated a total of £1.5 billion to various different types of businesses, many of which involved manufacturing and is expected to be worth over £3.2 billion over the period 2011-12 to 2016-17.

3.8. STATE OF THE ART IN ITALY

In September 2016, the Italian Government presented the "National Plan Industry 4.0", a strategic document that considers the specific peculiarities of the Italian industrial sector, traditionally focused on SMEs and the presence of a strong cultural connotation of the final products, and gets to identify a set of guidelines based on the adoption of a net-neutrality logic, horizontal actions' planning (and not strictly sectoral), prevision of interventions on enablers, orientation of existing instruments to support productivity and the necessary technological leap and, ultimately, coordination of main stakeholders.

The plan allocates a comprehensive amount of public resources equal to 13 billion euro, to be used in the next four-year period.

Following the definition of the general guidelines, the

3 Advanced Forming Research Centre (AFRC) in Glasgow, Advanced Manufacturing Research Centre (AMRC) in Sheffield, Centre for Process Innovation (CPI) in Sedgefield, Manufacturing Technology Centre (MTC) in Coventry, National Composite Centre (NCC) in Bristol, Nuclear Advanced Manufacturing Research Centre (NAMRC) in Sheffield, and Warwick Manufacturing Group (WMG) in Coventry.

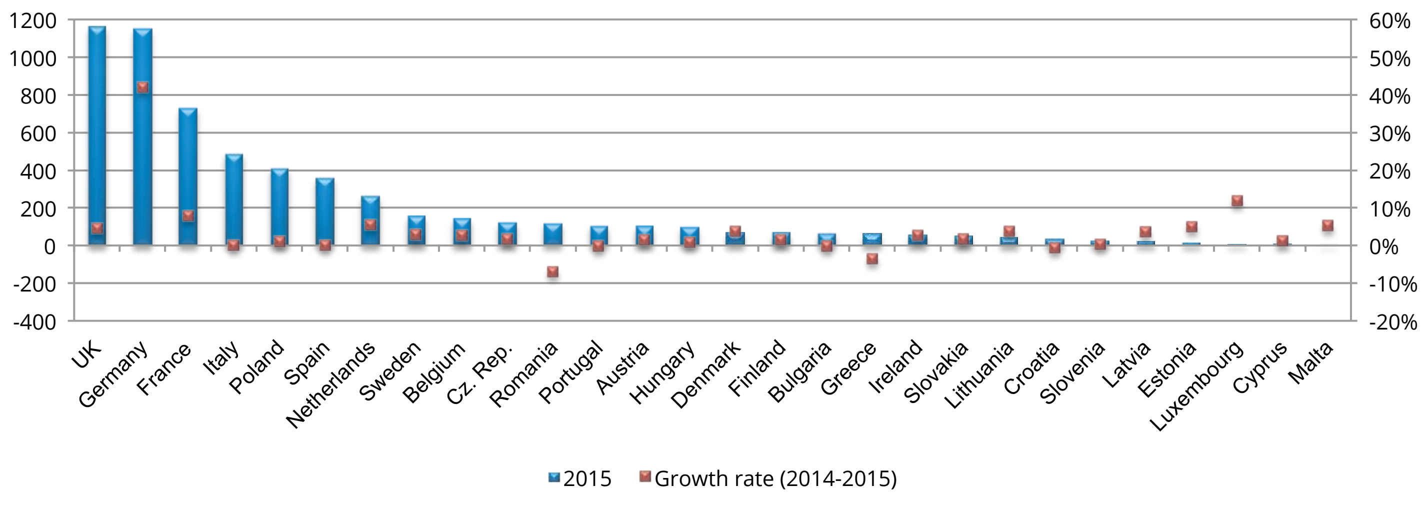
document identifies a number of strategic main lines of intervention, distinguishing them in key and side guidelines. The first recognizes, on the one side, the importance of incentives for private investment in technologies and Industry 4.0 assets, an increase of private spending on research, development and innovation and a strengthening of finance in support of Industry 4.0, VC and start-ups; on the other hand, it underlines the need to spread the Industry 4.0 culture through Digital School and Alternating School-Work, to develop the Industry 4.0 skills through university courses and dedicated Higher Technical Institutes, to provide funding for Industry 4.0 research by strengthening Clusters and doctorates and, finally, to create Competence Centers and Digital Innovation Hubs.

To achieve these ambitious goals, it is interesting to highlight the fundamental role of the side guidelines that, other than identifying some public support tools – such as support to the company decentralized bargaining and the support of major investments in innovation –, put in the spotlight the enabling infrastructure, highlighting the importance of the availability of adequate network infrastructures and the definition of standards and interoperability IoT criteria, already underlined in the Italian strategy for the ultra-broadband development adopted in March 2015 by the Government.

Proposals such as an increased rate for Industry 4.0 investments amortization (from 140% to 250%) (called

Fig 3.18 Data workers by country (2015, in '000s)

Source: European Data Market Monitoring Tool (2016)



"iperamortization") could have a significant impact on private investments in digital goods and services. In addition, the recently introduced tax credit for research is increased from 25% to 50% of incremental expenses (until a maximum of 20 million euro instead of 5 million euro) and tax deductions to 30% for investments up to 1 M€ in innovative SMEs are provided. Of particular interest are also the capital gain tax reduction on medium-long term investment and the provision of funds dedicated to the industrialization of innovative ideas and patents as well as VC funds dedicated toIndustry 4.0 co-matching start-ups.

With regard to another key guideline – the skill guideline – the Government's document provides a wide and varied range of interventions to promote, at the school level, the acquisition of new skills (for example through the diffusion of a computational thinking starting from primary school as well as the organization of Territorial Laboratories for the development of digital skills for the "Made in Italy"), the expansion of training in technical schools aimed at transferring new skills, the specialization of university courses, masters and doctoral programs on topics Industry 4.0 and the continuous adaptation of skills (in particular through Inter-professional Funds).

The skill gap represents, indeed, a major barrier to the effective development of the new industrial paradigm. Looking at the number of data workers – including both data scientists and business intelligence[4] – we can see that six countries (UK, Germany, France, Italy, Poland, and Spain: the "Big Six") account for 72% of the total data workers in 2015, while the remaining 28% of the data workers of the EU are distributed in the other 22 Member States (Fig. 3.18). Germany stands out with respect to the growth rate from 2014 to 2015 (+42%, comparing with almost exclusively one-digit rates in the other countries) and only three countries show negative variations relative to the previous year: Romania (-7%), Greece (-4%) and Hungary (-1%). In Italy, there are slightly less than 500,000 data workers, stable from previous year – as is the case of Spain, Portugal, Slovenia and Bulgaria.

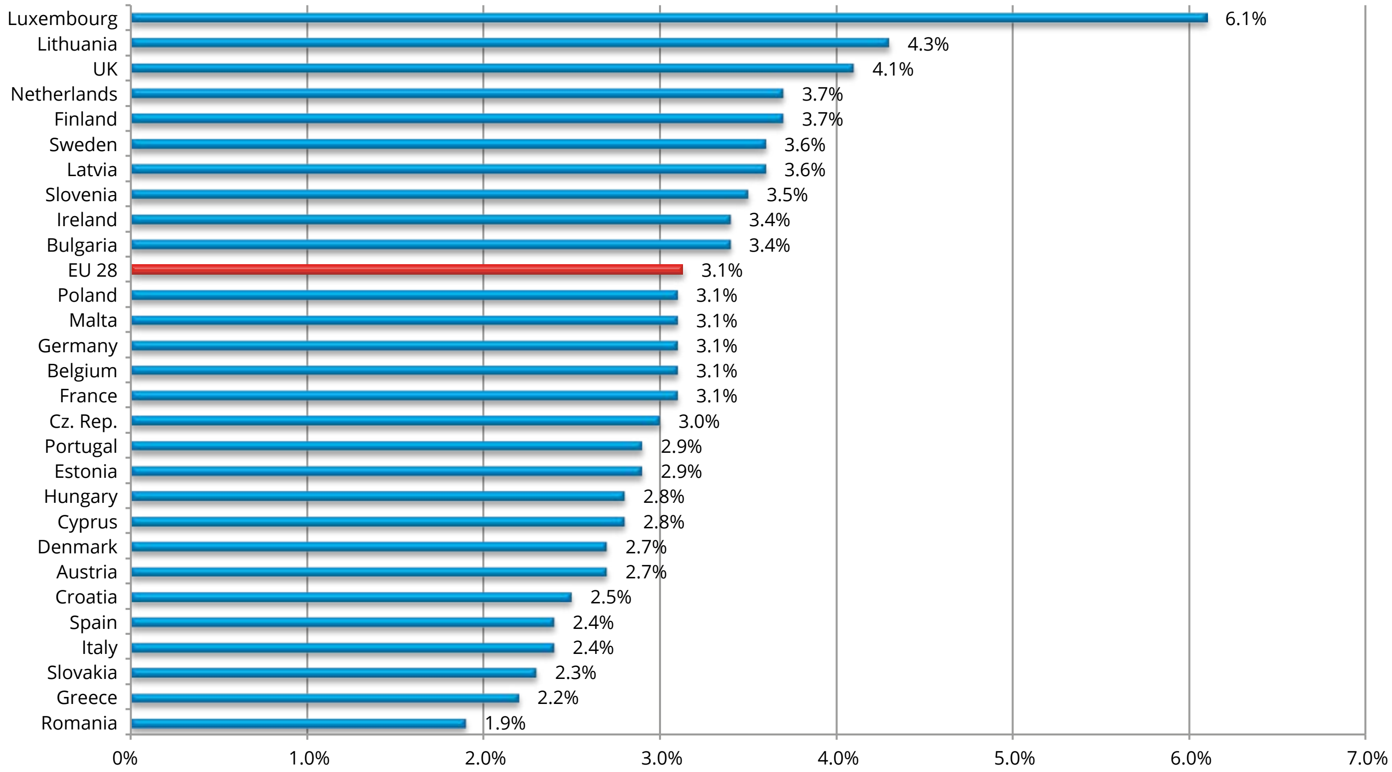
The share of data workers on total employment by country varies from 6.1% in Luxembourg to 1.9% in Romania. The average share of data workers employed in the EU is 3.1%. In Italy, data workers represent only 2.4% of total employment, better than just Slovakia, Greece and Romania (Fig. 3.19).

Finally, at the company level, the Plan promotes initiatives to spread Industry 4.0 awareness; in particular, a National Plan of Communication is foreseen in order to make the industrial sector sensitive to Industry 4.0 issues and to innovation and digital topics, to realize demos and presentations able to show recent manufacturing and digital technologies, for the organization of training and seminars, the provision of individual assistance to high-potential SMEs and to support the definition and implementation of a Industry 4.0 transformation plan.

4 Business intelligence professionals do their analysis and data processing with relatively simple databases and tools, although they require a medium level of creative thinking and usually work on structured data.

Fig 3.19 Share of data workers on total employment, by country (2015)

Source: European Data Market Monitoring Tool (2016)



PART 4

ENERGY EFFICIENCY

4. ENERGY EFFICIENCY

4.1. THE ENERGY EFFICIENCY (R)EVOLUTION

Energy targets for 2020

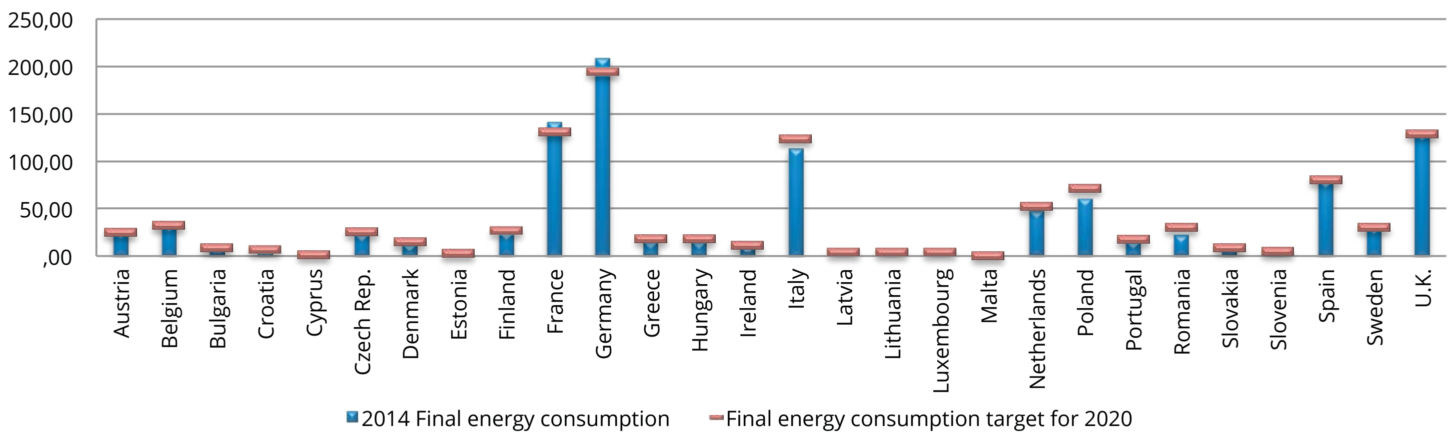
Energy efficiency has a fundamental role to play in the transition towards a more competitive, secure and sustainable energy system with an internal energy market at its core. The Energy Union Strategy confirmed the energy efficiency target of 20% by 2020, which means less than 1086 Mtoe of final energy consumption or less than 1483 Mtoe of primary energy consumption. This is the basis for moving forward to a reduction of at least 27% by 2030 to be reviewed by 2020, having in mind a figure of 30% proposed by the European Commission following a review of the Energy Efficiency Directive (EED).

The Commission estimates that the EU will achieve about 18-19% primary energy savings by 2020, while it has already met the target value set in the EED for 2020 in terms of final energy consumption. However, about one third of the progress towards the 2020 target will be due to the lower-than-expected growth during the financial crisis. It is therefore important to avoid complacency that could lead to underestimating the efforts that will be required in order to reach the 2030 target.

In 2013, Member States identified national indicative targets for energy efficiency. The objective was to

Fig 4.1 EU progress in 2014 towards indicative national energy efficiency targets for 2020 (Mtoe)

Source: EEA



decouple energy consumption from economic growth due to efficiency gains. In this context, the level of the targets set by Croatia, Cyprus, Finland, Greece, Italy, Portugal and Romania are not ambitious enough, as final energy consumption is projected to be higher than the forecast GDP development from 2014 to 2020. Figure 4.1 shows Member States progress in 2014 toward 2020 energy efficiency targets. Even if some States might have already achieved a level of energy consumption below their targets, they would need to make an effort to maintain this level, in particular if GDP is projected to grow.

Gross inland consumption & total final energy consumption

Gross inland energy consumption in the EU-28 in 2014 was 1606 Mtoe, 3.6% lower than in 2013 (Fig. 4.2). It was relatively stable before 2008, with a strong decrease of 6% in 2009 as a result of the economic crisis. A rebound in 2010, when gross inland energy consumption increased by 3.7%, was followed by further decreases.

In 2014 the final energy consumption in EU-28 was 4.1% lower than in 2013. By 2014, the final energy consumption decreased from its peak levels of 2006 by 11%.

The reduction between 2006 and 2014 was the result of decreased final energy consumption in industry, transport and household sectors, where final energy consumption dropped by 15.0%, 6.4% and 13.8% respectively. On the other hand, the services sector was the only one where

Fig 4.2 EU-28 Gross inland consumption (Mtoe)

Source: Eurostat

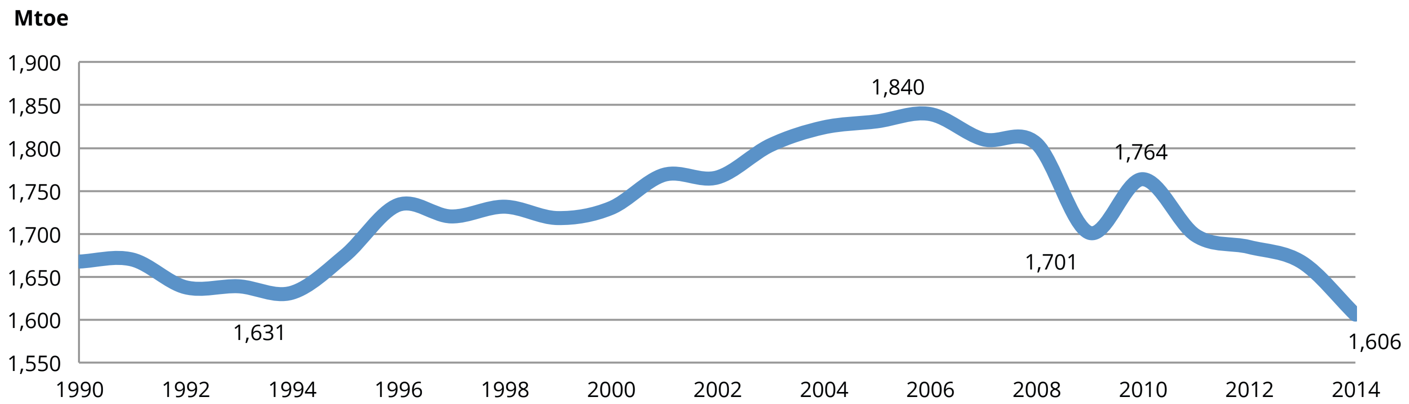
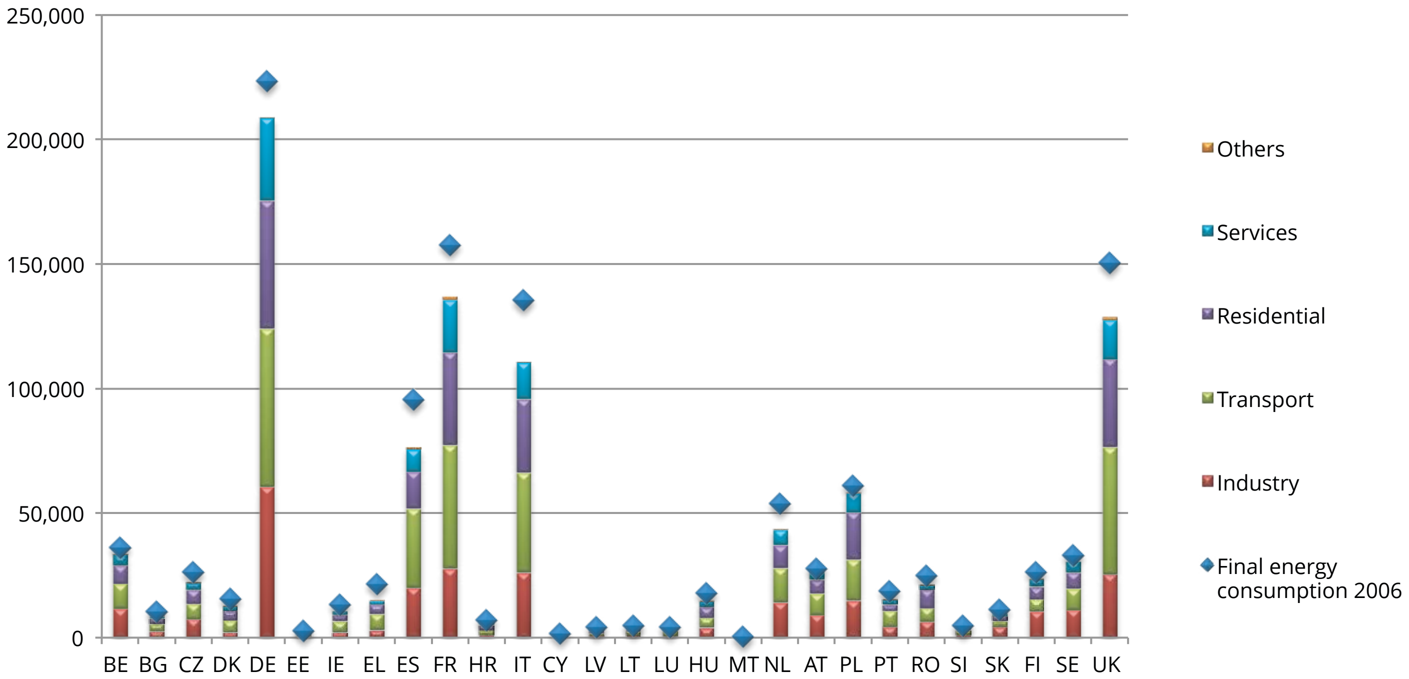


Fig 4.3 EU 28 Final energy consumption by sector (2014, ktoe)

Source: Eurostat



energy consumption increased, by 4.3%, but its economic output rose even more, which resulted in improved energy intensity. The decrease in final energy consumption since 2006 was affected by economic performance, structural changes in various end-use sectors, in particular industry, improvements in end-use efficiency and lower heat consumption due to favorable climatic conditions. An analysis of the European final end use of energy in 2014 shows three dominant categories: transport (33.2%), industry (25.9%) and households (24.8%).

Final energy consumption in buildings

In Europe a share of more than 40% of the energy end-use is consumed by the building sector. Member States are committed to follow Energy Performance Building Directive 2002/91/EC, which was recast in 2010, to improve energy efficiency in this sector.

About three-quarters of the building stock in Europe is made up of residential buildings. In year 2014, the residential sector accounted for 24.8% of the total final energy consumption, a slice larger than 60% of the pie

Table 4.1 Share of residential sector inj final energy consumption (2014)

Source: Eurostat

AT	BE	BG	HR	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE
21%	22%	24%	35%	18%	25%	29%	32%	21%	26%	25%	24%	29%	24%
IT	**LV**	**LT**	**LU**	**MT**	**NL**	**PL**	**PT**	**RO**	**SK**	**SI**	**ES**	**SE**	**UK**
26%	32%	29%	12%	13%	19%	31%	16%	34%	19%	23%	19%	21%	27%

representing the total final energy used by buildings. Tab. 4.1 shows the share of residential sector in final energy consumption in the Member States. Luxembourg is the state with the lowest residential percentage of consumption, at 12%. In Northern and Eastern Europe countries, the residential sector has the largest share in final energy consumption, with Croatia ranking first with 35%.

Globally in EU28, gas was the most important energy vector for energy use in residential sector (35.0%), followed by electricity (25.6) and renewable energies (15.3%).

Energy efficiency in the residential sector benefits from a wide range of policy actions, such as regulatory and financial measures, as well as information measures, voluntary agreements, infrastructure investment (smart-meter roll-outs), market-based instruments, and others. The Energy Performance of Buildings Directive includes minimum energy performance requirements and certificates for new and existing buildings, as well as inspections of water boilers and air conditioning systems. The Ecodesign Directive sets energy efficiency standards for appliances and equipment.

In the residential sector, there were significant improvements over the 2005-2014 period in the EU, with an average fall in energy consumption by 16.8% (Fig. 4.4). In 2014, the final energy consumption for households was lower by 9.5% with respect to 2000. This trend is explained by energy efficiency improvements driven by policy measures, higher energy prices (+64% since 2004) and, starting from 2008, by the recession. The decreasing trend was especially rapid in 5 countries (Ireland, Cyprus, Portugal, Luxembourg and Malta).

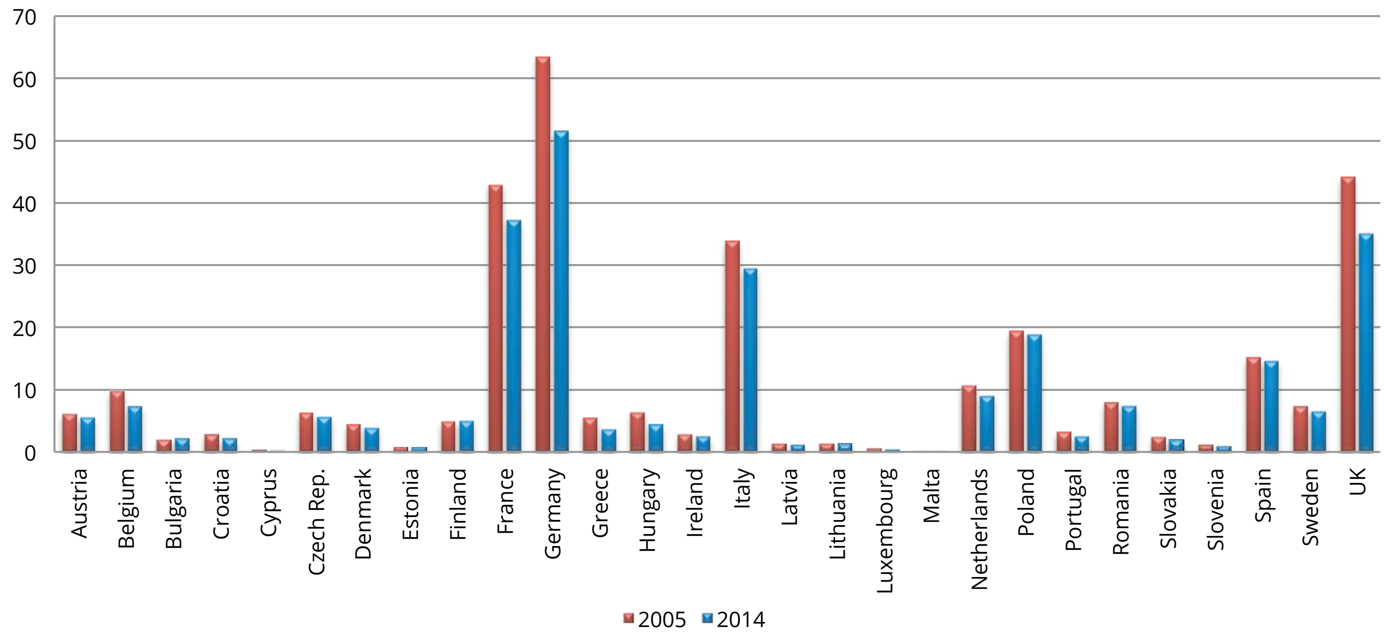
According to building regulations, new dwellings now consume 40% less than dwellings built before 1990, based on the EU average. The impact of these efficient new dwellings is however still limited as the number of new dwellings built since 1990 only represented 23% of the total stock in 2013. The average number of new dwellings built every year, in the 2000-2012 period, corresponds on average to 1.1% of the dwelling stock (percentage dropped to 0.8% since the economic crisis).

In order to achieve energy efficiency targets for buildings by 2020, more financial incentives and information sharing campaigns are required.

The most significant improvements in energy efficiency

Fig 4.4 Energy consumption in residential sector (Mtoe)

Source: Eurostat



have been registered for space heating, followed by water heating and large appliances (i.e. refrigerator-freezers, washing machines, dishwasher machines, cooking appliances).

Space and water heating is the most important end-use in the residential sector, with more than a three-quarter share of total residential consumption. Some EU15 countries, such as Sweden, Netherlands and Germany, experienced very strong energy efficiency improvements in heating appliances thanks to the replacement of old boilers and the penetration of more efficient heating systems, such as gas condensing boilers and heat pumps. Electrical appliances are the second most important final energy use in households. Energy label policies have proven successful in this sector, and as of 2014, 92% of the new Major Domestic Appliances (MDA) were class A+ or higher.

4.2. THE ADOPTION OF ENERGY EFFICIENCY DIRECTIVE (DIRECTIVE 2012/27/EU) IN MEMBER STATES

The Directive 2012/27/EU established a common framework for the promotion of energy efficiency in the Union with a set of binding measures to reach the 20% target by 2020. Under the Directive, all EU countries are required to use energy more efficiently at all stages of the energy chain from production to final consumption.
EU countries were required to transpose the Directive's provisions into their national laws by 5 June 2014.
New measures foresaw major energy savings for consumers and industry. For example:

- energy distributors or retail energy sales companies must achieve 1.5% energy savings per year through the implementation of energy efficiency measures;
- EU countries can opt to achieve the same level of savings through other means such as improving heating systems efficiency, installing double glazed windows or insulating roofs;
- the public sector in EU countries should purchase energy efficient buildings, products and services;
- every year, EU governments will carry out energy efficient renovations on at least 3% of the buildings they own;
- energy users will be empowered in order to manage their own consumption. As discussed hereinafter, this includes easy and free access to data on consumption through individual metering;
- national incentives for SMEs to undergo energy audits are foreseen;
- large companies will make audits of their energy consumption and identify ways to reduce it;
- monitoring Efficiency levels in new energy generation capacities have to be monitored.

To reach the energy efficiency target by 2020, individual EU countries have set their own indicative national energy efficiency targets. Depending on country preferences, these targets can be based on primary or final energy consumption, primary or final energy savings, or energy intensity.
In the Commission's assessment on progress towards the energy efficiency 2020 targets (published in November 2015), it was stressed that "there has been significant progress in reducing energy consumption at EU level. Overall, final energy consumption decreased by 8% between 2005 and 2013. Primary energy consumption decreased by 8% in the same period and preliminary estimates shows a continuation of this trend in 2014".
Although the Commission recognized the renewed effort of Member States in energy efficiency measures through NEEAPs, it underlined the need for full implementation of the European framework for energy efficiency, in terms of removal of existing barriers for investments, and of full implementation of the legislative framework on greenhouse gas reductions. Specifically, additional efforts are needed in the building, transport and generation sectors.
The indicators used in the European Commission report to analyze progress on energy efficiency show big differences between Member States. Nevertheless, most

have improved at European level.
In many Member States the transposition of the EED is not yet complete, preventing national 2020 targets from being met and the sharing of energy efficiency benefits to all market actors and consumers.
The Commission has launched infringement procedures to ensure full and correct transposition. Stronger efforts are required in this respect. The Commission has sent 27 letters of formal notice and some reasoned opinions to Member States for not notifying the Commission of all the national legislation necessary to transpose each of the EED requirements. The Commission also initiated bilateral contacts with all 28 Member States requesting a substantial level of information on the implementation of Article 7 of the EED (energy efficiency obligation scemes).
The energy efficiency market has strong investment potential, but it is still small, fragmented, risky, and relies predominantly on direct or indirect subsidies. The overall financing framework has improved for consumer loans and mortgages, but critical issues related to energy efficiency financing still persist. In the EU, investment is influenced by macro-economic conditions and the low-interest rate policy of the European Central Bank.
The European Structural and Investment Funds are the largest EU financing source in energy efficiency.
According to the Commission figures, during the 2007-2013 period, the EU allocated around € 6.1 billion to the energy efficiency, co-generation, energy management. More than half of this EU funding (€ 3.4 billion) was allocated for energy efficiency in public and residential buildings. In this period, 90% of support for energy efficiency was provided through grants, with loans representing only 8% of the EU support.
Also for the financial period 2014-2020 energy efficiency represents a high share of the available funding. Forecasts predict that out of € 45 billion € 13.3 billion will be used to support energy efficiency in public and residential buildings. In addition, € 3.4 billion will support energy efficiency in businesses, with a focus on small and medium firms, leading to over 50.000 companies with improved energy performance.
However, using effectively these funds will require high quality projects and the mobilization of private finance to address energy efficiency investment needs. Public and private funds should work together to attract private capital and deliver more and larger energy efficiency investments. In the 2014-2020 period, the EU is aiming to double the use of financial instruments in the form of loans, guarantees or equity. This change is expected to encourage private financing and to help small-scale projects that predominate in the area of energy efficiency.

4.3. THE ONGOING TRANSFORMATION: FROM CENTRALIZED MODEL TO DISTRIBUTED MODEL

Almost all economic sectors are being transformed by digitalization and data analytics. The ongoing revolution is finally reaching the power industry. Renewables, distributed generation, and smart grids demand are triggering new business models and regulatory frameworks. The competition for customers is shifting to the online channel; the IoT promises new product and management options.

The energy industry is also evolving from large centralized power plants owned by utilities to a new generation model, different in terms of ownership of the assets and the integration of new distributed energy resources into the grids. Currently, thanks to technological progress and distributed generation, the final consumer can produce, store and consume (or shift in time consumption) her own energy under fair conditions in order to save money, help the environment, and ensure security of supply. Through the process of "self-consumption", passive consumers are therefore becoming active, "prosumers" (European Commission, 2015).

Essentially, there are two energy efficiency areas of improvement permitted by digital technologies: the supply chain (reduction of time, waste and better interaction between economic players) and final consumption (better management & control of energy uses and costs).

As already mentioned, the energy sector has changed deeply over the last few years. The European Commission has also recognized that citizens must be at the core of the Energy Union and that achieving this goal will require a fundamental transformation of European electricity system that includes the redesign of the electricity market. Consumers should take full ownership of the energy transition to benefit from new technologies to reduce their bills and participate actively in the market, while ensuring protection for the vulnerable ones.

Demand Flexibility

Natural variations in the level of supply for some types of renewable energy (e.g. wind, solar, in particular), combined with strong variations in energy needs over time, can make it difficult to integrate renewable sources into existing power grids. Accomplishing full integration will require the expansion and modernization of existing infrastructure, as well as substantial back-up generating capacity (generally derived from fossil fuel) to meet peak energy demand. If supply and demand were better balanced, less energy infrastructure would need to be built or maintained, and the quantity of back-up generation capacity could also be reduced.

In this context every type of flexibility, in particular demand flexibility, is becoming increasingly important. Electric loads, that demand flexibility shifts in time, can be used to provide a variety of grid services. The demand-side resources may include consumption, use of distributed generation and/or storage capabilities. All these circumstances require a strong coordination between TSOs and DSOs.

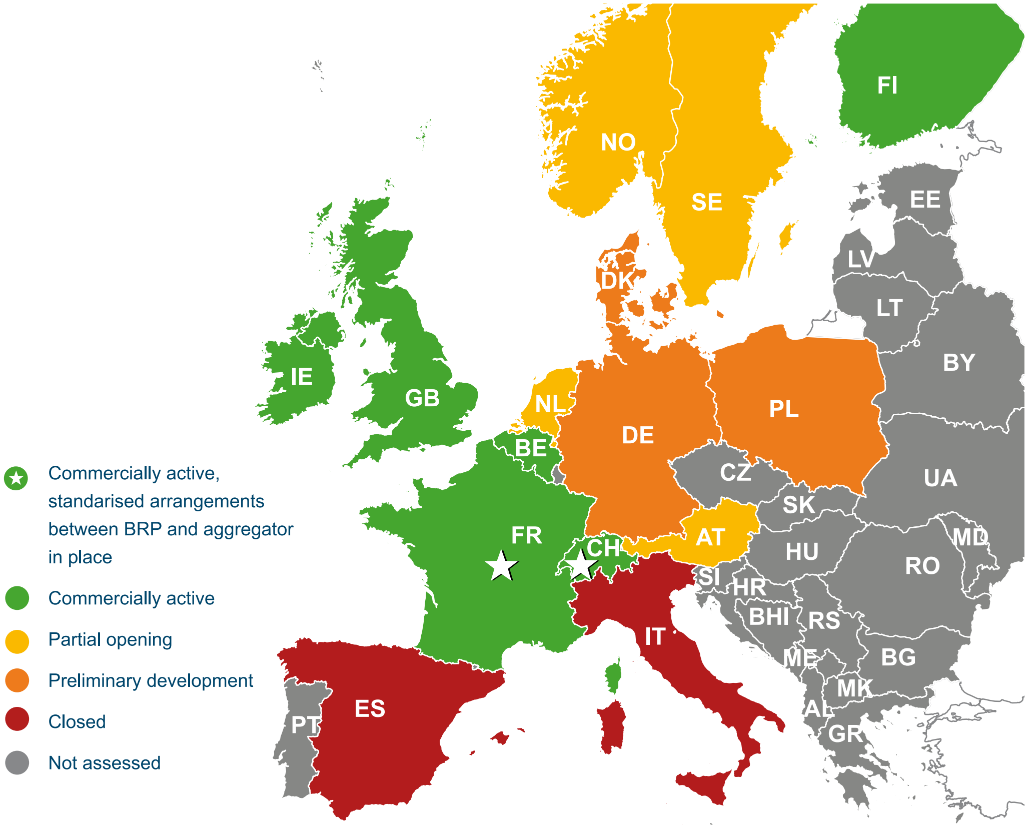
The Directive 2012/27/EU on energy efficiency establishes consumer access to energy markets, either individually or through aggregation, and national regulatory authorities responsibility in order to allow demand side resources to participate alongside supply in wholesale and retail markets.

By providing control signals and/or financial incentives to adjust their use of demand side resources at strategic times, Demand Response (DR) empowers all consumers. The programmes already in place, involving large industries, through interruptibility, have been gradually complemented by programmes aimed at commercial and residential customers.

There are two schemes of demand response. In the Explicit DR schemes the aggregated demand side resources are traded in all markets. Consumers receive

Fig 4.5 Map of explicit demand response development in Europe (2015)

Source: SEDC – 2015



direct payments to change their consumption (or generation) patterns upon request. Consumers can offer their flexibility individually or by contracting with an aggregator. Implicit DR refers to consumers choosing to be exposed to time-varying electricity prices or time-varying network grid tariffs that reflect the value and cost of electricity and/or transportation in different time periods. They respond to wholesale market price variations or in some cases, dynamic grid fees. Introducing the right to flexible prices for consumers (provided by the electricity supplier) does not require the role of an aggregator.

DR is a critical resource for achieving a low carbon, efficient electricity system at a reasonable cost and adoption of such tool vary substantially across Europe, reflecting national market and regulatory factors (Smart Energy Demand Coalition (SEDC), 2015).

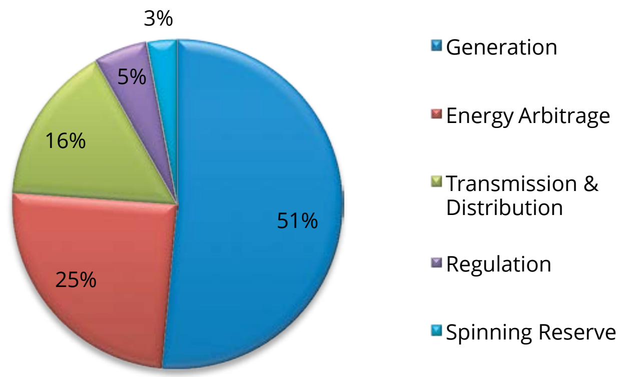
Belgium, Finland, France, Ireland and Switzerland are the Member States where DR is a commercially viable product (Fig. 4.5). Great Britain is part of the same group due to its highly competitive energy markets, and open balancing markets, but the future of DR has become more difficult due to the launch of the Capacity Market that does not create a level playing field for demand side participation.

In Sweden, Netherlands, Austria and Norway, instead, regulatory barriers remain an issue and continue to delay market growth.

In the remaining Member States, aggregated DR is either forbidden or its development is seriously hindered for all market participants by regulatory barriers. However,

Fig 4.6 Source of estimated saving in terms of grid costs from residential demand flexibility - US

Source: Rocky Mountain Institute (2015)



Denmark, Germany and Italy are conducting regulatory reviews and their status may change soon.

According to a recent study by Rocky Mountain Institute, residential demand flexibility can help avoid up to $13 billion dollars per year in grid costs only in the US (Fig. 4.6). This total number represents the potential avoided cost at the grid level, without accounting for the investment in control hardware and software. Roughly 70% of the total avoided costs derive from generation and transmission & distribution ($9 billion/year). Demand flexibility can also support 25% savings in energy arbitrage (£3.3 billion/year). Moreover, consumers can save from 10% to 40% annually, in terms of net bills.

The Energy Cloud

The old energy industry – characterized by large economies of scale, inflexible supply and demand and huge investments – is now evolving in a new system where the key word is flexibility, with a focus on the end user and its proactive approach to the system. This change poses significant risks to the power utilities, but it also offers more opportunities in a market that is becoming more open, more competitive, and more innovative.

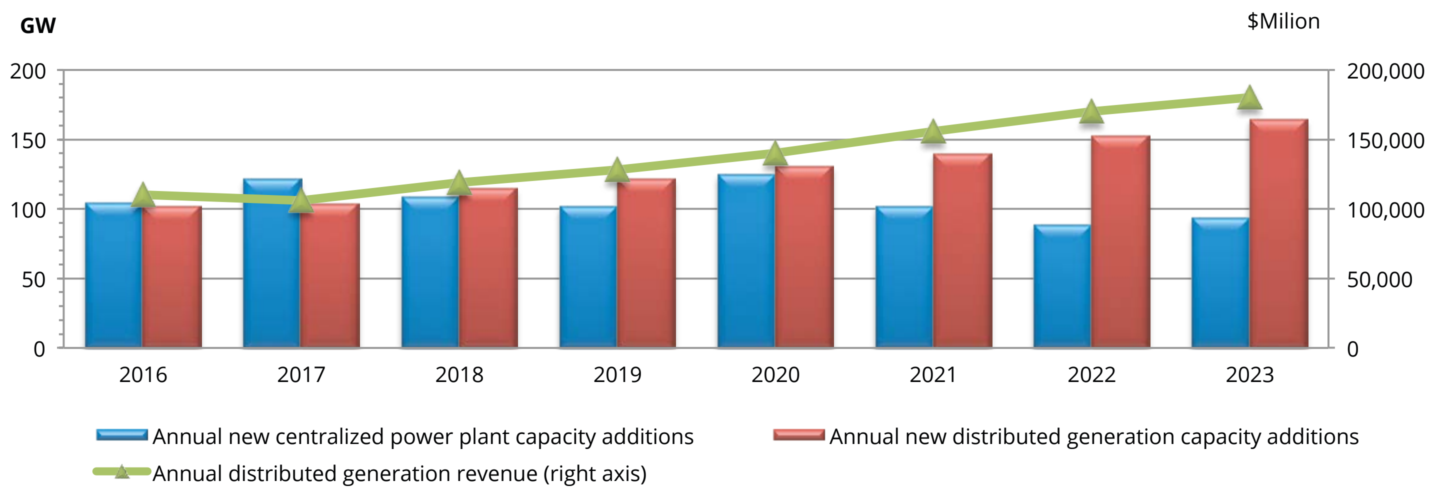
As Internet democratized information and knowledge, in a similar way the distributed generation resources gives people more control over their power consumption, including the ability to sell the surplus they produce. Moreover, economical and efficient energy storage is transforming electricity in a commodity that can be managed with much greater flexibility.

Energy efficiency, distributed energy sources, demand response, energy storage, advance software/hardware and emerging energy cloud are key components of the ongoing transformation. According to Navigant estimates, in 2018 the new Distributed Generation (DG) capacity is expected to overcome Centralized Generation (Fig. 4.7).

The energy cloud is the result of a technological, commercial, regulatory and operational change in a traditional energy model. It represents the evolution of traditional relationship between utilities and

Fig 4.7 Annual centralized power plant vs. DG capacity additions in the world

Source: I-Com elaborations on Navigant data (2015)



stakeholders. Essentially the energy cloud is a platform on which advanced technologies and solutions can be integrated and compete in a dynamic market.

There are 4 pillars that underpin the energy cloud evolution:

- regulation: Energy Efficiency Directive and low (or zero) carbon technologies are supporting the shift away from centralized generation;
- distributed energy sources instead of large central power generation, also thanks to storage technologies;
- consumer empowerment that relies on proactive approach to the energy sector by its end users;
- smart grid to replace infrastructure and support transition towards an innovative electrical grid.

The energy cloud derives from cloud computing. The electrical grid architecture resembles the computing architecture, with multiple customers connected to centralized power plants via transmission and distribution networks that enable a one-way flow of energy. The energy cloud represents the evolution of the prior generation models, combining the large-scale economies with the flexibility of the distributed energy sources. The energy cloud allows the embedding of traditional and more innovative interactions. This new context will encourage a closer engagement between companies and customers. Energy end users can be rewarded for their active participation to the market thanks to demand side management programs while more passive customers can be potentially penalized.

The grid of the future should integrate distributed energy sources fully in the distribution grid, which will enable a two-way power flow without a distinction between transmission and distribution grids. This system requires high level of digitalization. The energy cloud and the Internet of Energy are related, but not interchangeable, concepts. Internet of energy means interconnections between multiple devices and the shift to decentralized generation. Supported by digital and technological progress (e.g. smart meter, storage, etc.), energy cloud includes platforms to facilitate the matching of (traditional) market players and customers.

Flexibility is also a key term in the integration of new innovations in the energy cloud. Companies and grid operators should be careful in their planning to anticipate the potential issues these solutions will create. Utilities were initially concerned about the potential declining revenue due to the increase of distributed energy sources and the energy efficiency measures. But digital technologies and energy cloud can provide several opportunities for the energy industry to respond and capitalize on the ongoing challenges. In their long-term vision, utilities should redefine a flexible strategy with the aim of revising the offered services and influencing the changing dynamics.

The new role of TSOs & DSOs

Although Transmission System Operators (TSOs) and Distribution System Operators (DSOs) have different roles and responsibilities across the European Union, in their role as regulated operators they are required to support the functioning of the market and to ensure neutrality and a level playing field for existing as well as new market operators. TSOs and DSOs should guarantee operational security and economic efficiency over their grids. Generally, TSOs connect parties to the transmission grid, provide metering data (originated on the transmission grids), manage balancing and ancillary services, and contribute to the allocation of interconnection capacities. DSOs are responsible for the connection to distribution grid, provide metering data (from distribution grids) and facilitate the supplier switching.

The digitalization allows System Operators (as TSOs and DSOs) to achieve new levels of operational efficiency and modernize their communication, bringing huge opportunities to the system. The old passive networks are changing thanks to the growth of renewable resources and the empowerment of consumers. The large amount of variable generation and load requires a greater system flexibility to prevent or solve grid congestion and balance production/consumption at national level. With a greater number of sensors, DSOs can better manage the increased network complexity and fulfill security obligations.

Digitalization will enable system operators to handle more granular data and potentially move to a new model of data hub operations – centralized or decentralized depending on each country – where DSOs are responsible for metering operations and data exchange. Regulators should recognize the innovative role of DSOs as neutral market facilitators and encourage efficient technological modernization. Indeed, DSOs are requested to play a coordinating role between all market participants and facilitate markets and services in a neutral and non-discriminatory manner.

To maintain a balance between keeping the costs of the grid at a minimum level and guaranteeing fair market conditions, greater coordination and exchange of data are needed across system operators and other energy players. Currently, in many European countries, there is neither a consistent nor a systematic exchange of information across energy market agents on Distributed Generation (DG) and Distributed Energy Resources (DER). All market players should have access to certain smart grid data via DSOs (e.g. Balancing Responsible Parties – BRPs need to be informed by DSOs/TSOs about substantial impacts on their processes such as the activation of flexibility within their perimeters). Regulators should ensure the data exchange between system operators and market players in all relevant timeframes. Shared processes, data management models, data formats and communication protocols for data exchange should be agreed at EU level.

TSOs and DSOs should jointly agree on the technical data models, formats and communication protocols to be used for the exchange of information. Depending on the characteristics of a country, information needs of TSOs and DSOs may change. For instance, TSOs could require information on consumption and generation flows at the physical interface between TSOs and DSOs, with details to be provided about generation types, or detailed information on grid users in order to oversee the grid effects of flexibility offers. Likewise, in order to assess available grid capacity before the market can be cleared, and to evaluate the need for flexibility to manage any congestion at distribution-level, DSOs might need geographically differentiated information on planned loads, either directly from BRPs or via TSOs.

In 2015, under the supervision of the European Commission, a DSO/TSO platform was launched by the four European DSO associations and ENTSO-E (the EU network of TSOs). With the aim of clarifying data management and exchange between TSOs and DSOs in the overall context of the energy transition, this platform has studied five use cases: congestion management, balancing, use of flexibility, real-time control and supervision, and joint network planning. The platform is an appropriate tool to deliver EU-wide principles and solutions for information exchange between system operators.

The Italian Regulator also addressed this issue as part of the review of the dispatching service, in the consultation document (354/2013/R/eel), identifying three potential pathways of collaboration between TSOs and DSOs. In a centralized model the DSO plays a marginal role, while the TSO fully operates the dispatching service, also for sources connected to the distribution network. In the decentralized model, the DSO – duplicating its role – manages the local dispatching and submits the bids on balancing and ancillary markets. Finally, with the third option, the DSO manages local resources in distribution networks and maintains the energy exchange with the network in high voltage as similar as possible to that planned; TSO manages the units connected to the transmission grid.

4.4. SMART METERS: OPPORTUNITIES AND FORECASTS

The IoT in the energy sector can enable a large variety of services. Advanced communications infrastructure offers benefits to companies and consumers.

With smart meters, consumers have access to huge quantities of information, but they are not always able to interpret these data. So companies should bridge this gap and help their end user to understand and better manage their consumption habits.

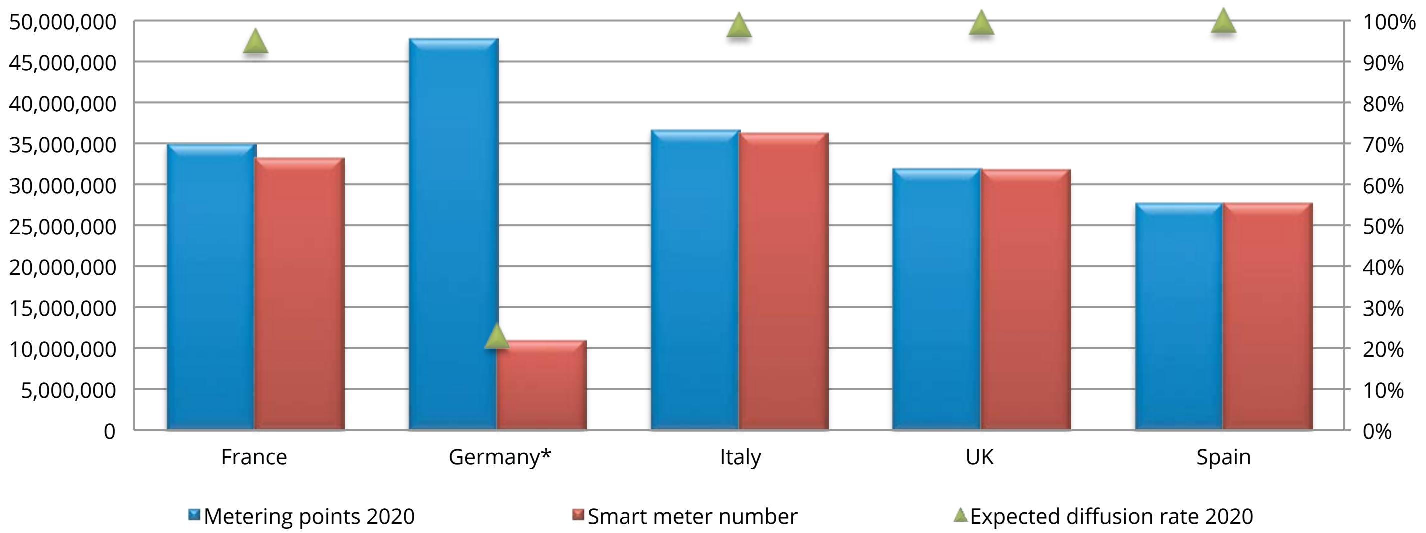
The European smart metering market is more advanced than in other regions because of the need to meet energy efficiency targets. Indeed, the Third Energy Package establishes for electricity a massive roll-out of smart meters by 2020, targeting 80% of all consumers to be positively assessed after a costs benefits analysis. No target was defined for gas sector due to expected benefits less significant than for electricity.

In terms of smart metering systems deployed penetration by 2020 (Fig. 4.8), almost all of the big five countries exceed the threshold set by the EU, with only Germany failing to do so because of the negative outcome of the CBA for a mass roll-out. According to European Commission figures, by 2020 the expected diffusion rate for electricity smart meters will reach more or less 100% for Italy, UK and Spain.

The smart meter roll-out was subject to different drivers in every Member State, e.g. in Italy it was originally led by potential operational savings (around €500 million per year), and now is moving toward customers

Fig 4.8 Number of electricity smart meters and diffusion rate by 2020 per country

Source: European Commission (2014)



**negative CBA*

empowerment. In contrast, for example, Finland started the roll-out of the smart meter to enable demand side management, better network management control and enhancement of the operation of retail markets.

According to data provided by Member States to the Commission, benefits exceed costs in the majority of countries, with several notable exceptions (particularly, Germany plus few Eastern Europe countries) (Fig. 4.9).

The advance-metering infrastructure (AMI) is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers.

In accordance with Zpryme estimates, the global market of AMI will grow, at a compound annual growth rate (CAGR) of 10.4%, from $13 billion in the 2012 to $28.6 billion in 2020 (Fig. 4.10).

During the same period, the European AMI market will rise to $9.2 billion. The figure shows a compound annual growth rate of 11.5% from 2012 to 2016 while from 2016-2020 the growth will slow with a CAGR of 6.7%.

Forecasted for 2020 is a decrease in the smart meter

Fig 4.9 Cost benefit values per metering point - electricity (euro)

Source: European Commission (2014)

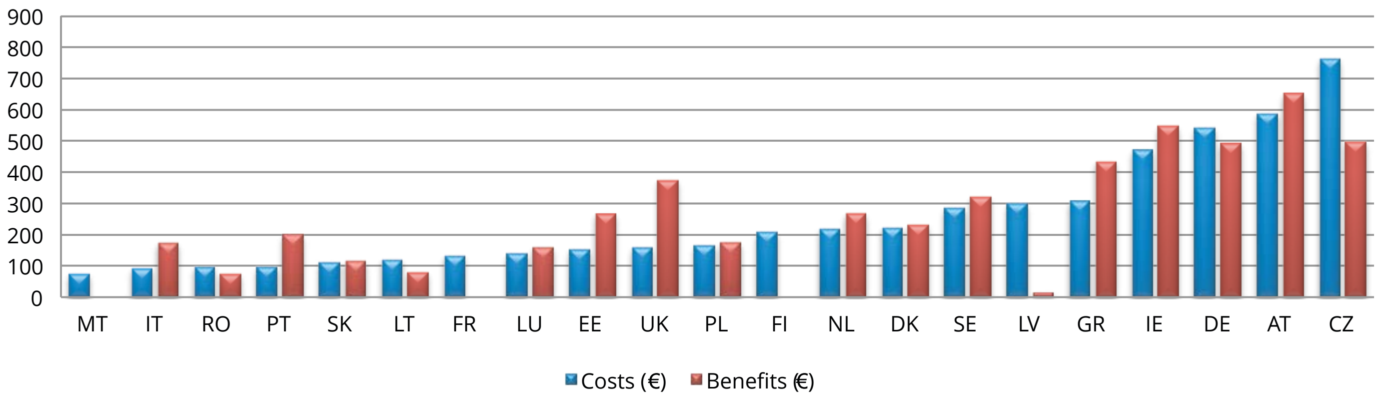


Fig 4.10 Advance Metering Infrastructure market value (US$ bn)

Source: Zpryme (2013)

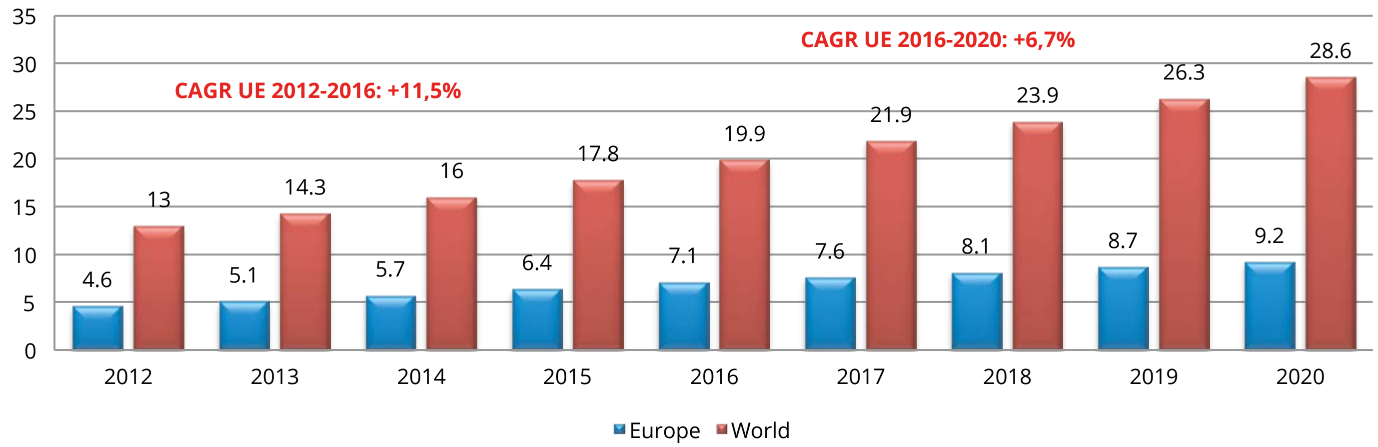
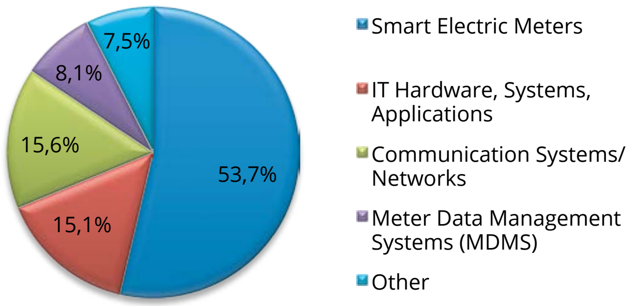


Fig 4.11 European AMI market segmentation by technology (forecasts, 2020)

Source: Zpryme (2013)



market share (65% in 2012) in favor of other AMI segments (Fig. 4.11), even if smart meters remain the largest market segment, accounting for roughly 54%, followed by communication systems and networks (15.6%) and IT hardware, systems applications (15.1%). At the same time, the share of meter data management will rise from 6% to 8.1%.

According to Frost Sullivan forecasts, the market revenues of European electricity smart meters in 2017 will increase to $1.93 billion from $318 million in 2010.

State of art in Italy

Italy is a leader in the roll-out of smart meters. Following the mass deployment that had taken place since 2001, Italy will soon proceed with the replacement of first-generation smart meters with those of the second (2G) in the electricity sector. An ambitious target has also been set in the gas sector for the roll-out of smart meters, corresponding to 50% of domestic delivery points by 2018.

As testified by the amount of public consultations, smart metering represents one of key items for the Italian Regulator aiming at consumer empowerment (e.g. energy footprint).

Within the logic of smart cities, and to use a single shared network to transfer the data on consumption from electricity, gas, water with different suppliers, at the end of 2014 AEEGSI approved 8 trials for multiservice smart metering, putting gas in the same basket as water and other services.

The tender was open to all gas distribution companies and approved projects are funded with a small contribution of about 10 cents a year per consumer on a national level, taken from gas bills.

Approved projects are listed in Table 4.2.

The gas and water distribution services are present in all selected projects. Examples of other services include experiments in public lighting, noise detection sensors (Verona), and investigation of water leaks from the public network (Bari).

Data are read from meters or sensors through communications infrastructure built and operated by third party operators and shared among the operators of the different services involved. Sharing infrastructure reduces costs and makes information available in an integrated manner.

The projects aim providing information to concerned customers on their energy consumption in a multi-

Table 4.2 Aeegsi pilot projects – multiservice smart meters

Source: Aeegsi

Company	Location	Metering points	Aeegsi regulated services	Other services description
AES Torino S.p.A.	Torino	4002	Gas distribution, power distribution, water service	District heating, environmental sensors, street lighting, etc.
AGSM Distribuzione S.p.A.	Verona	4710	Gas distribution, power distribution, water service	District heating, public lighting, etc.
A.M.GAS S.p.A.	Bari	10297	Gas distribution, power distribution, water service	District heating, water smart grid, public lighting, energy management
AESC	Catania	9390	Gas distribution, power distribution, water service	Public lighting, dumps, etc.
Hera S.p.A.	Modena	13364	Gas distribution, power distribution, water service	District heating, garbage collection
IREN Emilia Genova Reti Gas	Reggio Emilia Scandiano Parma Genova	16126	Gas distribution, power distribution, water service	District heating, garbage collection, public lighting
ISERA s.r.l.	Isera and others	3607	Gas distribution, power distribution, water service	Remote monitoring system of hydrogen production, remote monitoring system pv, Remote monitoring system public lighting, etc.
SED	Salerno	2520	Gas distribution, water service	Remote control of public parking, etc.

service approach and on a single website.
According to the AEEGSI timeline, the roll-out phase lasts one year and the operating phase should be concluded within three years from the project approval date. Preliminary reports on the projects were prepared in March 2015 and subsequent reports on progress should be periodically submitted to AEEGSI.
The Regulator periodic reports also aim at making available to all operators the results of pilot projects.

4.5. DATA MANAGEMENT IN THE ENERGY SECTOR

Data management model refers to the framework of roles and responsibilities assigned to any part of the electricity system and the following related duties (e.g. data collection, processing, delivery, exchanges, publishing and access).
The need for new traditional power plants has significantly decreased thanks to the energy democratization

deriving from renewables and distributed energy sources. The revolution in the energy sector is also led by big data arising from innovative software, hardware and analytics. Current business models could become obsolete due to the ongoing transformation of the entire energy value chain. The ability to collect, process and analyze larger amounts of data is crucial. Greater data availability should promote market efficiency.

Over the long run, the establishment of a "smart home" that integrates security, entertainment and energy management, is only achievable using new measurement and communication technologies. This strategy can also be an added value aiming at customer loyalty, as confirmed by some European and American utilities that provide these kinds of services.

Operators may use data acquired to improve their forecasting capacity and demand management abilities. For example, Nest smart thermostats by Google obtain information on customer habits, that allow companies to know in detail the time trend of heat demand and, therefore, to better plan their energy supply (also in terms of pricing) and provide services as demand response. Consumers can have more control over their energy usage and become active players in the energy market. All market players must always ensure data privacy and security.

In early 2015, the International Data Corporation (IDC) estimated the potential economic benefits for EU28 utilities deriving from the development of the data-intensive applications at €64.3 billion per year. The benefits for TSOs and DSOs could be respectively €16.3 billion and €28.6 billion per year.

These new technologies and new digital products enable more efficient management of traditional activities starting from the use of big data to optimize strategic and tactical decisions.

According to Eurelectric vision there are 3 types of data:

- smart meter data;
- smart grid data;
- smart market data.

The first class includes consumption, production and master (e.g. point of delivery identification) data. Generally unidentified, smart grid data covers all technical data originating in the network, that facilitate the infrastructure management. Finally, the most complex data to define are the market data that derives from the market. Market players to create innovative services collect smart meter, smart grid data and many other kinds of information as price, payment method, weather and demography data, etc.

Data should be exchanged between the operators in a bilateral way, based on defined standards for common processes such as billing, switching and settlement.

Data management is different across countries. Some MSs have chosen a centralized data hub, with a common clearing platform managed by a regulated party (e.g. DSO, TSO or third party), others prefer a decentralized model. In the first case the uniqueness of the contact point simplifies trade and reduces costs, but due to this characteristic is the most exposed to cyber security risks. In the second case the data will be of better quality than others, but the fragmentation could be a problem.

The 'one size' model is not applicable in all European countries. Each Member State should define its own strategy based on their needs and characteristics, considering some essential element. However according to the vision of TSOs and DSOs, some common principles related to data management must be established on a European level in order to:

- guarantee data privacy, data and communication security;
- increase transparency regarding different actors within the electricity system and market and towards national regulation authorities to ensure fairness of cost and benefits allocation;
- guarantee fair, equal access to the data and/or information in accordance with the legal mission of each party (e.g. eligibility, transparency, accuracy, data quality etc.);
- deliver non-discriminatory processing and preserving integrity of the data;
- target simplicity in supporting existing and new business models and process robustness;
- support competition;
- offer proven cost efficiency, as accepted by national Regulatory Authority;
- strive for European harmonized standards when applicable and efficient, and at least on the national level, if European ones are not reachable;
- facilitate innovation by opening, as much as possible and legally allowed, access to the data.

The parties responsible for data management should be subject to regulatory oversight and ensure neutrality. Cost efficiency and effectiveness of the different models should be assessed for each national context and technological decisions need to be transparent (e.g., customers with smart meters, when and by whom) for regulated missions.

In the digitalized world, companies have access to large amount of customer preferences through commercial contracts, smart appliances and devices, social media etc. Transparency, about the use of this information, privacy for consumers and a level playing field for operators should be guaranteed. If the Regulators have to ensure the prompt exchanging of data on networks among system and market operators, TSOs and DSOs should agree on the technical requirements, formats and communications standards for the exchange of information.

PART 5 E-HEALTH

5. E-HEALTH

5.1. E-HEALTH IN THE EUROPEAN UNION

5.1.1. eHealth Action Plan 2012-2020

The European Commission's eHealth Action Plan 2012-2020 "Innovative healthcare for the 21st century" defines eHealth as "*the use of ICT in health products, services and processes combined with organisational change in healthcare systems and new skills, in order to improve health of citizens, efficiency and productivity in healthcare delivery, and the economic and social value of health. eHealth covers the interaction between patients and health-service providers, institution-to-institution transmission of data, or peer-to-peer communication between patients and health professionals*"[5].

The European Commission drafted the first eHealth Action Plan in 2004; since then, policy initiatives have been developed to foster adoption of eHealth throughout the EU.

The adoption in 2011 of the Directive on the Application of Patients' Rights in Cross Border Healthcare (Directive 2011/24/EU) marked a further step towards formal cooperation on eHealth with the aim to maximize social and economic benefits through interoperability[6] and the implementation of eHealth systems[7]. The Cross-Border Healthcare Directive aims at giving patients the right to receive medical treatment in another EU Member State and its Article 14 establishes the eHealth Network. This Network aims to enhance interoperability between electronic health systems and continuity of care and to ensure access to safe and quality healthcare[8]. The eHealth Network is the main decision-making body on eHealth at EU level and brings together national authorities responsible for eHealth designated by the Member States[9].

In order to facilitate the mobility of patients seeking cross-border healthcare, the EU Commission is building an EU-wide eHealth Digital Service Infrastructure (eHDSI) allowing health data to be exchanged across national borders with a first focus on ePrescriptions and Patient Summaries. Member States can connect their health systems to the eHDSI through a dedicated national contact point for eHealth (NCPeH). When building the necessary NCPeH, Member States are required to take

5 European Commission, Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions, "eHealth Action Plan 2012-2020 - Innovative healthcare for the 21st century", December 2012.

6 According to HIMSS Dictionary of Healthcare Information Technology Terms, Acronyms and Organization, Healthcare interoperability is "*the ability of different information technology systems and software applications to communicate, exchange data, ad use the information that has been exchanged*". Moreover, "*Interoperability means the ability of health information systems to work together within and across organisational boundaries in order to advance the health status of, and the effective delivery of healthcare for, individuals and communities*".

7 European Commission, Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions, "eHealth Action Plan 2012-2020 - Innovative healthcare for the 21st century", December 2012.

8 European Commission, eHealth: connecting health systems in Europe, June 2016.

9 European Parliamentary Research Service, eHealth – Technology for health, March 2015.

into consideration the guidelines approved by the eHealth Network to support interoperability of national health systems in the EU[10].

Electronic prescription (ePrescriton) is defined as "*the use of computing devices to enter, modify, review, and output or communicate drug prescriptions*"[11].

ePrescription should provide[12]:

- computerized entry and management of prescriptions;
- immediate access to information on medicines;
- decision support, aiding the choice of medicines and other therapies, with alerts such as drug interactions;
- support during administration,
- computerized links between hospital wards/ departments and pharmacies;
- links to other elements of patients' individual care records.

Furthermore, thanks to ePrescription, patients can travel to another EU country and obtain their pharmaceuticals.

Patient Summary is a standardized set of basic medical data that includes the most important clinical facts of patients and it gives health professionals the essential information they need to provide care in the case of an unexpected or unscheduled medical situation; it can also be used to provide planned medical care[13]. Moreover, through Patient Summary, health professionals can access to data of patients treated in another EU country.

Another important instrument to improve safety, quality and access to health care is the electronic health record, which is more detailed than patient summary.

According to the WHO, "*electronic health records (EHRs) are real-time, patient-centred records that provide immediate and secure information to authorized users. EHRs typically contain a record of the patient's medical history, diagnoses and treatment, medications, allergies and immunizations, as well as radiology images and laboratory results. They expand on the information in a traditional paper-based medical record by making it digital and thus easier to search, analyse and share with other authorized parties. An EHR system plays a vital role in universal health coverage by supporting the diagnosis and treatment of patients through provision of rapid, comprehensive and timely patient information at the point of care*"[14].

Moreover, making EHRs interoperable will contribute to more effective and efficient patient care by facilitating the retrieval and processing of clinical information about a patient from different sites.

Direct objectives of interoperable EHRs include[15]:

- direct patient care;
- patient care management;
- patient care support process;
- financial and other admnistrative process;
- patient self-management.

10 European Commission, eHealth: connecting health systems in Europe, June 2016.
11 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4106541/
12 Ingenico, e-Health in Europe, June 2012.
13 http://www.epsos.eu/epsos-services/patient-summary.html
14 WHO, From innovation to implementation. eHealth in the WHO European Region, 2016.
15 Ingenico, e-Health in Europe, June 2012.

Although national plans exist for the introduction of an EHR system, there are still no electronic health records across the Europe.

There are some barriers, which hamper the development of eHealth and that need to be addressed in order to reap the benefits of a fully mature and interoperable eHealth system in Europe[16]:

- lack of awareness of and confidence in eHealth solutions among patients, citizens and healthcare professionals;
- lack of interoperability between eHealth solutions;
- lack of legal clarity for health and wellbeing mobile applications and the lack of transparency regarding the utilisation of data collected by such applications;
- lack of reimbursement schemes for eHealth services;
- high start-up costs involved in setting up eHealth systems;
- regional differences in accessing ICT services, limited access in deprived areas;
- lack of IT literacy.

The new eHealth Action Plan – in line with Europe 2020 Strategy and the Digital Agenda for Europe – aims at addressing and removing these barriers. In particular the eHealth Action Plan 2012-2020 establishes operational objectives to remove barriers to the development of eHealth, enhancing quality, access and safety in healthcare across Europe and it encourages all stakeholders to work together. These objectives include:

- achieving wider interoperability of eHealth services;
- supporting research, development and innovation in eHealth and wellbeing to address the lack of availability of user-friendly tools and services;
- facilitating uptake and ensuring wider deployment;
- promoting policy dialogue and international cooperation on eHealth at global level;
- addressing the organisational layer and legal issues.

It provides a roadmap to empower patients and healthcare workers, to link up devices and technologies, and to invest in research towards personalised medicine of the future. Given the fast uptake of tablets and smartphones, the Action Plan has also a special focus on mobile health (mHealth). Furthermore, the Action Plan includes actions to increase digital health literacy of health professionals and patients[17].

5.1.2. The opportunities for eHealth in Europe

The use of digital applications and solutions is becoming increasingly present in our daily lives, offering opportunities to take on several of the challenges of health systems (chronic disease and multi-morbidity, sustainability and efficiency of health systems, cross-border healthcare).

According to the European Commission, Information and Communication Technologies (ICT) applied to health

16 European Commission, Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions, "eHealth Action Plan 2012-2020 - Innovative healthcare for the 21st century", December 2012.

17 European Commission, eHealth: connecting health systems in Europe, 2016.

and healthcare systems can increase their efficiency, improve quality of life and unlock innovation in health markets[18].

eHealth offers many advantages and benefits[19]:

- helps patients to manage their own health (also known as patient "self-care" or "self-management") thanks to a better flow of information and interactions with health professionals (teleconsultations).
- through a greater access to personal health data for patients and health professionals, it enables faster diagnosis, improved monitoring, more effective treatment and better health outcomes.
- improves healthcare efficiency and thus contributes to alleviating the burden on European health budgets. For example, solutions for patient self-management could contribute to reducing the number and length of the hospital stays of chronically ill patients; other eHealth tools, such as electronic health records, could be used to avoid the duplication of medical examinations and to help access patient information faster.
- increases sustainability and efficiency of health systems by unlocking innovation and encouraging organisational changes.
- facilitates access to healthcare services across Europe. Indeed, the use of eHealth might also support patient mobility and facilitate cross-border healthcare, as laid down in the Directive on patients' right in cross-border healthcare.
- offers to hospitals the possibility to improve care process, for instance via patient flow management systems. It could help health professionals to reduce medical errors.
- assists Governments and healthcare providers in increasing access to care or managing epidemics.
- eHealth also facilitates socio-economic inclusion and equality, quality of life and patient empowerment through greater transparency, access to services and information and the use of social media for health[20].

5.1.3. The state of the art of eHealth in Italy

In the 2008, the Ministry of Health has initiated "*eHealth Information Strategy*": Electronic Health Records (EHRs), ePrescription, dematerialization, CUP online (that stands for Single Booking Centre), telemedicine. Moreover, Regions and Government recently signed – following a two year delay – the "Pact for Digital Health" (article 15 of Pact for Health 2014-2016), which aims at fostering technological innovation in Health through a multi-year Master Plan.

18 European Commission, Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions, "eHealth Action Plan 2012-2020 - Innovative healthcare for the 21st century", December 2012.

19 European Parliamentary Research Service, eHealth – Technology for health, March 2015; European Commission, eHealth: connecting health systems in Europe, 2016; GSMA, Digital Healthcare Interoperability, October 2016.

20 European Commission, Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions, "eHealth Action Plan 2012-2020 - Innovative healthcare for the 21st century", December 2012.

The policy initiatives of the Italian Government are in line with the Europe 2020 strategy but the digitization process of the Italian National Health System is still highly fragmented, especially in some specific regions and it still lags behind other European countries.

In 2015 in Italy, eHealth spending amounted to € 1.34 billion and it was equivalent to 1.2% of public health expenditure[21] while the EU average for spending on Healthcare IT and eHealth solutions ranged from around 2% to 3% of public health expenditure[22].

Main investments include Electronic Health Records (EHR), document management systems, digital services for citizens and electronic prescription (ePrescription). On the contrary, the level of investments in solutions for integrating hospital and community – such as telemedicine[23] services, ICT solutions for healthcare services provided by local pharmacies or other healthcare providers and home care – is still low[24].

According to AgID[25] (Agency for Digital Italy), there are seven italian regions which have implemented the Electronic Health Record: Aosta Valley, Lombardy, Trentino South Tyrol, Emilia Romagna, Tuscany, Sardinia and Apulia. In Campania, Calabria and Sicily, Electronic Health Record has still not been implemented while in the rest of Italy it is in the process of implementation (Figure 5.1).

Another eHealth application used in Italy is the electronic prescription (ePrescription). All the regions have introduced the electronic prescription and the share of ePrescription is now 80%. It may rise by a further 10 percentage points by the end of 2016: a result that will bring about more savings.

Not all regions, however, are following this trend. According to data gathered by Promofarma, Regions such as Campania and Veneto are leading the pack with 89.5% of electronic prescriptions, followed by Molise (88.4%) and Sicily (87.8%). Calabria (26.7%) and the Autonomous Province of Bolzano (2.6%) were the worst performers.

Therefore, despite some recent positive results, the process of health digitization has still to gain traction in Italy. No doubt that the Italian National Healthcare Service will need to invest more financial resources for eHealth in the coming years to increase efficiency, maximize service supply, reduce in medical errors, increase patient safety, and improve chronic disease management. Moreover, it should draft clear policies for safety and privacy.

21 Observatory Digital Innovation in Health of the Milan Polytechnic University's School of Management. http://www.osservatori.net/it_it/osservatori/executive-briefing/sanita-digitale-non-piu-miraggio-non-ancora-realta

22 Censis-Impresa Lavoro, Le condizioni per lo sviluppo della Sanità Digitale: scenari Italia-UE a confronto, July 2016.

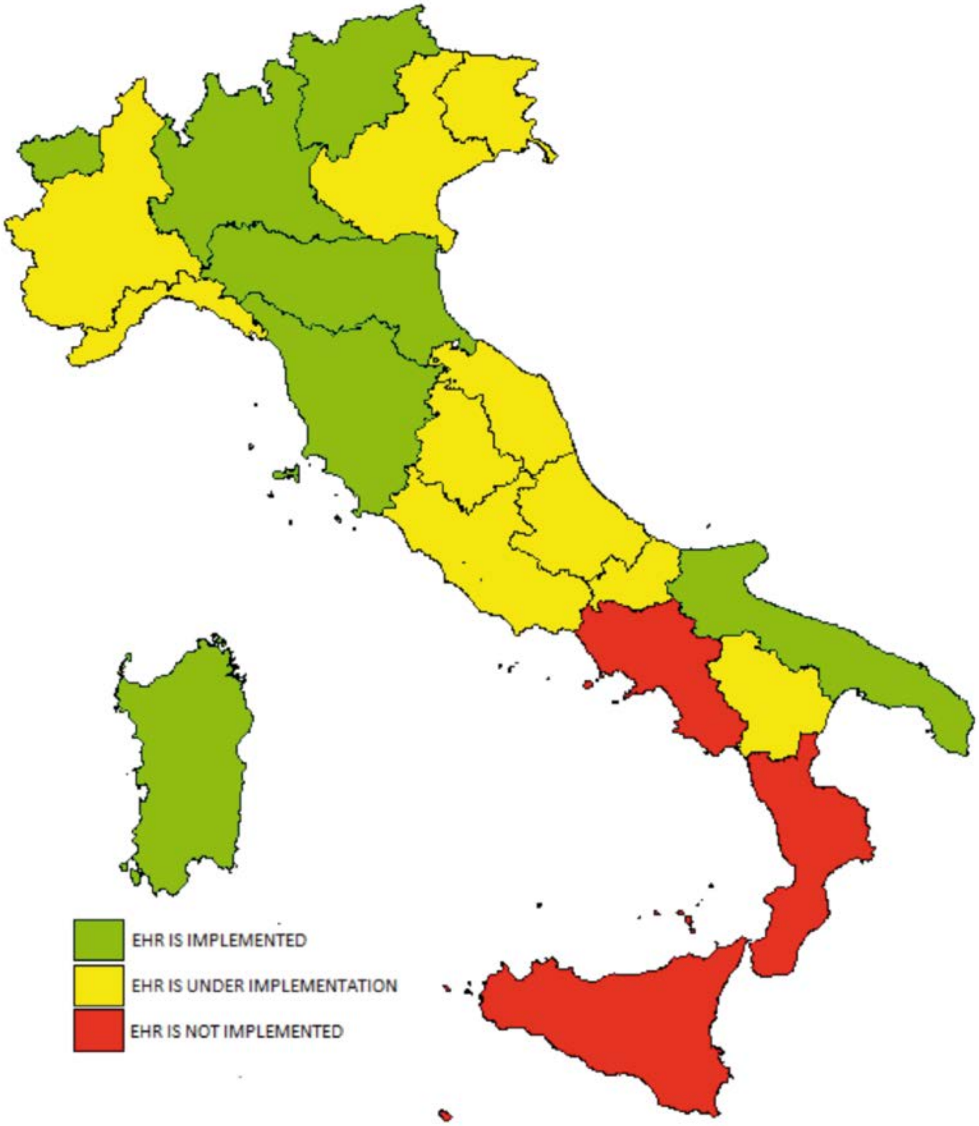
23 WHO defines telemedicine as "*The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities*".

24 Observatory Digital Innovation in Health of the Milan Polytechnic University's School of Management.

25 http://www.agid.gov.it/monitoraggio

Fig 5.1 State of implementation of Electronic Health Record in Italian regions

Source: AgID (Agency for Digital Italy), September 2016



5.2. E-HEALTH: THE PERFORMANCE OF EUROPEAN COUNTRIES

5.2.1. eHealth key indicators of European Commission: a comparison between Member States

The European Commission selected four key indicators:

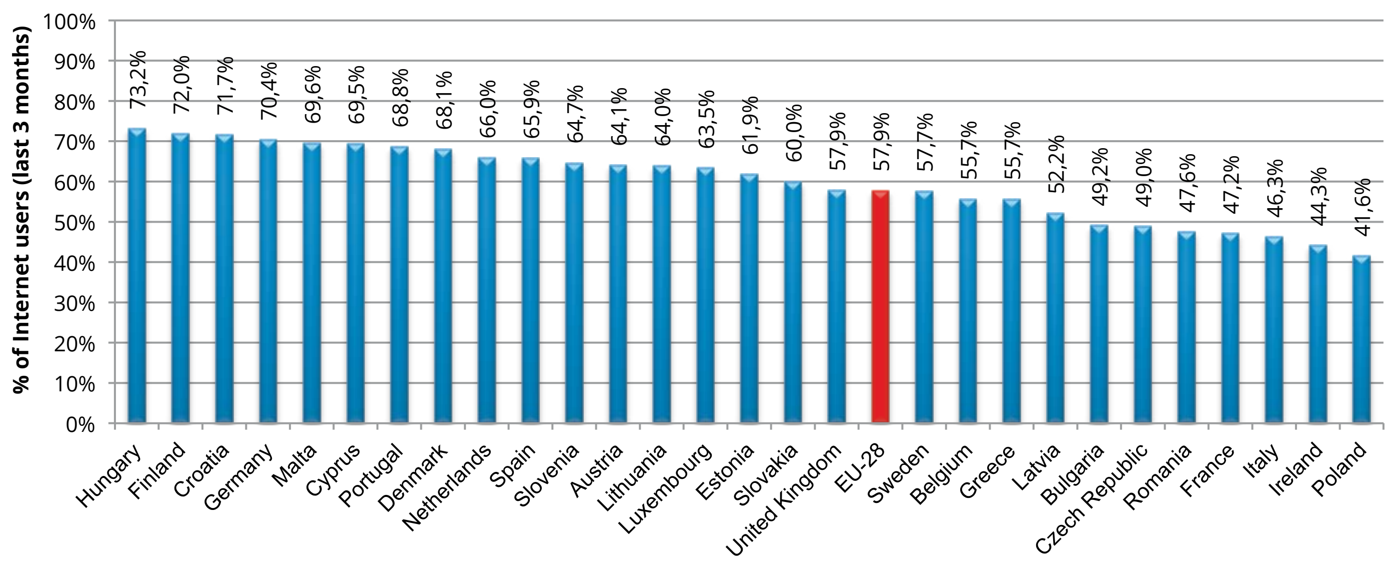
1. seeking online information about health;
2. making an appointment with a practitioner via a website;
3. GPs (General practitioners) using electronic networks to transfer prescriptions to pharmacists;
4. GPs (General practitioners) exchanging medical patient data with other healthcare providers and professionals.

These indicators illustrate the performance of European countries in terms of eHealth and allow a comparison between European countries and illustrate how doctors and patients use internet to communicate, inform and exchange information about health.

In Hungary, Finland, Croatia and Germany, more than 70% of individuals search for health information over the Internet (Figure 5.2). These countries are above the EU average; in Portugal, Denmark, Netherlands and Spain, the percentage of individuals using the internet seeking information about health is above the EU average (57.9%

Fig 5.2 Individuals using internet in the last 3 months seeking information about health (2015)

Source: European Commission, Digital Scoreboard



of Internet users) while the United Kingdom and Sweden are in line with average across the EU-28.

In Belgium, France and Italy, Internet use for searching health information is well below the EU average. In Italy, the percentage of individuals using the Internet to seek information about health is only 46.3% of internet users. Generally in Europe, the percentage of individuals using the Internet to seek information about health has grown from 42% in 2007 to 58% in 2015 (Fig. 5.3). In particular, Germany, Spain and United Kingdom have shown a positive trend: the percentage of Internet users seeking information about health has increased between 2007 and 2015. While in France and in Italy, it has decreased particularly within the last three years.

The highest number of patients making an appointment with a practitioner via a web site (more than 30% of Internet users in 2014) can be found in Spain, Finland and Denmark. Italy, with 10% of patients setting an appointment online, ranks below the EU average (13%, 2014). In France and Germany, the percentage of patients making an appointment with a practitioner via a website is also less than EU average, equal to 9,2% and 7,4% respectively (Figure 5.4).

The share of general practitioners who use electronic networks to transfer prescriptions to pharmacist varies between 100% (Estonia) and 0%

Fig 5.3 Evolution of number of internet users seeking information about health

Source: European Commission, Digital Scoreboard

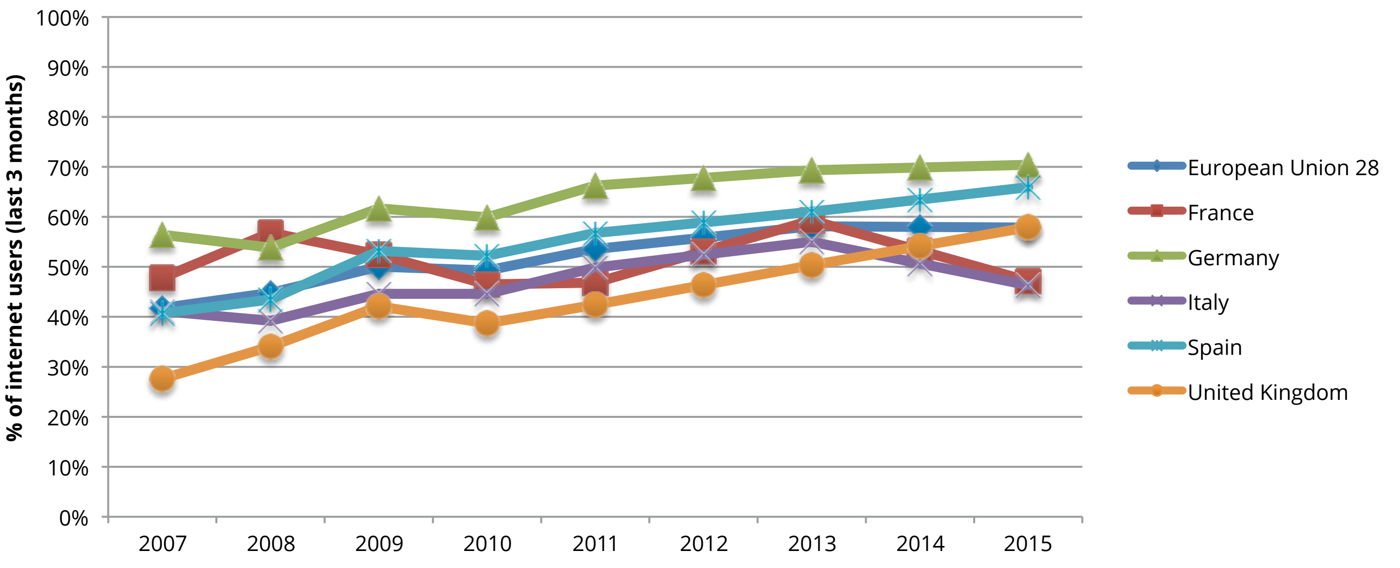
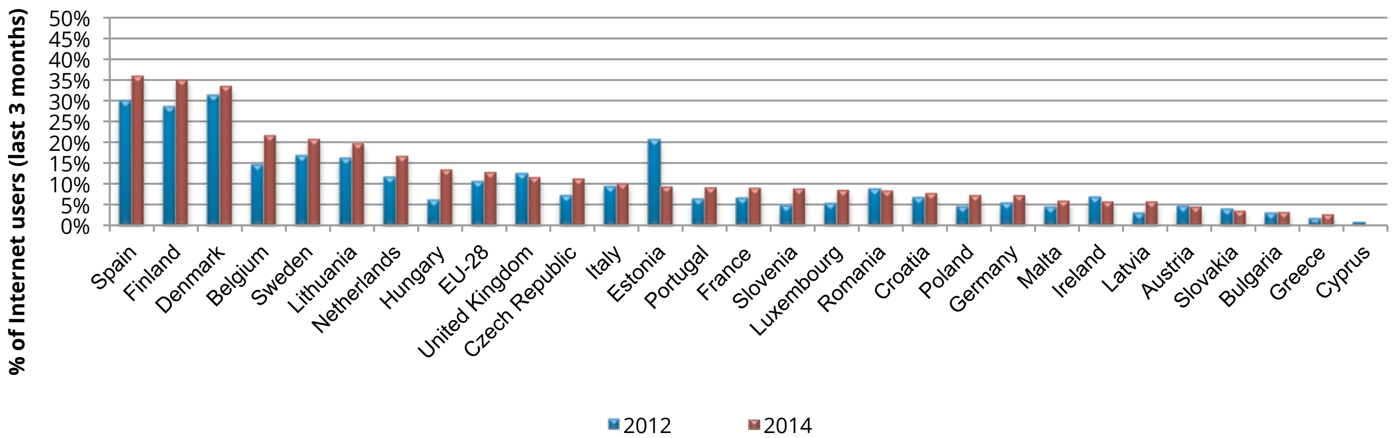


Fig 5.4 Patients making an appointment with a practitioner via a website in the last 3 months (2012 Vs. 2014)

Source: European Commission, Digital Scoreboard



(Malta). In Estonia, Denmark, Croatia, Sweden and Netherlands, ePrescriptions are already routinely used: all prescriptions are transferred to pharmacist electronically and patients are also able to reorder medication via web-service. There are some countries – including Italy and Poland – in which ePrescriptions are used infrequently (less than 10%) (Figure 5.5).

Denmark is the only country where exchanging medical patient data electronically is very common (91.8%). Other advanced countries, in which doctors exchange medical data electronically, are Netherlands, Estonia, Finland and Spain (more than 60% of general practitioners). Italy and Germany are ranked 12th and 15th respectively with 31.2% and 23.9% of general practitioners who exchange medical patient data with other healthcare providers (Figure 5.6).

In order to describe synthetically the level of progress in eHealth reached by European countries, an index has been developed, The I-Com index has been calculated considering for each country the average of variables (four key indicators of the EU Commission). The values obtained were normalized relative to the best performer country, so as to establish a ranking from 0 to 100.

The most advanced country is Denmark, followed by Finland, Netherlands, Estonia and Sweden. These countries have in common a high level of digitalization in doctor's offices and a high number of patients who use mobile and Internet technologies for searching health information and making appointments online with doctors. While Spain performs very well (74), the index values for large countries such as France, Germany, Italy and Poland are only 42, 40, 33 and 22 respectively (Figure 5.7) icom institute for competitiveness

Fig 5.5 General practitioners using electronic networks to transfer prescriptions to pharmacist (2013)

Source: European Commission, Digital Scoreboard

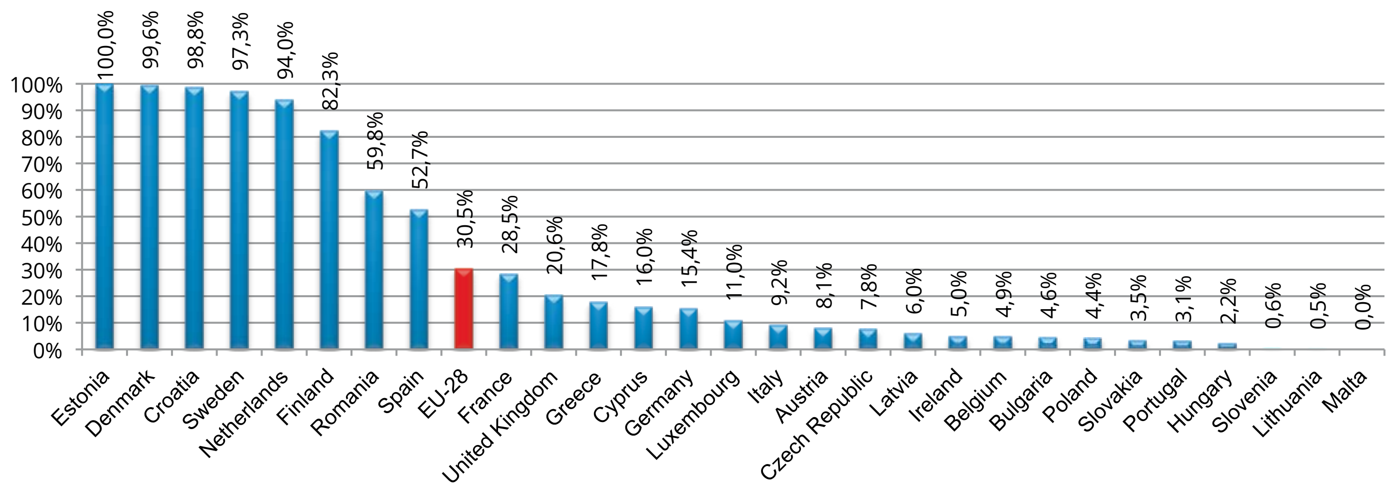


Fig 5.6 General practitioners using electronic networks to exchange medical patient data with other healthcare providers and professionals (2013)

Source: European Commission, Digital Scoreboard

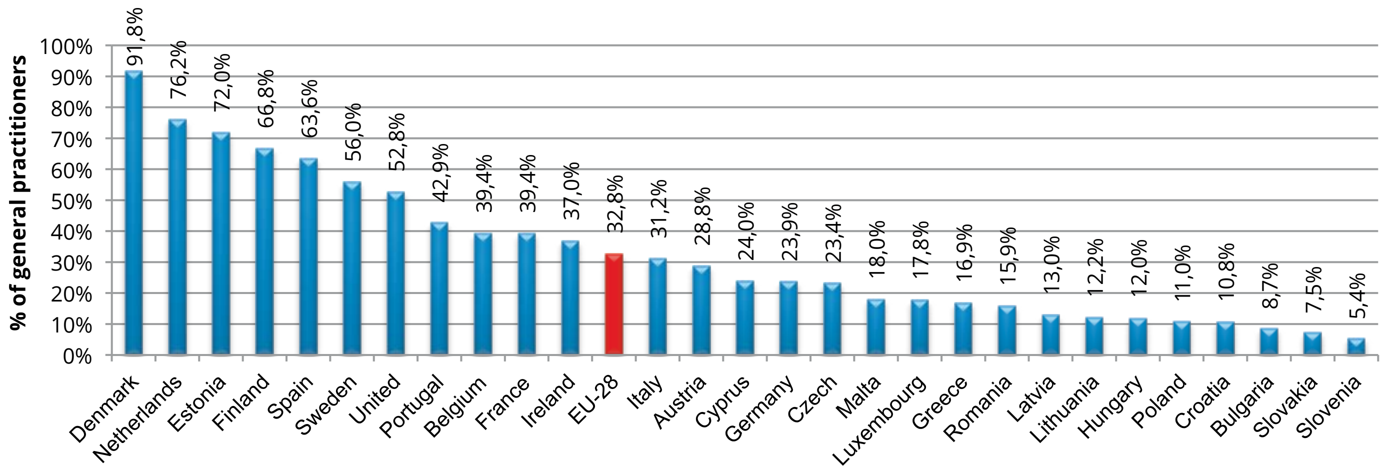
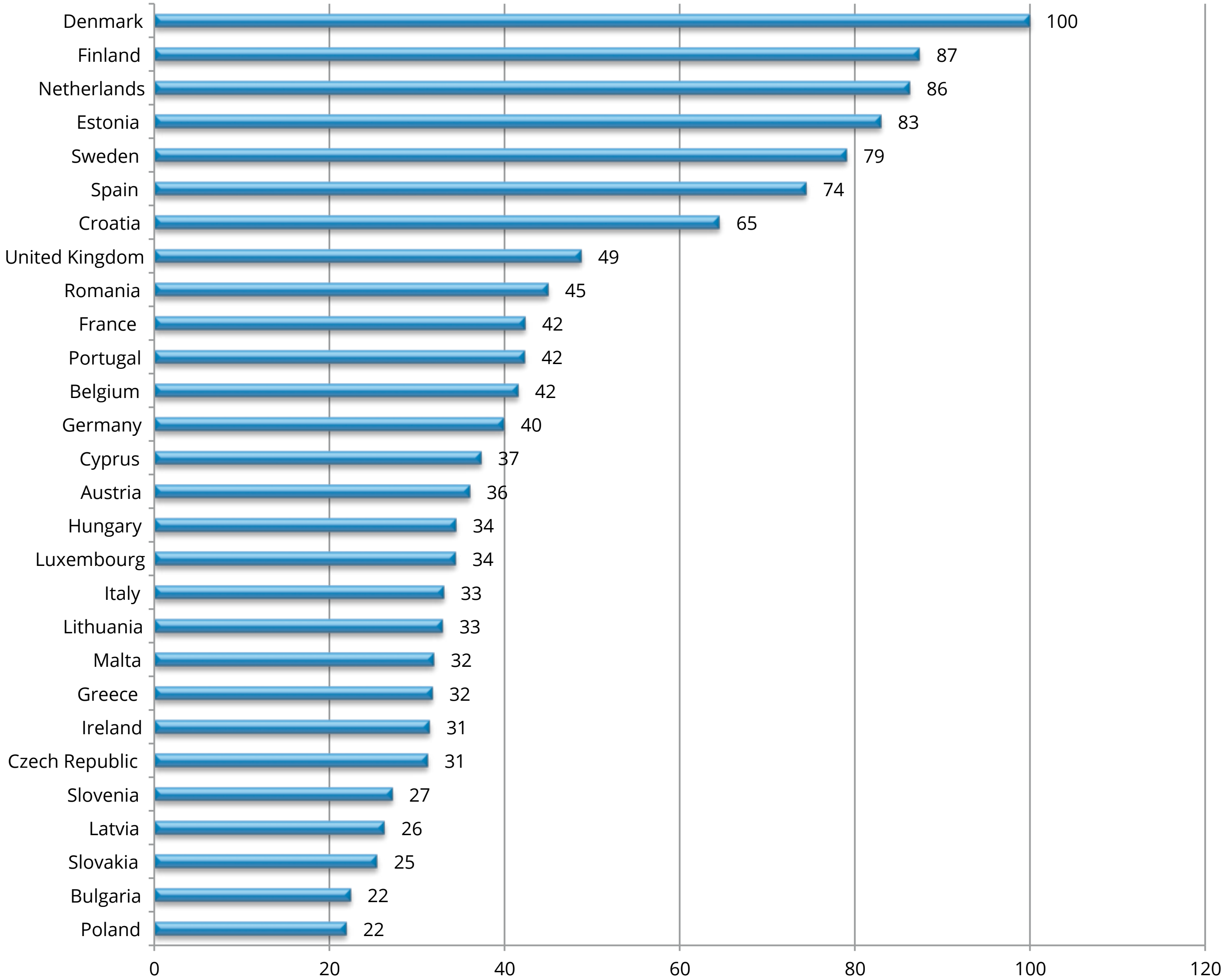


Fig 5.7 Level of eHealth in European countries (index ranging from 0 to 100)

Source: I-Com elaborations on EU Commission data



5.3. MOBILE HEALTH: A NEW OPPORTUNITY FOR HEALTHCARE SYSTEMS

5.3.1. Socio-economic impact of mHealth

The Internet of Things (IoT) has a considerable impact on the global economy, through the transformation of various sectors, including Health. This technology – known as mHealth as regards healthcare – is transforming the medical industry and is improving care system and cost efficiencies.

According to the report "Realising the benefits of mobile enabled IoT solutions" by PwC, commissioned by GSMA, the IoT could save up to €99 billion in healthcare costs in the European Union and add up to 93 billion EUR to the GDP. In particular, the largest savings would be in the area of wellness and prevention and in the area of treatment and monitoring. Moreover, the use of digital applications in healthcare could enable 11.2 million people with chronic diseases and 6.9 million people at risk of developing chronic conditions to extend their professional lives and improve their productivity[26].

In fact, connected smart devices are helping improve access to care and enable remote monitoring of chronic diseases and age-related conditions. In doing so, the connected devices will improve the quality of care, reduce response time, prioritise interventions, reduce clinic visits and cut costs. This will reduce the strain on the wider healthcare system, so that resources can focus on emergencies and cases requiring immediate attention[27].

According to the Green Paper of the EU Commission and definition by the WHO, mobile Health (or mHealth) is a component of eHealth and refers to medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices[28]. It also includes applications (apps) such as lifestyle and wellbeing apps that may connect to medical devices or sensors (bracelets or watches) as well as personal guidance systems, health information and medication reminders provided by sms and telemedicine provided wirelessly[29].

mHealth is an emerging and rapidly developing tool and holds enormous potential for facilitating the transformation of health services and data delivery by reaching wide geographical areas and in portable forms. Indeed, it allows for better coordination of care and is a key enabler for the provision of remote care services and health promotion[30].

Therefore, mHealth apps offer many advantages for patients, healthcare professionals and, in general, for healthcare systems[31]:

26 GSMA, Digital Healthcare Interoperability, October 2016.
27 PwC, Realising the benefits of mobile enabled IoT solutions, March 2015.
28 WHO, mHealth – New horizons for health through mobile technologies, Global Observatory for eHealth series Volume 3, 2011.
29 European Commission, Green paper on mobile Health (mHealth), 2014.
30 WHO, From innovation to implementation. eHealth in the WHO European Region, 2016.
31 European Commission, Green paper on mobile Health (mHealth), 2014.

- patients' engagement in their own healthcare is facilitated. In particular, mHealth supports the changing role of patients from a rather passive, to a more participative role while enhancing their responsibility over their own health through sensors that detect and report vital signs and mobile apps that encourage them to adhere to diet and medication.
- the use of mobile devices could help healthcare professionals and paramedic staff save up to 30% of time spent on accessing and analysing information. The healthcare workforce could be used more efficiently, supported by real-time communication with patients.
- analysis of the big data that mHealth generates may help improve healthcare effectiveness and disease prevention by providing healthcare authorities with a more accurate picture of patients' illnesses and behaviours.

However, some barriers are limiting the adoption of mHealth. These barriers are[32]:

- *regulatory*: an absence of adequate regulatory mechanism, lack of clarity on mHealth certification, lack of clarity on data protection legislation.
- *economic*: healthcare providers and policy makers require further evidence of clinical and economic benefits that mHealth can provide to increase its adoption. Other economic barriers are the lack of innovative and adequate reimbursement models for patients and limited awareness of benefits of mHealth.
- *structural*: low cohesion across levels of care and regions and lack of competition.
- *technological*: the absence of protocols to standardise solutions, lack of interoperability and late involvement of doctors in solution design.

The need for harmonisation between health and mobile regulatory frameworks, the lack of incentives for healthcare providers towards mHealth solutions and the absence of clearly defined business models aggravate the slow adoption of mHealth solutions; moreover, a perceived lack of an appropriate processing of the data collected through apps and a perceived lack of cybersecurity may be cause for concern for patients. So it is necessary[33] to:

- integrate mHealth with the nationwide healthcare strategy of various EU Member States to align the development of these solutions with their most relevant healthcare priorities.
- define the policies that encourage the development of mHealth solutions and harmonise the regulation between the delivery of healthcare and mobile health services.
- promote interoperability of healthcare systems.
- create the incentives that encourage patients and healthcare providers to adopt mHealth solutions.
- draft clear policies that safeguard the privacy and the security of health data and mitigate the risks connected to the use of mHealth solutions.

32 PwC, Socio-economic impact of mHealth. An assessment report for the European Union, June 2013.
33 Idem

5.4. THE GLOBAL MHEALTH MARKET

5.4.1. Categories of mHealth applications

The mobile health market comprises – as anticipated – a lot of applications that provide healthcare services through mobile communication and technological devices. According to GSMA and PwC, it is possible to categorize the mobile health services or applications in two distinct areas[34]:

1. Solutions across the Patient Pathway;
2. Healthcare Systems Strengthening.

With regard to Solutions across the Patient Pathway, most mobile health services and applications can be classified into five sub-categories – Wellness, Prevention, Diagnosis, Treatment, and Monitoring. In all these categories, the patient or consumer is the prime end-user and interacts directly with the services and applications.

- *wellness*: primarily includes self-help services that encourage people to adopt or avoid certain behaviours and practices to maintain or improve their general wellness and fitness levels. It includes content-based wellness and fitness services such as information tips, interactive games, applications and fitness monitoring through devices that measure body vitals while exercising. So, these applications encourage improved diet, physical activity and allow, for example, obesity management or quitting smoking;
- *prevention*: includes services used by government and non-government agencies to spread awareness and encourage people to adopt or avoid certain behaviours and practices to prevent or control disease outbreaks. These services and applications aim to leverage the reach of the mobile platform to mobilise communities and promote healthy living. Mobile health solutions addressing prevention are typically focused on reproductive health, child health, infectious diseases such as HIV/ AIDS and drug abuse;
- *diagnosis*: includes services and solutions that help healthcare professionals connect with patients geographically far away to provide diagnosis or triage. For instance, mobile telemedicine can also be used where both patients and healthcare professionals have access to high-speed mobile data transmission that enables video calls;
- *treatment*: includes services that help treat patients remotely and ensure adherence to the required treatment regimen. Compliance with treatment protocols is paramount to the success of effectively managing chronic diseases such as HIV or other illnesses (tuberculosis) that require patients to take their medicines at a certain frequency to avoid disease relapse;
- *monitoring*: includes monitoring patients to identify and confirm underlying illnesses and monitoring of the vital parameters of at-risk patients to track underlying conditions and take action in order to prevent exacerbation. Continuous monitoring is

34 GSMA and PwC, Touching lives through mobile health. Assessment of the global market opportunity, February 2012.

intended to assist in prevention, diagnosis, and treatment and after-care. For instance, body and heart monitors can help track the heart rate of patients and transmit the data to central servers accessible to physicians, who can then diagnose the condition or monitor the success of treatment and rehabilitation. Independent ageing services and applications that entail monitoring body parameters and activities of senior citizens are also included in this category.

Healthcare Systems Strengthening comprises mobile health services and applications aimed at improving the efficiency of healthcare providers in delivering patient care. This category can be classified into four sub-categories – Emergency Response, Healthcare Practitioner Support, Healthcare Surveillance, Healthcare Administration.

- *emergency response:* this category comprises solutions that enable rapid response in the case of emergencies. They include wireless system in ambulances to help paramedics interact with physicians' hospitals and send the vital parameters of patients to emergency rooms while they transport patients in emergency situations;
- *healthcare practitioner support:* this category includes mobile access to Information Technology systems and databases of varying sophistication – from the simple look-up of information (medical encyclopedias) to intelligent decision support systems that aid in diagnosis and treatment. It also includes the dissemination of medical information, training and updates to healthcare practitioners;
- *healthcare surveillance:* this category comprises services and tools that help healthcare workers collect health-related information of people and track the outbreak of diseases and epidemics. Through smartphones and PDAs with mobile connectivity, it is possible to provide timely information to the central planning authorities about disease outbreaks;
- *healthcare administration:* this category includes services such as appointment reminders, which can help reduce non-attendance rates and also improve patients' experience of the outpatient care process.

5.4.2. The current status and trends of global mHealth market

The market for mobile apps has developed very rapidly in recent years to become a key driver of mHealth deployment facilitated by smartphone penetration[35]. According to the recent estimations of IMS Institute and Research2guidance, the number of mHealth apps available to consumers now exceeds 165,000[36].

Most apps are published within Google Play or the Apple App Store. Each of the two main app stores offers almost 70,000 apps within the categories Health&Fitness and Medical (Figure 5.8)[37].

35 European Commission, Green paper on mobile Health (mHealth), April 2014.
36 MS Institute, Patient Adoption of mHealth, September 2015.
37 Research2guidance, mHealth App Developer Economics 2015, The current status and trends of the mHealth app market, November 2015.

Fig 5.8 Number of mHealth apps displayed in app stores

Source: Research2guidance, mHealth App Developer Economics 2015, The current status and trends of the mHealth app market, November 2015

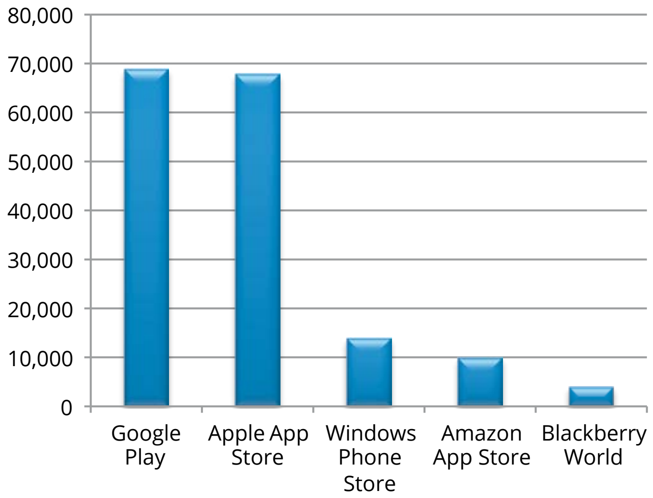
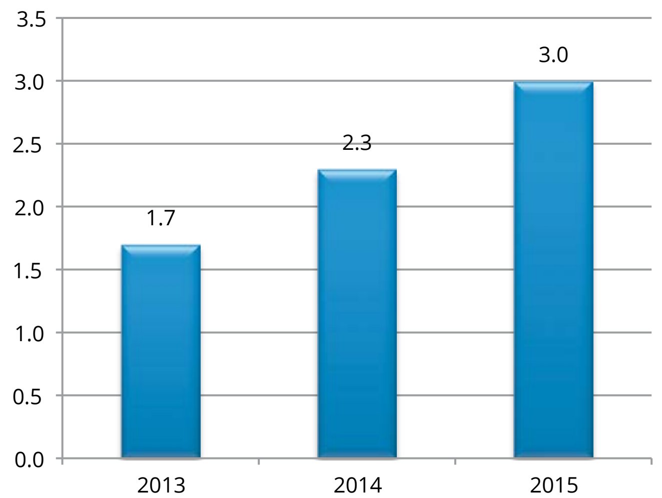


Fig 5.9 Overall downloads of mHealth apps (US$ bn)

Source: Research2guidance, mHealth App Developer Economics 2015, The current status and trends of the mHealth app market, November 2015



The demand for mHealth apps also is increasing every year. According to Research2guidance, 2015 was another fascinating year for mHealth: the total number of mHealth app downloads worldwide reached 3 billion from 165,000 app solutions on the market[38] (Figure 5.9). According to Allied Market Research, the global mHealth market was valued at US$ 10.5 billion in 2014[39] and it is expected to reach US$ 59 billion in 2020[40].

According to less recent estimates of GSMA and PwC reported by the European Commission in the Green Paper on mobile health (2014), the worldwide mobile health revenue is expected to reach about US$ 23 billion by 2017. The largest markets for mobile health services will be Europe (US$ 6.9 billion) and Asia-Pacific (US$ 6.8 billion) with 30% market share each, followed by the developed markets of North America with 28% share (US$ 6.5 billion). Latin America and Africa will get a share of 7% (US$ 1.6 billion) and 5% (US$ 1.2 billion) respectively (Figure 5.10).

Germany is expected to be the largest market in Europe with revenues of about US$ 1 billion in 2017. Other large markets for mobile health in Europe will be France, Italy

38 http://research2guidance.com/2016/02/09/the-2016-mhealth-app-developer-economics-study-has-been-launched-take-part-today
39 https://www.alliedmarketresearch.com/mhealth-2015-market
40 https://www.alliedmarketresearch.com/press-release/mhealth-market-is-expected-to-reach-588-billion-globally-by-2020.html

Fig 5.10 The worldwide mobile health revenue (2017, estimates)

Source: GSMA and PwC

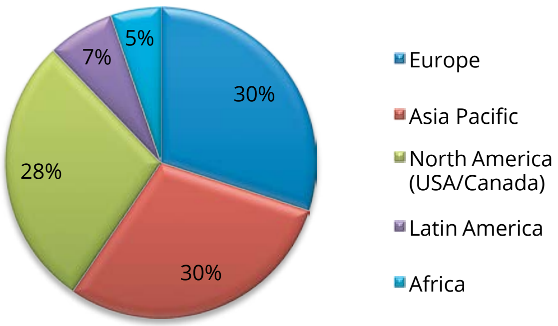


Fig 5.12 mHealth market by service categories in Europe (2017, estimates)

Source: GSMA and PwC

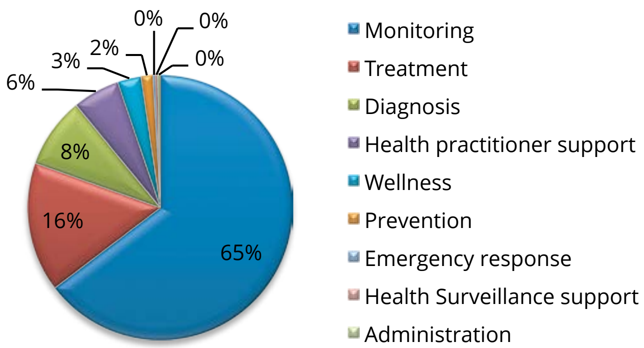
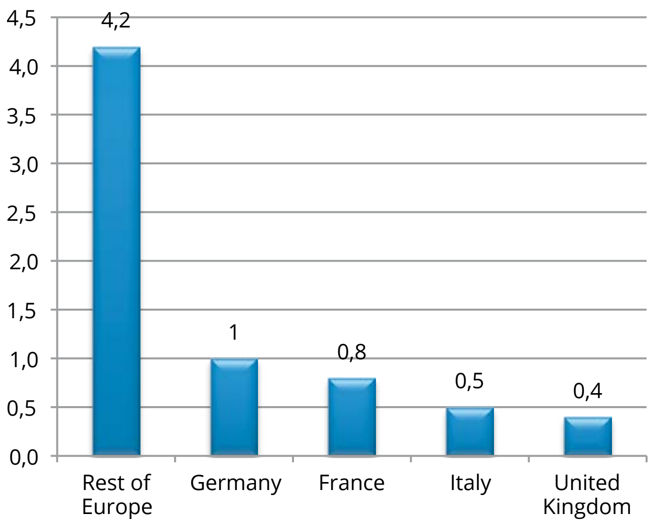


Fig 5.11 mHealth revenues in Europe by country (2017, estimates, US$ bn)

Source: GSMA and PwC



and UK (Figure 5.11).

Monitoring solutions and patient treatment will constitute almost 70% of the total mobile health market in Europe (Figure 5.12). Other important categories will be diagnosis (which includes mobile telemedicine) and health practitioner support.

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