



***Industry 4.0:
A Comprehensive
Approach
- Main Features and
Impacts on SMEs***

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Abbreviations and Acronyms

AI	Artificial Intelligence
BM	Business Model
CPS	Cyber Physical Systems
EU	European Union
GDP	Gross Domestic Product
HE	Higher Education
I4.0	Industry 4.0
ICT	Information and Communications Technology
IoP	Internet of People
IoT	Internet of Things
IoTS	Internet of Things and Services
MES	Manufacturing Execution Systems
OECD	Organisation for Economic Co-operation and Development
PSS	Product Service System
R&D	Research and Development
SME	Small and Mid-sized Enterprises
US/USA	United States of America

Welcome Note



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Dear colleagues,

In less than a decade, Industry 4.0 have grown from a blurry vision to a concept for digitising the European industry. It aims on increasing of the competitiveness of enterprises through development of product, process and business model innovations by implementation of various technology solutions. The scope of Industry 4.0 is very broad including tools and platforms such as: Internet of Things, Big Data and Cloud-Computing, Autonomous Systems, Artificial Intelligence etc. This variety contributes to infinite possibilities offered to companies, but also develops high entry barriers for companies with limited resources, which may contribute to additional lagging behind in technology and productivity of the small and medium-sized enterprises (SMEs).

This brochure aims to bring Industry 4.0 closer to SMEs, providing initial insight in the concept, its scope, and its potential impact on the innovation and competitiveness of SMEs. This brochure is a tool aimed to support the inception phase of implementation of Industry 4.0. It has been developed in the project **“Changing SME business by Industry 4.0”** – the CHAIN Project, financed through the Erasmus+ programme – Higher Education Strategic Partnerships.

The Chain project aims to contribute to the Digitizing European Industry initiative. Currently we are suffering a ‘de-industrialization’ process, in part due to the rise of manufacturing in other parts of the world and the growing automation. In 2012, in response to this decline in the relative importance of industry, the European Commission set a target that manufacturing should

represent 20% of total value added in the EU by 2020. Industry 4.0 (I4.0) could boost the productivity and value added of European industries and stimulate economic growth. As part of its new Digital Single Market Strategy, the European Commission wants to support all industrial sectors exploit new technologies and manage a transition to a smart industrial system. What I4.0 is trying to achieve is the improvement of the manufacturing process by utilizing atomization and data collecting. The effects of which are brought on by the implementation sensors, microcomputers and transceivers that allow the whole factory to not only have its physical embodiment, as also as a cyber-physical structure. This fact and cloud computing and other state of the art technologies will allow the machines to communicate with each in real time allowing for better performance, larger flexibility in product customization, decrease in labour costs, lower waste creation and the downtime of machines would be optimized. Chain aims to provide a basis for the creation of new competencies for HE students and SMEs (managers and owners) to deal with the change brought by this “revolution”. Europe needs to learn to deal with a profound digitization of society which is already blurring the lines between workers and self-employed, goods and services, or consumers and producers. there are challenges for SMEs in participating in I4.0 supply chains (costs, risks, reduced flexibility and reduced strategic independence). Chain aims to create a Position Paper on I4.0, encompassing, in addition to the definition of I4.0 and its main defining elements, a discussion of innovation and I4.0, a review of theories of innovation and technological revolution and illustrative examples of the transformation impacting at the economy and society in general by I4.0 and particularly on SMEs, as well as a set of Case Studies that highlight strategies and practices implemented by SMEs in the context of the growing digitization and the challenges the new paradigm poses and the practical impacts on work, employment, skills and business models. Chain will create a Manual for learners and teachers that will be the basis for a small course on I4.0. Finally, an interactive documentary about I4.0, aimed at several audiences, will be available online.

We wish you a successful journey in the fourth industrial revolution, hoping that we will accompany and support you to get to your destination.

Doris Kiendl, FH JOANNEUM

Graz, July 2019

Vitor Hugo Ferreira, Polytechnic of Leiria

Leiria, July 2019

1. Introduction

Bojan Jovanovski, FH JOANNEUM

“Europe will only be able to maintain its leading role if the digitisation of the industry is successful and fast. It requires a joint effort across Europe to attract the investments we need for growth in the digital economy”

Günther H. Oettinger, Commissioner for Digital Economy & Society

Industry 4.0 is the new Industrial Revolution focusing on digitalization and integration of the value chain. This, fourth industrial revolution changes the production processes and the logistical activities along the supply chain. The main goal of the implementation of Industry 4.0 in a company is to reach higher productivity and flexibility. This cannot be achieved only through improvements in the production process through incremental and disruptive process innovation, but rather through thorough technological and organisational transformation and updating the business model of the company. These aspects will be systematically discussed in the following chapters of this publication.

A **business model** describes the rationale of how an organisation creates, delivers, and captures value. (Osterwalder & Pigneur, 2010, p. 14)

Enabling different types of innovations, the implementation of Industry 4.0 fosters an evolution to systems in which the interaction, and even integration, of different previously rather independent business elements is achieved. Many large corporations, which have the resources and strategies for development, recognised the importance of adoption of these new practices. In the beginning of this decade, the early adopters seized the opportunity to develop an additional competitive advantage, chaining “the game” and setting it as a requirement for catching up and keeping market share. This second wave is increasingly engaging small and medium-sized enterprises (SMEs), many of whom are still in the phase of screening and cost-benefit analysis. In order to support them in this process, chapter 6 offers analysis of the main benefits and obstacles for SMEs in the implementation of Industry 4.0. Nonetheless, it is expected that like in the previous revolutions, when the changes are influencing many segments of the companies’ operation and the ecosystem itself, those that will fail to adapt, will fail to survive.

Porter (1990) emphasises the importance of the competitiveness on micro level (the firm) to the competitiveness on macro level (the nation). He also stresses the importance of a well lead innovation for development of competitive advantage. At national level, the competitiveness has been defined in different ways by different authors. Delgado et al. (2012) define, “foundational

competitiveness as the expected level of output per working-age individual given the overall quality of a country as a place to do business". They stress that competitiveness has to go beyond the expected level of productivity per worker, since prosperity lies in the ability to achieve high productivity while mobilising high share of the available workforce capacities. Silvia, (2006) analysing different literature definitions, presents three key approaches in defining macroeconomic level competitiveness: Competitiveness as productivity; Competitiveness as capacity to create welfare; Competitiveness as ability to sell on external markets. Luckily, the impact of the implementation of Industry 4.0 on the company's competitiveness, has become clear to the policy makers. Liao et al. (2017) has studied 18 public policies, all of them based on the German Industry 4.0 related national initiatives concluding that their main goals for more than half of them (55,6%) is to increase, maintain or regain competitiveness, and even more (61,1%) are expecting to support economic growth. To achieve those targets, specific activities, mainly related to Innovation and Technology (66.7%), are carried out and applied on three objects: human (61.1%), product (55.6%), and infrastructure (44.4%).

The concern with the challenge of shrinking portion of manufacturing in European Union's GDP, contributed the Industry 4.0 to be addressed very seriously. One of the main documents is a communication from the European Commission to the Parliament for "European Industrial Renaissance" in 2014 (COM, 2014 /14). It highlights cloud computing, big data and data value chain developments, new industrial applications of internet, smart factories, robotics, 3-D printing and design as the new technological opportunities for industrial modernisation. The conclusions of this document are aiming at increasing the industrial competitiveness through inter-areas policies, increased local-, national-government and EU investments, setting the specific objective of raising the contribution of industry to GDP to 20% by 2020.

In order to achieve this objective, the European Commission has earmarked € 80 billion in the period 2014 – 2020 for research and innovation including support for development of key enabling technologies, the Horizon 2020 programme. According to "Horizon 2020 First results" publication by European Commission (2015), even in the inception phase, the first 100 calls, many key indicators of the programme were reached. The increased number of new institutions involved (38%, 3 times more than in the previous FP7 programme's last call), high involvement of SMEs (the target of 20% budget for SMEs was achieved), and almost all grant agreements (95%) were signed in the targeted period. Unfortunately, we will have to wait for few more years for ex-post evaluation of the programme and for the measurement of the real impacts on industry transformation. What is clear now is that the focus of the European Commission and the Horizon 2020 programme has encouraged local, regional and national governments across Europe to develop different financial and non-financial support for reindustrialisation and increasing of the competitiveness of the European Union. The focus in most of these enablers is fostering innovation through further development of the ecosystem and supporting SMEs for restructuring, modernisation and knowledge acquisition.

Overall, the European landscape on one hand is pressuring SMEs to set implementation of Industry 4.0 higher at their agenda, and on the other is offering significant support in the process, which makes it the right time to start. This publication is designed to be the inception point of preparation for this important transportation.

2. Theory of Innovation and Technical Revolution

Fernando Sousa, AidLearn

"Speed is the new currency of business"

Marc Benioff, CEO, Salesforce

Innovation, as a research construct, has its roots in the fields of economics and engineering, later in sociology, political science and education and, only recently, social psychology. As mentioned by Rowley, Baregheh, and Sambrook (2011), the variety of models, frameworks, classifications and definitions of innovation make it difficult to understand the connection between all the definitions reported by different researchers, as well as the relationship between the various types of innovations. Schumpeter (1934) is acknowledged as being the first to state that innovation is the introduction of a new product, unknown qualities to the market, a new quality in an existing product, a new production method, or a new form of commercial treatment of an existing product, a new market to the sector in question, regardless if the market already exists or not, new suppliers of raw materials or semi-manufactured, or some form of monopoly. Schumpeter and other scholars in his field such as Freeman (1982) changed the view of the static equilibrium from mechanical engineering and classical economics, gradually abandoning the search for a relationship between macroeconomic measures, or the exploration of new technologies. Instead, they focused on the issue of national innovation systems (using a systemic approach, or the analysis of the innovation process at the organisational or institutional levels) as a process not only technical but, mainly, social, characterizing political and learning features. Progressively, starting from an invention perspective, as in Cebon, Newton, and Noble (1999) ...*the utility of an invention in the production of new products or services, or in improving the existing ones, or in improving the way they are produced or distributed*, the orientation has democratized itself, dropping the requirement of absolute novelty, as in Damanpour (1984) ... *the implementation of an idea produced or adopted regarding a product, artifact, system, policy, program, or service that is new to the organisation when it is adopted* and, recently, the tendency is to reinforce the direction to the customer and the market, as Coakes and Smith (2007) refer ... *to introduce the right products at the right time, in the right markets with the adequate distribution network and then continue to update, optimize, and remove them when necessary*.

There are various approaches to identify the different types of innovation. While Cebon et al. (1999) propose separating the adoption of products and processes from its development, the more classical way, distinction between product or process innovations is made. According to Adams (2006), most authors agree that the innovation capacity or organisational innovation, is a third important type of innovation, representing the potential of the workforce to promote changes for the organisation's benefit. As Huhtala and Parzefal (2007) state...*to remain competitive in the global marketplace, organisations need to develop continuously innovative and*

high quality products and services, and to renew the way they operate, based on the continuous ability of its employees to innovate.

Similarly, and although innovation can take place through the adoption or development of a product or service, available through investment in R&D or technology acquisition, only by creating and sustaining a creative workforce can the organisation develop a potential susceptible to overcome problems and difficult situations, which cannot be solved only through investments (Cebon et al., 1999). And although it is true that the use of the innovative potential of the workforce is not reflected in general, in radical innovations (Love & Roper, 2004), it should be understood that it is in small incremental innovations that the main innovative potential lies, occupying today more than 80% of every innovation introduced. This innovation is directly linked to forms of collaboration that are increasingly the basis of innovation (Uzzi & Spiro, 2005).

2.1 Technological Revolutions

If we look at the evolution of how people organize themselves to do their work, we find that we are in a technological cycle that continues the industrial revolution of the 1970s, when countries destroyed by the Second World War, such as Germany and Japan, began to ponder in the world economy. It was the end of the 1930s Fordist vertical model of large multidivisional companies (M-Form), in which professional managers (instead of the owners) coordinated the various stages of production within the company. This model was largely theorized by economists and sociologists such as Joseph Schumpeter, Talcott Parsons, Herbert Simon or Alfred Chandler, Weber's followers (Langlois, 2015).

The modern organisation has its roots in the North American revolution in transportation (railroad and steam ships) and in communications (telegraph and submarine cable) in the 1870s, which paved the way for the revolution in production and distribution (Chandler, 1990). That is why the railway companies became the pioneers in management, as early as in the 1850s, when there were already 9,000 miles of lines, with the typical company having less than 50 miles to no more than 500 miles. Around them were companies specialized in certain types of carriages, with the respective warehouses, as happened with the petroleum or bed carriages. These companies developed internal administrative procedures, accounting and statistical control, as well as the separation of management and property, as the financing needed growth beyond the available family capital.

The type of collaboration required between railway companies, in order to standardize the equipment, was a new phenomenon but with little success, given the pressure of competition. Were the middle-level managers who, becoming increasingly professional, made an integrated network possible in the 1880s. The federations still appeared as a solution, before the construction of a system, as the decrease in traffic forced the reduction of tariffs. However, the

speculators precipitated the events, giving rise to the merger and the existence of companies such as South of Santa Fe, at that time the largest in the world. In 1890, the railways already had the current configuration and, from 1893 on, bankers like J. P. Morgan played a fundamental role and replaced the state as a centralising entity of governance. And while bankers had great power in boards of directors, professional managers had even more, which gave firms the characteristic of management capitalism rather than financial capitalism.

Still in the USA, in the other sectors, the evolution was faster in distribution than in production, especially in cereals and cotton, since the necessary innovation was more organisational than technological. Before 1850 wholesalers sold on commission, except in cities, and commodity dealers bought directly from farmers and sold to manufacturing companies. After the Civil War the wholesalers were replaced by mass retailers in the form of supermarkets, mail order and chain stores. Macy's and Bloomingdale's (1869) in supermarkets, as well as Sears & Roebuck, in mail orders, went beyond the concept of supermarket, forming distribution networks, and took the place of wholesalers by adopting a single price policy. Although they included the production of goods which they did not find at desirable prices, specifications or quality, they preferred to concentrate exclusively on sales. They also started using advertising, giving rise to the first advertising agencies.

The second industrial revolution (1850-1970) was characterized by the separation between the ownership of the company and its management, made by salaried professionals, as well as by functional or divisional specialization (Multidivision, or M-Form). General Motors, which created the post-Fordism model with Alfred Sloan (1920), marked the advent of the modern company, which was maintained until the 1970s. It was the era of steel and electricity that, combined with the combustion engine, allowed a radical increase in the speed of transportation and mass production. However, the true revolution in production was not the electrification but, 60 years later (1920), its organisational adaptation to individual machines, as in 1911 had been the placement of the transmission belts on the assembly lines. Despite the great transformations after 1871 (German unification, Long Depression 1873-79, Franco-Prussian War and Paris Commune), 1914-18 (World War I), 1929-34 (Great Depression), and 1939-45 (World War II), this period is considered only as one revolution, which included the invention of the welfare state, first by Bismarck, in Prussia, in the late nineteenth century, and then in England and the Nordic countries. The Great Depression demonstrated the inability of the private sector to maintain growth by balancing supply and demand, which led to a progressive increase in state intervention in society, with Keynes as its herald, accentuated by World War II and the crisis of the mega governments in the 1970s.

This revolution transformed the food and beverage industries (eg. Quaker Oats, with the breakfast cereal industry, Heinz with automatic packaging, Nestlé with condensed milk), much due to the innovations of Thomas Edison and Werner von Siemens, which made mass production possible with the distribution of electric energy, as already mentioned. In the US, companies like

Otis, Singer, Eastman, and Westinghouse were among the first to take advantage of the enormous electrical potential made available by the Niagara Falls.

But it was the light armament industry, in the 1850s, that drew what can be called the "American system of manufacturing," later perfected by companies like Singer in the post-depression in 1880, where 75% of sewing machines in the world were produced. The innovation in the offices came later with Remington (who switched from guns to typewriters) and, above all, computerization in the 1970s, which began the industrialization of services.

This period is perhaps best known as Fordism and mass production, which is the hallmark of American industry, although this designation can only be ascribed to Alfred Sloan, CEO of General Motors (Sloan, 1963). Although propagated by the automotive industry, mass-production techniques first appeared in the liquid or semi-liquid processing industries, such as crude oil and then cereals, cotton and tobacco.

Innovation, although favoured for machines, increased quality of raw materials, intensive application of energy sources and design of factories, was mainly organisational, revolutionising the movements of workers in manufacturing, as well as forms of coordination and control by management. The oil industry is an example of continuous production. Founded in Titusville, Pennsylvania, in 1859, it took roughly 20 years for Rockefeller to produce two-thirds of the world's oil with only three major petroleum refineries. This would have been impossible in industries such as cotton, textiles or furniture since production would have exceeded the market's consumption possibilities. It was, in fact, the reduction of consumption, during the depression of the 1870s which emphasized the need for organisational innovation over technological innovation.

2.2 *The Information Age*

The third industrial revolution (1970-?), with the oil crisis and the advent of the economies recovered from the World War (Germany and Japan), marked the end of the great vertical enterprise. It was the era of specialization, in which companies disintegrated and relocated, retaining only design, development and marketing. In the face of neo-liberal policies inspired by Milton Friedman, which favoured deregulation (e.g. Thatcher, Yeltsin, Carter and Reagan), and taking advantage of the internet and new technologies, companies were pulverized, following the principle of Ronald Coase (1937) that when transaction costs exceed the organisational costs the company must autonomise units or subcontract activities.

The electronic revolution was similar to electricity. In 1956 the transatlantic cable replaced radio communications and in 1965 satellite communications were installed. In the 1970s the computer already coordinated production, marketing and finance, especially in multinational companies, which leased telephone lines. Companies such as Xerox, Texas Instruments or

Motorola, emerged because of the new technologies and because they had a broader range of choices in terms of suppliers and product outlets, reinforced vertical integration.

The 21st century emphasized specialization (and "Fordism" modularization), but it did reverse the de-verticalisation, given the need to integrate knowledge to innovate, together with the need for regulation caused by the 9/11, the crisis and the financial scandals. However, Trump's policies, perhaps the main brand of this century, are again in the deregulatory sense, accentuating the tendency that has already occurred to restore the regional clusters of knowledge, strongly reduced with relocation, together with the capacity to innovate.

2.3 *Where do we go from here?*

The days of simple product innovation seem to be over, as the fourth industrial revolution (also known as Industry 4.0) gives rise to new innovation ecosystems, which are building greater complexity into our final innovation offerings. And this exponential pace of change is increasingly reliant on collaborative platforms to realize the result, as we have unprecedented processing power, storage capacity, and access to various avenues of knowledge, combined with emerging technology in fields such as artificial intelligence, robotics, 3D printing, nanotechnology, biotechnology, material science, and quantum computing. But the technological question alone seems not enough to explain the 4th revolution in simple words, perhaps because it is occurring in the bottom - up perspective, with companies bringing in new digital solutions every day. On one side, we are seeing advances and retreats in organisational models, with companies in various stages of evolution (in a sort of a "revolution averaged 2.2"). Also, we witness the cohabitation of companies' representative of the merging of physical, digital and biological frontiers, with others of a more classic model (also updated and successful in the market). On the other side we are facing the crisis of the State, with a crisis of ideas and of being an enemy of freedom, in terms of creed, expression, private life and property (Micklethwait & Wooldridge, 2014).

Keeping the organisational perspective, what the XXI century brings us is the increase in vertical specialization, or "de-verticalisation", accentuated in the 1990s by the relocation and specialization of the productive process, in which companies could retain design, development and marketing (branding), but not manufacturing and maintenance, after-sales, or even research. Just as the post-Civil War globalization of the US was revolutionary through standardization and volume of production, so is the present outsourcing, in response to the possibilities of coordination and extension of markets allowed by technology. In a way, it is a return to the modular Fordism system, but in a non-vertical way, in which distribution ends up playing the main role in value creation, understood as the ability to deliver the maximum possible utility to the final consumer, at the minimum cost.

If we may have doubt regarding the evolution of the organisational model, this is not the case with the certainty that creativity and knowledge will continue to be fundamental in

innovation. Regardless of the organisational form adopted, we know that the growing specialization of knowledge will increasingly be based on collaborative teams, whose integration requires sophisticated social techniques to produce collective innovation. Teams that are guided by forms of leadership capable of effecting the adjustment between ends and means, as external conditions change.

It is in the maintenance of a balance between the company's routines, capable of generating automatic forms of problem solving, and the creation of new, change-generating capabilities, that the primacy of people will continue to drive the evolution of organisations. A knowledge made of a tacit and subjective character, hardly transmissible outside the networks in which it is established, and more resident in the connections between individuals than in individuals themselves.

3. Definition of Industry 4.0

Martin Tschandl, FH JOANNEUM

Clemens Fischer, FH JOANNEUM

Emilie Chapotot, ESTIA

About 80% of all European exports are industrial goods. The European industry accounts for 16% of EU GDP and employs about 32 million people in more than 2 million businesses. These figures show that the industry is an engine for prosperity and growth in Europe (Plattform Industrie 4.0, 2019). For many decades an ongoing process of industrial automation and digitalization has been one of the sources for European companies to succeed in global competition. In 2011 at the Hannover fair a political initiative branded this process with an “industry 4.0”-label as a proposal for the development of a new concept of German economic policy based on high-tech strategies (Mosconi, 2015) to preserve and foster the industrial competitiveness. In almost every European country, industry is now forced to increased and systematic digitalisation in order to become more efficient (cost reduction), more flexible (individualised products without increasing costs apiece) and – above all – to innovate new, digitalised business models. Thus, digitalization has become an indispensable success factor for European companies (Tschandl/Kogleck, 2018). Before using Industry 4.0 massively as a common concept in the world, many strategic initiatives have been led (Figure 3-1). It depends mainly on the geographic origin: “Smart manufacturing” in the United States of America, “Internet +” in China, “Factory of the future” in France and finally “Industry 4.0” in Germany.

Additionally, the emergence and finally the omnipresence of IoT solutions in our daily lives force industries to adapt their organisation to a high level of connectivity. The upheaval of our practices brought by internet and digital technologies now reached manufacturing process in industries. This need of connection starts a deep change and give a new paradigm – Industry 4.0. It is based on holistic organisation of processes. This new organisation considers the decentralization of decisions with information spread through all the company entities. Thus, company will be more responsive and more agile in facing ecosystem changes. Business executives have to redesign their business model to begin the transition to Industry 4.0. It refers to a phenomenon related to new consumer uses and new objects that directly impact the current business models and organisations. It is increasingly associated with the definition of digitisation and this term is increasingly used in the context of the digital transformation of companies (Mario, Hihigoyen, 2019). Facing digital disruption, digital transformation has become a major and strategic issue for all organisations of all sizes: business, marketing, human resources, production process, information system, data, etc. (Vivier, Ducrey, 2019).



Figure 3-1: Overview of European Initiatives on Digitising Industry (European Commission – state 11/2018)

3.1 Digitization and Digitalization

Fraysee (2013) based his definition of digitalization on three different approaches: First, from the business point of view, digitalization is like partially or totally changing a product, a service, a brand or a business activity in the digital world. This transformation also considers information technology and communication as well as connected uses of consumption. Second, from an organisational point of view, it corresponds to the conduct of the change inherent in the integration of ICT (Information and Communications Technology) in the processes and organisation of work. Third, it can be defined as the explosion of life that is daily associated with multiple screens. Brennen and Kreiss, however, base their

Internet of Things - A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies. (ITU-T, 2012)

definition on the third view of Fraysee, the social life and how people interact with each other in the 10s of the 21st century (Brennen, Kreiss, 2014; Bloomberg, 2018).

In the narrow sense of digitalization in the industrial context it can be defined as the transformation of business models using digital technologies and their internet based Internet of Things (IoT) networking to create value (Wallmüller, 2017; BMWI, 2015). This implies the increasing transformation of (all) analogical information into data that can be processed with information technology (digitization). Digitalization can take place on three levels: (1) products and services, (2) processes and decisions, and (3) business models (Matzler et al., 2016).

Digitization is defined, as the conversion of analogue information in any form (text, photographs, voice, etc.) to digital form. (Schallmo and Williams, 2018)

In general digitalization implies the integration of digital technologies into everyday life by the digitization of everything that can be digitized. Consequently, digitization can be defined, as the conversion of analogue information in any form (text, photographs, voice, etc.) to digital form (Schallmo and Williams, 2018) with suitable electronic devices (such as a scanner or specialized computer chips) so that the information can be processed, stored, and transmitted through digital circuits, equipment, and networks. In this context three terms are used partly overlapping in literature: digitalization, Internet of Things (IoT) and Industry 4.0 (I4.0).

Digitalization implies the integration of digital technologies into everyday life by the digitization of everything that can be digitized. (Schallmo and Williams, 2018)

The terms overlap in part and can be differentiated analytically as follows (see Figure 3-2): Digitalization covers the entire consumer IoT field (consumer IoT, e.g., smartphones, TV sets) and a large part of Industry 4.0, with the latter being a part overlaps with IoT (Industrial IoT), but also has components that can function without internet technology (e.g., automation, Manufacturing Execution Systems [MES]).

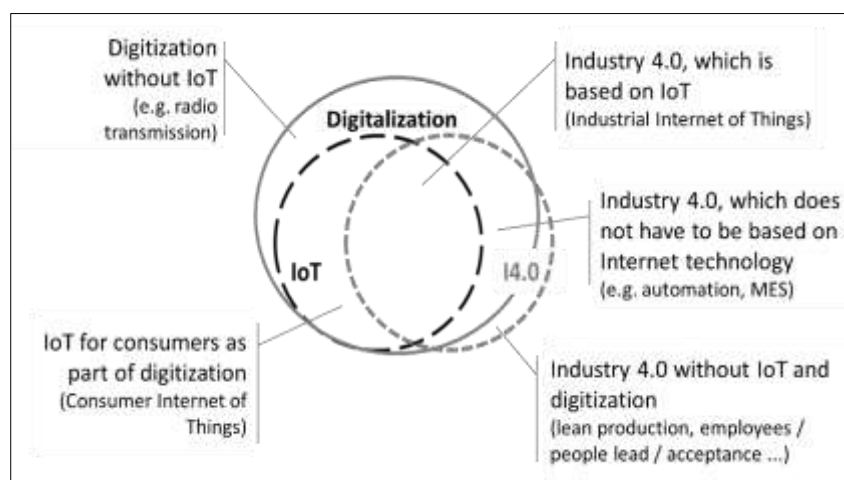


Figure 3-2: Definition of terms in digitalization

A smaller, but all the more important part of Industry 4.0 does not include digital technologies, which are lean production - management and people (e.g., acceptance issues). Finally, there are also digital technologies outside the terms of IoT and Industry 4.0 (e.g., digital radio transmission) (Bischof, Tschandl and Brunner, 2017).

3.2 Industry 4.0

Industry 4.0 is the fourth in a series of industrial revolutions (Lasi et al., 2014). Three industrial revolutions have hitherto led to paradigm changes in manufacturing process such as water and steam mechanization, mass production in assembly lines and automatization through IT solutions (Danjou et al, 2018). The fourth industrial revolution marks a new stage in the transformation of companies' organisation. All along the implementation of Industry 4.0 phenomenon, many definitions were given depending the context of applications. However, the term Industry 4.0 as well as digitization is not yet universally defined. Essential components of Industry 4.0 are the technical integration of cyber-physical systems into production and logistics, their interconnection via the Internet of Things and Services (IoTS), as well as the implications for value creation, business models, work organisation and downstream services.

More specific and widespread is the definition of "Platform 4.0" (Obermaier, 2016), for which the term is synonymous with the fourth industrial revolution, a new level of organisation and control of the entire value chain across the lifecycle of products. The basis is the availability of all relevant information in real time through networking of all entities involved in the creation of value. The combination of people, objects and systems creates dynamic, real-time optimized and self-organising, cross-company value creation networks that can be optimized according to different criteria such as cost, availability and resource consumption.

Kagermann et al. (2013) describe Industry 4.0 as a collection of seven concepts. Smart factories, cyber-physical systems, self-organisation, new systems in distribution and procurement, new systems in the development of products and services, adaptation to human needs and corporate social responsibility.

Internet of People - All networking functions take into consideration that Internet devices can be users' personal devices, and therefore exploit models of the human behaviour to determine the way these devices should operate in the network (Conti M., Passarella A., 2017)

Hermann et al. (2014) suggest definition of Industry 4.0 around its ability to design and provide new products to the variety and complexity intensification with low cost and low environmental impact. That means that Industry 4.0 presents a set of technologies and concepts linked to value chain reorganisation (Hermann et al., 2015).

Zeulka et al. (2016) states that Industry 4.0 is used for three, mutually interconnected factors; digitization and integration of any simple and complex technical, digitization of products

and services offer, new markets models. All the human activities are interconnected thanks to Internet solutions (IoT-Internet of Things, IoS-Internet of Services (Lasi et al., 2014; Ning, Liu, 2015) and IoP-Internet of People). These technologies help companies to spread information during all life cycle systems.

In his research activities based on risks identification, opportunities and critical factors of success for the Industry 4.0 in SMEs, (Moeuf et al., 2018) give a definition of Industry 4.0 that focus particularly on specific steering of SME. “the Industry 4.0 is an approach of industrial steering aim at real-time flow synchronization and unitary and customized Build to Order (BTO) from customers”.

The evolution due to new technologies and new market models highlight the necessity to identify new challenges in terms of management, skills, jobs and organisation. It is mentioned in the White Paper published by European Commission (COM (2017)2025), “Making the most of the new opportunities whilst mitigations any negative impact will require a massive investment in skills and a major rethink of education and lifelong learning systems.” This is the main objective of CHAIN project to changing SME business by introduction of Industry 4.0 concepts and preparing a new future with strategic guidelines for HE students.

4. Technological and Organisational Transformation

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4.1 Organisational Innovation

Innovation is one of the main drivers behind organisational transformation. It is almost a given fact that, through the adoption of innovation, organisations will be able to face increasing challenges, succeed and stay ahead of countries with cheap labour costs (Cardozo et al., 1993). An OECD (2010) report emphasized the potential of innovation for long-term economic growth, as well as its determining role in economic development and the competitiveness of nations and enterprises (Cefis & Marsili, 2006; Tellis, Prabhu, & Chandy, 2009). I4.0 and its main “components” are innovations that may help firms improve their competitiveness.

Innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.
Oslo Manual (OECD, 2005:46)

The scope of innovation and its related concepts is wide. Authors make distinctions between "diffusion" and "adoption" of innovations (Kimberly & Evanisko, 1981), as well as between the studies of "innovation" and "propensity for innovation" (Van de Ven & Rogers, 1988). Although there may be an overlapping between these concepts, several studies focus on the adoption of innovations in organisations and examine organisational properties that improve or impair organisational innovation.

The adoption of innovation is designed to encompass the generation, development and implementation of new ideas or behaviours. An innovation can be a new product or service, a new production process technology, a new structure or administrative system, or a new plan or program related to members of the organisation. Thus, innovation can also be defined as the adoption of a device, system, policy, program, process, product or service that is new to the adopting organisation, whether generated internally or acquired from the outside (Daft, 1982; Damanpour & Evan. M, 1984; Zaltman, Duncan, & Holbek, 1973).

Several of the concepts discussed in previous chapters are part of a new way of thinking industry and companies, as such adopting Industry 4.0 is part of an innovation process, but this innovation process is not only technological but also organisational (adopting this framework is an organisational innovation).

In their research, Ram et al. (2016), presented the refinement of the innovation process model developed by Rogers (1995), composed of the phases of initiation, adoption, implementation and its use, which results in the performance impact. The authors define the

phases of the innovation process, such as initiation, adoption, implementation and use. Initiation is defined as the phase that aims at the recognition of a need in order to find solutions, to identify suitable innovations and to propose some for adoption (Damanpour and Schneider, 2006). The adoption phase, which for Bouwman et al. (2005) is a decision-making phase where organisations consider investing in innovation. It is a step that reflects the evaluation of the proposed idea from technical, financial and strategic perspectives, making possible the decision to accept an idea and providing resources for its acquisition, alteration and assimilation (Damanpour and Schneider, 2006). This phase is the one, that the majority of European companies may be going through regarding Industry 4.0.

The implementation stage includes framing strategies that may counteract the users' potential resistance, as well as familiarize and train users in the applications, acting as a bridge to translate the organisational adoption decision into a series of individual adoption decisions (Bouwman et al., 2005). Use is defined as the stage in which the members of an organisation begin to apply technological innovation in their daily operational activities (Bouwman et al. 2005). Organisations adopt innovations to achieve performance improvements (Damanpour and Schneider, 2006), as such the dissemination and adoption of I4.0 depends clearly on the dissemination of the concept but also on the ability of firms to perceive the advantages of this concept. According to one study conducted by the consultancy firm Deloitte (2018), only one-third of the executives surveyed are highly confident that they are capable of acting as stewards for their organisation during this time of change. Further, just 14% are highly confident that their organisations are ready to fully harness the changes associated with Industry 4.0. And although executives say their current technology investments are strongly driven by technology that can support new business models, very few executives say they have a strong business case for investing in advanced technology (Deloitte, 2018). When asked what the hindrances were, executives most often point to a lack of internal alignment (43%), a lack of collaboration with external partners (38%) and a focus on the short term (37%) (Deloitte, 2018).

Product innovation: A good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user friendliness or other functional characteristics. (OECD, 2005)

Process innovation: A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. (OECD, 2005)

Marketing innovation: A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. (OECD, 2005)

Organisational innovation: A new organisational method in business practices, workplace organisation or external relations. (OECD, 2005)

Industry 4.0 is mainly an organisational innovation. Organisational innovation encompasses the generation, acceptance and implementation of new processes, products or services from an organisational environment in order to achieve better results (West, 2000). In the view of authors Lambert and Cooper (2000), when speaking of organisational innovations, we understand changes in the structure and processes resulting from the implementation of new managerial and

work concepts and practices, which may include the implementation of teamwork, in supply chain management or in quality management systems.

Following these definitions, we can identify organisational elements that point to a more specific definition of organisational innovation. In fact, Damanpour and Aravind (2012) define organisational innovation as the set of activities leading to changes in the company's structure, strategy and systems.

Therefore, innovation is a mean for changing an organisation, either as a response to changes in its internal or external environment or as a preventive action taken to influence an environment. Since even the most stable environments change (Hage, 1980), organisations continually innovate over time. Thus, the propensity for organisational innovation is more precisely represented when several innovations are considered rather than isolated innovations.

Based on a research of organisational innovation in the Danish business sector, Gjerding (1996) stated that organisational innovation is more frequent in manufacturing than in service sector.

Following the previous mentioned authors, we can state that organisational innovation in the company includes:

- introduction of significantly altered organisational structures
- application of advanced management techniques
- implementation of new or substantially changed strategic guidelines

Large numbers of resources have been channelled into technological innovation (processes and products), but they are not enough – organisational, methodological and management innovations need to be urgently considered. Mol and Birkinshaw (2009) argue that companies can benefit from their ability to invest in organisational innovation simultaneously with the ability to invest in product and process innovations. Acosta et al. (2015) follow other authors and show for a sample of Spanish SMEs that organisational innovation as a mediator role between several determinants and performance. Prange and Pinho (2017) highlight the mediator role of organisational innovation between personal drivers and international performance. In a study conducted by Camisón and Villar-López (2014) the authors state that managers should not focus solely on technological or non-technological innovations. The introduction of new organisational practices and methods are important and have a positive effect on the OP, facilitating the development of innovations in processes and products, although in the latter case it occurs indirectly through processes. Bingi et al. (1999) and Davenport (1998) concluded through their research that changes in business processes result in massive organisational changes for those performing best practices.

Summing up, I4.0 is a broad concept that includes new technologies but also new ways of thinking about production, innovation, work and customer service. As such, we may consider this as an “Organisational Innovation”, since it does include the introduction of significantly altered

organisational structures, new management techniques and new strategic guidelines. This type of innovation complements the technological innovations that companies may introduce therefore driving performance and changing companies.

4.2 *The Transformation from I4.0*

4.2.1 **The Impact of IT Investment in the Firm - a Brief Survey**

The value of new technologies and software for the organisation can be represented as the impact on the organisation resulting from its use, both at the level of business processes and at organisational performance level, including both the efficiency and effectiveness impacts or in competitiveness (Melville et al., 2004). Investments on technologies such as the ones that are part of this I4.0 framework can provide differentiated impacts. Kraemer et al. Gurbaxani et al. (1994) found ten different dimensions for the impacts of IT related technologies on organisational performance, of which several are part of I4.0 today:

1. Organisational effectiveness, regarding the potential impact of IT in decision-making, communication, coordination and planning processes.
2. Organisational efficiency, regarding increasing gross margin and reducing labour costs and productivity.
3. Innovation in introducing new products and / or services in the market, by introducing new features enabled by technology, by reducing the development times of new products and by increasing reliability in terms of quality and delivery times.
4. Automation of production – increased production capacity and reduction of design costs and product customization for small market segments.
5. Relationship with customers in terms of ease of information exchange and real-time transactions.
6. Improvement of products and / or services in terms of quality and cycle time.
7. Interorganisational coordination with the main business partners, allowing the geographic expansion of the target market and better coordination with customers and suppliers.
8. Relationship with suppliers, reducing transaction costs and faster information exchange.
9. Marketing support with regard to market research and the identification of new market segments.
10. Competitive dynamics, in terms of building entry barriers and reducing the response time to the market.

Zuboff (1985) identified automation and information as the two primary dimensions of corporate goals in IT related implementations. The investments in automation and support for transactions aim at the efficiency of operations, usually in terms of cost reduction and

replacement of labour by capital. Informational investments are designed to provide more and better information and communication facilities to improve decision-making processes. Turner and Lucas (1985) added the strategic dimension whose investments seek to change the way in which the organisation competes or even the nature of its products and/or services with a view to increasing market share and gaining competitive advantage. In order to develop a measurement instrument that identifies the various dimensions of the benefits of information systems projects, Mirani and Lederer (1998) identified three sub-dimensions for each of the three main dimensions:

Strategic benefits:

- Competitive advantages provided by changes in business processes.
- Alignment characterized by the support to the organisational objectives and the best connection of the organisation with its immediate and general surroundings.
- Relations with customers, for the improvement of the image abroad.

Informational benefits:

- Speed and ease of access to information for decision-making.
- Quality of information, making it more useful, reliable and accurate.
- Flexibility of information, facilitating its manipulation in terms of content and form.

Transactional benefits:

- Communication costs.
- Development of systems in terms of cost and time.
- Efficiency of business processes and better use of human and material resources.

Mooney, Gurbaxani, and Kraemer (1996) proposed three complementary effects of IT in business processes that can create value for organisations. First, the effect of automation, essentially related to efficiency. The use of robotic production systems or just-in-time systems are examples of this, resulting in increased productivity or cost reductions (Hitt & Brynjolfsson, 1996; Mukhopadhyay, Kekre and Kalathur, 1995). The second effect, the informational one, derives from the ability of IT to collect, store, process and disseminate information. This effect provides a quality improvement in decision-making, communication and relationship with their stakeholders, quality of planning and the overall effectiveness of the organisation (Goodhue, Wixom and Watson, 2002). Third, the transformational effect, which refers to the ability of IT to facilitate and support innovation and change in the way business processes are executed. This effect can result in reductions in cycle time, increased responsiveness and flexibility of the organisation, and redesign of the organisational structure.

Davenport et al. (2004) argue that the impact of these types of systems on performance is realized through three vectors: integration, optimization and information. Integration comes from the centralization and standardization of databases and applications, ease of access and

information sharing throughout the organisation as well as with its key business partners. Optimization is linked to the improvement, change or reengineering of business processes and the mutual adjustment between current or desirable work practices and the system. The information relates to the use of the system to improve the decision making in the company and implies the production of reliable, consistent, complete, timely and accessible information throughout the organisation.

Looking at the I4.0 technologies framework we can map more specific impacts than the ones described above.

4.2.2 Customers

It is expected that these technologies will allow more adapted, engaging experiences for customers, from initial research and sales to account management and aftermarket service (Hood et al., 2016; Cotteleer and Sniderman, 2017). Customers may interact with the company through several touchpoints, that generate data that can be aggregated with historical information and data from other clients to better understand and even predict customer preferences or be fed back into the research and development process to inform better-designed offerings (Cotteleer and Sniderman, 2017). This information collected from connected systems can improve selling and marketing strategies, expand the customer experience and enable companies and their partners to offer post-sales support to customers, strengthening the customer relationship (Hood et al., 2016; Cotteleer and Sniderman, 2017). The journey of the customer will be determined not just by the physical product but by the information, analytics, and customization that make the customer's interaction with that object more transparent, and the ways the company acts on the insights they gather. Through connected products, digital marketing, connected value chains, companies will maintain a stronger degree of connection both internally and throughout their network, and better monetize products and services (Hood et al., 2016; Cotteleer and Sniderman, 2017).

4.2.3 Processes and Value Chains

Every company has its one supply chain, albeit they can be rather unique taking into account the specificity of each firm (Cotteleer and Sniderman, 2017). These supply chains are comprised of materials, parts, and other physical substances but also of data, information, and expertise, that companies rely on to function. Industry 4.0 enabled the rise of smart factories, allows the interconnection of logistics capabilities and supply networks and informs planning and inventory processes, allowing companies to learn and improve their decisions (Cotteleer and Sniderman, 2017).

The idea of the **value chain** is based on the process view of organisations, the idea of seeing a manufacturing (or service) organisation as a system, made up of subsystems each with inputs, transformation processes and outputs. How value chain activities are carried out determines costs and affects profits. (Porter, 1985)

With the integration of IoT (Internet of Things) technologies, integrated software suits that collect data from machines, production, parts, robots and the addition of AI (that uses all the collected data to learn and optimise) companies learn instantaneously instead of monitoring processes in a linear fashion and operating reactively. These changes can lead to better-designed products, systems and services and smarter decisions, possibly more efficient use of resources, and a better capability to forecast future needs (Mussomeli et al., 2016; Cotteleer et al., 2016; Cotteleer and Sniderman, 2017). This process links the entire design and production process with a unified strand of data that stretches from the initial design concept to the finished part (Cotteleer et al., 2016; Cotteleer and Sniderman, 2017). With all this integration and data companies are able to predict and understand their machines (state and capacity), their facilities, simulate possible scenarios, and comprehend the impacts of changes in one node of the value chain on the rest of the network (Parrott and Warshaw, 2017; Cotteleer and Sniderman, 2017). Tang (2018) exemplifies this process in a company that uses emerging technology to build up the smart manufacturing process and vertical integration (the company uses sensors to collect the manufacturing data for analysis, where the results are shown on a mobile system immediately for managers and operators controlling the manufacturing process and productivity).

I4.0 transforms the company driving the change from a linear, sequential business operations/processes to unified, open and connected systems that can modify industries and lay the foundation for how companies operate, collaborate, and compete in the future (Mussomeli et al., 2016; Cotteleer and Sniderman, 2017). Smart, connected, digital technologies change how consumers and other stakeholders interact with a company or its products and services.

But it is not only the supply chain or manufacturing processes that are changing. Business operations and revenue growth are also affected. Companies become more efficient and sustainable, reducing waste, time and costs, and improve their ability to motivate and engage workers. Operational improvements include productivity increases derived from improving labour efficiencies and managing costs and schedule accuracies (intelligent monitoring, optimising, predictive maintenance) and risk reductions (such as mitigating vendor, data, and geographic risks and ensuring availability of supplies) (Mussomeli et al., 2016; Cotteleer and Sniderman, 2017). The capability to correct and learn from data in real time can make organisations more proactive, flexible, responsive and predictive, and enables the organisation to possibly avoid operational downtime and other productivity challenges (Cotteleer et al., 2016). Revenue growth can comprise incremental revenue improvements, such as using customer data to expand customer understanding and finding new efficiencies in the main business and completely new revenue streams such as using data from linked systems to create new products and services or using demand data/marketing data and digital technologies to diversify to new markets (Mussomeli et al., 2016; Cotteleer and Sniderman, 2017).

4.2.4 Products

The use of wearables and sensors, IoT devices, data collection and analytics, machine learning, advanced manufacturing in the form of additive manufacturing, advanced computer numerical control and robotics can lead to completely new products and services. It enables rapid prototyping and testing and connectivity in previously unconnected products, to innovative new offerings (Parrott and Warshaw, 2017; Cotteleer and Sniderman, 2017). These products become smart and open a door to new business models, as companies can sell data and services in addition to physical objects. Data from products out in the field could also be very important. Digital signals from customer interactions with fielded assets—or from the assets themselves—can enable better service, improved warranty claims, visibility into usage patterns, and data to monetize (Parrott and Warshaw, 2017; Cotteleer and Sniderman, 2017).

4.2.5 Decisions/Organisation

Industry 4.0 represents a change not only on how companies would operate and products would be produced, but also of the specific ecosystems—the suppliers, customers, regulatory considerations, investors, and other third-party experts and influencers—would function and interact. Industry 4.0 technologies create the potential for interactions between every point of a network. These types of investments add a strategic dimension since they change the way in which the organisation competes or even the nature of its products (Turner and Lucas, 1985). The global effect of Industry 4.0 provides improvements in decision-making, communication and relationship with their stakeholders, quality of planning and the overall effectiveness of the organisation (Goodhue, Wixom and Watson, 2002). Thus, stakeholders can work together more effectively, using a constant stream of data from connected systems to learn and adapt to new conditions, and even begin to predict rather than react (Cotteleer and Sniderman, 2017). Nevertheless, this means increased complexity in a transformation period, with rapidly evolving technological capabilities, increased supply chain complexity and global fragmentation of production and demand, growing competitive pressures from unexpected sources, locked-in effects from certain suppliers (software and data analytics), organisational realignments resulting from the marriage of digital and physical technologies and ongoing talent challenges (Cotteleer and Sniderman, 2017). Summing up, traditionally combined investments as the ones linked to Industry 4.0 may generate the following impacts:

Decision-Making and Strategy

1. Better decisions (based on real data continuously) – these decisions can be optimized and automated
2. New Business Models
3. Better coordination and communication
4. Holistic decisions

Innovation & Human Resources

1. Collaborative innovation
2. Innovation directly linked to the customer (data gathering) from the products, interactions with customers, etc.
3. New and better products and processes
4. Innovation centred on human needs (less one size fits all)
5. Repetitive Tasks (mental and physical) replaced by intellectual – more satisfaction
6. New skills and competencies required

Customer and Market

1. Increased Customer Satisfaction
2. Reduced time to market
3. Increased changing costs (costs more connected with suppliers)
4. Real time integration
5. Communication across the value-chain

Efficiency/Organisation

1. Optimization
2. Increased sustainability
3. More collaboration and information
4. More flexibility
5. Reduced costs
6. Preventive and Intelligent monitoring - reduced costs across the value chain

4.2.6. Shifting Demands for the Workforce

Impacts on work

Industry 4.0 likely means different things for different individuals. As we have seen for the customer, Industry 4.0 could enable greater customization, less cost, better solutions. For managers increased efficiency, new business models, new ways to create value, but represents a shift in the work they are expected to do, and how they are expected to do it (Cotteleer and Sniderman, 2017).

Smart automation and factories, ubiquitous and connected systems, data analysis and AI, software-based services, integrated value chains strongly impact workers, what skills they may require, the nature of tasks and roles. Though several of these technologies are labour saving, the truth is that for now, not necessarily means the loss of jobs: In the United Kingdom, for example, technology helped to create 3.5 million new jobs between 2001 and 2015, even while it

contributed to the loss of 800,000 (Cutler and Lewis, 2016; Mariani et al., 2017; Schwartz et al., 2017).

Human-Machine Interaction

Smart digital and physical technologies can be used as tools to enhance workers' jobs and make their tasks easier. Autonomous technologies may work alongside people - each leveraging their inherent strengths to achieve an outcome greater than either one could accomplish alone. Repetitive and mundane tasks are no longer a human endeavour, freeing workers to perform complex, variable, and often unpredictable tasks that require an ability to access and understand data but also to exercise their creativity. Humans and machines will work cooperatively. Cyber-Physical System, machines and software are a tool and play a supportive role, while skilled labour will retain the determinant role (Buhr, 2015). Tasks are likely to become partially virtualized and reorganized in real-time processes that were previously manually and chronically shifted (Geisberger & Broy, 2012; Ludwig et al., 2018).

Nevertheless, complex production processes need to be analysed in a timely fashion and provided in situ for the employees, thus creating the challenge to a more worker-orientated design of new worker/machine interaction systems (Ludwig et al., 2018). The problem is to balance autonomous systems that are externally controlled (by AI) with the need to give employees a certain control in a specific situational context and thereby adjust and restore a regulated working process. Thus, developing concepts for supporting conveying competences to employees is also fundamental and new user interfaces and support tools are, therefore needed, from a technological point of view, to allow the users to keep up with development, to understand the machines independently, and to use them effectively and efficiently for their own work (Ludwig et al., 2018).

Industry 4.0 transformation will produce better outcomes, if the human-machine relationship is designed in a positive way. This means a human-centred focus rather than a technology-centred way and attempt for user-friendly solutions for production workers (Schröder et al., 2017). In order for this process to work, the active involvement of the affected skilled workers in SMEs in the development and implementation of networked technological is needed. The aim is to create robust interfaces that are also intuitive and provide tailor-made information to cope with issues as they arise giving effective support to employees (Schröder et al., 2017).

Stress

Ludwig et al. (2018) refer that I4.0 while providing software solutions that help monitor factories, value chains, products in real time, every time/everywhere, may worsen work-life-balance (since workers are always available and can use software remotely). Time-critical activities in working environments are challenged by the increasing provision of real-time information and by the generally complex requirements regarding information processing (multi-

tasking, frequent work interruptions, and changing demands, etc.) thus negatively impacting workers (Ludwig et al., 2018).

The digital transformation of the society and economy entails a new sensitivity to deal with employees and demands. It also requires new combined guidelines of working hours – for example, by means of operating agreements. Restrictions can be set by means of advanced conditions for work-life boundaries. Employees may avoid unfitting stress – even in working contexts that are mostly automatic and self-organized (Ludwig et al., 2018).

Unemployment

Increased automation may imply that the value of human labour will decline and that technology will take over monitoring and control tasks (Buhr, 2015; Schröder et al., 2017). Though the evidence suggests that purely technology-oriented production, in which human beings play a secondary role in the production process, is not yet very likely (Schröder et al., 2017).

Hierarchies

Hierarchies in production will change although it is still unclear to what extent (Schröder et al., 2017). Networked production is conveyed by more decentralized planning. Decisions, governance and control may be delegated to lower levels and this way the former activities of production workers could be upgraded. Also, due to the rise in real-time data many indirect jobs will be established around production (Schröder et al., 2017).

At the same time, as discussed before, simple manual activities (or intellectual repetitive tasks) will be automated and cease to be performed by human beings, thus liberating workers to more creative tasks and empowering them (Schröder et al., 2017).

Competences and Training

New technologies and the ways in which they are incorporated into the daily functions and workflows can lead to new training needs. Individuals will need to navigate how they interact with and work alongside Industry 4.0 technologies, and how their responsibilities and roles may evolve as a result (Cutler and Lewis, 2016; Mariani et al., 2017; Schwartz et al., 2017).

IT knowledge will be necessary at all operational and management levels, not only because Industry 4.0 involves the integration of IT and machinery and machine operators will have to have the necessary IT knowledge, but also because the borders of companies will increasingly become blurred. Industry 4.0 also involves the integration of various IT systems along the value chain. Sales staff will be put in a position to set production processes in motion directly from a tablet and to give customers sat next to them real-time production information on the stage of completion of their order. An understanding of processes and their consequences is also an advantage (Cutler and Lewis, 2016; Mariani et al., 2017; Schwartz et al., 2017).

But not only IT competences are important. For example, as decentralized planning and control functions are delegated to operational levels, competences for self-guided action and self-organisation will become more and more important (Schröder et al., 2017), thus employees should develop skills to be able to constantly introduce improvements in the production process.

Similarly, the aptitude to quickly understand procedures and processes outside one's own subject area is becoming increasingly important. At the same time, the capacity to perform cooperative and interdisciplinary work, to communicate and integrate knowledge across horizontal and vertical levels becomes essential (since vertical and horizontal networking and close informational links between suppliers and customers are increasingly retracting the common differentiation of manufacturing, service, and administration work) (Ludwig et al., 2018). Traditional work becomes less separated into specific tasks; it tends to be "hybrid", like the anticipated company networks.

These new realities create the necessity to focus on job-related qualification opportunities and "training on the job" (Jacobs and Bu-Rahmah, 2012; Ludwig et al., 2018). This comprises integrative and comprehensive knowledge (process knowledge, operating competences, the ability to understand unknown working procedures, social and analytical competences, and optimization of role interfaces) that is not subject to the employees' specific activity (Ludwig et al., 2018).

In the context of Industry 4.0 advanced training and lifelong learning become ever more important. Competence building and qualification opportunities entail analysing the requirements of a specific task and putting employees in a position to meet them. Communities of practice and cooperation play a significant role in the acquisition of occupational competences (Ludwig et al., 2018). Therefore, it is necessary to create new processes of competence development with network technology and also new processes regarding the preservation and provision of experience and its exchange amongst employees within the company or even beyond (Ludwig et al., 2018).

Human Capital Management

But the problem is not simply one of acquiring new skills or planning new and better careers. Organisations need also to focus in leadership, structures, diversity, technology and the overall employee experience in new and exciting ways (Cutler and Lewis, 2016; Mariani et al., 2017; Schwartz et al., 2017).

At the same time, managers can no longer consider their workforces to be only the employees on their balance sheets, but must include freelancers, gig economy workers and crowds (since the borders become blurred). These on- and off-balance-sheet workers are being improved with machines and software (for example Uber drivers that use their platform) (Cutler and Lewis, 2016; Mariani et al., 2017; Schwartz et al., 2017). This requires adopting a human capital management approach, departing from more traditional linear HR practices (from training and development to

managing culture) to more holistic approaches (Cutler and Lewis, 2016; Mariani et al., 2017; Schwartz et al., 2017).

Summarising, from new competencies to new ways of organising labour and new ways of learning, we can identify radical changes in the workforce.

5. Innovation and New Business Models

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5.1 Business Model Definition

A model is always a simplification of the complex reality (Stähler, 2002). Following Osterwalder and Pigneur (2010), a business model is basically a tool that helps entrepreneurs to capture, visualize and define their business idea in a way that reflects the core values of the product or service delivered to the client and sustained by the company. Planning will minimize expenditure and time consumption, while the most important will help transform goals into operational activities and tasks (Delmar and Shane, 2003; Schwarzkopf, 2016).

The purpose of a **business model** is to identify how the company will present a value proposition to its clients, thereby capturing value for itself that is, it identifies the way an organisation creates, delivers and obtains value. (Osterwalder and Pigneur, 2010)

Meira (2013) defines a business model as the interconnection of processes and methods, which are creating the business itself. The product or service that is put on the market, should solve a customer problem that a company is targeting (Schwarzkopf, 2016). Also, a business model should not be confused with a business plan.

According to Meira (2013) value creation is an essential issue that each entrepreneur must aim at, when thinking of a solution to a problem (Schwarzkopf, 2016). Many entrepreneurs, but also large companies have difficulties in defining their business model. Today, a wide range of tools, models, and concepts help entrepreneurs to describe their business and the delivered and captured value that the company, product or service adds (Schwarzkopf, 2016).

The definitions of the term "business model" vary, but most of them encapsulate "value creation" that is value to the customer; "Value capture," the internal processes necessary for value creation and capture to succeed (Gudiksen, Poulsen and Buur, 2014).

The purpose of a business model is to identify how the company will present a value proposition to its clients, thereby capturing value for itself (Johnson, 2010), that is, it identifies the way an organisation creates, delivers and obtains value (Osterwalder et. al., 2010). Similarly, Linder et al. (2000) define business model as the logic of an organisation in creating value. "The business model elucidated as a company interacts with interested external entities with which it engages in economic exchanges in order to create value for all parties involved" (Zott et al., 2007). In this way, it can be used as a powerful tool for the analysis, implementation and communication of strategic choices (Shafer et al., 2005). When "a new model changes the economy of an industry and it is difficult to replicate, it can by itself create a strong competitive advantage" (Magretta,

2002). The business model can therefore be used as a tool that facilitates the analysis, testing and validation of strategic choices of the company, but should not be confused with a strategy alone (Shafer et al., 2005).

For Johnson et al. (2008) business model is defined as the interconnection of four elements that together create and distribute value, being: value proposition, profit formula, key resources and key processes.

Chesbrough (2010) and Chesbrough et al. (2002) display a detailed view of a business model as a vehicle for marketing new ideas and technologies, fulfilling the following functions: articulating the value proposition, identifying a market segment and specifying the revenue generating mechanism, defining the chain structure value needed to distribute the value proposition and complementary assets required to support the position in the value chain, detail the revenue generating mechanism by which the firm will be paid for its offer, estimate cost structure and profitability potential, given the value proposition and structure of the value chain, describe the company's position within the value chain interconnecting suppliers and customers, formulate the competitive strategy by which the innovative company will win and retain advantage over the rivals. In conclusion, a business model describes how your business pieces fit together. It explains how value is created and delivered to the customer, at what cost and how the company generates revenue in doing so "(Sniukas, 2012, p. 8).

5.2 Business Model Innovation

At the same time business models can themselves be a vehicle for innovation. Disruptive firms such as Uber and Airbnb or Lime didn't deliver significant innovative technologies, but what they did was innovate in terms of business models. Business Model Innovation represents a research stream within business model literature that recognizes the BM as a potential source of innovation next to product, service, process and organisational innovation (Weking et al., 2018; Foss and Saebi, 2017; Zott et al., 2011). Innovations in business models "are designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements" (Foss and Saebi, 2017).

5.3 Business Model Evolution in Industry 4.0

The way firms create value and different pieces of model interact is fundamentally changing under industry 4.0. Fuller and Haefliger (2013) posit that business models are fundamentally connected with technological innovation (although the concept is essentially separable from technology. Fuller and Haefliger (2013) state that the business models mediate the link between technology and firm performance and also the right technology is a matter of a business model

decision regarding openness and user engagement. Thus, within the industry 4.0 concepts new business models emerge, originating from different technologies.

Technology is, of course, transforming businesses in every sector. Cloud and connected devices are becoming more ubiquitous, and companies are starting to use their information to intelligently gain real time insight into customers. It is therefore no surprise that, according to Dimension Data's recent Digital Workplace report 25% of organisations are investing in new digital tools such as workspace analytics, augmented reality and micro-training (Dimension Data, 2018). Cognitive solutions such as AI and machine learning are also being embedded in many areas of work, from the office to shop floor. Much of an organisation's transactional and routine work will be handled by intelligent machines.

As previously stated, CPS, AI and big data are integral parts of the different technologies in Industry 4.0. CPS and IoT integrated in manufacturing enable smart machines and processes, smart products, new systems and smart factories (Hermann et al., 2016; Weking et al., 2018). These elements can autonomously connect and exchange information with each other, trigger autonomous actions and direct the production (Pereira and Romero, 2017; Ramsauer, 2013; Weking et al., 2018). This results in the emergence of smart factory with "sensors, actors and independent systems" (Lasi et al., 2014; Weking et al., 2018). This smart factory can "context-aware assist people and machines in execution of their tasks" (Hermann et al., 2016) by drawing on information of the physical and virtual world. Additional fundamental concepts of I4.0 are horizontal and vertical end-to-end integration (Weking et al., 2018). Horizontal integration combines resources, processes and is intra- and interorganisational, across the entire value chain. Vertical integration refers to data sources within an organisation (Kagermann et al., 2013; Weking et al., 2018).

Making full use of CPS and other smart technologies requires companies to additionally deploy complementary IT technologies (Schröder, 2017). Since data analytics is an integrant part of this integration (software is needed to analyse the large quantities of data generated by CPS in order to govern, regulate or monitor target-oriented processes (Schröder, 2017), hardware performance and new internet connections are needed, making downstream business models possible: an embedded CPS enables a turbine manufacturer to provide customers with remote maintenance and, at the end of the product's life cycle, recycling as additional services (Schröder, 2017). At the same time this leads to the growing field of predictive maintenance where AI anticipates the repairing/maintenance needs of parts and goods, optimising time and costs (Oracle, 2018). There is a growing number of start-ups in this field that are using machine sensors to collect data and the predictive analytics is decreasing downtime up to 45%. Furthermore, this is increasing productivity by 25%. It is the age of creating new business models through proactive monitoring which results in better customer service (Machine Sense, 2018).

At the same time new companies emerge to service the hardware and software needed to cope with large real-time data streams, using cloud-based technologies. These suppliers of cloud

computing services make IT infrastructure available to their customers online, thus enabling other companies to reduce their investments in their own infrastructure and increasing their efficiency. The use of CPS also helps companies to connect to digital integrated vertical and horizontal creation networks. Through these virtual platforms in the cloud companies can access production according to need in order to coordinate production stages in real time (Schröder, 2017). This may allow companies to “rent” machine capacity to companies with capacity bottlenecks.

These technologies allow companies to sell data and services in addition to physical objects. Also, smart products can generate signals from customer interactions with fielded assets — or from the assets themselves — enabling better service, improved warranty claims, visibility into usage patterns, and data to monetize (Deloitte, 2018).

5.4 New Types of Business Model in Industry 4.0

Following the previous discussion and the ideas within the report developed by PwC (2016) we highlight the new business “areas” for Industry 4.0 in Table 5-1.

Table 5-1: New Business Areas for Industry 4.0

New Digital Business Models	Digital Engineering	Vertical Integration	Integration of the horizontal value chain	Intelligent maintenance and services	Digital Workplace	Sales and Digital Marketing
<ul style="list-style-type: none"> - Optimization of digital processes - Pay per use model - Global Platform Management - Big Data Analysis and performance management 	Collaborative Digital R&D Digital Models, virtual prototyping and simulation	Smart factories Machine Automation MES Digital Asset Management	Value chain control centre Digital sourcing Digital transport and logistics management Logistics Smart sites Demand and supply planning	Preventive maintenance Integrated digital engineering Augmented Reality Solutions	E-finance / controls Digital HR Internal knowledge sharing Agility of systems	Digital CRM Omni-channel trade Self-service portals Personalized Marketing and Sales Services E-payments

Enablers:



Source: adapted from PwC (2016)

New Digital business models include analysis or algorithm building for manufacturing companies that may want to outsource this type of service and other services such as Big Data Analysis and performance management.

Digital engineering includes firms that provide collaborative R&D and/or also Digital Models, virtual prototyping and simulation (for other firms that lack this ability). Also, this may include firms that develop simulation and virtual prototyping software.

Firms that help create smart factories (with hardware and software) and enable technologies such as Machine Automation and Manufacturing execution systems (MES) are another component of the ecosystem. At the horizontal level we find services that allow for value chain control centre, digital sourcing, digital transport and logistics management and help create smart sites. Vertical and horizontal value chains and their integration is further improved with services such as Preventive maintenance, Integrated digital engineering and Augmented Reality Solutions.

Manufacturing execution systems (MES) are computerized systems used in manufacturing, to track and document the transformation of raw materials to finished goods. *MES* provides information that helps manufacturing decision makers understand how current conditions on the plant floor can be optimized to improve production output. *MES* works in real time to enable the control of multiple elements of the production process. (McClellan, 1997).

PwC (2016) also identifies new service areas as such as technologies that enable digital human resource management and the financial control of the above described integrated value chains and other services that help firms reach the customer (digital marketing).

Finally, businesses that enable the whole ecosystem are necessary, such as Cyber security (since this paradigm is intensive in data collection, networks of people and devices and connected value chains that are prone to cyber-attacks). Infrastructure (machines, sensors, etc.) and system agility (the interconnectivity of all parts) are fundamental and companies will offer comprehensive solutions (companies such as Siemens are already providing integrated solutions for Industry 4.0).

And in the end new ways to organize people and enhance their capabilities will be necessary. As such there will be opportunities for training that may use new technologies (such as augmented reality) but also traditional training in order to capacitate people to work within the new paradigm and acquire new competencies (PwC, 2016).

Ibarra et al. (2018) try to summarize the new possibilities and present the following features of industry 4.0 and how they affect business models:

Table 5-2: Features, Challenges and requirements related to the Industry 4.0

Main Features of the Industry 4.0	Main issues affecting traditional Business Model	Main requirements to face digital transformation
Interoperability	Networking and reduction of barriers	Standardization
Virtualization	Flexibility and personalization	Work organization
Decentralization of decision making	Individualized mass production	Availability of products
Real-time capability	Local production	New Business Models
Service orientation	Low price	Know-how protections
Modularity	Smart goods and services	Availability of skilled workers
	Fragmentation of the value chain	Research investment
	Globalization and decentralization of production	Professional development
	V-H integrated production systems	Legal frameworks

Source: Ibarra et al. (2018, p.6)

Ibarra et al. (2018) suggest that the features on Table 5-2 lead to 3 possible approaches: A service-oriented approach, a network-oriented approach and a user-driven approach.

Industry 4.0 is pushing companies to a change from product to service mindset (Fleisch et al., 2014; livari et al., 2016; Ibarra et al., 2018). Manufacturing firms in developed economies are expanding their role in the value chain by extending their product with services, so they do not have to compete solely on manufacturing cost (Ibarra et al., 2018).

A good example of this model is Car-as-a-service (CaaS). Essentially an extension of ride-sharing using driverless vehicles, CaaS will enable people to summon a car via an app or to be used for deliveries (IHS Automotive, 2018). IHS (2018) estimates that the deployment of driverless CaaS will begin before 2025 and will have an increasing impact as technology advances and driverless car volumes grow. In addition, autonomous driving and the associated costs will dramatically lower the cost of mobility services as a whole (IHS Automotive, 2018).

The “product service system” (PSS) concept is a framework that describes the combined development and offering of specific product-service bundles as a solution for the customer. As a result, suppliers, customers, and other partners become part of a networked ecosystem around the CPS (Ibarra et al., 2018). Following our previous discussion, it is clear that companies can derive new business models, such as selling a product and its maintenance (based on digital predictive maintenance allowed by data collecting and its analysis) or transform the product in a clear service

The following existing offerings illustrate the PSS concept (Ostaeyen, 2014):

- Xerox' pay-per-copy model for selling office equipment
- Rolls-Royce's Power-by-the-Hour service package for aircraft engines, whereby maintenance, repair and overhaul services are charged per hour of flight
- Atlas Copco's Contract Air service, whereby air compressors are sold per m³ of compressed air delivered

- Philips' pay-per-lux model for selling lighting equipment, whereby customers pay for a promised level of illuminance in a building
- Michelin's fleet management solution whereby truck sold per kilometre driven

As for the network-oriented approach, Ibarra et al. (2018) state that the horizontal and vertical integration of the value chains and its interconnection may increase firms' traditional boundaries due to the organisation and the stakeholders' network. As stated previously, new actors arise to provide data analytics, integrate value chains and traditional manufacturing companies oriented to product sales, feel progressively bound to revise their existing Business Models in response to new competitive dynamics (Ibarra et al., 2018).

Finally, Ibarra et al. (2018) focus on the user-driven approach, that comprehends the efforts to make manufacturing more responsive to user-driven design lining up with a customer value creation strategy. Through data collection, integrated value chains, digital manufacturing technologies, companies are able to customize products to the final customer or automatically respond to B2B requirements. Industry 4.0 delivers the technology and processes that allow to create value propositions to respond to customer demands such as the provision of customized products and even batch-size-line production (Ibarra et al., 2018). Therefore, firms need to develop new competences in both, learning more about their customers (using digital capabilities to obtain information about customers, promoting evidence-based decision making, developing integral customer experiences, etc.) and becoming more of an ecosystem beyond individual value chains (become great at building partnerships with new stakeholders) (Ibarra et al., 2018).

From this 3 perspectives Ibarra et al. (2018) propose the following changes for business models:

Table 5-3: Transformation in Manufacturing Companies – New Business Models

Digital Transformation in Manufacturing Companies	Main Technologies	Value Creation	Value Delivery	Value Capture
1. Internal and External Process Optimization	Big Data, Cloud Computing, Collaborative Robots, Additive Manufacturing, Artificial Vision or Augmented Reality	Product and Resource traceability: More efficient productions, logistics, quality control, inventory management and better maintenance	More flexible offers: Customization, etc.	Cost optimization due to more efficient processes and use of resources
		Machine to Machine: Connect internal processes/Connect Internal processes with supplier processes		
		Employee training: work from any place at any time, greater and faster communication, knowledge exchange		
		More Transparent management: Data driven decision making		

2.Customer Interface Improvement	Big Data, Cloud Computing, Augmented Reality or Virtual Reality, new ways of interaction through new or improved touchpoints are created, allowing a better understanding of customers' needs and greater customer	Management of new touch-points	Segmentation based on data analytics	Cost saving
		Data collection, monitoring and interpretation,	More direct, efficient and long-term relationships	New revenue streams: dynamic pricing, pay per use, online payment
		Development of new services	Improved Digital Sales: wide range of devices, coherence between channels, comprehensive customer experience, self-service channels that offer instant answers, saving time and costs	
3.New Ecosystems and Value Networks	Big Data, Cloud Computing, Augmented Reality or Virtual Reality. By this way, the focal firm's value creation process is linked with the stakeholders' processes. Moving from value chains to ecosystems and, in consequence, increasing stakeholders' knowledge	Business infrastructure connected to Key partners infrastructures	Access to new customer segments	Potential increase in value capture due to cost reductions to all stakeholders
		Real time information about production, inventories and sales, availability and personnel	Broader offering of products	
4.Smart products and services	Big Data, Cloud Computing, Intelligent Sensorisation and Embedded Systems, among others, that allow to offer innovative and smart goods and services (e.g. remote installation of maintenance or activation of product upgrades)	New Physical, human and intellectual resources are needed	Smart Products that constantly collect information from customers	New revenue streams: dynamic pricing, pay per use, performance-based revenues
			Innovation in associated services: predictive maintenance, activation product upgrades, ordering spare parts,	
			co-creation: customers are part of the value process	
			Direct relationship between the firm and the customers	

Source: Adapted from Ibarra et al. (2018)

Similarly, Weking et al. (2018) identified three super-archetypes and ten sub-archetypes of I4.0 Business Models using the taxonomy they created. The 3 “super archetypes” are Integration, Servitization and Expertise as a Service. Integration allows for Business Model

innovation around new processes, servitization around new products, and expertise as a service around a hybrid of products and processes.

Servitization is the innovation of an organisations capabilities and processes to shift from selling products to selling integrated products and services that deliver value in use. (Baines, et al. 2009)

Integration mainly builds on new online channels and portals (innovation platforms, online shops and digital manufacturing). Covering more parts of the value chain replaces intermediaries and enables faster reaction to changing customer demands (Weking et al., 2018). This is a mix from the ideas proposed by Ibarra et al (2018) concerning smart products and services and Customer Interface Improvement.

Weking et al. (2008) propose 3 different “sub archetypes”: Crowd sourced innovation, Production as a service and Mass customization. The first one is related with “open innovation” and highlights the possibility of online/network collaboration in innovation processes. Since all platforms are linked and companies are able to use virtual technologies to simulate and prototype it is possible to cooperate to create new products. PwC (2016) refers to this as collaborative R&D. Production as a service, happens when value chain shifts from producing custom-made, expert designed goods (I3.0) to mass individualized, user-designed goods (I4.0) (Weking et al., 2008). Companies integrate customers and other externals in product design and development.

Value chains are integrated in a way that end customer (but also a B2B customer) can determine his individual product characteristics/or order specifications in online shops/portals (Ibarra et al. 2018). The end customer can determine his individual product characteristics in online shops, and these individualized products are produced at competitive prices when compared with mass products. New digital manufacturing techniques, such as 3D printing, reduce the human labour intensity and allow closer to the market production. The combination of direct digital-to-physical transfer allows for shorter times to market (Weking et al., 2018).

As discussed before, Weking et al. (2018) also emphasize the “servitization” side of industry 4.0. Combining the use of CPS, IoT and analytics, IT-enabled remote product monitoring and predictive maintenance services reduce downtime of the customer’s plant and help customers to reduce costs. Weking et al. (2018) propose 3 sub archetypes: Life-long partnerships, Product as a service and Result as a service.

Life-long partnerships are possible since firms become solutions providers since in I4.0, firms add continuous revenue streams with subscription-based, lifelong service contracts (Weking et al., 2018), offering services such as predictive maintenance and remote monitoring. Firms that supply software services generate continuous revenue streams due to multi-year contracts and increase the customers’ switching costs. Moreover, predictive maintenance and remote monitoring allows supplying firms to reduce their own service costs with more efficient scheduling of service teams and maintenance visits. Instantaneous monitoring makes rental more attractive and enables usage-based revenue models (Weking et al., 2018).

As seen before, Product as a service. Means that lines between products and services become blurred, instead of buying products customers pay for the use and availability of the product which may lead to “result as a service”. Result as a service means that firms sell the output or result of the product which also enables continuous revenues streams. As seen above (Ostaeyen, 2014), gives several examples of firms such as Xerox' (pay-per-copy model) or Atlas Copco's Contract Air service (m³ of compressed air delivered) and we discussed Car as a Service models above.

Finally, Weking et al. (2018), propose a last category of business archetypes, centred on “Expertise as a service”. Some firms will advantageously use IT to offer new, complementary goods and services. These new products may emerge from digital trading platforms, two-sided market platforms for business applications or IoT platforms. Further, these advanced suppliers will use their expertise of digital products and processes to consult customers.

The sub archetypes devised by Weking et al. (2018) are: Product related consulting, Process related consulting, Broker platforms and IoT platforms. The first one is linked the ability of firms to sell advice on how to optimize their own products (Tukker 2004). Process related consulting refers to the ability of firms of complement the solutions they provide by helping their customers transition into the digital paradigm. Broker platforms refers to the ability of firms that sell machines to also provide platforms that help their customers with different problems (a firm that sells machinery may also sell cloud-based services to optimize the factory management, digital assets, etc.) (PwC, 2016; Weking et al., 2018). Finally, IoT platforms are centred around analytics, specially linked with big Data Analysis and performance management (PwC, 2016). Products, production and value chains become data sources and manufacturing firms, specialized firms and other actors use platforms and new forms of analytics as new key elements (Weking et al., 2018).

These new digital technologies enable continuous, usage-based revenue models as part of the value capture component. New possibilities for monetization arise from this type of integration, and services and production are mixed. Firms can address new customer segments online and directly (B2B our B2C), thus answering more quickly to change and customising products or logistical services.

Digital technologies may transform the value chain towards decentralized, individualized and on-demand production (Weking et al., 2018). They support the vertical and horizontal end-to-end integration of the value chain.

6. Impacts on SMEs

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“As all these trends happen, the winners will be those who are able to participate fully in innovation-driven ecosystems by providing new ideas, business models, products and services, rather than those who can offer only low-skilled labour or ordinary capital.”

Prof. Klaus Schwab, a German engineer and economist, best known as the founder and executive chairman of the World Economic Forum and author of *The Fourth Industrial Revolution*

The use of digital technologies and the internet is now a must for any small and medium-sized enterprise (SME). This is well-known by the management of small-scale manufacturing industries but they often lack time, knowledge and tools for developing and implementing digital transformation in their companies. According to “Digital skills in the workplace” study (Curtarelli et al., 2017), for SME workplaces it is difficult to allocate time and resources (training, financial resources, etc.) to acquire high digital skills. Significant discrepancies are identified in different economic sectors as some have high speed of penetration of digital technologies and others use them at a much slower pace. In addition, the use of ICT is connected to the increase of productivity. In the paper it is recommended to include promotion of training access to address digital skills gaps, consider diversity, abandon “one size fits all” attitude and build multi-stakeholder partnership to increase the availability of digital skills. Following the EU Craft & SME Barometer, by SMEunited (2019), Business Climate Index has dropped since 2017, showing growing uncertainty of the future in SMEs and crafts and also indicating skills mismatch in European labour markets. In order to promote and support SME growth and job creation, SMEs should be nurtured to move effectively towards digitalisation within the concept of Industry 4.0. Smart factory is considered to be the next phase in the digital process in terms of Industry 4.0, especially in the manufacturing industry. The factory construction will be driven by developments in human-machine interaction, computing power and robotics that would enable for 3D printing to be conducted. Collaborative robots are also a key element of Industry 4.0 and the smart factory since they allow for flexibility, increased production, ownership of the automation process and customization of products in SMEs. But adequate competencies and skills in companies are needed in order for them to operate effectively in the new realities. Thus, through the Chain project implementation, a basis for the creation of new competencies for SMEs will be provided creating highly positive impact on SMEs throughout Europe connecting companies and countries.

6.1 Benefits from Industry 4.0 adoption

Nowadays, SMEs are growing more and more inclined to integrate and apply Industry 4.0 concepts within their business operations on macro and micro levels. The influence of Industry 4.0 on companies and industry is expected to enable the emergence of new business models affecting and reshaping the entire lifecycle of products from their preparation to their marketing leading to improvement of business processes and ultimately, increasing the companies' competitiveness (Pereira and Romero, 2017). The conclusion that SMEs' success is connected with the adoption of new Industry 4.0 industrial technologies is drawn by numerous companies worldwide. According to Müller et al. (2018) the process of implementing new technologies is being conducted in all industries so as to lead to reducing costs, increasing productivity and providing customers with solutions tailored to their specifics. Since the term "Industry 4.0" originates from a high-tech strategy introduced by the German government, the impact on SMEs will be analysed considering several studies and reports based on data gathered by German companies.

Following a study conducted by Boston Consulting Group (Lorenz et al., 2016) with more than 600 German and US companies, about 19% of German companies have fully applied Industry 4.0 meaning that they implemented smart factory measures or first measures toward a concept (such as the introduction of autonomous robots), compared with 16% of US companies. Other data provided shows that German manufacturers can be regarded as very ambitious since 60% of them are planning to apply or have applied advanced technologies (within the next one or two years) such as digital factory logistics or predictive maintenance, compared with approximately 40% of US manufacturers. German companies seem to also be further ahead in terms of preparing for Industry 4.0 compared to their US colleagues as almost half (47%) of the German companies have developed their first full Industry 4.0 concepts, and only 18% of German respondents said that their company is not yet prepared to introduce Industry 4.0 technologies. In comparison, only 29% of US companies have developed their first concepts, and 41% stated that their company is not yet prepared.

The slight differences in the advancement stage of Industry 4.0 in German and US companies are not reflected in the opinions of respondents about the important benefits of its adoption. For example, three-quarters of German respondents and two-thirds of US respondents associate Industry 4.0 with **increased productivity and cost reduction**. Almost equal amount of respondents in both countries (48% in Germany and 43% in the US) also connect it with **revenue growth**. But it is worth mentioning that the benefits from Industry 4.0 depend on how successfully, companies develop and manage newly skilled personnel.

Schröder (2016) in the report “The Challenges of Industry 4.0 for Small and Medium-sized Enterprises” published by Friedrich-Ebert-Stiftung focuses on the main challenges of small and medium-sized enterprises (Mittelstand) in Germany in regard to the implementation of Industry 4.0. He has observed a strong connection between company size and implementation of Industry 4.0, as large companies are substantially more advanced in the integration of their production plants in higher-level IT systems than medium-sized companies. As there is no universal model for applying Industry 4.0 in SMEs, the perception of the challenges and opportunities posed by Industry 4.0 depends on the different characteristics of companies (Müller et al., 2018).



Source: pixabay.com

The overall impact and potential arising from the adoption of Industry 4.0 in companies can be outlined in several aspects:

- **The economic potential of Industry 4.0** – The evaluation of economic effects is rather difficult and they can vary. One thing that could be considered as a major opportunity is the cost reduction as mentioned above leading to economy of financial resources. Since nowadays, many of the business tools and software are available through cloud computing, SMEs do not need to pay high costs for digitisation of their businesses (King, A., 2018). Even if a SME partially applies Industry 4.0 inexpensive technologies, it would still benefit economically through automation of some tasks, for example through a simple smart application. This rather non-complicated automation software will also have a positive impact on the productivity rates in the enterprise. Other researchers, such as Schröder (2016), argue that since Industry 4.0 combines different and many technologies, only when applied together their full potential in SMEs will be realized. Since these technologies are in different state of advancement when being implemented in SMEs so it would be unclear when and to what extent positive effects will be utilized.
- **The smarter the production process, the better the product quality** – Smart technologies are now used in every industry, especially in the manufacturing processes in SMEs which lead to the creation of smart products. By incorporating smart technologies in the production process, SMEs are able to monitor, follow and control it and do so autonomously (Maresova, P. et al, 2018). The smart products also carry important information about their production process, as well as regarding their purpose and

application. Such smart products are equipped with sensors, components and processors that are aimed to collect information and guidance to customers and to send this data to the manufacturing system (Abramovici and Stark, 2013). In this way, the quality of the products is significantly improved as well as the efficiency of the production process in terms of time and costs. Experts even predict that soon a customised product will be made at the same price as a serial product is developed today, which will contribute to reaching optimal customer satisfaction and attracting more clients. These benefits can transform SMEs model of work into a smart model and help them grow (Schröder, 2016).

A forecast of the potential savings for different areas of production is shown below:

Evaluation of potential benefits

Type of cost	Total value
Inventory costs	- 30 % to – 40 %
Manufacturing costs	- 10 % to – 20 %
Logistical costs	- 10 % to – 20 %
Complexity costs	- 60 % to – 70 %
Quality costs	- 10 % to – 20 %
Maintenance costs	- 20 % to – 30 %

Source: Condensed presentation by Schröder (2016) after Bauernhansl (2014: 31)

- **New way of communication** - As it was mentioned in Chapter 5, new business models and value creation networks are one of the direct outcomes of the transformation in manufacturing companies as a result of Industry 4.0 implementation. The impact of these changes will allow for a new way of communication along supply chains (Maresova, P. et al, 2018). It is envisaged that the chain of suppliers, companies, factories, the logistics' agents along with customers will be connected in a whole new communication network to be operated in real time. Through that type of networking, all actors will manage to reach maximum profit using limited sharing resources (Maresova, P. et al, 2018). The new way of communication has a significant effect on SMEs' business models. It is suggested that managers are interested in the development of customer-driven rather than product-oriented innovations when speaking about business model innovations (Müller et al., 2018). It can also be said that the supply as well as the technical support chains will be digitalized in light of the new and complex ways of communication, the process of conducting operations as well as manufacturing and distributing of products and services.

An important opportunity introduced by Industry 4.0 and with great impact on SMEs is the “digital twin” concept. It is defined as virtual illustration and model of a given asset (tangible and intangible). The digital twin is described through the structure and behaviour of connected elements or “things” generating data in real time. The data is analysed, combined with other data connected with the working environment and presented to the SMEs or the user in the form of “digital twin” with the idea to understand its history, needs, background and interact with it in order to complete certain tasks. The digital twin presents companies and users with possibilities to explore and find the best solutions to given problems in a fast and pragmatic way. A good example of using such solution in practice is The Laboratory for cooperation within Industry 4.0 of the Institute for Information Management in Engineering (IMI) and the Karlsruhe Institute of Technology (KIT). There a digital twin of a machine for grinding is used for optimization of the process and for working in a virtual reality network. Along with these activities, the resource flow is also taken into consideration in order to showcase the practical advantages of the suggested solution allowing for increase of the productivity with over 20%. According to the German association of information technologies, telecommunications and new media (BITKOM), digital twins in manufacturing industries will have combined economic potential of over than 78 billion EUR by 2025 (based on Popova, M. et. al., 2018).

Digital twin is a set of virtual information constructs that fully describes a potential or actual physical manufactured product from the micro atomic level to the macro geometrical level. (Grieves, 2016)

The potential benefits of Industry 4.0 are increasing by the minute and with every network partner. As large companies are the pioneers of implementation of Industry 4.0 in its full potential, SMEs are the ones to follow and adapt their production technology gradually in order to make their own production increasingly networked.

6.2 Obstacles before SMEs regarding Industry 4.0 Adoption

SMEs are more challenged when it comes to adopting Industry 4.0 compared to large companies since most of them do not have a fully automated production, so the proportion of manual and hybrid activities is higher. They are thus advised to turn to networked production in order not to lose their competitive edge on the international markets. One of the biggest challenges that SMEs face or will face is the **elaboration of a relevant strategy, a cost-benefit analysis** of the Industry 4.0 technologies that will be useful to them and **the lack of data security and uniform standards** (Schröder et al., 2016). The study by the Boston Consulting Group (Lorenz et al, 2016) cited above observes also that **lack of data security** is one of the main challenges of companies. The same source points out the **lack of qualified employees** as the top challenge followed by **investment requirements**. According to Türkes et al. (2019), lack of expertise also represents a boundary to Industry 4.0 development meaning that there is a lack of culture in the company, no internal training is conducted on acquiring digital skills and no specialists to drive

the implementation of new technologies. A significant conclusion is derived by Boston Consulting Group (2016) summing up that small companies as well as large ones in US and Germany need **careful planning in order to address their major concern to cover the necessary investment costs.**

More in-depth analysis of the obstacles for the technological implementation of Industry 4.0 is provided below:

Cost-benefit analysis is a systematic approach to estimating the strengths and weaknesses of alternatives used to determine options which provide the best approach to achieving benefits while preserving savings (for example, in transactions, activities, and functional business requirements). (David, Rodreck, 2013)

- **Lack of digital strategy** – A digital strategy that is adapted to the digital and business realities and challenges is described as one of the opportunities for development that Industry 4.0 presents (Popova, M et. al., 2018), but the lack of it is considered a limit to the growth of SMEs in light of Industry 4.0. The senior management of manufacturing SMEs is presented as more cautious regarding Industry 4.0 and more concretely, the networking of production compared to the production managers (Pierre Audoin Consultants, 2015). This caution could be problematic as the application and integration of Industry 4.0 in SMEs have to be carefully planned and a development of comprehensive digital strategy should be initiated at a very early stage of implementation. Within the strategy the restructuring of all company processes, employees’ roles and qualifications should be taken into consideration, especially regarding the development of new business models and opening of new markets. (Schröder, 2016)

- **Lack of uniform standards & legislation** – Another obstacle before SMEs regarding the adoption of Industry 4.0 is the absence of uniform standards and norms in terms of the integration of IT systems and other data and machinery within the company. According to Schröder (2016), an international standard has not yet been implemented and no up-to-date information has been found as such. This allows for the occurrence of mistakes and mismatches in the integration process along with rising unrest about unauthorised access to certain data. In addition to standards, proper working measures and legislation regarding Industry 4.0, such as the development of cyber security, artificial intelligence, etc., are not in place in developing countries. (Türkes, et al., 2019). This allows for significant lagging in the progress of Industry 4.0 in some countries and creating a multi-speed Europe and the world as a whole.



Source: pexels.com

- **Lack of data security** – This obstacle is intertwined with the lack of uniform standards and legislation. If a SME wishes to create a functioning digital network, it is required that all actors have mutual trust over the data they share. The data in question ranges from information on the production merits of SMEs to new ideas about innovative products’ creation. Leakage of important documents can affect the reputation of companies negatively (Türkes et al., 2019) and lead to loss of profits and clients. SMEs perceive that using Industry 4.0 technology, such as cloud services, is not protecting confidential data of the company and it is allowing for a third party to access it. The security issues are heightened by the fact that SMEs are not sure about the geographical location of the data stored and what jurisdiction it is applied (Schröder, 2016). In 2017, computers in 74 countries were “ransomware” attacked by hackers which affected the Telecom system in Portugal, the IT system in Spain and the National Health System in the UK (Türkes, M. et al., 2019).

Ransomware is a type of malware from crypto virology that threatens to publish the victim's data or perpetually block access to it unless a ransom is paid. (Young, A. et al, 1996)

Smith et al. (2016) in “Industry 4.0” study requested by the Policy Department A: Economic and Scientific Policy of the European Parliament's Committee on Industry, Research and Energy (ITRE), identified the main difficulties and therefore, obstacles encountered by SMEs with regard to participating in the Industry 4.0 supply chain are:

- **Lack of awareness** about high-tech solutions and the potential advantages of implementing them in production processes;
- **Lack of financial resources** to buy the necessary technology and/or invest in R&D activities to create the needed technology when it is not readily available. Each of this requires easy access to funding which is an obstacle for many SMEs.
- **Insufficient or lack of capacity to test Industry 4.0-based solutions** including limited access to facilities to test the solutions and advanced technologies;
- **Insufficient amount of highly qualified experts in the field of ICT** to implement and use advanced Industry 4.0 solutions. SMEs often fail to attract such highly skilled workforce due to competition from big companies. They also do not tend to frequently invest in training or requalification of their current personnel.
- **High entry barriers for acquiring and using advanced technologies.** Due to the eased access to funding that large companies have, they are considered to be the ones that test and patent advanced technological solutions which makes it harder and more expensive for the followers, SMEs in particular, to make use of them. In addition, the development of Industry 4.0 regulating legislation, if developed following some US and Asian examples, itself may favour “industrial champions” bringing benefit to large corporations raising the entry barriers for SMEs and newcomers. That is why, extending the entry barriers is one of the solutions to overcome this obstacle.

In addition, one of the effects of Industry 4.0 will be a higher degree of internationalisation of production which will be easier to achieve for the large companies which have implemented

Industry 4.0-based solutions and it would be harder for SMEs who, in turn, may become more dependent on big corporations as their main customers.

Following the same study, these challenges need to be addressed by adopting multi-pronged approach including the following measures:

- Locating a place in existing supply chains next to Industry 4.0 leaders and benefiting from their knowledge and experience.
- Targeting developing niches in a more dispersed production system and marketing them in more localities internationally.
- Implementing advanced solutions which facilitate production on more decentralised basis such as 3D printing.
- Improving data processing with regard to resource planning and customer relationship management.

It is possible for the transition to Industry 4.0 to be enabled by the public sector on EU and national level through lowering entry barriers for SMEs to the Industry 4.0 market and supply chains and also through increasing public investments in R&D which may balance the market of high-tech solutions.

An interesting solution to address one of the biggest challenges for SMEs, namely the lack of qualified employees along with the lack of financial resources is implemented by The Institute for Information Management in Engineering (IMI) and the Karlsruhe Institute of Technology (KIT) where a laboratory for cooperation within Industry 4.0 is created and more particularly, a *digital “sandbox”* in order to gather SMEs and encourage them to brainstorm, exchange ideas and come up with solutions through gamification. The “sandbox” enables participants to use common tools and instruments in order to try new things and achieve their goals working together. In this way, the acquired digital knowledge transforms into skills used in their everyday job tasks. In the “sandbox”, the financial risks that SMEs take are limited due to the fact that a real investment is conducted only when there are clear, measurable advantages. That concept has been implemented in ELABO in Crailsheim, Baden-Wuerttemberg, as part of the introduction of their "Shopoor Execution System"(SES) (Popova, M. et al., 2018). The digital “sandbox” can be used as a good practice example that can have a positive impact on other SMEs as they can adopt and test it when faced with various problems.

Digital “sandbox” is used to gather SMEs and encourage them to brainstorm, exchange ideas and come up with solutions through gamification. In this case, the sandbox can be referred to as a testing environment for SMEs where financial risks are limited and the acquired digital knowledge can be used to transform their skills (Popova, M. et al., 2018).

The new technologies and approaches introduced by Industry 4.0 are rapidly changing the business landscape for SMEs. Willing or not, they would need to address the upcoming trends in order to maintain their competitive edge and thrive. Thus, becoming aware and educated on the complexity and prerequisites for the implementation of Industry 4.0 is of utmost importance for both the management and the employees of SMEs. Requalification, life-long learning, and

constant adaptation to the needs of the market and the industry, driven by the increasing digitalisation of the economy and work processes, could be the key assets for the success of Industry 4.0. The adequate talent pools are predicted to become one of the main advantages of SMEs even though automation will take up some of the tasks of employees. The impact of Industry 4.0 on machinery, systems, and processes in companies would consist of them becoming integrated and connected wirelessly, but highly skilled employees would have to interact with them in order to enable an efficient work process to be conducted. With the new developments taking place, new opportunities for reorganising the way people work also arise, for example, using machines for physically demanding work or introducing more flexible and family-friendly working hours. Closing the skills gap of employees in SMEs as soon as possible would mean that SMEs have a high chance of catching up with the Industry 4.0 development and not staying far behind large companies. Not addressing the irrelevancy of skills on time especially in the digital and ICT field would leave them struggling to tackle their competitors and even in some cases, not being able to become highly competitive again at all.

7. Conclusion

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The concept of Industry 4.0 through most of its scope is leaning on the possibilities deriving from digitalization and internet of things, but also it has a small section that is based only on non-digital elements, such as people, organisation and processes, providing the best illustration of its scope. The fourth industrial revolution is only driven by the contemporary technical and technological opportunities, representing a new era of new, flexible business models pivoting around the key competences of the organisation. This is creating completely new ecosystem in which the prerogative for success will be given solely to those companies which will have the ability to utilize optimal resources and to respond both proactively and reactively to the fast changing environment.

Internal and external process optimization, customer interface improvement, new ecosystems and value networks and smart products and services, give us a framework on how business models are changing. The “super archetypes” (Integration, Servitization and Expertise as a Service), that encompass several ideas on how businesses are changing (and these are linked with: Crowd sourced innovation, production as a service and mass customization, life-long partnerships, product as a service, result as a service product related consulting, process related consulting, broker platforms and IoT platforms). This will drive changes in various business areas such as New Digital Models, Digital Engineering, Vertical Integration, Horizontal Integration, Intelligent Maintenance and Services but also focus on the Digital Workspace and Digital Marketing.

Some concepts are transversal in our analysis, e.g. product as a service, mass customization, the use of IoT to provide analytics, optimization and link value chains. Use of smart technologies (software, interaction) and connected vertical and horizontal networks allow firms to innovate in associated services such as predictive maintenance, monitoring, consulting, building new platforms and services on top of hardware of their main services. Co-creation becomes possible (within the B2B) space but also new business models arise from the use of digital manufacturing technologies that value chain integration that allow customers to be part of the value process and to buy tailored products that are competitive in price. These changes also change revenue models, and firms sell subscriptions, results and able to transform their products into services.

Analysing the influence on the business models we should not forget several dimensions that are away from the value chain. Technologies that enable digital human resource management and the financial control of integrated value chains and other services that help firms to reach the customer (digital marketing) are also fundamental in this new field. Firms that

deliver cyber security, infrastructure (machines, sensors, etc.) and system agility (the interconnectivity of all parts) are also fundamental. And new business models also comprehend firms that help other firms in their digital transformation, providing expertise, training and new technologies that help organize, motivate and include people in this process.

The impact that Industry 4.0 has over the competitiveness of industry through the productivity, flexibility and efficiency is changing its position of revolutionary reform into essential concept. The SMEs that are already analysing their opportunities for restructuring according to the new trends, have already overcome the main entry barrier(s) connected to lack of awareness and strategy. The inclination of the European Commission, the national and local authorities towards Industry 4.0 suggest that at least on the middle run, SMEs across Europe will have alternative options for affordable financing (loans or co-financed grants) as a support in the restructuring. This process of implementing public funded projects is usually much longer, but SMEs need this lag to start with the non-digital reforms. This revolution in the organisation's business model, culture, and mindset, needs to be in line with human capital development, technological and market strategy of the organisation. Clearly, for many SMEs the fulfilling of the prerequisites for successful Industry 4.0 implementation will be benefit itself.

I4.0 means different things for different actors. For the firm it means greater efficiency, less costs, less time to market, better communication and increased flexibility. At the same time, it changes the fundamental way value chains are configured, changing the way companies interact with their suppliers and customers. Products become smarter, more focused and customized to the final customer and information flows through the value chain allowing for smarter development, production and distribution. Decisions become data based and can often be improved with AI. But what does this mean for workers? Their competencies skill set is transformed, with all organisational levels requiring now, to some degree, the use of data, IT tools or other related knowledge. Human-machine interaction becomes smarter, but this also means freeing workers for more creative tasks. These transformations influence how people are managed and trained. If in one hand we need more technical and mathematical competencies, on the other hand, we need to realize that automation frees people to more creative tasks where critical thinking is required and to other tasks that involve interacting with other people (thus soft skills and emotional intelligence become even more important).

Industry 4.0 is defined considering different point of view in Europe. Digitization and Digitalization was defined in order to establish a common definition for the stakeholders in the CHAIN Project and beyond. Finally, it is important to underline the necessity to SME to adapt their business model by introduction of new concepts, new organisation model, new management approach and new technologies to be more attractive and competitive in this new market model. In this way, this publication aims to become Manual for learners and a concise document for supplying HE representatives with relevant information for creating a new Curriculum dedicated to European SMEs in the digital economy.

Glossary

Business model	A <i>business model</i> describes the rationale of how an organisation creates, delivers, and captures value. (Osterwalder & Pigneur, 2010, p. 14)
Cost-benefit analysis	A systematic approach to estimating the strengths and weaknesses of alternatives used to determine options which provide the best approach to achieving benefits while preserving savings (for example, in transactions, activities, and functional business requirements). (David, Rodreck, 2013)
Digital “sandbox”	<i>Sandbox</i> is a term used in connection with software testing referring to a type of software testing environment that enables the isolated execution of software or programs for independent evaluation, monitoring or testing. (www.technopedia.com). <i>Digital “sandbox”</i> is used to gather SMEs and encourage them to brainstorm, exchange ideas and come up with solutions through gamification. In this case, the sandbox can be referred to as a testing environment for SMEs where financial risks are limited and the acquired digital knowledge can be used to transform their skills (Popova, M. et al., 2018).
Digital twin	A set of virtual information constructs that fully describes a potential or actual physical manufactured product from the micro atomic level to the macro geometrical level. (Grieves, 2016)
Digitalization	implies the integration of digital technologies into everyday life by the digitization of everything that can be digitized. (Schallmo and Williams, 2018)
Digitization	is defined, as the conversion of analogue information in any form (text, photographs, voice, etc.) to digital form. (Schallmo and Williams, 2018)
Internet of People	All networking functions take into consideration that Internet devices can be users’ personal devices, and therefore exploit models of the human behaviour to determine the way these devices should operate in the network. Stretching this further, the IoP concept embraces even a tighter integration between new generation internet (NGI) devices and humans, allowing humans themselves to contribute resources to NGI functions, evolving current rudimentary examples such as crowdsourcing and crowdsensing. A few key elements are at the basis of this view of IoP: IoP is inter-disciplinary, IoP is quantitative (not qualitative), IoP has a technological focus, IoP is networking, and IoP embraces data-oriented Internet functions. (Conti M., Passarella A., 2017)
Internet of Things	A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on

existing and evolving interoperable information and communication technologies. Including two aspects: (NOTE 1): through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled; and (NOTE 2): From a broader perspective, the IoT can be perceived as a vision with technological and societal implications. (ITU-T, 2012)

Manufacturing execution systems (MES)	are computerized systems used in manufacturing to track and document the transformation of raw materials to finished goods. <i>MES</i> provides information that helps manufacturing decision makers understand how current conditions on the plant floor can be optimized to improve production output. <i>MES</i> works in real time to enable the control of multiple elements of the production process. (McClellan, 1997).
Marketing innovation	A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. (OECD, 2005)
Organisational innovation	A new organisational method in business practices, workplace organisation or external relations. (OECD, 2005)
Process innovation	A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. (OECD, 2005)
Product innovation	A good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user friendliness or other functional characteristics. (OECD, 2005)
Ransomware	is a type of malware from crypto virology that threatens to publish the victim's data or perpetually block access to it unless a ransom is paid. (Young, A. et al, 1996)
Servitization	Is the innovation of an organisations capabilities and processes to shift from selling products to selling integrated products and services that deliver value in use. (Baines, et al. 2009)
Value chain	The idea of the <i>value chain</i> is based on the process view of organisations, the idea of seeing a manufacturing (or service) organisation as a system, made up of subsystems each with inputs, transformation processes and outputs. How value chain activities are carried out determines costs and affects profits. (Porter, 1985)

8. References

The references of the sources used in this brochure have been structured by chapter for easier accessibility.

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