

Fourth Industrial Revolution: Current Practices, Challenges, and Opportunities

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Abstract

The globalization and the competitiveness are forcing companies to rethink and to innovate their production processes following the so-called Industry 4.0 paradigm. It represents the integration of tools already used in the past (big data, cloud, robot, 3D printing, simulation, etc.) that are now connected into a global network by transmitting digital data. The implementation of this new paradigm represents a huge change for companies, which are faced with big investments. In order to benefit from the opportunities offered by the smart revolution, companies must have the prerequisites needed to withstand changes generated by "smart" system. In addition, new workers who face the world of work 4.0 must have new skills in automation, digitization, and information technology, without forgetting soft skills. This chapter aims to present the main good practices, challenges, and opportunities related to Industry 4.0 paradigm.

Keywords: Industry 4.0, innovation, opportunities, digitalization, economy

1. Introduction

In recent decades, producers and suppliers of goods and services have improved the quality of their organizations through the use of innovative technologies [1]. This is because the industry is undergoing transformation and evolution toward complete digitization and the intelligence of production processes to ensure high efficiency [2]. To achieve these goals, it is necessary to implement new technologies for the automation of industrial processes. These concepts are the pillars of the fourth industrial revolution called "Industry 4.0" [3]. The fourth industrial revolution was developed in Germany in 2013 but is spreading rapidly in Europe

and the world as a whole [4]. This new work model focuses on the integrated man-machine approach through “sustainable” production.

The Industry 4.0 is based on the concept of smart factory, where the machines are integrated with men through cyber-physical systems (CPS). In other words, Industry 4.0 is a new level of organization that manages and controls the whole value chain of personalized products to satisfy customer needs [5]. Digitalization is the most important element in Industry 4.0 because it allows to connect man and technology [6].

Industry 4.0 covers three fundamental aspects:

1. *Digitization and increased integration of vertical and horizontal value chains*: development of custom products, customer's digital orders, automatic data transfer, and integrated customer service systems.
2. *Digitization of product and service offerings*: complete descriptions of the product and its related services through intelligent networks.
3. *Introduction of innovative digital business models*: the high level of interaction between systems and technology opportunities develops new and integrated digital solutions. The basis of industrial Internet is the integrated and real-time availability and control of systems across the enterprise.

The effect is a radical transformation of traditional industries that are changing their “approach” to the work. It means the use of new production technology, new machinery, new materials, and new inputs. In this context, knowledge has become the crucial input. Furthermore, a complete integration between the cyber and physical dimensions is occurred.

Western civilization has passed through three stages of the industrial revolution, and the fourth revolution is in progress. An industrial revolution can be defined as a disruptive leap in the industrial process [7], a development that produces fundamental changes in the society and the economy [8].

Figure 1 describes the main phases that characterized industrial revolutions. The first industrial revolution was developed in the eighteenth century due to mechanical production obtained by water and steam, with the development of machine tools and an improvement of their efficiency. The second industrial revolution developed with the arrival of electricity and mass production, theorized by Smith and Taylor and implemented by Henry Ford in his Detroit factory for the production of the Model T. The third revolution was characterized by machine automation through the use of electronics and IT applied in the production processes [9].

The fourth industrial revolution integrates IT systems with physical systems to get a cyber-physical system that brings the real world in a virtual reality. There are also several opposing opinions. For example, *The Economist* [10] stated that the fourth industrial revolution is only an evolution of the third industrial revolution. Harald Krüger, Chief Production Officer at the BMW Group, instead, considers this development not as a fundamental revolution taking a huge digital leap forward. He explained that it is a constant development

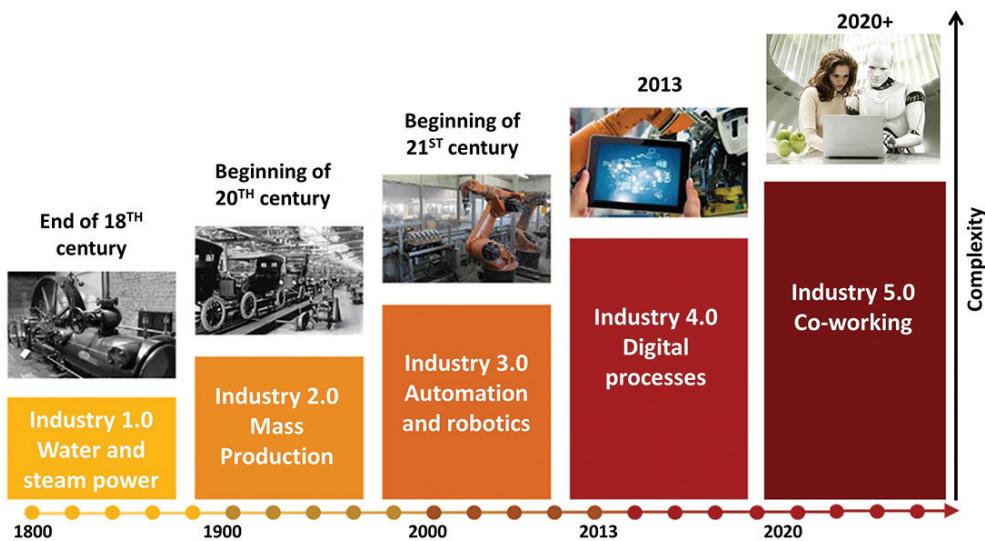


Figure 1. Industrial revolutions.

of technologies that will enable companies to achieve higher productivity, flexibility, as well as enhanced product and service qualities [11]. Roland Berger [12] also mentioned that there are slow and steady changes in some areas and described some evolutionary effects of this development. However, the majority of experts, including those in leading companies such as McKinsey & Company, Boston Consulting Group, Capgemini Consulting, Accenture, and General Electric have clearly pointed out the fundamental change of this development considering this transformation toward digital manufacturing as a new and considerable industrial revolution with tremendous effects on countries, economics, businesses, and human labor.

The current industrial revolution is characterized by the collaboration of intelligent machines, storage systems, and production systems into intelligent networks, merging the real and virtual worlds in cyber-physical systems (CPS) [13]. CPS are the integration of IT system with mechanical and electronic components connected to online networks that allow the communication between machines in a similar way to social networks [14]. These innovative technologies enable factories to become “smart,” resulting in productions of customized products on an industrial scale while providing many opportunities for improvements in operational flexibility and efficiency. Japan begins to talk about the fifth industrial revolution coming, which will be based on cooperation between man and machine.

The rest of the chapter is organized as follows: Section 2 presents state of the art on the “Industry 4.0”; Section 3 analyzes the main principles of digital technologies and industrial transformations. In Section 4 the main opportunities related to Industry 4.0 are analyzed. Then, Section 5 presents qualification and skills operator required for Industry 4.0. Finally, in Section 6 the main conclusions of the chapter are presented.

2. State of the art on “Industry 4.0”

A comprehensive overview of the state of the emerging industrial revolution is essential to understand the *phenomenon* around the world. To this purpose an investigation on Scopus database, the largest abstract and citation database of peer-reviewed literature, was carried out. The methodological approach used for literature review survey is shown in **Figure 2**.

Search string used in the literature survey was “Industry 4.0.” The string was defined according to the standards of Scopus database. Articles, conference, and book chapters in which the string was found in *keywords* were analyzed. The analysis on Scopus pointed out that from 2012 (the year in which the first article was published) until October 2017 (the period of research), there is a constant, growing interest on this topic. Considering this time period, the Scopus database returns 886 results related to the topic “Industry 4.0.” From 2015 onward scientific production has increased considerably, as shown in **Figure 3**.

The survey confirmed that most of the publications are German. It is worthy to note that German publications are quadruple compared to Chinese publications, and compared to Italian publications, the value is seven times more as shown in **Figure 4**.

The search was refined considering only articles. The research shows 274 published articles since 2012. Since 2015, there is a growing trend of publications on these issues. This strong interest is certainly due to the strong attractiveness of the issues of smart manufacturing both

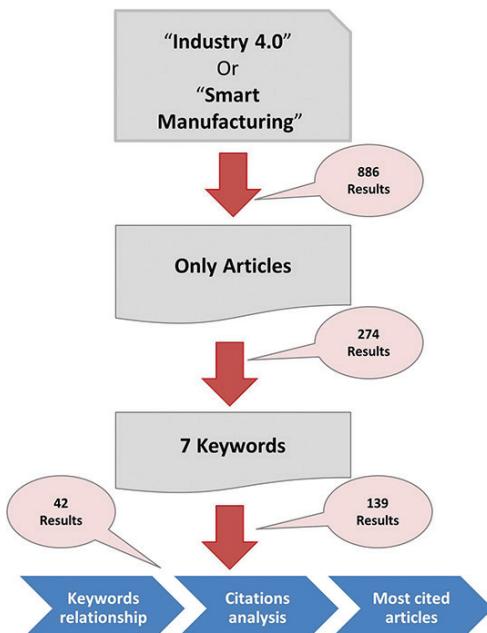


Figure 2. Literature review methodological approach.

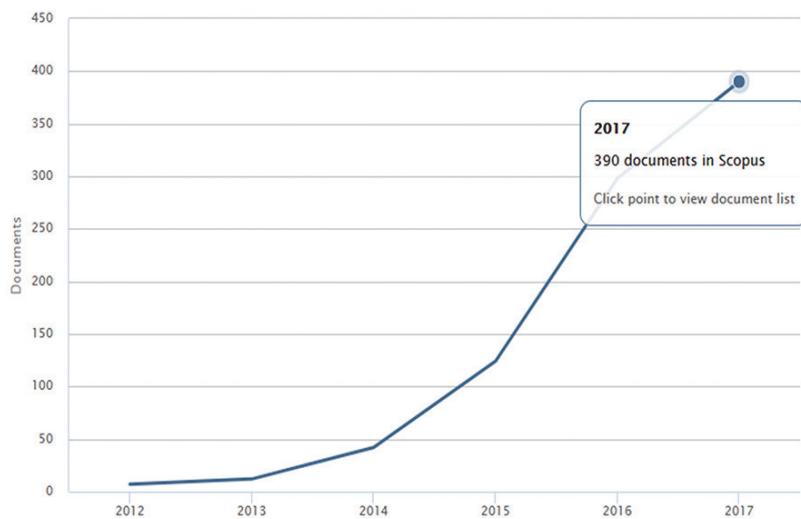


Figure 3. Documents by year.

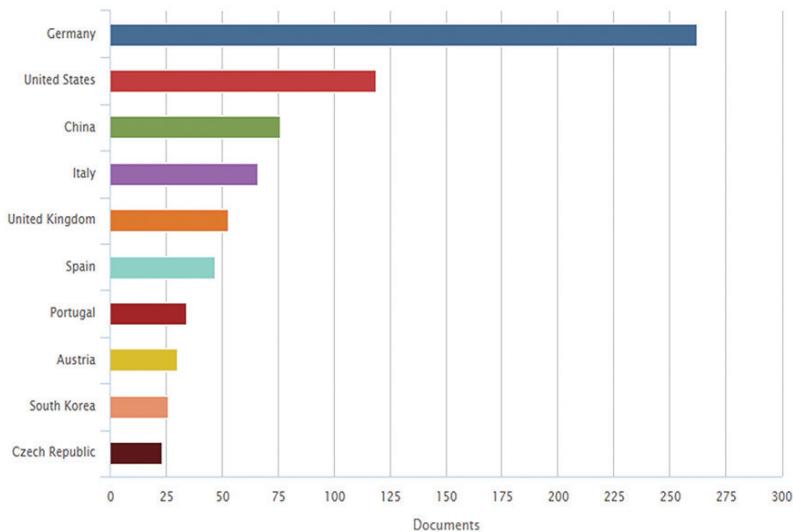


Figure 4. Documents by country.

from a research and business point of view. The analysis pointed out that 73% of the analyzed publications refers to engineering issues, 39.4% refers to communications issues, and 20.4% refers to business process management. Analyzing the 274 articles found, the search was more refined using seven specific keywords that characterize "Industry 4.0" as detailed below:

- *Cyber-physical systems*. There are 55 articles (20.07%) that contained the keyword (CPS) between the keywords. The first publication dates back to 2012, but since 2015, a “stable” research on this issue has started.
- *Big data or digitalization or digital*. There are 43 articles (15.69%) that contained the previously defined keywords. The first publication dates back to 2015, and in 2016–2017, there was a growing, extremely positive trend.
- *Internet of things (IoT) or wireless*. There are 50 articles (18.25%) that contained the previously defined keywords. The first publication dates back to 2016, while in 2017 there has been a downward trend of about 10 publications. This trend could turn out to grow, as several months remain missing at the end of 2017.
- *Automation or artificial intelligence or robotics*. There are 18 articles (6.57%) that contained the previously defined keywords. The interesting publications for the analysis are from 2015 to 2017 which show a positive trend.
- *Additive manufacturing or 3D printers*. There are six articles (2.19%) that contained the previously defined keywords. The first release dates back to 2014; there are other publications until 2017, but the number is very limited.
- *Cloud*. There were 10 articles (3.65%) that contained the previously defined keywords. The first release dates back to 2015. There are no such publications for 2017.
- *Simulation/augmented/virtual reality*. There were 10 articles (3.65%) that contained the previously defined keywords. The first publication dates back to 2012. But in the 2-year period 2016–2017, research began to produce more complete and complete documents.

Figure 5 describes the number of articles classified for each keyword.

In the rest of the papers, other keywords are cited. Furthermore, it is worthy to note the relationship between different keywords in the same article. The results are shown in **Table 1**. The most important relationships are developed between cyber-physical systems and big data systems.

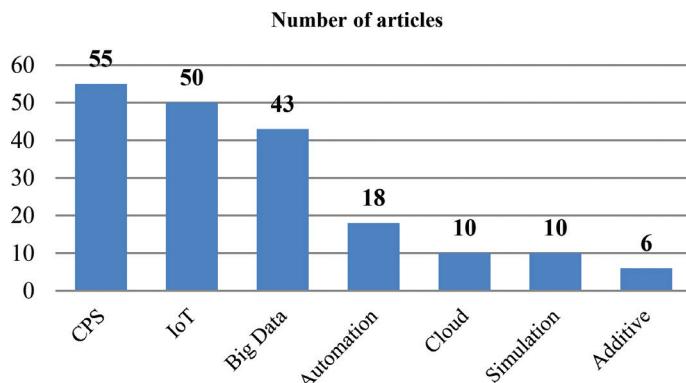


Figure 5. Number of articles classified for keywords.

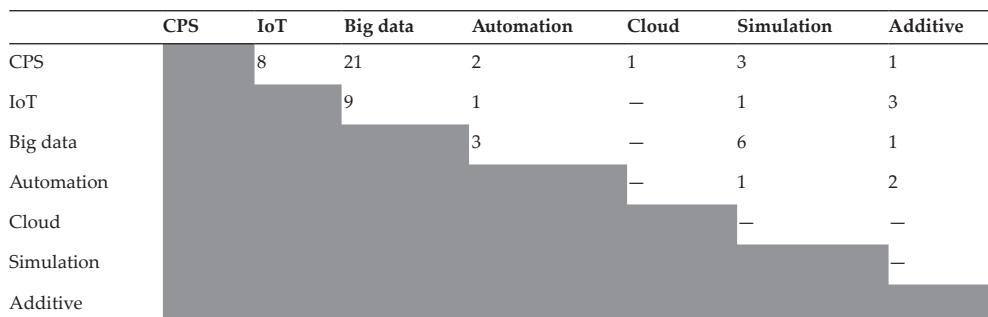


Table 1. Relationship between keywords.

Authors	Title	Year	Citations
Lee, J.; Bagheri, B.; Kao, H.	A cyber-physical systems architecture for Industry 4.0-based manufacturing systems	2015	258
Davis, J.; Edgar, T.; Porter, J.; Bernaden, J.; Sarli, M.	Smart manufacturing, manufacturing intelligence, and demand-dynamic performance	2012	103
Posada, J.; Toro, C.; Barandiaran, I.; Döllner, J.; Vallarino, I.	Visual Computing as a Key Enabling Technology for Industrie 4.0 and Industrial Internet	2015	45
Kang, H.S.; Lee, J.Y.; Choi, S.; Kim, B.H.; Noh, S.D.	Smart manufacturing: past research, present findings, and future directions	2016	38
Yue, X.; Cai, H.; Yan, H.; Zou, C.; Zhou, K.	Cloud-assisted industrial cyber-physical systems: an insight	2015	19

Table 2. Most cited articles.

Table 2 shows the most cited analyzed articles. In detail, the most cited article is proposed by Lee et al. that present an integrated five-level system for the implementation of a cyber-physical system [1]. Then, Davis et al. present the smart manufacturing approach based on intelligent cyber-physical components for smart organization management [15]. In 2015, Posada et al. describe the positioning of visual computing within the smart manufacturing system to indicate specific future scenarios [16]. In 2016, Kang et al. develop a literature review analysis identifying and analyzing different articles related to smart manufacturing to create a clear view of existing technologies, practices in companies, and future trends [17]. Finally, Yue et al. analyze the development of industrialization and technology digitization by presenting a model supported by a cloud system for managing a sustainable industrial system [18].

3. Digital technologies and industrial transformations

The key objective of Industry 4.0 is to be faster and to drive manufacturing to be more efficient. The main technology used in the context of Industry 4.0 is **cyber-physical systems (CPS)** [19]. CPS are considered a Key Enabling Technology (KET) in the fourth industrial revolution.

CPS are a set of different enabling technologies, which generate a stand-alone, intercom, and intelligent system and, therefore, can facilitate integration between different and physically distant subjects. This system enables three sequential scenarios: *data generation and acquisition*, *computation and aggregation of previously acquired data*, and finally *decision support*. This definition includes the presence of interconnected objects which, by means of **sensors**, **actuators**, and a **network connection**, are able to generate data, thus reducing the distances between the various subjects involved. Therefore, a CPS can be defined as a system in which physical objects are required to be flanked by their representation in the digital world; are integrated with elements that are capable of computing, memorizing, and communicating; and are networked with each other [20]. The functionality of a CPS can be summarized in five levels, as defined below:

- **Level #1. Smart connection:** The ability to manage and acquire data made available in real time thanks to intelligent sensors and to transfer them with specific communication protocols
- **Level #2. Data-to-information conversion:** The ability to aggregate data and convert it to value-added information
- **Level #3. Digital twin:** The ability to represent real time in a digital reality
- **Level #4. Cognition:** The ability to identify different scenarios and support a proper decision-making process
- **Level #5. Configuration:** Provides feedback on physical reality from virtual reality and applies corrective actions to the previous level

Following the development of CPS, the fourth industrial revolution is characterized by the use of specific enabling technologies. The main nine technologies are described below and depicted in **Figure 6**.

Big data is certainly one of the most important technologies adopted in Industry 4.0. It is related to the large collection, processing, and analysis of structured and unstructured data with intelligent algorithms. It has recently become a topic widely debated in the business and university world, as it offers a number of new opportunities for businesses. Another important technology is **cloud computing** that allows to manage huge data volumes in open systems and ensure real-time communication for production system. Cloud computing allows access to information from anywhere in the world at any time, thus increasing flexibility [21]. In intelligent factory, data are transmitted digitally, so **cybersecurity** plays a key role in the new industrial revolution. IT security systems are important to enable the full potential of the other technologies. Industry 4.0 includes the use of **automated robots** managed directly by the intelligent factory and connected to the rest of the enterprise system. Processing is automatically handled by cyber-physical systems. Generally, automatic robots are used for ergonomically difficult or highly tiring jobs. The evolution of technological systems and the increasingly personalized demands of customers have led to the evolution of **additive manufacturing** techniques and 3D printing. Through this technique, it is possible to construct prototypes but also finished products in three sizes for the most different purposes. With prototypes it is possible to test the material while the finished products are used. In particular,

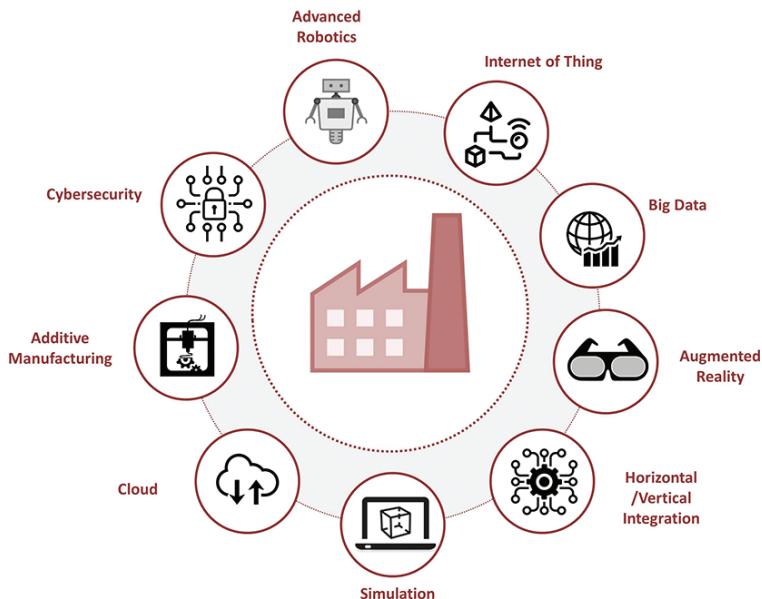


Figure 6. Enabling technologies for Industry 4.0.

3D printing for the production of finished products is used for highly personalized products, such as biophysical part or parts for cars of formula 1. New educational models 4.0 exploit increased reality technology, through **augmented reality**. Through virtual reality it is possible to educate operators, by teaching the right operations to do for maintenance or machine setup. The augmented reality system aims to replace old paper manuals that are difficult to understand. Through **horizontal and vertical integration** technology, it is possible to cross company data integration based on data transfer standards. In other words, computer and command processes are increasingly networked and integrated.

Finally, **simulation systems** and software are also very much used. Through these tools it is possible to simulate business systems and manufacturing processes by analyzing system input and output in real time and obtaining a detailed report about the process under study.

Industry 4.0 has developed a profound impact on society, factories, household, public sector, economies, etc. There are developing countries that are already preparing for and adopting strategies regarding Industry 4.0, such as China and India. A major challenge for developing countries is to reverse their strategy. In the past, they have pointed to low labor costs. With the advent of Industry 4.0, this is not possible because it is necessary to have highly specialized operators. Industry 4.0 offers opportunities, such as increased productivity, reduced waste, and promotion of the circular economy and more sustainable patterns of production and consumption [22].

Industry 4.0 requires different **prerequisites** for its application. Digital skills are definitely the most important factors. In addition, other important elements are automation and big data

analysis that connect all stakeholders of a system and create a smart network that transmits real-time data. The correct implementation of a 4.0 system within a company depends on its ability to respond to change and innovation management.

The most important steps for supporting Industry 4.0 are:

- Step#1: Create awareness of the importance of innovation.
- Step#2: Educate the innovation management.
- Step#3: Identify potential improvements.

Another key prerequisite for implementing system 4.0 is related to the skills of operators (the last paragraph analyzes this topic in depth).

It is crucial to distinguish the expected **changes** with the implementation of the 4.0 systems. In this case it is considered the change of a developed country, developing country, business manufacturing, and research organization.

For a **developed country**, the implementation of 4.0 systems involves several challenges:

- The need for experimentation and learning, to give a way for companies to strengthen their business
- Data explosion, to send information more and more quickly and increase data volume
- Transformation of the workforce, integrating the system operators with new skills that enable it to manage work digitally with the help of cyber-physical systems

There are three major challenges for **developing countries**:

- Training of operators with specific skills in managing digital jobs.
- Scalability. There are few companies that have now implemented industry-leading 4.0 systems.
- The need for funding to start planning at the national or regional level for the implementation of systems 4.0.

The implementation of an Industry 4.0 system involves significant changes to **business manufacturing**. Firstly, it is necessary to attract strong investments, as the industrial Internet is expecting a great digitization and therefore a strong investment [23]. In addition to investments, it is important to promote strong leadership practices to promote the proposed changes. If the company is not open to change, it will fail. Another major obstacle to the digitization process is the inability to predict the return on investment, and this pushes many companies to invest.

According to Accenture and General Electric [24], a major change concerns big data analytics, since all operations will be managed by intelligent sensor systems, which will have to transmit huge volumes of data in a shorter time. The task of the operator will be to capture and

analyze the data [25]. Companies should take advantage of the opportunities offered by CPS to generate added value from the collected data to meet customer needs.

Further challenge for companies will be the security of computer data. Standard will be needed to ensure communication between intelligent systems by avoiding any external intrusion. Companies face the challenge of ensuring that their operations are safe to avoid data leaks that could compromise their competitiveness and include the loss of confidential information on major customers.

Companies implement 4.0 systems that have been developed and tested by **research organizations**. Therefore, it is crucial to invest and progress technologically in research centers that are the lifeblood of the industrial system.

4. Opportunities of Industry 4.0

In Germany, Industry 4.0 was born in the direction of developing a collaboration of all stakeholders. Now, a new phase has started that aims to overcome national borders and establish new international collaborations, especially at the European level.

Figure 7 shows the main initiatives for Industry 4.0.

From a PWC analysis on a sample of 235 European companies (**Figure 8**), it is noted that an average about 3.3% of 4.0 investment revenue is invested in Industry 4.0 applications [26].

Only a quarter of the surveyed companies do not have the skills related to Industry 4.0. Intelligent industrial solutions enable to improve efficiency and reduce costs across the value chain. The investments of the analyzed companies correspond to 140 billion euros. Of these, 3.9% is intended for information and communication, and 3.5% is for industrial production and engineering (**Figure 9**).

Investment priority shows the supply chain at first, followed by engineering and services, while distribution takes on lesser values (**Figure 10**).

In 5 years, more than 80% of companies will have to digitize their value chain. The industrial Internet has now been added to the agenda of the majority of companies. One-fourth of the respondents already classify the current degree of digitization of their value chain as high. In concrete terms, this means that most of the companies are already using or have implemented industrial Internet solutions in different divisions (**Figure 11**).

Industry 4.0 affects different sectors, and this is one of its strengths. The major industrial sectors examined by Accenture and General Electric [27], which are heavily influenced by the industrial revolution, are manufacturing, oil and gas, power generation/distribution, railway, and mining.

The **economics opportunities** of Industry 4.0 are wide and affect the entire economies and countries. Several studies and figures have been published in recent years illustrating the value of these new developments. A survey developed by Accenture [28] predicts the IoT

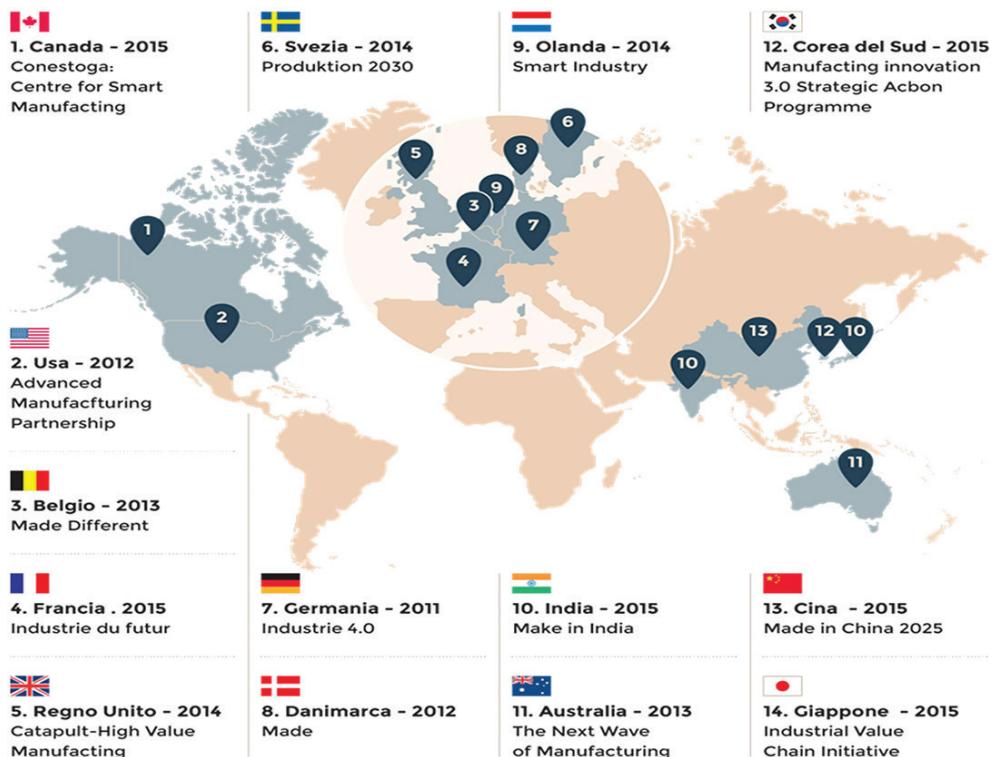


Figure 7. Main initiatives for Industry 4.0 (source: IL sole 24 Ore magazine).

value for countries including the United States, China, Germany, and the United Kingdom by 2030. The United States is likely to have the biggest benefits (US \$ 7.1 billion) followed by China (US \$ 1.8 trillion), Germany (\$ 700 billion), and the United Kingdom (\$ 531 billion). This study highlights the extraordinary opportunities offered by Industry 4.0. The significance becomes even more evident given the value added to GDP by the manufacturing sector in different countries. For example, the production contributed 22% of Germany's GDP in 2013 and 12% of US GDP in 2013 [28]. Another great opportunity created by Industry 4.0 is the strengthening of national production in Europe and North America. As a result, it could also convey the trend of the outsourcing industry to low-cost and low-income countries, due to changes in production requirements and factors [29].

To achieve **business opportunities** at the national level, manufacturing enterprises need to recognize the new possibilities that offer companies Industry 4.0 paradigm [30] that could exist in different fields, as follows:

- *Efficiency*: savings of raw materials and energy
- *Productivity*: intelligent technologies that are more productive
- *Flexibility*: use of cyber-physical systems

- *Individualization on demand*: integration of customer through network (cyber-physical systems)
- *Decentralization*: faster and data-driven decision-making

Other opportunities are related to the new technologies integrated into the 4.0 systems. The fourth industrial revolution is characterized by the merger of digitization and automation to make the machines intelligent, interactive, and easy to use. These new technologies will have a huge impact on working patterns. There will be new types of robots that can interact with humans. This technology will complement human activity, in particular cognition, combined with other emerging technologies to give us completely new computer models. Thus, *new skills* are needed to bridge the gap between engineering and computer science, automatic learning, and artificial intelligence. Industry 4.0 must also be a suitable tool for **eco-sustainable production**. This is because industry will continue to depend on resources and energy, and each country will play in the production and supply of resources and energy. In order to combat climate change, China has promised to reduce the intensity

Amount of investments in % of annual revenues

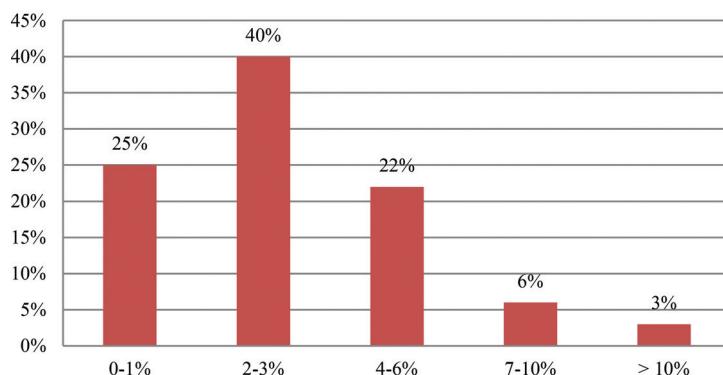


Figure 8. Average annual investments in Industry 4.0 applications (Source: PWC Industry 4.0, 2014).

Investment amount (% of annual revenues)

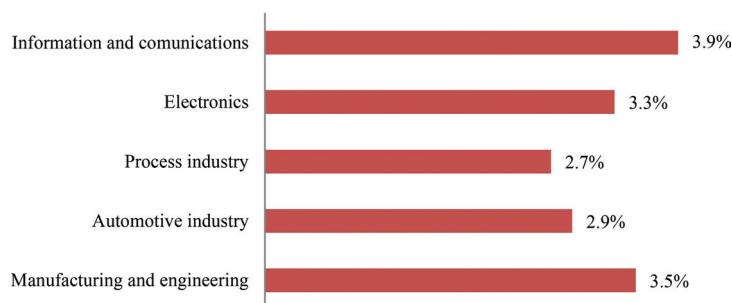


Figure 9. Annual investment in Industry 4.0 (Source: PWC Industry 4.0, 2014).

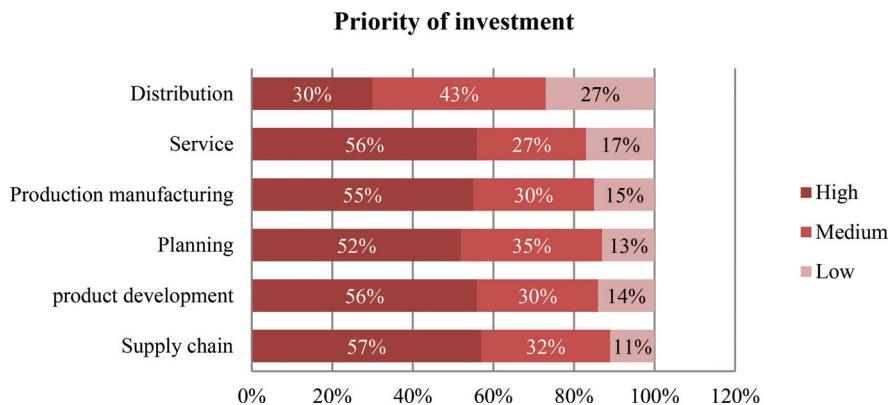


Figure 10. Priority of investments (Source: PWC Industry 4.0, 2014).

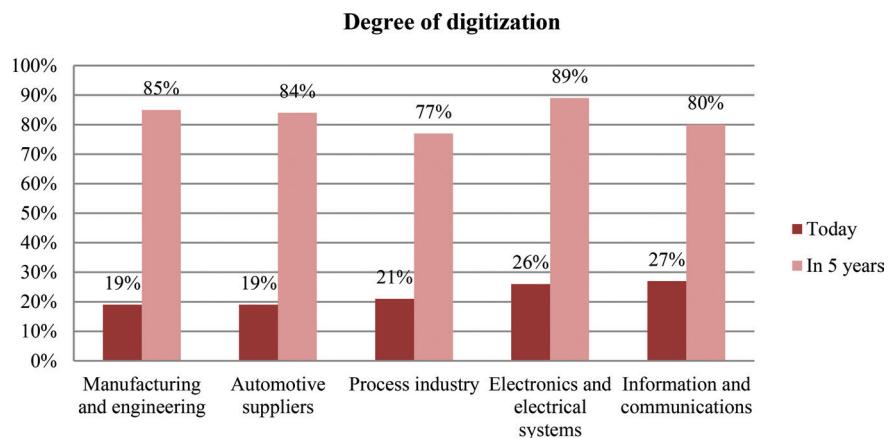


Figure 11. Degree of digitization of the value chain by industry sector (Source: PWC Industry 4.0, 2014).

of carbon dioxide emissions from 60–65% by 2030, compared to 2005. The main objective of the strategy is to ensure that Chinese production is geared toward innovation and green. It has ten priority development areas, including energy conservation and new energy vehicles, electrical equipment, and modern rail equipment, which aim to reduce carbon dioxide emissions. Some examples are energy-saving (mainly electric) vehicles, third-generation nuclear power plants, and the construction of new high-speed railways between Beijing and Shanghai, 1200 km away. The PWC survey reports the percentage of companies that have increased their efficiency and that have decreased costs. Figures 12 and 13 show the quantitative effects of the benefits of Industry 4.0 applications, considering the efficiency increase and cost reduction, while Figure 14 describes the quality benefits of Industry 4.0 applications.

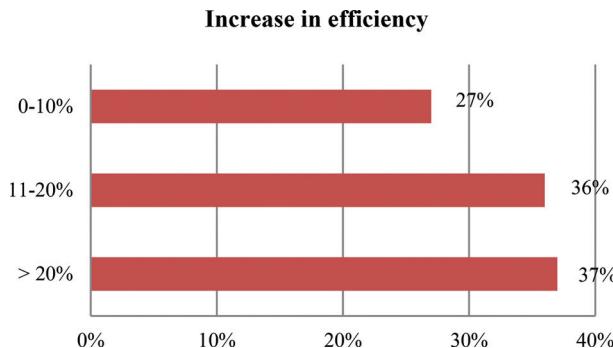


Figure 12. Increase in efficiency (Source: PWC Industry 4.0, 2014).

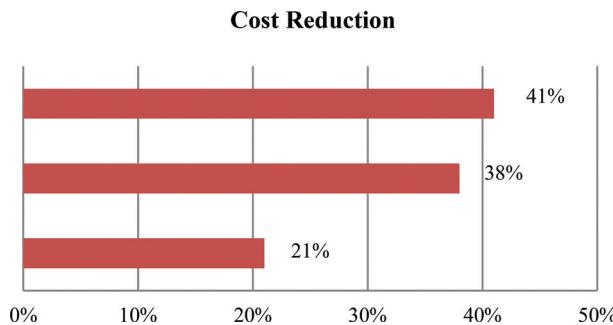


Figure 13. Cost reduction (Source: PWC Industry 4.0, 2014).

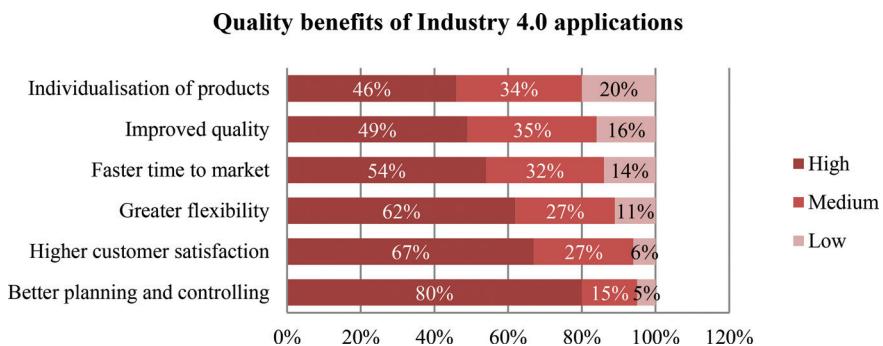


Figure 14. Quality benefits of Industry 4.0 applications (source: PWC Industry 4.0, 2014).

5. Qualification and skills of Industry 4.0

The work of the future will be very different from the traditional work, so traders will also have some different skills than those required today [31].

Influence on the human factor is linked to four elements: (1) tools and technologies, (2) organization and structure, (2) working environment, and (4) organizational cooperation.

In the future factory will increase the need for skilled digital work, will decrease the need for manual work, and will provide the worker with the exact information they need in real time or in a certain situation to perform their task efficiently. Workers are able to control and monitor production processes through the analysis of data and information supported by these devices. Intelligent systems will further make it possible for the worker to make qualified decisions in a shorter time. Collaborative robotics will share a work station with humans. These robots support the worker, for example, in situations that are critical with respect to ergonomics. Intelligent tools and technologies will become more autonomous and automated, but the supervision and efficient application of machines by humans will become more important than ever before.

Technologies can perform at high efficiency if the organization and structure of a company provide the right environment for them [32]. So, a significant change in the used technologies should and will proceed jointly with a significant change in organization and structure. Workers, capable of working with the information and data flow, will not necessarily be bound to a certain production area anymore, but the new operator skills will improve job management by making it more qualified, responsive, and more decision-making.

In the recent past, the world of industrial production was perceived from the outside as being a dark and dirty place with no windows where raw physical work is carried out by a horde of [33]. The perception of the working environment of the future will again be different. The future working environment will be an open and creative space. Work will be more flexible and transparent, more planned, and balanced. Surely, the homework will increase. Modern assistant systems will provide the workers with the ability for quick decision-making despite the increased complexity of their job contents. The work will be improved with respect to ergonomics. In particular, non-ergonomics processes are likely to become automated to improve the production workers' conditions.

In the factory of the future, intraorganizational cooperation and communication will be fundamental. Networking and interconnectedness are focal components of the Industry 4.0. Workers will collaborate and communicate real time without borders using smart devices. The Internet provides the possibilities to meet globally in virtual rooms at almost any time and to reach out for required information as needed. All kinds of information and data will be ubiquitous and at the fingertips of the workers leading to a whole new level of knowledge management. Humans communicate with other humans and with intelligent machines.

It is necessary to define a model to identify the skills of operators required in the factory of the future, from the school's point of view, and after school.

Here, below is a summary of the main phases required to ensure appropriate skills.

Phase #1: Education. It is necessary to attract the attention to the manufacturing topics already in the school education system. The ideal would be the creation of educational courses required for the introduction of the systems behind the factory of the future, to prepare future workers. Similarly, computer courses and foreign language that often are optional should be mandatory. The school placements should become more common, limiting the bureaucracy. Extension of the offer summer schools with enhanced programs to raise awareness of

computer science. Fundamentals are also visits to smart factories, to introduce students to the company and to give the company the opportunity to present their technologies.

Phase #2: School (work transition). Professional development courses are crucial to giving a first technical qualification to future workers. Workshops are recommended as they strengthen technical skills and qualifications. Workshops cannot only tackle both technical issues but also refine soft skills (self-management, teamwork, stress management, etc.) that are fundamental to the worker. The collaboration of university companies that allows to adapt the student profiles with the demands of the companies is very important. Students will be in contact with companies through their university. Developing professional bachelor's degrees to train the intelligent factory operator and give more insights than those already provided in high school and to develop technical skills and soft skills.

Finally, the internships are very important, as they allow students to know experiences in the company. They include not only both technical aspects but also interdisciplinary models such as personal skills and teamwork.

Phase #3: Continuous training. The last phase involves the continuous training of the operator in the workplace. Companies can only be competitive by investing in continuous training and improvement. Accenture [34] reviewed more than 300 US manufacturing companies between 2013 and 2014 and found that 80% of companies invest around \$ 1000 each year in training of each employee. Professional courses enhance technical and personal skills such as World Class Manufacturing or Six Sigma belt, which also enable certifications.

6. Conclusions

Several advanced economies are implementing the concept of Industry 4.0, marking the fourth industrial revolution. Increasingly, companies are applying innovative solutions, including through the "Internet of Things" (IoT), cloud computing, miniaturization, and 3D printing, that will enable more interoperability, flexible industrial processes, and autonomous and intelligent manufacturing. The new industrial revolution will be characterized by merging of technologies. Among the consequences of "Industry 4.0" and structural problems in the world, economy will be an escalation in competition at the geo-economic level. Industry 4.0 will concur to create new wealth and further improve living standards. The implementation of a 4.0 systems has considerable advantages. This chapter has analyzed a series of data showing efficiency increase and cost reductions for European companies that have implemented smart manufacturing systems. The implementation of a 4.0 system represents a real revolution within the company. In addition, the implementation of intelligent systems implies a considerable economic investment, and often the company cannot assess the economic return of that investment. For this reason, it is necessary to develop national or regional investment plans to encourage companies to invest in the 4.0 revolution. Companies that remain out of this revolution could disappear, as they would remain technologically obsolete with respect to their competitors. Before developing digitized systems, it is necessary to check if there are any prerequisites within the company to ensure the correct implementation of the new system. If there are no proper prerequisites, the first step to digitizing the company is to invest in training and information activities to train operators. As far as training

operators in the chapter, the formation of the new working class 4.0 has been of great importance. Communication should start from high school, through school-work alternation and by providing basic knowledge of computer science and robotics, to make it clear to young workers what is the trend toward which we are moving. This chapter has also analyzed the various changes that companies will face, distinguishing between developed countries and developing countries. In addition, business, economic, and financial opportunities that can be exploited by implementing Industry 4.0 systems have been described. The chapter also presented softly the most important intelligent factory technologies such as big data and cloud data analysis systems, cyber-physical systems that allow self-regulating operations run by intelligent robots, simulation systems and virtual reality to train addicting operators, and additive manufacturing to develop more and more customized products that meet customer needs. In conclusion it is worthy to note that to face the challenges of the future it is strategic to digitize manufacturing processes and implement intelligent automated systems that can self-manage. The commitment must be extended not only to companies but also to governments, whose task is not only to develop investment plans that are easy for companies wishing to renew their processes but also to train young workers from high schools by making compulsory modules of computer science, automation, and foreign languages, to create a new generation of "workers 4.0" who possess the hard and soft skills needed to operate within the intelligent factory. Only in this way, it will be possible to properly implement the new Industry 4.0 practices and to make technological advances to companies and the whole civilization.

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