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Evolution of Industry 4.0 and Its Implications for International Business

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Abstract

Industry 4.0 is the natural consequence of the techno-industrial development of the last decades. It has the huge potentiality to change the way globalization of manufacturing and consumption of goods and services that take place in the global markets. This chapter will focus on the evolution of Industry 4.0 and how this new technological framework will create values for firms and consumers, and how we can use it for a firm's competitiveness and save them from the fallout of its development. An extensive literature review shows that the multi-faceted technology will hugely impact the global value chain, global supply chain, and new global division of labor (NGDL). It will reconfigure and re-distribute the business activities in the developing, emerging, and developed country markets and small and medium sizes firms and MNCs. The rapid development of technological and human capabilities can allow firms to reap benefits from this technology. At the same time, there are many challenges related to skill shortages, technological issues, business ethics, and values that need to be overcome to reap a profit from this new technological advancement.

Keywords: industry 4.0, cyber-physical system (CPS), global value chain (GVC), global supply chain (GSC), big data

1. Introduction

Industry 4.0 has both expanded the possibilities of digital transformation and increased its importance to manufacturing, with an emphasis on globalization, international trade, and foreign direct investments. Industry 4.0 combines and connects digital and physical technologies including artificial intelligence, the Internet of Things, additive manufacturing, robotics, cloud computing, and others to drive more flexible, responsive, and interconnected enterprises capable of making more informed decisions [1]. The infusion of digital technologies in the value chain processes of research and development, design, production, marketing, distribution, and customer services will drive efficiency in production, thereby increasing the ambits of international trade.

Developed in Germany, currently, Industry 4.0 has become the most discussed issue in the industrial arena in the world. Both managers and policymakers from developed, emerging, and developing countries are debating this issue about how

they can participate in this fourth industrial revolution as well as save them from the fallout of this advancement. The issue is still evolving, and experts from all spheres of industry and markets are debating on it. The objective of this chapter is to participate in this debate and explore how Industry 4.0 will evolve in the coming years and how it might affect international trade and the global value chain. We will take an in-depth look into what exactly is Industry 4.0 in our globalized context, what it brings to the table when it comes to international businesses and how international organizations can benefit from Industry 4.0 in their globalization strategies? As a matter of fact, Industry 4.0 outperforms the previous industrial revolutions we have gone through during the past centuries. The fourth industrial revolution is the result of the combination between the real and the virtual world, in which deep learning encourages and challenges human capacities and frontiers, particularly, with the increase of cyber-physical systems. Indeed, the new industrial revolution which develops deep learning is not limited to the use of automation systems based on machine learning, but autonomous ones that do not systematically depend on human beings and which can learn and act by themselves. Industry 4.0 refers to many concepts such as artificial intelligence, smart technologies, smart factories, smart automation, or smart management like the implementation of enterprise resource planning and automation of robotized processes. The global business environment has already started to enhance efficiency with futuristic and high-value-added technologies, from which we are not able to see the frontier clearly for now.

Firstly, we will undertake a brief literature review to explain how we structured our work. We will then be having a great detailed analysis of Industry 4.0 and its main components and how it is changing the way corporations do business in an increasingly connected world. Parallely, we will explore the opportunities that the fourth industrial revolution brings as well as the challenges which emerged from this new revolution in order to counterbalance and give a realistic view of the latter. Finally, we will illustrate the major strategies that can enable the organization to avail opportunities emanated from Industry 4.0.

2. Opportunities and strengths of Industry 4.0

Industry 4.0 contributes to the virtualization of a physical production environment that facilitates connectivity and interaction between the machines as well as man and machines in real-time. The automation and connectivity as well as machine learning facilitate the inter-connectivity and improve the production process and bring several benefits to the organization. Some of them are presented in the following sections.

2.1 Generator of efficiency

Industry 4.0 is a generator of efficiency. Indeed, the great use of technologies within the different steps in the supply chain helps with optimizing the latter. It is, therefore, cost-effective, time-effective and it globally enhances productivity as well as flexibility and quality of outputs, which also raises the overall reliability of the firm and so the value of the company and its competitiveness. Industry 4.0 is not only about using high technology machines to produce more rapidly. There is indeed much more to that. Industry 4.0 can contribute to streamlining the value chain thanks to its transformation of every aspect of the production process from the logistics, passing through the managerial issues, to the networks, and more generally, the whole structure of firms in the network.

First of all, firms can benefit from *advanced planning and controlling with relevant, real-time data* [2]. Indeed, the collection and great use of data help with a greater inner and outer communication and organization, even from an international perspective: from a headquarter in Quebec City (Canada) to a manufacturer in Dhaka City (Bangladesh), for instance. Planning is simple and effective, and accessible for all employees who need to access it, and can be easily changed. The improvement of communication also implies a greater control of the organization thanks to easy access of the information, anywhere, anytime.

Data is the basis of all the improvements around artificial intelligence and the comprehension of the opportunities that can be taken in the organizations. Used correctly, data and communication tools can help firms to better respond to customers' demands and allow a better accuracy of forecasts too. Data within the industry can help to see what should be improved in terms of production methods to gain efficiency. In that sense, they can also more easily identify bottleneck products which would result in better opportunity costs. Firms can also benefit from greater management and control thanks to adapted software within the firm. Data can be used to analyze production time and costs, as well as comparisons of portfolios of suppliers and materials to get the best of their interest. It allows a rapid reaction to changes and errors. It also allows a quick adaptation when it comes to stock levels, wherever it is from the production or the purchasing teams' perspectives. Finally, data is the base of artificial intelligence. Thanks to machine learning, data is used to learn from mistakes and successes, which is crucial to be exponentially improving.

Thanks to data, programs are elaborated to improve the business networks such as suppliers with industries or with clients, or from clients to employees when they make a requirement for a change in the process of making an order. The communication is smoother, quicker, and easier to take action. Technologies also allow better safety of work conditions. The efficiency of new technologies allows companies to be more sustainable thanks to smart production facilities, which allows a better allocation of resources and vertical networking of smart production systems. The vertical networking of smart production systems can be defined as *Smart factories and smart products, and the networking of smart logistics, production and marketing, and smart services, with a strong needs-oriented, individualized and customer-specific production operation* [3]. Most firms affirm that Industry 4.0 and its innovations contribute to efficiency and profitability [4]. Industry 4.0 gives companies a better competitive advantage. This has a great impact on a company's profitability. This is partially due to a reduction of costs from the efficient use of resources. On top of this, we can observe the benefits of Industry 4.0 through its four main components [3]:

- *The vertical networking of smart production systems:* Vertically integrated Smart productions use deeply integrated data in order to rapidly orient the production in a customer-specific direction depending on the demand and the stock levels. The production is monitored by cyber-production systems (CPS) and smart sensor technologies (SST) that automatize the organization, making it autonomous. As a result, maintenance and management of production systems are optimized. All the processes at all stages and the resources that come with them are logged, which helps to perpetually update the fluctuations and adapt quickly to any movement of these factors. In a nutshell, the goal of this vertically integrated system is the efficiency of resources, and the satisfaction of specific, individual requirements of customers. These advanced systems allow firms to communicate in real-time with their supply chain partners across the globe, from producers to the clients and suppliers, and consequently to adjust their global supply chain on a continuous basis.

- *Horizontal integration via a new generation of global value chain networks:* The horizontal integration is a new model of the value-creation network: *optimized real-time networks that enable integrated transparency, offer a high level of flexibility to respond more rapidly to problems and faults, and facilitate better global optimization* [3]. Similarly, to the previous model of integration, horizontal integration works via CPS, in order to log and meet all the logistics challenges continuously (the traceability, the accessibility, management of warehouses, and production). Processes are therefore more flexible in every step of the value chain. Modifications and adaptations following the customer's requirement can be made at any level.
- *Through-engineering across the entire value chain:* The third main characteristic of Industry 4.0 is cross-disciplinary through-engineering across the entire value chain and across the full life cycle of both products and customers [3]. It consists of the development of integrated and coordinated to product-life-cycle production systems that creates an optimization of the relation between the production systems and the product development. The key to this component of I4.0 is also the deep integration of data, used at every step of the value chain.
- *Acceleration through exponential technologies:* The fourth main benefit of I4.0 is its impact on flexibility, individualization, and cost savings in terms of industrial processes thanks to its ever-growing set of innovative solutions.
 - a. *Autonomy:* Artificial Intelligence allows automation systems to be highly cognitive and autonomous thanks to advanced robotics and sensor technology that can perfect each individual production process.
 - b. *Safety and quality:* Nanomaterials and nano-sensors allow the close monitoring of production for better quality assessment and safer collaboration of humans with next-generation robots.
 - c. *Automated logistics:* The use of AI programmed machines like drones to make inventories, driverless vehicles in factories and warehouses to deliver components is particularly efficient thanks to their ability to function day and night under any weather conditions. These logistics solutions of smart factories allow for cost-cutting, flexibility, reliability, and time savings.
 - d. *3D printing:* Additive manufacturing (3D Printing) brings new functionalities and higher complexity of products without additional costs and new inventory management solutions thanks to delayed differentiation of products allowing for smaller stocks, and supply chain risk pooling between different factories. There are, however, still challenges to overcome before additive manufacturing can make an impact on manufacturing sectors given the fact that this technology is still expensive and unit cost of production is high, and do not follow economy of scale principles.

2.2 Customization

The most blatant of the effects of efficiency in this modern revolution is customer satisfaction. Indeed, thanks to the advanced technologies, customer demand is well – *if not above expectations* – aligned with the market's needs and wants while remaining highly profitable for the firm.

Customization is an important issue in the global manufacturing industry, and its relevance is expected to even increase in the future. Customers want to customize the design of their products and by influencing the development and production processes at an early or even late stage. This tendency creates the need for manufacturing companies to move from the objective of better products for their customers to the objective of an individualized understanding of customer needs and specialized, industry-specific solutions [5]. That is to say, a major shift from an economy of scale to an economy of customization regardless of the location of production sites in the global value chain.

This ongoing change of customers' needs results in more and more system complexity in system design as well as in assembly. Furthermore, commissioning can only be partially compensated by manufacturers' standardization and modularization efforts. Nevertheless, *end-to-end product data modeling* from engineering to commissioning enables efficient production at locations with a global presence and supply chain, as well as, an efficient way to cope with the increasing product complexity resulting from the demand for customized system solutions [6]. One way to implement individualization in the production process is through *assembly line production systems*. Modern assembly line systems have the increasing ability to offer each customer a different product that is better suited to their needs and preferences. These assembly line systems are enormously profiting from the upcoming Industry 4.0 technologies. Moreover, this development enables the proposal of business models covering product customization, i.e., customers can change attributes of their product once production of the product has started. This business model requires manufacturing tools to be able to make decisions online and negotiate with the customer on the changes that can be made, depending on the workload flowing through the production system [7]. The ability to make changes online also reduces the disadvantages of the large geographical distance between the manufacturer and the customer caused by international business activities.

Assembly line production systems will also be affected by an increase in flexibility in production. Bortolini et al. [8] state that products produced in assembly lines will not only be able to be personalized but that late customization (i.e., after the order has been placed) will also be possible because real-time information on the status of the production process will be available. This means that customers will not only be involved in the definition and design of the product and its specifications, as is the case with mass customization products but will also be launched once in a late customization mode [9].

In contrast, mass-customized production facilities typically produce large volumes of products that share a common core but may be customized to a certain degree [9], creating production process sections with repetitive larger lots (e.g., automotive press shop) and sections of high product variance (e.g., final automotive assembly). The customers of mass-customized production factories typically customize their products based on a predefined set of configuration options, which can be integrated into a common modular architecture. Mass-customized production type factories are typical in the automotive industry, automotive Tier-1 suppliers, and, to some extent, in the truck, bus, agricultural, and construction equipment sectors. Industrial equipment manufacturers – where factories simultaneously have large production volumes and accommodate an ever-increasing number of variants – run mass-customized production type factories as well.

Therefore, the strategy of providing differentiated products leads to a paradigm change in manufacturing planning, posing new challenges for industrial activities. To satisfy the new kind of markets, industries had to adopt agile models, exploiting the competitive advantages of each organization [10]. These manufacturing models intend to face the uncertainty of the market by increasing the response capability of the

organization in order to satisfy the customers with similar costs to mass-production industries [11]. Handling the production of large amounts of customized products presents a tough challenge since product differentiation hampers scale economies.

However, managing the production of personalized or customized goods will be quite demanding, given their different requirements. Finally, when late customization of the customer is possible to be accepted and when it is not, it depends on the production sequence in execution, and when it is possible to apply to re-sequence to incorporate the late customizations. Moreover, the advantages of late customization processes can be achieved only if the system is autonomous and can keep running the fabrication process. The customer needs real-time information about the evolution of the production of its personalized product [12]. And, as Kietzmann et al. [13] comment in the context of additive manufacturing, *As with most disruptive technologies, it is likely that we will over-estimate the potential of 3-D printing in the short term while underestimating it in the long term* [13]. In particular, for manufacturing companies, it can be concluded the widespread adoption of the constituent technologies has the potential to transform the location and organization of these production firms worldwide.

2.3 Big data analytics

Before Industry 4.0, companies used traditional data sources such as production records, internal accounts, and market research reports with a limited range for their decision-making process. The way of data sourcing is changing. Data is more and more generated from sources like sensor-generated data from smart products and data from search engines and social media sites. This technological shift offers multinational companies (MNC) the opportunity to access new worldwide business-relevant information. Additionally, technical progression regarding computing power and data storage costs is taking place. This results in the development of big data analytics [14–16].

To understand the innovational power of big data analytics, it is important to understand the changed concept about time in comparison to data analytics before Industry 4.0. Big data analytics is looking into the future and tries to generate existing and new data sources. The traditional role of information technology has been more backward-looking and concerned with monitoring processes and notifying management of anomalies. Firms that have adopted big data analytics report improvements in productivity and financial performance. For example, analysis of big data can enable managers to identify defects, faults, and shortcomings in the production process at an early stage, optimize automation processes and carry out trend analyses, use resources more efficiently and carry out predictive maintenance [17].

The potential implications of big data analytics for international business are several. In particular, firms will be able to monitor emerging trends and opportunities in overseas markets without the need to make substantial resource commitments in those local marketing affiliates, and they will be able to optimize more effectively their supply, production, and distribution activities around the world [18]. But there are two major drawbacks. The first is that the availability of good-quality big data may well be a source of value for firms, but successful firms will require a range of technical and governance capabilities to analyze and operationalize that data so as to realize the potential benefits [19, 20]. The second is that individuals' privacy will be under threat from widespread big data applications. Like Facebook knows what we like, Google knows what we browse, and Twitter knows what is on our mind [21].

New data protection laws and/or stronger industry self-regulation will need to be formulated to safeguard the privacy of individuals and companies, and to put limits

on what data can be accessed, stored, and transmitted both nationally and across borders [22]; Rose et al. [23]. It has to be discussed who will have legal title over what, and who will bear legal responsibility for, products that involve consumer-generated intellectual property [24] and how will these issues be handled in cross-border settings? Some form of (transnational) governance regime will be necessary to regulate this dilemma between the benefits of big data analytics described earlier and data privacy. Finally, this may influence or even determine the abilities of firms to maximize the commercial potential of big data analytics [25, 26].

2.4 Environmental impact: Energy sustainability

The optimization of production and logistics processes allowed by Industry 4.0 could have a major impact on the management of the environmental crisis. Indeed, the processes of Industry 4.0 that allow energy savings and waste reductions to cut costs for firms would be equally beneficial for the preservation of natural resources and biodiversity. The Sustainable Development Goals established by the United Nations include the improvement of energy efficiency and better management of waste. Therefore, the improvements brought by Industry 4.0 would be in adequation with government environmental policies and regulations, which will most probably become much stricter in the coming decades.

Industry 4.0 allows improved production management thanks to the production monitoring capabilities of Industry 4.0. Constant monitoring of production efficiency and intelligent quality control offer great opportunities in terms of production efficiency, waste reduction, and improved reliability. Consequently, firms would have a better energy efficiency [27]. Industry 4.0 allows firms to make informed decisions based on the data-mining possibilities brought by sensors and AI. Relevant statistics on production efficiency, product life cycle, and energy consumption will be available to the firms [28]. Industry 4.0 will also connect the consumer with its energy consumption thanks to the sharing of statistics made possible by smart data communication technologies [29]. Energy consumers will be informed on their consumption, and this will promote self-responsibilities.

However, these improvements could easily be counterbalanced by the fact that Industry 4.0 requires the collection and storing of massive quantities of data in data centers, which significantly contribute to global warming. But this is not a fatality, and firms should not be stopped by this challenge, as innovative solutions allow the heat produced by data centers to be reused as a heating source. This strategy is especially used in Nordic countries such as Finland or Sweden.

3. Evolution of Industry 4.0 and implications for global business

Research on Industry 4.0 is numerous and rapidly evolving. Many types of research have addressed the evolution of the Industry 4.0 (I4.0) phenomenon and its contribution to international business activities. Especially the major drivers of I4.0 that underlines its involvement to enhance current business practices by streamlining both the production and supply chain networks [30, 31]. Those developments in Industry 4.0 have huge implications on the way the current business activities both at home as well as across the globe (i.e., international trade) are being conducted. Mamad [2] has addressed how Industry 4.0 works and has made a broad illustration of the subject in detail through an exhaustive literature review. Deloitte [3] provided an overview of the beneficial application of Industry 4.0 to enhance organizational processes. McKinsey's [6] study focused on customization and explained how Industry 4.0 has reshaped the manufacturing industry to fit

customer demand and how companies can reap profit from these upcoming innovations by showing application opportunities. UNIDO [32] report has presented an impact analysis and showed how Industry 4.0 could contribute to environmental sustainability. Jayashree et al. [33] showed how Industry 4.0 could contribute to developing dynamic capabilities and realizing triple bottom line (TBL) sustainability. Bibby et al. [34] give some tools to assess the current level of Industry 4.0 maturity of businesses that want to transition to I4.0 and better approach the issue. Dhanpat [35] reminds us of the underlying dimensions of I4.0 as a growing need for learning capacities of smart technologies to cope with the new era of cyber-physical systems. Ahmadi et al. [36] addressed the main architecture models of value-chain structure in Industry 4.0.

3.1 Industry 4.0 and international trade

Industry 4.0 brings both enormous opportunities and challenges for the industry and international trade. It helps not only to modernize the production process and self-initiated execution but also allow the managers to undertake the management of the production process across the globe by creating a flexible global supply chain.

The fourth industrialization is changing the way we perform different kinds of business activities by drawing its main components and their contribution to the business environment. Industry 4.0 is the implementation of cyber-physical systems for creating smart factories by using the IoT, big data, cloud computing, artificial intelligence (AI), and communication technologies for information communication in real-time between the man-machine and machine to machine communication which is redefining the global value chain.

According to Horvath et al. [37], there are five key drivers of Industry 4.0: Digitalization, optimization, and customization of the production, automation, and adaptation, human and machines interactions, and collaborations, high value-added offers, and automatic exchanges of data and communication. The fourth industrialization has contributed to critical transformation to the international business environment in the different stages of an organization such as human resources, financial systems, management, organizational structure, or production processes.

Those key drivers are highly illustrated by the implementation of cyber-physical systems, the internet of things, smart factories, smart technologies, cloud computing, and big data. The latest architecture of industrialization pursues new objectives and faces completely different challenges that increase in a global perspective. Industry 4.0 offers an opportunity of restructuring declining manufacturing industry in the high-cost-country (HCC) and permit to maintain a strong industrial base in developed countries [38]. It could represent a great opportunity in the context of declining manufacturing in the developed markets. Industry 4.0 answers three key challenges: better competitiveness, flexibility, and agility by facing global offer end demand fluctuation and the regionalization of production [38]. To sum up, Industry 4.0 can be understood as multiple solutions built to change the international industrial sector to gain stronger competitive positions, market shares, especially within a risky business environment. This ambition should be realized by using smart technologies and factories that ensure efficient response to the variation of the global market by improving competitiveness and agile management, which will conduct the changes implied by Industry 4.0.

3.2 Industry 4.0 and implications for international businesses

Central to the fourth industrial revolution is an interconnected network. The internet enables many small firms to participate in global trade, thus, leading

to more inclusion. It makes it possible for more products to be exported to more markets, often by newer and younger firms. A 10-percent increase in internet use in the exporting country is found to increase the number of products traded between two countries by 0.4 percent. A similar increase in internet use of a country pair increases the average bilateral trade value per product by 0.6 percent [39]. The transformation implied by the fourth industrialization, Industry 4.0, might lead to significant changes in existing business models allowing new ways to create value. These changes are expected to result in the transformation of traditional value chains. Industry 4.0 affects three elements of manufacturing small and medium enterprises (SMEs): value creation, value capture, and value offer [37].

The 4th industrialization will completely change global value chains by transforming its practices and objectives. The purpose is not limited to monetary rewards but includes new trends such as the willingness to gain efficiency, to create and sustain global competitive advantages, finding new ways of producing, generating innovations, stimulating automation and learning, or even increasing customer implications in the production processes.

Several opportunities generated by Industry 4.0 are transforming the current business levels and activities through its drivers. Multiple business models are flourishing in the Industry 4.0 era. One of the fast-emerging models of them is the *expectation* [40]. The expectation represents a combined model in which a firm built its expertise through the production processes of its general offer. This new trend led a company to create consulting services (about products or processes) or a new platform-based model. The platformization of the product refers to a company that uses its know-how and intensive capacities of production to create digital products that answer customer queries by using a cloud-based platform. The platformization of processes reflects the use of the smart factories' concepts and internal processes to transform their capacities into a digital platform. The value created is the result of an integrated solution of digital products and related Information technologies services. The expectation gives us an illustration of how I4.0 changes our model to do business and how complex it is to put in place within an organization and will impact the current business activities. The major Industry 4.0 drivers will redefine business activities [30].

Internet of things (IoT) is retained as a pillar of I4.0. This type of technology provides access to the internet by using deep learning technologies. This equipment transforms machines into smart objects that could, for instance, detect wear, control the performance of the production process, plan the capacity or even manage stocks in real-time. Cloud computing allows interconnection between computers and the internet. It can solve many issues such as Big Data storage as well as the costs and capacities linked to this storage.

Cyber-physical systems (CPS) are mechanisms that allow Humans, software, and machines to interact. It implies an aggregate level of networking. The main purposes of this technique are, by creating such virtual interconnection, to exchange key information to make better strategic decisions. It establishes strong links between production processes, machines, and the virtual world, which work and communicate thanks to computation and the internet in real-time cooperatively. The machines and physical systems will be synchronized to software, and it will allow the control and assessment in real-time production efficiency, adjusting it and making the right strategic decisions easily. Also, CPS enhances the integration of autonomous machines and the collaboration between humans and cyber work.

Autonomous robots are created with deep learning capacities. Deep learning technological advances permit a robot endowed with artificial intelligence to adapt itself to its working environment, make adjustments that enhance its working environment, and take appropriate decisions when observing disruptive issues. This

is one of the major pillars of I4.0 that is very challenging as it can replace Human works forward and generate greater benefit for a company. Enterprise resource planning (ERP) systems are considered the backbone for the Industry 4.0 [41]. ERP systems, for instance, the systems Applications and products in data processing (SAP) software, helps companies in various areas, to manage better their processes, and enhance their efficiency by integrating its operations to increase flows of information and collaboration between the company and its partners. ERP systems help companies in many areas starting from increasing better information sharing between departments, improving workflow, better supply chain management, integrating of data, processes, and technology in real-time across internal and external value chains, standardization of various business practices, improve orders management and accurate accounting information of inventory management [42].

The result of the use of the different drivers (IoT, CPS, Internet of Service, ERP) will lead to the creation of smart factories, which brings all the smart tools and models together in its production model. This integrated system will facilitate the globalization of production and expansion of global supply chain. It is true that some of manufacturing activities might be re-shored but at the same time, the new smart technology will allow firms to reconfigure their production network overlooking the national boundaries and distance. That is the reason why it is still in the pre-paradigmatic stage of Industry 4.0. implications it is a continuous process that conducts the transformation of our current or traditional methodologies to do business and conceive industrial purposes and processes. As a result, the production model of smart factories becomes cost-effective and flexible to market changes and sustainable, which would reflect the highest level of effectiveness feasible to achieve. This newfound technological prowess will modify drivers of global production networks (GPN), reduce the importance of physical distance as well as re-configure the global value chain (GVC). The new global division of labor (NGDL) is likely to emerge and re-distribute the manufacturing activities integrating different hubs from both the developed, emerging, and developing markets.

4. Challenging issues related to Industry 4.0

There are no doubts about the enormous challenges that Industry 4.0 will bring to the current practice of production, consumption, and global value chain (GVC). Firms and policymakers need to take into consideration adequate strategies to better implement the Industry 4.0 systems, re-organize business activities by taking into consideration of new context and take other caution for the long-term growth of the fourth industrial revolution and reap profit from it. We will define and analyze in this section the challenges raised by Industry 4.0, starting with implementation challenges, then the challenges surrounding the management of Human resources, then the risks to data security, then the Big Data challenges, and finally, the challenges concerning the environment.

4.1 Implementation challenges and inequalities

As we established earlier, the transition to Industry 4.0 brings countless opportunities for businesses to increase their efficiency and development. However, there are many barriers to the implementation of Industry 4.0, the most important lackings are the shortages of skill-sets that are required in the Industry 4.0 phenomenon. There is also a lack of experience and hindsight on the transition, the necessity to remodel the entire organization, and the coordination of data resources. Added to these challenges are the inequality between SMEs and MNCs in terms of

resources, focus, and strategies in the transition to Industry 4.0. This section will present the three main difficulties faced by firms integrating Industry 4.0.

4.1.1 Lack of experience and established models

The lack of experience is certainly one of the biggest factors that hold back the businesses from transitioning to Industry 4.0 era. Indeed, the transformation of the companies is very costly, and no clear business case is available as a reference for companies. It is very difficult to justify such investments when there is no perspective, no pattern to follow, and no successful case to reproduce. Therefore, most frequently, companies will either fail in their transition (60% rate of failure) or simply lack the necessary courage to follow through the process of radically changing their organization and investing as much time and resources.

To tackle this challenge effectively, some interesting research in the field has started to emerge, building the first tools to approach the transition. According to Bibby et al. [34], firms should begin by assessing the current level of Industry 4.0 maturity in their specific context or supply network. This analysis will help them determine their strengths and weaknesses and focus their improvement on the right area. Few academic research has been done so far in this area, and many research are done by consulting firms. As an example, in order to assess the industry maturity level of firms, two Industry 4.0 assessment models have been developed in 2016 by consulting firms, IMPULS management consulting GmbH (IMPULS) and PWC. While the PWC model helps companies self-assess their level of maturity based on various criteria, the IMPULS model is focused on delivering improvement advice based on the company's preparation. More of these models are currently developing, showing that the challenge of the lack of experience will likely be overcome with time as Industry 4.0 spreads across the manufacturing world.

4.1.2 The cost of restructuring the firms

The transition to Industry 4.0 from a traditional organization requires the restructuring of the entire organization, as tasks are automated and decision-making processes are programmed. Every firm that will adopt Industry 4.0 system. We will have to create new business models and define a new strategy. Indeed, this transition requires rethinking the whole organization and processes, interconnecting departments, buying new equipment or modernizing the existing one, re-assigning roles to employees, recruiting new operators, and many other disruptions of their current model. These major changes have a great cost for any business on many levels: financially, of course, but also in terms of time. Therefore, firms have to be especially careful when investing in these transitions in order to not fail its implementation of Industry 4.0.

4.1.3 Advanced coordination across the firms

Another challenge of the implementation of Industry 4.0 is how to connect all data efficiently. Industry 4.0 requires the cooperation of all organizational units, from manufacturing, R&D, IT, to sales and finance departments. Sometimes the walls separating these departments are very hard to break, adding to the difficulty of the transition. But the coordination of functions is only part of the issue: Industry 4.0 requires the management of the large quantities of data generated by diverse sources in the company. For example, production data will have to be processed and coordinated along with data from customer information systems.

Data Integration is, therefore, a very difficult task, and the firms need to have the necessary talent from data scientists that will be able to process and model this data.

4.1.4 Inequalities for SMEs compared to large firms

More than 98% of firms in the developed markets are considered as SMEs, and they are increasingly participating in the global value chains and global trades of goods, services, and components. Introducing the new I4.0 paradigm may have varying levels of difficulty depending on the size and available resources of the targeted firms. Starting conditions between Small and Medium Enterprises (SMEs) and larger firms are obviously very different and bring different challenges. According to Matt et al. [43], SMEs need specific strategies to properly implement I4.0 to their business model.

Large companies will usually follow the higher maturity level in the technological domain faster and more easily than SMEs because of the resources. Indeed, they have more money, expertise, and time to invest in this project. As a consequence, I4.0 is spreading more quickly across large companies which are investing and working intensively on introducing and enabling the necessary technologies. SMEs, however, are lagging behind because they lack the financial and human resources to research into the risks and potential of implementing I4.0. These difficulties further enlarge the gap between SMEs and large multinational companies. However, SMEs have an advantage over large companies, which have a much more complex organizational structure and production processes. Therefore, it is much easier to implement the necessary changes to the organization and culture of SMEs.

4.2 Human resources challenges

According to the study made by Glass et al. [44], across 176 SMEs and 71 large enterprises, numerous barriers to Industry 4.0 must be underlined across business processes and models. The most important challenges include, of course, the multiple issues which arise from Industry 4.0 strategy modeling and the growing need for highly skilled workers with specific know-how, particularly oriented in high technologies, smart engineering, automation, and digitalization competencies and expertise, etc.

We can easily understand that, beyond such technical and future-oriented subjects applying to industries, which is already developed in multiple kinds of business corporations, human resources remain a major challenge for the spread of Industry 4.0 concepts, methodologies, models, and tools. For instance, Mubarak and Petraite [45] have raised a fundamental HR component of Industry 4.0 implementation: The concept of digital trust. Digital trust is situated between trust and Industry 4.0 implementation and implies HR issues. We can identify major human resources issues related to Industry 4.0 as the followings:

4.2.1 The dangers of the technocentric approach

When digital trust refers to a new working environment where technology and Humans interact for the welfare of a company and to answer the stakeholder's needs, a danger of this approach would be the growth of technocentric businesses. In fact, in this model, the stakeholders will give more confidence to technologies, artificial intelligence, and automation to run their business activities and corporations rather than human beings. Indeed, The Deloitte reports questioned the

preparedness of HR in an era of Industry 4.0 and the global value chain. Among the 32% of firms that are ready to face technological challenges, only 12% are ready to face the challenges emanating from the Industry 4.0 ecosystem [46]. This statistic illustrates the new trends for companies to focus on efficiency with the highest technological implementation rather than hiring people and maintaining their position through retention policies.

4.2.2 The digital transformation: The increase of ISHR, ARP systems, and ERP

The information systems of human resources (ISHR) illustrate the Industry 4.0 impact upon Human resource function. Indeed, the ISHR technologies permit to automate, standardize with the intervention of smart technologies, activities that belong to HR functions as the following ones: Administrative procedures, training, payrolls management, recruitments, talents management, or even career development of employees within a company [47, 48]. The different systems like automation of robotic processes (ARP) and enterprise resource planning (ERP) were conduct to rethink the HR function. Those different tendencies push HR workers to acquire new competencies geared towards smart technologies and which are transforming their workstation, and which are implying news risks. On the one hand, we can identify the complexity of adaptation to the rapid change of HR function but also the risks linked to the security of information systems and the possibility to lose sensitive data to the benefit of the competition. As a reminder, ISHR systems such as the one proposed by the SAP software can contain confidential data such as the wages, the positions, the personal data of each employee, their curriculum vitae, the annual reports, information posted on the different job board and the main partners of the company, etc.

4.2.3 The recruitment, retention, and attraction of new talents

The fourth revolution required a highly-skilled workforce to be implemented, developed, used and maintained. As a result, a wide range of industries needs a certain level of cooperation between machines and workers. If Industry 4.0 implies this tendency, it also underlines the growing trend of Google, Apple, Facebook, Amazon, Microsoft (GAFAM) to conquer traditional industries in which they have the necessary knowledge and capacities to become undisputable competitors in multiple fields [49]. As an example, we can remember the creation of the Google autonomous car, the collaboration between the Volkswagen group with Amazon web services to collect and analyze its industrial data and becoming a major global leader of the automotive industry, and even the collaboration between Apple and General Electric (GE) to create new applications for the internet of things (IoT) platforms that benefit to GE industries purposes thanks to IOS (exploitation system owned by Apple) opportunities. Industry 4.0 increases competition, in traditional industries and markets (but not only), which seems to be overwhelmed regarding the fast spread of the fourth industrial revolution. To overcome these challenges, companies must recruit high skilled workers, implementing continuous reskilling, learning, and training programs in their HR policies [44]. Besides, one of the major HR issues is constituted by the launch of retention practices which will reduce the diffusion of confidential business information and enhance efficiency and profitability by staying competitive at the same time. We can understand that the rise of high skilled workers' demand would create a danger if it is not associated with HR policies to enhance workforce abilities to work in a new smart and autonomous workplace.

4.2.4 The adaptation to change

One major issue to face urgently for HR function is the resistance to change. According to Deloitte [50] report, 17% of their interviewees are ready to manage working environments composed of people, robots, and AI interacting together when 60–70% will fail because they do not manage the adaptation to change properly. Also, Dhanpat et al. [35] confirmed this problem. They have shown that some employees can be resistant to change by being afraid of losing their jobs and being replaced by machines. Bonekamp et al. [51] also agree on the fact that the introduction of Industry 4.0 led to the suppression of standardized tasks by smart and autonomous systems. As a consequence, strong pressure is put on HR managers who require highly skilled people, to train employees and manage to dismiss workers for whom their tasks will be replaced by smart technologies to gain efficiency and competitiveness in the global market. In 2016, The World Economic Forum (WEF) already raised awareness by making an announcement before the opening of the Davos forum: around 5 million jobs in 5 years will be suppressed within 5 years in the main global economies [52]. It is necessary for the HR function globally to answer and react to the exponential expectations of the fourth industrial revolution by taking into account its effect on the global workforce demand and its impact on the global economy and competitiveness.

4.3 Big data challenges (storage, RGPD, societal challenge)

The fourth industrialization reveals new challenges in business activities such as the management of Bigdata and cybersecurity. Multiple obstacles to Industry 4.0 remain redundant: The constraints are numerous because the digitization of the industry poses formidable problems of standardization and cybersecurity [52].

Indeed, through their researches, one of the major challenges implied by this concept in the working environment is the deployment of Big Data, which creates a growing need to provide a legal framework for the protection of personal data and private life. Among the different cyber issues reported in Industry 4.0, the Deloitte report [50] identifies the top 10 cyber threats and their major data protection concerns.

Indeed, if legal restrictions increase to manage big data challenges, the different issues persist. In terms of an international legal framework, the ISO norm ISO/IEC 27001 defines the data security management for sensitive subjects such as financial, intellectual proprietary, employees, or even data entrusted to another company in the context of business activities. This norm is also called “Management systems of Information security” [53]. In addition, the European Union has implemented the General Data Protection Regulation (GDPR) to mitigate different kinds of challenges affiliated with the management of Big Data. GDPR regulations refer to “imposing a legal framework on the processing of personal data” [54].

However, despite the willingness to build an international legal framework to reduce risk related to Big data cybersecurity, there are still a long-ways to go for a proper framework of Industry 4.0. For instance, Deloitte report has shown that one out of four firms is not developing, implementing, or documenting the industrial cybersecurity (ICS) specific policies and procedures, and more than 33% of manufacturers have not performed any cyber risk assessments specifically focused on the ICS operating on their shop floors, resulting in a potentially significant risk to their operations [55].

In terms of internal management, other issues can arise when a company starts using big data analytics in order to grow. The challenges to take into account include the lack of proper understanding of big data, and therefore, proper usage of the latter; data growth issues, or, “what do I do with this much information?” because

the collection of such an amount of data must be useful for something. But what, exactly? Another issue is the confusion when selecting a Big Data tool. There is an increasing number of tools available on the market for firms to have reports and data concerning their businesses. However, it is often not very precise and easy when one is not really aware of what is best for them. This last point brings us to another issue which is the lack of professional expertise in the field of Big Data. Indeed, more and more companies are recruiting professionals and experts in the field of data, such as data scientists, engineers, and analysts. These professions are rare, and as the demand and supply rule confirms, it is quite costly for a firm to recruit, though it is a must when expecting to grow, especially in our current globalized market.

5. Strategies of Industry 4.0 implementations

Concerning the international strategies of Industry 4.0 applied to firms, we can find key references in terms of Smart Manufacturing architectures: Reference Architecture Model or Industry 4.0 (RAMI 4.0), Smart manufacturing ecosystem (SME), Intelligent manufacturing system architecture (IMSA). In Smart manufacturing, the architecture corresponds to the designing of the arrangement and connectivity of the organizational structure. The Smart manufacturing ecosystem (SME) provides a standard overview of Smart Manufacturing Systems (SMS). It has three dimensions: product, production, and business. It allows information circulation, in order to follow the production of products through its entire life-cycle. It focuses on the entire value chain and the interaction between the three dimensions. *Each dimension comes into play in the vertical integration of enterprise systems (ERP), manufacturing operations management (MOM), and cyber-physical production system (CPPS) [36].* The IMSA is a 3D intelligent manufacturing system framework, consisting of life cycles, system hierarchy, and intelligent functions. It takes into account the standards and features of all intelligent manufacturing systems to a framework with key dimensions: Lifecycle, to represent the chain integration; system hierarchy, to control, workshop, enterprise, and cooperation levels; and finally, Intelligent Functions which illustrate *resources, integration, interconnection, information fusion, and new business patterns*, [36].

According to a BGC report on Industry 4.0, related to the German manufacturing industry, Industry 4.0 will be used by an increasing number of firms and generate significant productivity gains of this industry sector (90 to 150 billion EUR). The productivity will improve by 15 to 25%. If material costs are considered, productivity upgrades of 5 to 8% are realistic. Individual effect size depends on the specific manufacturing industry. E.g. industrial component manufacturers will see the largest productivity gains (20 to 30%), while automotive manufacturers may assume 10 to 20% [56]. Furthermore, Industry 4.0 will impact the revenue growth of the German industry. Need from manufacturers for improved devices and new data applications, as well as customer demand for a greater range of increasingly customized products, will provide further revenue growth of around 30 billion euros per year, equivalent to around 1% of German GDP.

The BCG study predicts that the growth and productivity increase described above will also positively impact the employment growth of 6% over the next decade. The need for mechanical engineering workers could increase even more – by up to 10 percent over the same period. In the next few years, the automation trend will replace some low-skilled workers in repetitive and monotonous tasks. However, the increasing use of big data analytics will increase the demand for workers with ICT skills. This shift of needed skills transformation is one of the most important challenges of future growth and innovation. Making the mandatory steps

to be economically successful in the world of Industry 4.0 will cost manufacturers about 1 to 1.5 percent of their sales in absolute value over the next decade. Finally, it can be concluded that Industry 4.0 will transform the global value chain, labor market, and logistics.

6. Conclusion

Global trades are going through lots of volatility from geopolitical instability and natural disasters. The current situation requires businesses to develop their strategic goals for growth, risk management, and global supply chain for the short term, mid-term as well as long term. Manufacturing firms need to develop multi-pronged and multi-disciplinary approaches to address challenges facing current and future supply chain disruptions. The use of advanced technologies like artificial intelligence (AI) and Business analytics can be helpful to analyze large-scale data and keep track of supply chain movements in real-time and develop the ability to re-configure the Supply chain on short notice. A firm's ability to succeed in global markets will depend on the capacity of the industry to adapt to a rapidly changing business landscape.

To sum up, Industry 4.0 seems to have reached heights when it comes to the organization of enterprises at a global level. We described how international organizations could benefit from Industry 4.0 doing international business. We explained how the components of Industry 4.0 had enhanced many aspects of SMEs and MNCs, by analyzing the evolution of the different phases of the historical context to come to such a strong, advanced stage. We, therefore, defined the industry and its key components to explain its contribution to the organization.

Managers need to develop the ability to identify the opportunities and the strengths brought up by this industrial revolution. We took a look into its efficiency features, and opportunities to satisfy the varied demands thanks to capabilities of customization, and the power of the use of Big Data Analytics, as well as the great impact that this evolution has on the environment. Nevertheless, all these benefits do not come without some challenges. Indeed, Industry 4.0 has full of potentialities of innovation and quite complex transformations to simplify and adapt organizations, especially in terms of human resources because robotics and automation will have huge a repercussion on the social aspect. Most especially, developing and emerging countries that participate in the global value chain by offering advantageous manufacturing production locations will face stiff competition between Industry 4.0 based technologies with those of cheap and abundant labor force in those countries. There is no option other than up-grading the workforce and integrating into the 4.0 era to face these new challenges in the era of Industry 4.0. Finally, as valuable as Big Data can be for the industry, we have found out that it is still a domain that requires particular attention since its use remains quite laborious.

Nonetheless, this modern revolutionary phase is not the last of its category. In fact, the very recent rise of Industry 5.0, a solution provider for people and the planet has flipped the script. Indeed, the new revolution of Industry 5.0 puts an emphasis on the well-being of the workers and captures all the added-value components of Industry 4.0 with the aim of prosperity in the new industry as an ambition for a better future.

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References

- [1] Tim Y, Pan SL, Bahri S, Fauzi A. Digitally enabled affordances for community-driven environmental movement in rural Malaysia. *Information Systems Journal*. 2018;**28**(1):48-75
- [2] Mamad M. Challenges and benefits of industry 4.0: An overview. *International Journal of Supply and Operations Management*. 2018;**5**(3):256-265
- [3] Deloitte AG. Industry 4.0: Challenges and solutions for the digital transformation and use of exponential technologies; 2014
- [4] Kasim T, Haracic M, Haracic M. The improvement of business efficiency through business process management, economic review. *Journal of Economics and Business*. 2018;**16**(1):31-43
- [5] Lasi H, Fettke P, Kemper HG. Industry 4.0. *Business and Information Systems Engineering*. 2014;**6**:239-242
- [6] McKinsey. Industry 4.0 after the Initial Hype: Where Manufacturers are Finding Value and How They Can Best Capture it. Chicago, USA: McKinsey; 2016
- [7] El Maraghy H, El Maraghy W. Smart adaptable assembly systems. *Procedia CIRP*. 2016;**44**:4-13
- [8] Bortolini M, Ferrari E, Gamberi M, Pilati F, Faccio M. Assembly system design in the industry 4.0 era: A general framework. *IFAC-Papers OnLine*. 2017;**50**(1):5700-5705
- [9] Baum G. Innovationen als basis der nächsten industrie revolution. In: Sandler U, editor. *Industrie 4.0*. Berlin and Heidelberg: Springer Vieweg; 2013. pp. 37-53
- [10] Yusuf YY, Sarhadi M, Gunasekaran A. Agile manufacturing: The drivers, concepts and attributes. *International Journal Production Economics*. 1999;**62**(1-2):33-43
- [11] Yusuf Y, Gunasekaran A, Adeleye E, Sivayoganathan K. Agile supply chain capabilities: Determinants of competitive objectives. *European Journal of Operation Research*. 2004;**159**(2):379-392
- [12] Rossit A, Tohmé A, Frutos A. An Industry 4.0 approach to assembly line resequencing. *The International Journal of Advanced Manufacturing Technology*. 2019;**105**(9):3619-3630
- [13] Kietzmann J, Pitt L, Berthon P. Disruptions, decisions, and destinations: Enter the age of 3-D printing and additive manufacturing. *Business Horizons*. 2015;**58**(2):209-215
- [14] Davenport TH, Barth P, Bean R. How big data is different. *MIT Sloan Management Review*. 2012;**54**(1):43-46
- [15] George G, Haas MR, Pentland A. Big data and management. *Academy of Management Journal*. 2014;**57**(2):321-326
- [16] Mayer-Schönberger V, Cukier K. *Big data: A revolution that will transform how we live*. Boston and New York: Work and Think, Houghton Mifflin Harcourt; 2013
- [17] McAfee A, Brynjolfsson E. *Big data: The management revolution*. Harvard Business Review. 2012;**90**(10):61-67
- [18] Strange R, Zuchella A. Industry 4.0, global value chains and international business. *Multinational Business Review*. 2017;**25**(3):174-184
- [19] Constantiou I, Kallinikos J. New games, new rules: Big data and the changing context of strategy. *Journal of Information Technology*. 2015;**30**(1):44-57

- [20] Henke N, Bughin J, Chui M, Manyika J, Saleh T, Wiseman B, et al. *The Age of Analytics: Competing in a Data-Driven World*. Chicago, USA: McKinsey Global Institute; 2016
- [21] Shukla, A. The Big and Small of Big Data. 2015. Available from: <https://medium.com/smart-products/the-big-and-small-of-big-data-2dec0106f5c5>
- [22] Weber RH. Internet of things: Governance quo vadis? *Computer Law and Security Review*. 2013;**29**(4):341-347
- [23] Rose K, Eldridge S, Chapin L. *The internet of things: An overview, Understanding the Issues and Challenges of a More Connected World*. Reston, VA: The Internet Society (ISOC); 2015
- [24] Berthon P, Pitt L, Kietzmann J, McCarthy IP. CGIP: Managing consumer-generated intellectual property. *California Management Review*. 2015;**57**(4):43-62
- [25] Helbing D, Frey BS, Gigerenzer G, Hafen E, Hagner M, Hofstetter Y, et al. *Will Democracy Survive Big Data and Artificial Intelligence?* Scientific American. Amsterdam, Netherlands: Elsevier; 2017
- [26] Maughan A. *The legal implications of the internet of things*. Hennik Research, UK: The Manufacturer; 2014. Available from: <https://www.themanufacturer.com/articles/the-legal-implications-of-the-internet-of-things/> (Retrieve on January 05, 2022)
- [27] Ghobakhloo M, Fathi M. Corporate survival in Industry 4.0 era: The enabling role of lean-digitized manufacturing. *Journal of Manufacturing Technology Management*. 2019. DOI: 10.1108/JMTM-11-2018-0417/full/html
- [28] Dalenogare L, Benitez G, Ayala N, Frank A. The expected contribution of Industry 4.0 technologies for industrial performance. *International Journal of Production Economics*. 2018;**204**:383-394
- [29] Marinakis V, Doukas H, Tsapelas J, Mouzakitis S, Sicilia A, Madrazo L, et al. From big data to smart energy services: An application for intelligent energy management. *Future Generation Computer Systems*. 2018;**110**:572-586
- [30] Özüdoğru AG, Ergün E, Ammari D. How Industry 4.0 changes business: A commercial perspective. *International Journal of Commerce and Finance*. 2018;**4**(1):84-95
- [31] Rupp M, Schneckenburger M, Merkel M, Börret R, Harrison DK. Industry 4.0: A technological-oriented definition based on bibliometric analysis and literature review. *Journal of Open Innovation: Technology, Market, and Complexity*. 2021;**7**(1):68. DOI: 10.3390/joitmc7010068
- [32] Nagasawa T, Pillay C, Beier G, Fritzsche K, Pougel F, Takama T, Bobashev I. *Accelerating clean energy through industry 4.0 manufacturing the next revolution. A Report of the United Nations Industrial Development Organization*. Vienna, Austria: UNIDO; 2017
- [33] Jayashree S, Reza MNH, Malarvizhi CA, Mohiuddin M. Industry 4.0 implementation and triple bottom line sustainability: An empirical study on small and medium manufacturing firms. *Heliyon*. 2021;**7**(8):1-14. DOI: 10.2139/ssrn.3877180
- [34] Bibby L, Dehe B. Defining and assessing industry 4.0 maturity levels – case of the defense sector. *Production Planning & Control*. 2018;**29**(12):1030-1043. DOI: 10.1080/09537287.2018.1503355
- [35] Dhanpat N, Buthelezi Z, Joe R, Maphela T, Shongwe N. Industry 4.0:

- The role of human resource professionals. *SA Journal of Human Resource Management*. 2020;**18**(1):1-11. DOI: 10.4102/sajhrm.v18i0.1302
- [36] Ahmadi A, Cherifi C, Cheutet V, Ouzrout Y. Recent advancements in smart manufacturing technology for modern industrial revolution: A survey. *Journal of Engineering and Information Science Studies*. 2020. Available from: https://hal.archives-ouvertes.fr/hal-03054284/file/AHMADI_etal.pdf
- [37] Horváth D, Roland ZS. Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities? *Technological Forecasting and Social Change*. 2019;**146**:119-132
- [38] Blanchet M. Industrie 4.0: Nouvelle donne industrielle, nouveau modèle économique. *CAIRN*. 2016;**82**:37-53
- [39] Papachashvili N. Industry 4.0 and its Impact on the International Trade. IV International Scientific and Practical Conference “Strategic Imperatives of Modern Management” (SIMM-2018). Kiev, Ukraine; 2018. pp. 444-453. <http://ir.kneu.edu.ua/bitstream/2010/24244/1/444-453.pdf> (Retrieve on January 05, 2021)
- [40] Wekinga J, Stöcker M. Leveraging industry 4.0 – A business model pattern framework. *International Journal of Production Economics*. 2020;**225**:107588. DOI: 10.1016/j.ijpe.2019.107588
- [41] Haddara M, Elragal A. The readiness of ERP systems for the factory of the future. *Procedia computer science*. 2015;**64**:721-728
- [42] Gërvalla M, Ternai K. The impact of industry 4.0 to the ERP approach. *SEFBIS Journal*. 2019;**13**:56-59
- [43] Matt DT, Modrák V, Zsifkovits H. Industry 4.0 for SMEs Challenges, Opportunities and Requirements. London: Palgrave Macmillan; 2020. pp. 1-412
- [44] Glass R, Meissner A, Gebauer C, Sturmer S, Metternich J. Identifying the barriers to Industry 4.0. In: *Proceedings of 51st CIRP Conference on Manufacturing Systems*. Amsterdam, Netherlands: Elsevier; 2018
- [45] Mubarak M, Petraite M. Industry 4.0 technologies, digital trust and technological orientation: What matters in open innovation? *Technological Forecasting and Social Change*. 2020;**161**:1-11
- [46] Le Clair K et al. *The Future of White-Collar Work: Sharing Your Cubicle with Robots*. Cambridge, MA: Forrester; 2016. Available from: <https://www.forrester.com/report/The-Future-Of-WhiteCollar-Work-Sharing-Your-Cubicle-With-Robots/RES132404> (Retrieve on January 05, 2022)
- [47] Storhay P. *Le SIRH: Enjeux, facteurs de succès, perspectives*. Paris: Dunod; 2013
- [48] Storhay P. RH au quotidien, Dossier 5. Le SIRH. Page 78 à 99, Collection: Pratiques en Or. Éditeur: Dunod; 2015
- [49] Ktitareff, M. GAFAM et Industrie 4.0: La Discrète Stratégie De Conquête. 2020. Available from: <https://www.forbes.fr/technologie/gafam-et-industrie-4-0-la-discrete-strategie-de-conquete/?amp>
- [50] Deloitte AG. *Rapport mondial Tendances relatives au capital humain: Un nouvel avenir pour les organisations canadiennes*. 2017. Available from: <https://dupress.deloitte.com/dup-us-en/focus/humancapital->
- [51] Bonekamp L, Sure M. Consequences of industry 4.0 on human labour and work organisation. *Journal of Business and Media Psychology*. 2015;**6**(1):33-40

[52] Malengreau D. La 4ème révolution industrielle entraînera la perte de plus de 5 millions d'emplois dans le monde en 5 ans. L'Echo. 2016

[53] Kohler D, Weisz JD. The Digital Transnational of the Industry: A Franco-German Issue, Notes du Cerfa, No. 145, Ifri. 2018. Available from: https://www.ifri.org/sites/default/files/atoms/files/ndc_145_kohler_weisz_digital_transformation_industry_4.0_dec_2018.pdf (Retrieve on January 05, 2021)

[54] Delforge A. Comment (ré)concilier RGPD et big data? Revue du droit des technologies de l'information. 2018;**70**:15-29

[55] Deloitte AG. Cyber Risk in Advance Manufacturing. The Manufacturers Alliance for Productivity and Innovation Report (MAPI). 2016. Available from: <https://www2.deloitte.com/us/en/pages/manufacturing/articles/cyber-risk-in-advanced-manufacturing.html>

[56] Rübmann M, Lorenz M, Gerbert P, Waldner M, Justus J, Engel P, et al. Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries. Boston, MA: Boston Consulting Group; 2015