

Impacts of adopting Industry 4.0 technologies on supply chain management: A literature review

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ABSTRACT: Industry 4.0 is gaining importance lately in several countries, especially as part of the strategy of diversification and industrialization of the eco-system. Nevertheless, the topic remains abstract for companies that encounter difficulties to comprehend different aspects of this subject. The purpose of this article is first to discuss the context of industry 4.0 and the most cited advanced technologies in literature that play an important role in Industry 4.0. Then to highlight the impacts of supply chain digitalization: success factors and challenges. This will help organizations formulate their initiatives and practices to successfully achieve the transition from traditional to digital supply chain. We analyzed the literature in this field to understand trends and propose future directions for research.

KEYWORDS: Digitalization, Digital Supply Chain, Industry 4.0, Advanced technologies, impact, challenges.

1 INTRODUCTION

Today, the manufacturing environment not only needs to be flexible and able to reduce its operating costs, but it also needs to be smart enough to act intelligently and autonomously [1]. Service quality and quick turnaround are the differentiating factors in front of demanding customers. Nowadays, achieving high personalization in a short time and at low cost has become a reality [2].

In the past few years, the new concept of Industry 4.0 has developed rapidly, and the literature on many of its enabling technologies (especially those related to the engineering field) has grown exponentially [3]. Industry 4.0 represents the fourth industrial revolution, which is characterized by the introduction of advanced technologies (for example, the Internet of Things (IoT), cloud computing, big data, and Internet of services concepts) into the manufacturing industry [4]. It is defined as the integration of these modern technologies to achieve automation and control manufacturing [2]. One of the main features of Industry 4.0 is the use of information and new technologies to support the integration and virtualization of manufacturing design and production processes, thereby gaining a competitive advantage [5].

In fact, the increasingly fierce global competition and demand for production flexibility require that the converted production process can achieve a high degree of connection and integration between business processes and systems. Manufacturing companies are constantly under pressure to meet the different preferences of customers [1]. As a result, most organizations are reshaping their strategies to move towards fully integrated boundaries and become more and more transparent in business practices including supply chain management [6]. Supply chain organizations in the current global environment operate in increasingly complex and dynamic markets. A sustainable supply chain becomes inevitable to meet the drastic changes in customer demand [7].

Industry 4.0 technology brings the production system to a higher level [2]. Digital technology has brought opportunities and challenges to the sustainable development of manufacturing companies [8]. It creates new opportunities and vulnerabilities, which must be managed and governed to have a positive impact on the enterprise and society [3]. In addition to realizing the strategic vision of digital transformation, companies should also understand the best way to invest in them based on a deep understanding of the challenges and opportunities of advanced technologies in manufacturing [9]. Industry 4.0 will provide

many positive aspects for the industry, but the organizational structure should not underestimate the challenges and risks brought by the implementation of this new technology in supply chain management [10].

In this context, this article aims to review the literature of industry 4.0 and its advanced technologies while focusing on the impacts of supply chain digitalization: success factors and challenges. This research will help managers to understand and conceptualize the impact of industry 4.0 during the transition from traditional supply chain to digital supply chain.

2 BACKGROUND

2.1 CONTEXT OF INDUSTRY 4.0

The term "Industry 4.0" was first introduced at the Hannover Messe 2011, which originated from a national project initiated by the German government to promote the digitalization of manufacturing [12]. The current literature provides different descriptions of Industry 4.0 [2], [13], [3]. It involves the connection and integration of digital/virtual and real/physical worlds through cyber-physical systems (CPS) and Internet of Things (IoT). In these environments, smart objects continuously communicate and interact with each other's [14]. Industry 4.0 is the integration of various modern technologies (especially IT and robotics) to achieve automation and control manufacturing [2]. Industry 4.0 will change the complete production, operation and maintenance of products and services through interconnected components, machines, and people [7].

The integration of advanced technologies and real-time communication are the essence of Industry 4.0. The introduction and collaboration of digital technologies such as big data, IoT, and CPS help transform traditional manufacturing systems into intelligent manufacturing systems [2]. Figure 1 represent the most cited advanced technologies that play a role in Industry 4.0 [2]. Its implementation allows the development of intelligent manufacturing processes, which consist of devices that can exchange information, perform actions, and control each other. Many basic innovations that involve not only machines, but also sensors and IT systems connected throughout the value chain [15].

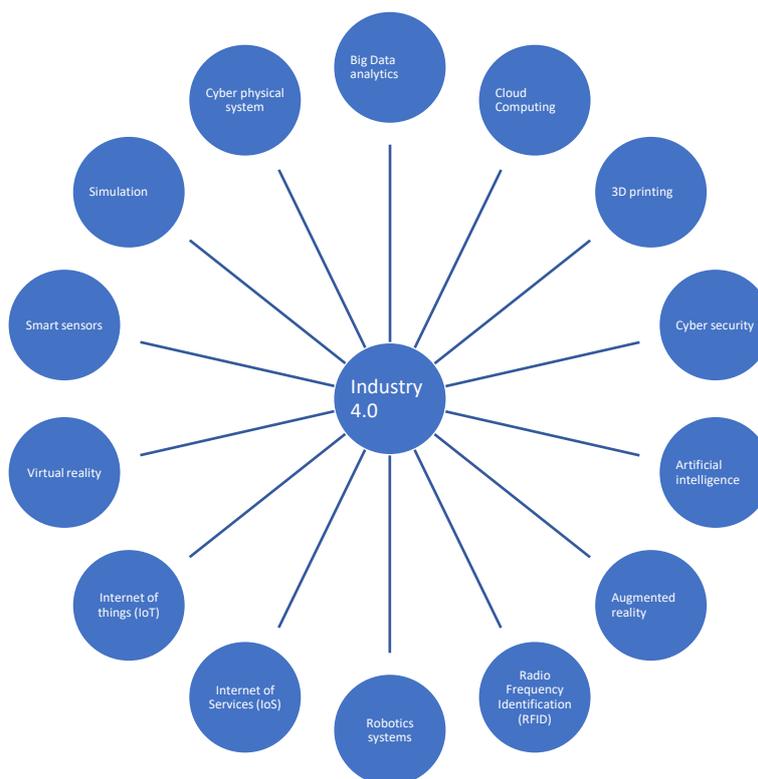


Fig. 1. Advanced technologies of industry 4.0 [2], [15]

Reference [2] shows that on the one hand, Industry 4.0 has become a complex concept due to its advanced technology, but with the development of manufacturing technology, the integration and real-time application of these technologies increase its complexity. On the other hand, it has a disruptive nature, the implementation of these new advanced technologies will

cause trigger several changes to the current ecosystem. However, it is inevitable that the increased availability of data due to Industry 4.0 will compel managers to not only improve existing processes but also to change them [11].

Figure 2 represents the nature of I4.0 through three aspects: Complex, Disruptive, and Inevitable.

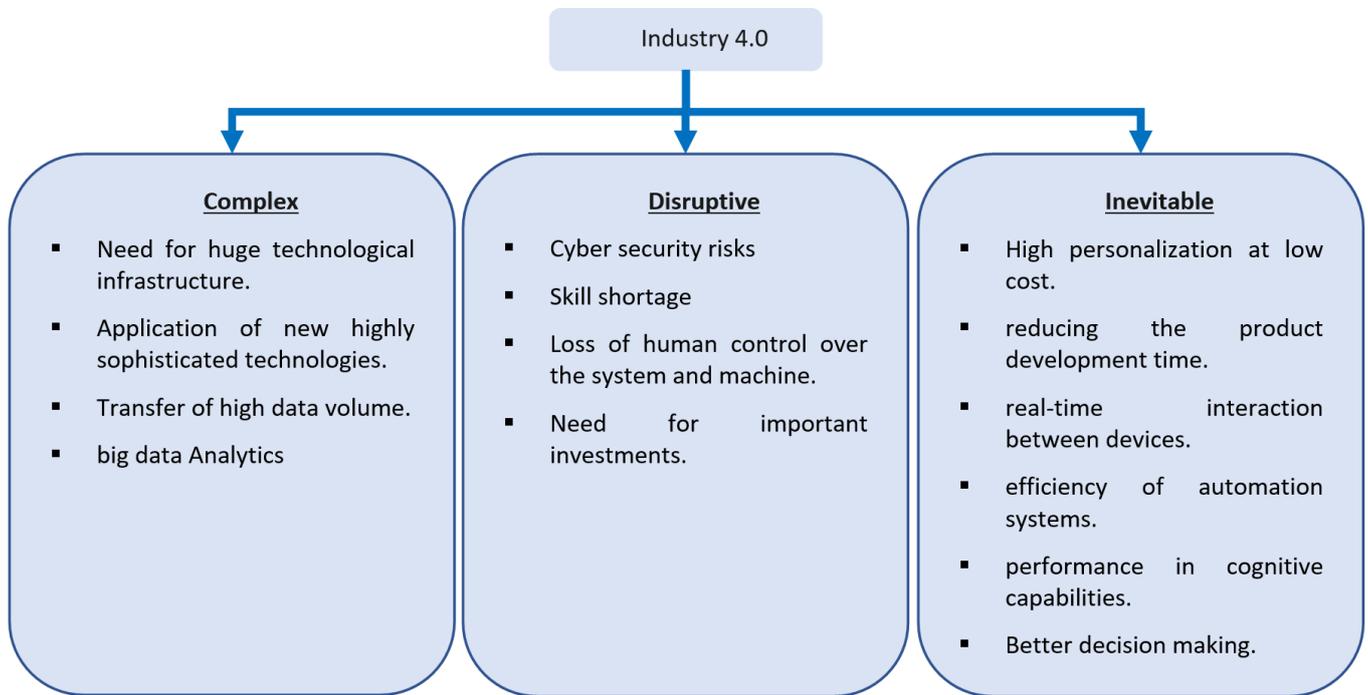


Fig. 2. Industry 4.0 aspects [2]

It is apparent from the above, in the context of manufacturing digitalization, the adoption of Industry 4.0 has its challenges. However, it is imperative to reduce cost and increase efficiency. In the future vision, every country and every industry must adopt it [2]. It can quickly respond to customer needs, increase productivity, and enable stakeholders to make faster decisions in real time, paving the way for adopting new business models and improving manufacturing processes [7]. Industry 4.0 can provide a wide range of benefits in manufacturing, including flexibility, resource efficiency, and extensive integration and interoperability. Industry 4.0 will provide new opportunities for improving operational productivity and efficiency, which will bring competitiveness and revenue growth to the organization [1]. Major industrial countries have already begun to take measures to implement the plan. Some industries, such as Amazon, Boeing, Nokia, etc., have begun to practice the concepts and tools of Industry 4.0 in their daily operations, while other industries must follow [2].

2.2 SUPPLY CHAIN DIGITALIZATION

The network established between the company and its suppliers for the production and distribution of specific products is defined as a supply chain. It represents the necessary steps required to deliver a product or service to a customer [16]. Supply chain management (SCM) operations include processes, infrastructure, and systems to manage the flow of information, materials, and services from suppliers to end consumers [7]. It can also be defined as a series of interrelated activities involving the coordination, planning and control of products and services between suppliers and customers [16]. Supply chain operations are very important to business and have a great impact on costs and profits [7]. An optimized supply chain will lead to lower costs and faster production cycles. However, the traditional supply chain lacks certain attributes required by today's and future business needs. The traditional supply chain includes a series of decentralized and isolated steps. It also requires many complex activities, which need to be coordinated and tracked [16].

Nowadays, with the deep integration of smart technology in the manufacturing industry, the digital transformation in the supply chain has changed the traditional methods. The digitalization of the supply chain provides potential for improving product development, production efficiency and customer service [8]. New technological advancements such as the IoT, cloud computing, and automation help to maximize the operational efficiency of partners within the organization and throughout

the supply chain [7]. The IoT technology has changed the supply chain industry and overcome the challenges and factors that affect uncertainty, such as global competition, lack of adaptability, and delayed market entry [7].

Reference [16] defines the digital supply chain as an intelligent technical system based on massive data processing capabilities and excellent collaboration and communication capabilities of digital hardware, software, and networks to support and synchronize organizations by making the interaction between services more valuable, accessible, and affordable with consistent, agile, and effective results. Digitization in the supply chain has covered digital products and services, as well as the processing of supply chain processes within companies that are undergoing these rapid changes [16].

Lately, an increasing interest in researching Industry 4.0 is seen in the supply chain literature [11]. Reviews in the related field are still in the early stages. However, there is a growing number of studies focus on managing the change from traditional supply chains to digital supply chains. These studies address issues like the role of smart cities in supply chain management [14], implementation guidelines for managing new technologies [17], [18], [11], managing information systems for data security and confidentiality laws [19], or The role of smart technologies in managing the digital supply chain [20]. There is also a growing amount of attention to investigate on how technologies and IT-enabled advancements can be utilized in the supply chain in its transformational route to becoming fully digitalized [6]. Others investigate on How digital technologies influence economic and environmental sustainability through the establishment of digital supply chain platforms [21]. Some authors have also examined the role of IoT and its impact on SCM, they recognize the importance of Industry 4.0 and its technologies in supply chain management, but they focus mainly on the process-centric view of supply chain management that is being affected by IoT applications [22]. While others present an overview of the digital supply chains showing an interest in addressing Industry 4.0 [16]. However, there is a lack of literature that analyze the challenges and issues of implementing industry 4.0 in Supply chain management.

Transforming a traditional supply chain into digital supply chain breaks down walls so that the chain turns into an integrated system that runs flawlessly. Digital supply chain is not about whether the products or services are physical or digital, it is the way how supply chain is managed [16]. Organizations are gradually moving towards implementing digital technologies for enhancing the outcomes. It guarantees wide prospects to gain competitive advantage and set the tone for the future sustainable supply chain practices. Industry 4.0 technologies offers quick response to customer demand, it improves the productivity and allows the stakeholders to make quicker decision in real time [7]. The confluence of internet, wireless technologies, predictive analytics, and cloud technologies change the entire supply chain operations and bring more value out of it. With IoT, controlling supply chain dynamically and execute the decisions on external location is viable [11]. In other words, IoT can create an intelligent network along the value chain, in which connected machines, products and systems can autonomously connect and control each other [1]. From the analysis of the literature, it can be concluded that Industry 4.0 encompasses a large number of changes across the different aspects of supply chain management which are primarily driven by the Industry 4.0 technologies [11].

The digital supply chain ecosystem have picked up its pace for the deployment, management, and integration of services that can power Industrial Internet applications [23]. Customers will cooperate with manufacturers to gain value through the creation of personalized products adapted to the individual customer's requirements and needs [11]. The interconnected ecosystem can adapt and respond to shifting demands by itself. To achieve this, CPS is seen as the next generation system, which integrates information systems, Radio Frequency Identification (RFID), sensors, devices equipment [15]. CPS monitors physical processes and communicates the status to human in real time who can access it from anywhere, which improves the human machine interaction (HMI) [7].

Many different companies from diverse sectors are investing profoundly on digitalizing their business operations and their supply chains. Take major logistics service providers such as DHL, for example, which monitors and reports on the trends that could have an impact on the logistics industry in the future. Airlines with strong cargo operations, such as THY, Lufthansa and Emirates expand their paperless e-freight offerings with data cleaning for customers. Global retailers Amazon and Alibaba have invested in drones for handling and delivery of goods [16].

3 IMPACTS OF ADOPTING INDUSTRY 4.0 IN SUPPLY CHAIN MANAGEMENT

3.1 SUCCESS FACTORS OF DIGITAL SUPPLY CHAIN

Since digital solutions are disrupting traditional supply chains, there are some distinct features associated with digital supply chain [16]. Further, numerous benefits have been associated with implementing successful digital supply chain management. Rising global competition, data availability and enabling technologies will drive the change towards digitalization [11].

Figure 3 represent the main features that digital supply chain aims to achieve according to reference [16]:



Fig. 3. Features of digital supply chain [16]

3.2 CHALLENGES OF DIGITAL SUPPLY CHAIN

The area of supply chain digitalization is starting to attract growing attention lately [6]. Nevertheless, if companies are to make the digital supply chain a reality, they can't just gather technologies and build capabilities. They must also understand the challenges of implementing industry 4.0 advanced technologies. In other words, they must prevent actions to every challenge in order to successfully complete the transition to digitalization. Furthermore, while scholars aim to integrate digital technologies with supply chains, few studies have empirically explored defining responsibilities for effective and efficient handling of smart supply chains [11]. The literature indicates that digitalization of supply chains will lead to an improvement in quality, flexibility, responsiveness. However, its challenges must be well studied and considered from the beginning of the transition.

Industry 4.0 affects manufacturing industries, and therefore it will influence the economic and social life of the individuals. In general, it is vital to ensure that the organizational structures and manufacturing infrastructure are ready to grasp new opportunities and values created by Industry 4.0. That is why the anticipation of understanding the challenges that might be encountered by adopting new technologies is essential. represent the challenges underlined in the literatures.

Table 1. Challenges and issues of digital supply chain

Challenge	Description	References
Skill shortage in using new digital technologies	The industry 4.0 adoption process requires more qualified work force involvement. Organizations must find people with the right skills; however, this could be expensive with the lack of experience in working with the new technologies. They must transform their entire organization to go with the new flow of digital supply chain.	[24], [25], [26]
Human machine Interaction	The collaboration between machines and humans could socially influence the life of the employees and society, the interaction of humans with all the smart objects in a complex system is a priority that must be managed as well as other specifications about the architectural structure of decision-making.	[11], [15]
Workers resistance	User resistance can limit the successful implementation of digital supply chain, workers get frustrated with limited information on upcoming changes. If the new technologies do not accommodate the user's needs, they might end up misappropriating the technology.	[25], [26], [27]
Decision making	Decision making in the digital supply chain is a complex process under uncertainty, managers must analyze real time data to make fast decisions.	[11]
lack of standardization available	The lack of standards for many technologies address an important challenge when using digital technologies in supply chain management.	[11], [28]
Data security	It is always challenging, in any industry, to manage the cybersecurity risk. Nevertheless, data security and confidentiality are the forefront challenge in industry 4.0 with the integration of internet technologies.	[11]
Regulatory compliance	Legal and contractual ambiguity might also pose a challenge for digitalization.	[11],

4 CONCLUSION

The supply chain is an extremely complex organism, and no company has successfully built a true digital system [24]. In this review, we analyzed the literature of industry 4.0 to understand trends, and the potential impact of its adoption in supply chain management. We discussed the features and challenges of using new advanced technologies. This research expands existing knowledge by focusing on the digital supply chain area. The goal is to identify the pros and cons of supply chain digitization. This will help the organization formulate its initiatives, practices and prevent solutions to solve problems and successfully achieve the transition from traditional to digital smart supply chain. Managers need to understand the potential challenges and benefits associated with adopting Industry 4.0, and how these benefits exceed the challenges.

In this field, future research should focus on the challenges of supply chain digitalization while using industry 4.0 technologies. Different industries have implemented digital supply chains at different speeds, companies that get there first will gain a difficult-to-challenge advantage in the race to Industry 4.0 and will be able to influence technical standards for their industry. Future research can also focus on formulating strategies while considering all the issues cited in the literature to ease the management staff when adopting digital technologies.

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