



Use of industrial 4.0 technologies in supply chain management

A.Yildiz^{1,a}, I.E.Parlak¹

Bursa Technical University, Faculty of Engineering and Natural Sciences, Bursa, Turkey

Accepted 1 September 2019

Abstract

In recent years, developments such as the difficult competition conditions, globalization, rapid development of technology, increasing the complexity of the networks in the supply chain and shortening the product life process require enterprises to reconsider their supply chain strategies. In order to compete under these conditions, enterprises should be able to effectively manage their supply chains. Effective management of the supply chain is not possible without real-time information sharing and coordination among the stakeholders of the supply chain. For this, digitalization should be achieved by using in the supply chain of industry 4.0 technologies that affect all sectors. The digitalization of the supply chain enables the reduction of inventory costs, management costs, and distribution and transportation costs. Accordingly, companies with a digital supply chain management strategy respond 25% faster to changes in market demand and achieve a higher margin of up to 110%. In this study, a research has been made on the digital supply chain which is formed by the integration of industry 4.0 technologies into traditional supply chains. The integration process of Industry 4.0 technologies into the supply chain is examined and the benefits of these technologies to the supply chain are discussed.

Keywords: industry 4.0, supply chain, digital supply chain.

1. Introduction

In recent years, Information Technology (IT) systems have made significant progress, affecting every aspect of everyday life. The most radical of these advances is the transition to smart devices using cloud-based infrastructure services. The latest developments in information technology use not only the unlimited possibilities of direct interaction of people and machines in the context of the cyber-physical system, using information from different sources, but also direct communication between machines. The implementation of such a network in a production and operational environment is called Industry 4.0 [1].

Until the present period, three major industrial revolutions have taken place [2]. In the industrial sense, the First Industrial Revolution (Industry 1.0), which first started with steam engines in the 18th century and aimed at increasing production, was followed by the Second Industrial Revolution (Industry 2.0), which emerged as a transition to mass production at the beginning of the 20th century and paved the way for the utilization of electrical energy. Then, the Third Industrial Revolution (Industry 3.0), where production systems ceased to be analog and digital systems took place in the industry, emerged [2, 3, 4]. Thus, the first three industrial revolutions

electricity and IT into human production [5]. These three industrial revolutions aimed at increasing productivity in production [2]. However, the production companies in the world have faced serious difficulties due to the environmental, social, economic and technological developments experienced at that time and only increasing productivity has not brought companies to the forefront in global competition. In order to overcome these challenges, companies have been in a constant search for virtual and physical structures that allow close collaboration and rapid adaptation throughout the entire life cycle, from innovation to production and distribution [6]. After the Cold War, trade borders between the countries disappeared and exchanges between these countries began to increase. In the 1960s, the change in the demands and expectations of the customer who bought only the existing product in 2000s caused the production processes of the companies to be more complex [3]. Thus, companies now have the need for interdisciplinary work and the Fourth Industrial Revolution (Industry 4.0) has emerged where all objects communicate and interact over the Internet [3, 4]. The development of these emerging industrial revolutions is shown in Figure 1 [4].

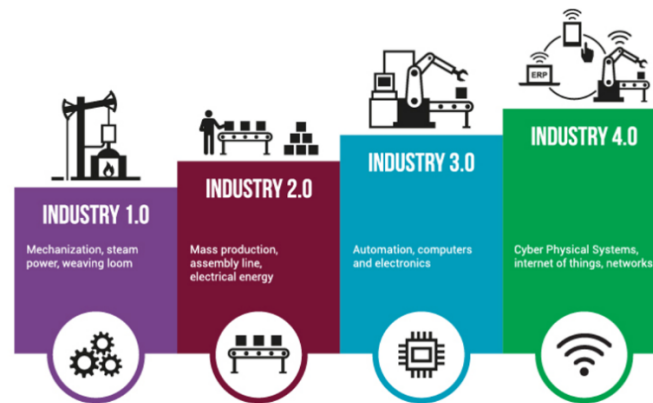


Figure 1. Industry revolutions [4].

Since the first industrial revolution, subsequent revolutions have led to radical changes in production, from water and steam electric machines to electrical and digital automated production. Production processes have become increasingly complex, automated and sustainable. This has led to the need for simple, efficient and stable operation of the machines [5, 7]. On the other hand, the continuous development of information and communication technologies continued to offer great potential to manufacturing companies in order to meet their needs [8]. Accordingly, during the 2011 Hannover Fair event Industry 4.0 was introduced by the Germans, a new concept that symbolized the beginning of the 4th industrial revolution [5, 7]. It also became a strategic initiative of the German government in the same year and was included in the High Technology Strategy 2020 Action Plan. Thus, the concept of Industry 4.0 was seen as a strategy to compete in the future [9]. Similar strategies have been proposed in similar industrial countries. For example, At the European level, the corresponding concept is the Factories of the Future, Industrial Internet in the US and Internet + in China. Since then, the term Industry 4.0, also known as intelligent manufacturing, the industrial internet, or the integrated industry, also known as the Fourth Industrial Revolution, has become one of the most popular manufacturing issues among industries and academics and is presumed to have the potential to affect all sectors at present [5, 10]. Fourth Industrial Revolution has arisen in industry when machines in general have started to manage themselves and their production processes without the need for labor [11]. While Industry 4.0 was initially considered a technology trial, it has now become a requirement to maintain competitiveness in an ever-changing industrial environment [10]. Because of industry 4.0, it is expected that more computerization and more software decision-making processes and intelligent systems will be involved in production [2, 12].

The success of companies in today's markets depends on their ability to offer products and services, which are important values for their customers, at low prices, high quality and fast [13]. Because of the emergence of global markets, a sharp competitive environment was created in the world. Companies are no longer self-sufficient and are in a chain with other businesses. These chains try to coordinate their processes to become more competitive and achieve the goals their partners' desire. One of these chains is the supply chain, which consists of a group of processes that want to fulfill the customer order. According to the Supply Chain Operation Reference Model (SCOR), plan, source, production, delivery, return and activation are the main processes of the supply chain [14]. Therefore, managing buyer-supplier relationships has always been crucial to the success of enterprises [15, 16] and should maximize their collaboration, minimize risk, and collaborate on goal setting and realization [16]. However, the traditional supply chain lacks the specific features needed in today and tomorrow's business needs [15]. Traditional supply chain management have various problems, such as over-stocking, delays in delivery and lack of stock. These problems often arise from a variety of factors, such as the complexity and uncertainty that exist in actual supply chains. Although cheaper, better and faster products are required from supply chain managers, traditional supply chains are more costly, complex and vulnerable [14]. Activities such as the ability to integrate data from customers, distributors, production and suppliers in real time and even monitor supplier performances have become more important to optimize supply chain performance by reducing lead times and inventory costs while improving customer experience [13]. All of these activities require clear and comprehensive communication channels. However, these communication channels in the traditional supply chain have changed in today's digital age. Buyer-

supplier relationships are now more dependent on digital communications than face-to-face communications. In addition, the continuous emergence of new technologies such as service softwares and social media has made digital

communication of the supply chains more effective by making communication between companies themselves and their supply chain partners more effective. Industry 4.0 revolution has had a major impact on the digitization of the supply chain [16].

2. Industry 4.0

Industry 4.0 includes a structure that will completely change the relationship between production and consumption. On the one hand, it promotes close cooperation between various disciplines in product development [17]. Mrugalska and Wyrwicka [9] integrate the concept of industry 4.0 with physical machines and devices with networked sensors and software used to better predict, control and plan commercial. Industry 4.0 has focused on optimization of value chains due to autonomous control and dynamic production. It covers strong and flexible logistics and production systems. Can and Kıymaz [2] state that Industry 4.0 plans to cooperate with all units directly or indirectly related to production, and envisages the integration of digital data, software and information technologies. Batista et al. [18] say that industry 4.0 is an advanced stage of development in the organization and management of the entire value chain process in the manufacturing industry. Oin et al. [5] say that industry 4.0 means a complete network of companies, factories, suppliers, logistics and customers. Here, each section optimizes the configuration of the relevant sections in the network in real time depending on the demand. Schumacher et al. [6] state that industry 4.0 is the backbone of the integration of the internet and support technologies into the physical objects, production lines and processes.

In Industry 4.0, a new type of product emerges as the

smart product produced in production. These products are embedded with sensors, identifiable components and processors that carry information to provide functional guidance to customers and provide feedback to the production system [5]. Under Industry 4.0, a new procurement method is provided to offer customers many advantages. For example, their ideas can be taken at any time during production, or they can change orders for free, even at the last minute [5]. Despite the growing complexity of the Industry 4.0 system, it also has the potentials outlined below [9]:

- Increasing competitiveness and flexibility resulting from the dynamic nature of business processes,
- Eliminating failures in the demand chain,
- Optimizing decision-making through real-time end-to-end visibility,
- Reducing energy and personal costs.

Industry 4.0 includes numerous technologies. Some of these technologies are Radio Frequency Identification (RFID), Internet of Things (IoT), Enterprise Resource Planning (ERP), Cyber-Physical Systems (CPS), Cloud Based Manufacturing (CBM), smart factory, smart product, etc. [4, 6, 19]. The digital supply chain that emerges from the integration of these technologies into the traditional supply chain is discussed below.

3. Digital supply chain

The introduction of Industry 4.0 into manufacturing has had many impacts on the supply chain as in other areas. Collaboration between suppliers, manufacturers, customers and the digitization and automation of processes is crucial to increasing the transparency of all steps from the time the order is shipped to the end of the product's life. After the introduction of these new technologies, it is necessary to analyze the impact of industry 4.0 on the supply chain as a whole to understand possible opportunities and potential threats [1].

A supply chain is a network of suppliers, factories, distribution centers, retailers and customers throughout the purchase, conversion, production and

delivery of raw materials. Supply chain management is a series of concurrent activities that enable the integration of suppliers, manufacturers, carriers and customers to ensure that the right product or service is delivered to the right places at the right amount, at the right time [20, 21]. Businesses are forced to expand their offerings in order to remain competitive in the market. As a result, they offer a high level of flexibility, which brings a high degree of uncertainty to supply chains. Failures to cope with these uncertainties can lead to fluctuations in the firm's supply chain. As a result, the right products cannot be delivered to the customer at the right time. Such a situation may not only be a problem of the firm, but may also affect other companies that it does business

because the supply chain is interdependent [13]. The efficient and efficient way of supply chain, which is a complex network, depends on the rapid flow of information flow and material flow [20, 21].

Information systems continue to grow as an effective supply chain, characterized by real-time collaboration and developed integration. Research has shown that supply chain management cannot be possible without advances in information systems. Studies show that sharing information will significantly improve supply chain performance. At the same time, the importance of information sharing is emphasized in order to achieve supply chain integration, increase coordination among supply chain organizations and achieve better overall performance. It is clear that supply chain operations are not possible without suitable information structure and sharing [21].

With the development of economic globalization and the development of information technology, the implementation of a supply chain management strategy has become mandatory in order to gain comprehensive advantages over challenging market competition. It is also necessary to ensure the smooth transmission of information between businesses in the supply chain to improve the advantages of the entire supply chain. However, in most existing supply chain systems, information requests and feedback information are transmitted step by step. Such vertically integrated supply chain models have some disadvantages. Because top suppliers cannot get market information on time and it is very difficult for them to react correctly. This leads to distorted demand information [22]. Rapid advances in information technologies have led to innovations as the internet. The Internet has emerged as an effective means of maintaining information integration for a supply chain. IoT, which is a comprehensive extension of the internet and at the same time capable of collecting common connections between objects, gathering information and in real time, can close the gap between objects in the material world. In this way, it can monitor the supply chain process in real time and further improve the efficiency and efficiency of the supply chain [20]. Internet technologies allow supply chains to dynamically utilize virtualizations in operations management processes. In this way, it is ensured that supply chain

stakeholders can monitor, control, plan and optimize their business processes remotely [23].

According to the assumptions of Deloitte Consulting, the global population today has access to the Internet at around 76% and social media use at around 50%. In addition, 9 out of 10 Internet users buy online products, 43% of sophisticated big data analytics companies are using and 44 zettabytes of data are expected to be produced by 2020. According to the assumption, cloud storage will reach 37% of all data generated and there will be 26 billion devices connected to the Internet. These figures show that digitalization rates will increase in the activities and processes over the years.

Since the emergence of new technological solutions, businesses have also tried to transform themselves into digital to use the emerging innovations [24]. Digitalization, which is the absolute necessity of the way of doing business of our age, is of course very much affecting the development of next generation supply chains [25]. Developing digital platforms are becoming more important, changing competition rules and paving the way for paradigm shift in supply chain management [26]. Now, as every business becomes digital, it has the potential to transform the supply chain by making the supply chain more valuable, accessible and cost effective. Organizations should redesign the supply chain not only in the form of physical product and service flows, but also as a digital supply network that combines talent, knowledge and finance [27]. Business analytics has always been an integral and vital component of effective and successful supply chain management in obtaining valuable information. However, due to the adoption and diffusion of various disruptive digital information technologies, the amount of information and data created for businesses is constantly increasing. Accelerators that increase data volume; IoT, sensor technology, effective monitoring, cloud computing, social media feeds and computerized mobile devices [28]. These technologies digitize the supply chain as shown in Figure 2, having a transformational effect on the supply chain. A series of separate steps (walls) in the conventional supply chain are broken down after the supply chain has been converted to digital in this way and the chain is transformed into an integrated system that operates perfectly [15].

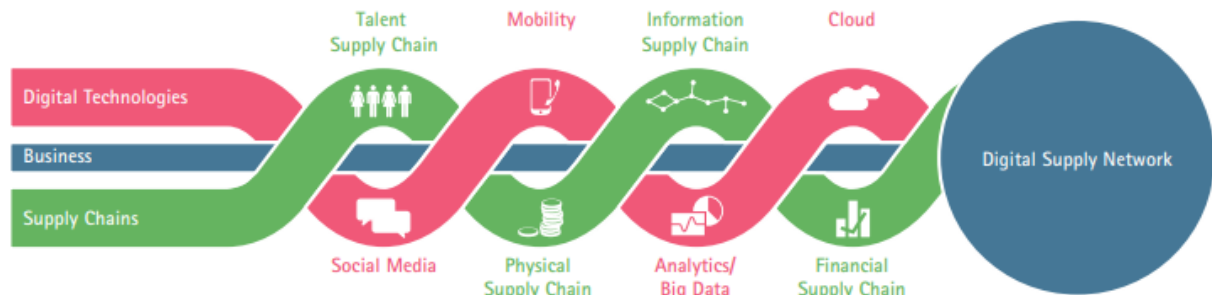


Figure 2. Conversion of Conventional Supply Chain to Digital Supply Chain [27].

The applications of these sophisticated technologies in SCM range from service parts management to loss of cargo in logistics systems, estimation of online product sales, city transportation or disaster flexibility [28]. Currently many supply chain systems are hybrid; that is, supply chains are used as a mixture of paper-based and computer technologies. However, the actual digital supply chain (DSC) goes beyond the traditional hybrid system and uses system integration and the knowledge generation capabilities of key components [14]. Although there are many definitions in the literature about DSC, some of these definitions are given below.

Abdel-Basset et al. [14] describes the digital supply chain; As a modern and interconnected system that extends from dedicated, regional and single business applications to the broad and systematic implementation of supply chains, Akben and Avşar [13] define a supply chain based on capabilities that are basically effective on the web, Büyüközkan and Göçer [24] digital hardware, software and networks for big data, excellent collaboration and communication capabilities, intelligent, have

4. Importance and benefits of digital supply chain

The main benefit of DSC is its ability to uncover outstanding performance capacity in customer satisfaction [30]. DSC has features such as reassignment of alternative routes with logistic flexibility, capacity control and capacity control, changing supply chain members with channel flexibility, controlling supply quantity and delivery times against environmental changes. The flexibility of the DSC enables supply chain activities to be performed more efficiently and freely than a conventional supply chain [31].

DSC can help businesses save time, money, and resources. With DSC and highly digitized operations, enterprises can increase annual productivity increases by 4.1% and revenue by 2.9% [24]. Many companies from different sectors are investing in-depth to digitize their business operations and supply chains.

identified as the most appropriate technology system. Raab and Griffin-Cryan [29] argue that the traditional supply chain is based on a mix of electronic processes and paper-based documents, while DSC has ability to communicate through widespread knowledge, superior collaboration and digital platforms results in greater reliability, agility. DSC covers the process of digitally transmitting digital media from the original point (content provider) to the destination (consumer). A digital supply chain system consists of systems that support the interaction between global distribution organizations and regulate the activities of the supply chain partners (hardware, software, network). In other words, big data, IoT and so on. is a supply chain created using advanced information technologies. Digital supply chain management focuses on the use of information technologies for the integration of resources, production and delivery processes [13]. It synchronizes the interaction between enterprises by concluding services with more value-added, accessible and cost-effective, stable and agile activities [24].

For example, such as DHL follows trends that may affect the logistics industry in the future, DB Schenker, another 3PL or 4PL, invests in a digital mobility laboratory, and airlines such as Lufthansa, THY and Emirates offer paperless e-freight offers for customers. Monsanto, an agricultural company, invests in sensor technology to digitize agricultural operations, Alibaba and Amazon invest in drones and robotics for the transport and delivery of goods. Based on these examples, it is important for the supply chain managers of other companies to evaluate the current digitalization status of supply chains, to create a vision for technology implementation and to develop a transformation roadmap for supply chain management in DSC environment, to increase the efficiency and profits of enterprises. To do this, the areas of the existing

supply chain need to be elaborated, disassembled and

their structures formed [15].

5. Conclusion and evaluation

In recent years, the industry has changed dramatically as a result of successive innovations and devastating developments, especially in the field of digital technology and manufacturing. Industry 4.0, which aims to improve production and engineering processes, improve the quality of products and services, optimize the relationship between customers and organizations, bring new business opportunities and provide economic benefits, has begun to affect many areas.

Industry 4.0 is the latest move in intelligent automation technology. In this new revolution, the use of modern production skills in the context of integrating new information technologies plays an important role in economic competitiveness. Supply chain agility and flexibility, which are capable of quickly adapting to fluctuations in business environments of supply chain firms and increase the competitiveness of firms, can be done more easily by digitizing the supply chain.

From the internal processes of the supply chain management departments to the demand management of the internal customers of the organization, from the digitalization of the processes to the order letter delivered to the suppliers, to the execution of the cooperation with the suppliers in the digital environment, it is important to transfer all possible processes to digital environments. In this way, it is provided the opportunity for enterprises to

gain competitive advantage by using their resources more efficiently. The use of digital transformation and intelligent systems in the supply chain to carry out the mentioned activities will make the supply chain smarter, more transparent and more efficient at every stage. Therefore, in order to raise awareness in this study, a general literature search on DSC has been conducted and the importance, features and benefits of DSC have been discussed and the importance and place of information technologies in DSC have been explained. According to the results of the literature research in the study, increasing the transparency in DSC competition, reducing the costs due to the rapid implementation, transparency and healthy data bank in the market, sharing the relevant documents with all participating companies, equal approach to all participating companies, ease of supervision of suppliers to new markets will provide both companies and their suppliers to survive in the global competitive environment by offering advantages such as reducing sales costs and transparent competition. Therefore, all possible processes need to be transferred to digital environments, from the processes of the internal supply chain management departments to the demand management of the internal customers, from the digitalization of the processes to the order letter delivered to the suppliers, to the digitalization of the cooperation with the suppliers.

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