BMIJ
ISSN: 2148-2586

bmij (2021) 9 (1):32-55
doi: https://doi.org/10.15295/bmij.v9i1.1673

Research Article

Digital transformation in supply chains: Current applications, contributions and challenges

Tedarik zincirlerinde dijital dönüşüm: Güncel uygulamalar, katkılar ve zorluklar

Özden Özkanlısoy[1]

Erkut Akkartal[2]

[1] Res. Asst., Istanbul Aydın University, Istanbul, Turkey, ozdenozkanlisoy@aydin.edu.tr, ORCID: 0000-0001-7879-0733

[2] Prof. Dr., Yeditepe University, Istanbul, Turkey, erkut.akkartal@yeditepe.edu.tr, ORCID: 0000-0002-7090-4449

Corresponding Author:
Özden Özkanlısoy,
Istanbul Aydın University, Istanbul, Turkey, ozdenozkanlisoy@aydin.edu.tr

Submitted: 6/11/2020

Revised: 27/01/2021

Accepted: 1/02/2021

Online Published: 25/03/2021

Citation: Özkanlısoy, Ö., & Akkartal, E., Digital transformation in supply chains: Current applications, contributions and challenges, bmij (2021) 9 (1): 32-55, doi: https://doi.org/10.15295/bmij.v9i1.1673

Abstract

Digital transformation in supply chain management enables businesses to gain a competitive advantage by using their resources more efficiently, making every stage of their supply chain brighter, more transparent and more efficient, closer to customer needs, and increasing the quality of decision-making. Besides, it ensures that the supply chain will become increasingly flexible and have efficient new business models shortly. Unfortunately, digital transformation is at the digitalisation stage rather than digital transformation due to the high initial investment cost and concerns about applications' success. In this study, successful digital transformation applications implemented in supply chain management to guide companies and supply chains that have not yet entered the digital transformation process, the advantages of these applications and the difficulties of the digital transformation process are discussed. In the study, using qualitative data analysis, open-ended interview questions were applied to 28 companies, and the answers were separated based on industries and applications and were grouped according to industries. The companies' contributions and their supply chains with digital transformation and the challenges faced in the transformation process are discussed jointly to cover all industries. The study ends with an evaluation and a summary of the findings.

Keywords: Supply Chain, Digital Transformation, Industry 4.0

Jel Codes: O14, M10, M15

Öz

Tedarik zinciri yönetiminde dijital dönüşüm, işletmelerin kaynaklarını daha verimli kullanarak rekabet avantajı elde etmelerine, tedarik zincirlerinin her aşamasını daha akıllı, daha şeffaf ve daha verimli hale getirmelerine, müşteri ihtiyaçlarına daha yakın olmalarına, karar verme kalitesinde önemli bir artışa ve tedarik zincirinin yakın gelecekte giderek daha esnek hale gelmesini ve verimli yeni iş modellerine sahip olmalarını sağlamaktadır. Ne yazıkki günümüzde dijital dönüşüm, yüksek ilk yatırım maliyeti ve uygulamaların başarısına ilişkin endişeler nedeniyle dijital dönüşümden çok dijitalleşme aşamasındadır. Bu çalışmada, henüz dijital dönüşüm sürecine girmemiş şirketlere ve tedarik zincirlerine rehberlik etmek amacıyla, tedarik zinciri yönetiminde gerçekleştirilen başarılı dijital dönüşüm uygulamaları, bu uygulamaların sağladığı katkılar ve dijital dönüşümün zorlukları ele alınmaktadır. Araştırmada nitel veri analizi kullanılarak toplam 28 firmaya açık uçlu görüşme soruları uygulanmış, cevaplar sektör ve uygulamalar bazında ayrıştırılarak sektörlere göre gruplandırılmıştır. Şirketlerin ve tedarik zincirlerinin dijital dönüşüme katkıları ve dönüşüm sürecinde karşılaşılan zorluklar tüm sektörleri kapsayacak şekilde ortak olduğundan bir bütün olarak ele alınmaktadır. Çalışma, bulguların değerlendirilmesi ve kısa bir özetiyle sona ermektedir.

Anahtar Kelimeler: Tedarik Zinciri, Dijital Dönüşüm, Endüstri 4.0

JEL Kodları: O14, M10, M15

Introduction

"*The supply chain is a network of producers and distributors that supply raw materials, convert them into intermediate goods and final products, and distribute final products to customers*" (Lee and Billington, 1992, p. 66). Supply chain management (SCM) can be characterised as the assimilation of all actions between the supplier and the end customer (Ellram and Cooper, 1990, pp. 1-2). SCM is a model that regularly controls and coordinates the processes between companies (Hammer, 2001, p. 84).

Digitalisation and digital transformation are different concepts. Since digitalisation emerged as a term, many definitions have been expressed. The North American Review first coined the term digitalisation in 1971 as "the digitalisation of society". This concept was related to the context and potentials of "computer-aided humanities research" at that time (Brennen and Kreiss, 2016). While digitalisation brings together technologies that everyone can access, it is also a concept that is included in the most significant changes in many aspects such as cultural, behavioural, demographic and life cycle. The concept of digitalisation has brought with it many new concepts (Kupiainen, 2006, p. 280).

After digitalisation, the concept of digital transformation emerged. The early scholars who studied the theoretical aspects of the emerging concept of digital transformation defined digital transformation through information technologies. According to this definition, digital transformation is a process towards "*a world where everything is interconnected*" (Stolterman and Fors, 2004, p. 687). With this definition, digital transformation is framed as a general trend of our daily life. In today's world, in terms of business, it can be characterised as an innovation in how a company generates and offers value by applying technological systems and structures and how it increases revenue (Tiersky, 2017).

Digitalisation is when images, sounds and texts in the physical format are transformed into digital binary format, where information is transformed into a digital-analogue. At the same time, digitalisation is the actual application of digital information at a different level. Terms such as big data, mobile applications and IoT are examples of digitalisation. It would be correct to say that it has a complex result that develops in line with the developments achieved by implementing systems, so it would be correct to describe digitalisation and digital transformation as successive stages, respectively (Khan, 2016, p. 6).

Comparing how deeply people and companies can embrace new thinking, surprising results are obtained. There is virtually a gap between companies that have adopted new technology to old processes and systems retrospectively and companies that dare to go deeper and invest more money and make more effective changes. Nowadays, the significance of this deepening is more understood as it brings more efficiency and more growth (Goodwin, 2019, pp. 124-125).

SCM has been integrated with the developing information systems since the end of the 1990s and has become an approach aiming to increase customer satisfaction. In this period, sharing information technologies and information simultaneously with all supply chain members bring SCM activities to a more transparent and reliable level (Metz, 1998, p. 46). In the changing world, competition among companies is not mentioned anymore. Competition is now experienced between supply chains in which companies are involved (Kehoe and Boughton, 2001, p. 516). Links between supply chain members are significant and need to be managed successfully (Johannson, 1994, p. 521). At this point, digital transformation is vital as it increases the connection between the members of the supply chains and enables the supply chain to be managed more successfully.

Industry 4.0, also called the 4th Industrial Revolution, is expressed as the digitalisation of industrialisation or physical production and cyber technologies through new technologies. With the digital transformation of the supply chain, a more advanced automation and inter-system integration application is realised. In this way, all machines and equipment in production are coordinated over the internet and sensors to make production simultaneously. In this process, all necessary data are stored with the cloud system. Therefore, Industry 4.0 creates a transformation that changes the entire supply chain and business models.

While some supply chains are performing digital transformation in the supply chain, others have not started this transformation and have been limited to digitalisation. There is a gap in the literature that deals with the current digital transformation applications in the Industry 4.0-based supply chain, the contributions of the applications and the challenges experienced during and after the transformation process. This study aims to help companies make digital transformation decisions by bringing together transformation contributions and challenges. Thanks to this study, the companies will be able to take action against these challenges and determine the best road maps by evaluating the challenges encountered during and after the transformation.

Background

The term digital transformation (D.T.) has become a highly debated topic in academic discourse and practice and still does not have a concrete definition. Industry 4.0 is at the digital transformation background in supply chains, as it continues to be used as a synonym for digital transformation and Industry 4.0. Consequently, the process of industrial revolutions to date without mentioning digital transformation constitutes the background of the concept of digital transformation (Junge and Straube, 2020, p. 736; Hofmann and Rüsch, 2017, pp. 23-24; Kersten et al., 2017, p. 47; Ward et al., 2016, p. 605).

Mass production started with the economy based on human, animal and soil production factors before the Industrial Revolution, the effect of new inventions on production with the Industrial Revolution and the birth of the mechanised industry of steam-powered machines. There have been three Industrial Revolutions to date (Drath and Horch, 2014, pp. 56-58). The First Industrial Revolution (Industry 1.0) started in England, and textile productivity increased with new machines' discovery. Steam engines and iron production were essential factors that started the First Industrial Revolution (Coleman, 1956, pp. 1-2). The Second Industrial Revolution (Industry 2.0), called the Technology Revolution, emerged with the further development of railways, facilitating distant markets and raw material supply. The change in energy resources and raw materials and the advancement of technology is another factor in the Second Industrial Revolution's emergence (Jänicke and Jacob, 2009).

As of the 1970s, automation started to spread with the effect of developing technology, and the technologies developed in line with the needs during the Second World War shed light on the beginning of Industry 3.0. As a consequence of World War II, with communication, communication and technology, automation in production became possible. During this period, with the development of the software industry, machines have also changed. Furthermore, production has moved to a completely different dimension. Globalisation has gradually increased due to the ease of communication and transportation. As seen in every industrial revolution, a change in energy resources has been attempted here. Due to the danger of depleting the resources used, the trend towards renewable energy resources has started. As the essential concept of age, the concepts of sustainability and sustainable growth have gained tremendous significance (Redclift, 2005, p. 212).

The Industry 4.0 concept introduced by Germany is more common and has gained significant importance. Industry 4.0 is recognised as the Fourth Industrial Revolution (Alexopoulos et al., 2016) and is predicted to lead to severe changes in many industries. Industry 4.0 has brought many new technologies with it. These technologies are advanced technologies such as cyber-physical systems, additive manufacturing, the internet of things, intelligent robots-cobots, big data analytics, cloud computing, augmented realism, cybersecurity, and horizontal and vertical integration. Many of these technologies have been developed over the past few years. Generally, these technologies are called Industry 4.0 technologies (Smartindustry, 2017, pp. 10-11). Industry 4.0 has brought a digital transformation in supply chains. While examining the digital transformation background in industrial revolutions and Industry 4.0, it is also necessary to examine the academic studies in this field so far.

Literature Review

The digital transformation brought about by Industry 4.0 is a subject that has been frequently studied scientifically in recent years. It has been noted that there have been significant developments in this field

in the last five years. Menon et al. (2019) emphasised the significance of intelligent production, one of the products of Industry 4.0, for the digital supply chain, and Liboni et al. (2019) emphasised the significance of Industry 4.0 for the supply chain of human resources management in their studies (Menon et al., 2019, p. 178; Liboni et al., 2019, p. 124).

Ivanov et al. (2016) proposed a dynamic model and algorithm for short-term supply chain scheduling in intelligent factories. Edirisuriya et al. (2018) examined the green and lean supply chain perspectives for logistics 4.0 and evaluated the difficulties encountered in transforming the traditional logistics concept into Logistics 4.0 (Ivanov et al., 2016, p. 386; Edirisuriya et al., 2018, pp. 1-8).

Teng et al. (2018) examined the relationship between "Internet +" and logistics. They categorised the Internet + contributions, the value it brings, and the challenges it faces in the digitalised logistics industry. With the countermeasure analysis, they presented suggestions that can be applied in front of the difficulties and stated that the logistics industry's significant position would increase as it adapts to digital trends (Teng et al., 2018, pp. 1-4).

Hartley and Sawaya (2019) interviewed supply chain experts at 14 large scales, mature manufacturing and service organisations in their studies. They included robotic process automation (RPA), artificial intelligence (A.I.) / machine learning (ML) and blockchain technologies, which they think will change the supply chain business processes. It outlined each technology's promises and predicted its large-scale adoption potential (Hartley and Sawaya, 2019, p. 707).

Junge and Straube (2020) investigated the improvements provided by digital transformation technologies to sustainable supply chains with qualitative case studies. They revealed that the widespread digital transformation in logistics and supply chain management has a moderately positive effect on the environmental and social sustainability dimension (Junge and Straube, 2020, p. 736).

Li (2020) examined how digital technologies facilitated business model innovations in creative industries and concluded that digital technologies facilitate common changes in business models and some significant trends emerged (Li, 2020, pp. 1-10). Yu and Schweisfurth (2020) researched how SMEs are related to Industry 4.0 applications and applied an Industry 4.0-focused survey in SMEs. According to the research results, the expected benefits of knowledge and technology are very significant in applying Industry 4.0 technologies, and companies with a high level of process automation are more likely to apply Industry 4.0 technologies (Yu and Schweisfurth, 2020, pp. 76-84).

Centobelli et al. (2020) examined 90 articles on agile supply chains in their studies and presented an integrative effect of these digitalisation articles. Thus, the contributions of digitalisation in the supply chain were determined. The study explains how technology is handled in supply chains and reports analytically (Centobelli et al., 2020, p. 324).

Cichosz et al. (2020) conducted case analysis with the information collected from 9 LSPs, nationally and internationally, to discover the barriers in logistics service providers (LSP) and identify the organisational elements and the leading practices associated with them. As a result of the study, five obstacles, eight success factors and associated leading practices were determined (Cichosz et al., 2020, p. 209). Singh et al. (2020) conducted multiple case studies to investigate organisational design parameters surrounding digital transformation (D.T.) activities. According to the results of the study, it was concluded that companies that appointed a Chief Digital Officer (CDO) to implement the digital transformation strategy should place this manager in the organisation and choose a governance architecture that provides CDO with sufficient appreciation and influence in order to fulfil the D.T. strategy (Singh et al., 2020, pp. 1-12).

When the academic studies conducted in this field so far are examined, there is no study examining the current applications in digital transformation and companies' opportunities through transformation and the company's difficulties in the transformation process. As shown above, studies on this subject are either based on a literature review or are limited to current applications. Although this does not

reflect the current situation, it is not enough to take only the technology and applications used in digital transformation within the study's scope. The digital transformation decision for companies in the supply chain is a decision that must be weighed on a scale, the difficulties to be experienced in this process, and the benefits to be gained as a result of the process. The fact that this study handles digital transformation not only with current applications but also in terms of its difficulties and benefits reveals its difference from other studies.

Digital Transformation in Supply Chains

The categorisation of SCM Softwares

In this study, SCM software is discussed in two groups: enterprise software and enterprise resource planning (ERP). The enterprise software is divided into the cloud-based enterprise software and open source and licensed enterprise software. This software used in SCM are explained in detail below:

Enterprise Software

When enterprise software is looked at historically, the most well-known production planning and control approach was material requirement planning (MRP) (Chen et al., 2008, p. 616). It attracted significant attention from many researchers in the literature (Orlicky, 1975, p. 188). Initially used in the 1960s, MRP was designed and developed for a stable and predictable production environment. It aimed to reveal exact material requirements based on product tree, stock information and MPS (main production schedule) and creates planned production orders (Koh et al., 2002, p. 2439).

MRP is widely used in determining batch quantities during its use. Certain assumptions/acceptances are generally made in MRP. These; deterministic demands are product and preparation times (DePuy et al., 2007, p. 574). MRP produces production orders, capacity requirements, raw material and semi-product requirements as output (Plenert, 1999, p. 92). MRP systems, which are used in determining the production program in multi-stage production systems, are a system that plans with unlimited capacity without considering capacity constraints. However, in reality, planning is done in a finite capacity environment (Billington et al., 1983, pp. 1126-1127).

MRP II is an information system used to plan and control production activities in the long-term and medium-term. The purpose of planning is to evaluate capacity and resource needs, convert sales forecasts into production schedules, maintain stock levels, and satisfy customer requests. MRP II system software is designed to cover all company functions. However, it plans according to priorities by accepting the current planning parameters such as procurement times, lot sizes, scrap rates, and preparation times. Based on future demand forecasts and customer orders, the MRP II generates in-shop orders and orders for purchasing according to the main production schedule, usually prepared weekly, and components in the materials bill. It aims to reach the standards. Central control is applied with excessive feedback activity to prevent deviation from the standard (İlyasoğlu et al., 1994, p. 28).

Enterprise software is application software that supports the main business processes between departments and other businesses. The purpose of corporate applications is to manage corporate operational data and increase efficiency. Enterprise software is generally not flexible. They are software that is low in documentation and challenging to maintain. Despite this, it is still very significant for businesses and the supply chains they are members, as they support complex business processes (Supulniece et al., 2015: 30). Packaged enterprise software provides companies with an economic gain by saving cost and time (Verville and Halingten, 2003, p. 585).

Research to date has shown that there are significant differences between enterprise software package development and the customised enterprise software development (Sawyer, 2001, p. 97). Enterprise software package development refers to the development and sale of enterprise software as a product. The customised enterprise software development means that companies develop enterprise software within their organisation or develop custom software by agreement with another company. In the

software acquisition process, the needs should be determined in a customised corporate software environment, and then the software that will meet these needs should be developed. While the software package is developed, customers should choose the software that best suits their needs from pre-developed software packages (Keil and Tiwana, 2006, p. 237).

Cloud-Based Enterprise Software: Cloud-based enterprise software is used by sharing software and hardware over the internet and shared with the pay-as-you-go logic. In these software users, users are not the owner or manager of the infrastructure, application or platform (Mell and Grance, 2011). Users access resources over the internet. Thanks to the rapid development of cloud computing, companies have started to access cloud service providers' enterprise software packages. Cloud-based enterprise software is physically different from in-house enterprise software. Cloud-based enterprise software has several features such as self-service acquisition, limited adaptations, limited update control, user interface-based configuration, broad service ecosystem, outsource maintenance and pay-as-you-go (Schneider et al., 2018, p. 153).

Open Source and Licensed Enterprise Software: In earlier times, businesses used licensed software when building their application systems. However, with open-source software development, a new model has emerged in software development and distribution. Licensed software is mostly software belonging to a person or company. This software is protected by patents and copyrights, while its source code is kept confidential. Open-source software is distributed under the license of "Open Source Initiative", and when purchased, the user is given the right to read, redistribute, modify and use the software code free of charge. Volunteer software developers, testers, and end-users come together in a public web environment to develop open-source software. Open source development is often referred to as a project, and developers support continuous development.

Organisations have realised the benefits of open source software with the rapid development of open-source enterprise software and increasing the maintenance fees of large enterprise software providers such as SAP. Therefore, information technology managers started to change their decisions from licensed software to open source software (Benlian and Hess, 2011, p. 503).

A Role of ERP Software in New Era

The approach that only material or capacity is significant in a manufacturing company has evolved that planning and controlling all resources is necessary. This situation enabled the transition from Manufacturing Resource Planning (MRPII), one of the software support systems, to Enterprise Resource Planning (ERP) in the 1990s. ERP technology is presented as an integrated approach for systems integration (Olhager and Selldin, 2004, p. 353).

ERP can be defined as developed systems and software that enable or support the end-to-end management and efficient use of businesses by bringing together all resources, including human resources, physical resources and financial resources (Haddara, 2014, p. 394). ERP systems allow the information to be followed at all times and provide global visibility within the business and throughout the supply chain to which the business is connected. This real-time information helps a supply chain improve the quality of its operational decisions. ERP systems keep track of information and see information from this aspect (Chopra and Meindl, 2007, p. 57).

ERP can be thought of as the digital nervous system that activates the organisation's backbone to enable an organisation to respond quickly to customers and suppliers. Most ERP providers develop their systems to operate on the web to meet the needs of ever-changing business environments. ERP systems support a wide range of processes that try to integrate supply chains. At the organisational level, this is easier to achieve when ERP modules replace information systems. In this case, ERP systems; supports and integrates SCM. As a result, ERP systems are significant in terms of customer satisfaction, supplier satisfaction and productivity. However, ERP systems have their limitations and must be tailored to the needs to support business processes and supply chains fully. ERP systems are complex, inflexible, and often not designed to collaborate with other autonomous applications. Therefore, the adaptation of ERP

systems in the digital transformation process is a point that should be highly considered, as it can cause significant integration problems (Themistocleous et al., 2004, pp. 395-396).

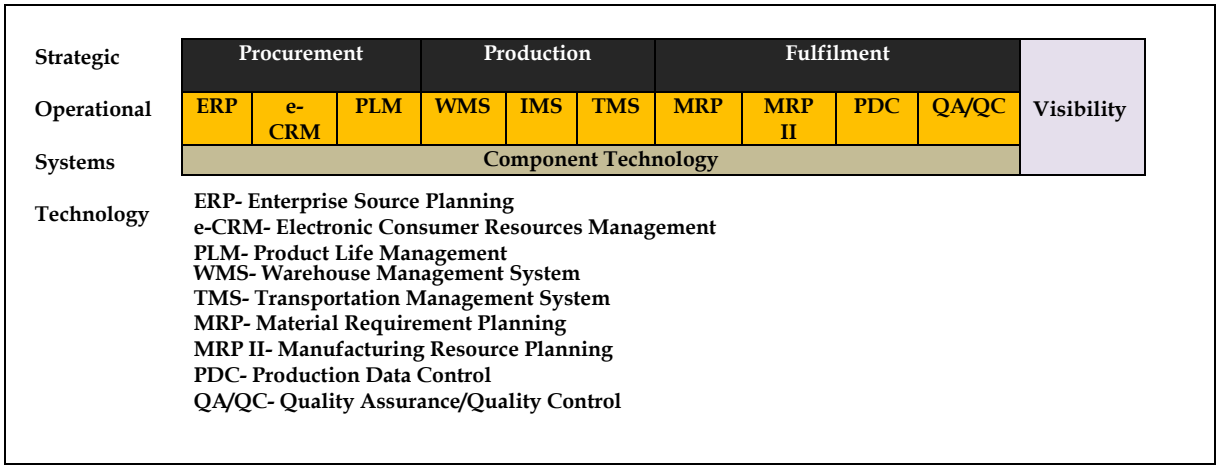

Figure 1: Supply Chain and Visibility Relationships

Reproduced from source: Pagano, A. M. and Liotine, M. (2020). Technology in Supply Chain Management and Logistics: Current Practice and Future Applications. Elsevier. p.9.

As it creates more excellent value for the customer base with supply chain technology, it increases profitability. Companies with greater end-to-end visibility into the complexity of their supply chains and logistics operations, digitally transformative processes and systems provide accurate, timely and incomplete access and transparency to events and data for transaction, content and related supply chain information, and within and across organisations and supports the effective planning and execution of supply chain operations. (Titze and Barger, 2015). Fig. 1 shows these relationships above (Pagano and Liotine, 2020, p. 9).

Contribution of Industry 4.0

Cyber-Physical Systems (CPS): As a concept, "cyber" derives from the scientific discipline known as cybernetics, which has taken communication and control over living beings and machines the subject of research. By the 1940s, the term "cyber" has been used to describe information technologies, computer and internet-based control processes (Bradley and Atkins, 2015, p. 23023).

The systems that connect the physical world and cyberspace are called cyber-physical systems (Cyber-Physical System- CPS). These systems supported by sensors collect movements in the physical world with internet services and include objects globally (Geisberger and Broy, 2012, p. 314).

Role of Internet of Things (IoT): It means "things" and "things" that are connected to the internet and each other. Each of these objects has its identification number (UID) and internet protocol (I.P.). Thus, objects can be identified easily. An important distinction here is the variety of these objects. Generally, they are divided into physical origin objects and digital origin objects. For instance, while the printed book or a business is a physical object, electronic book and virtual store are digital objects. Although both produce data, digitally derived objects generate more data (Greengard, 2017, pp. 30-31).

The concept of IoT was firstly used in 1999 by Kevin Ashton in its presentation, where it expressed the benefits of using RFID technology in the supply chain of an enterprise (Rifkin, 2015, p. 82; Atzori et al., 2017, p. 123). IoT can be used in every industry and every business. Nowadays, it is seen in areas of use, innovative infrastructure, healthcare, supply chain and security, energy, production and related industry sectors and enterprises (Roblek et al., 2016, Uslander, 2016, p. 219). The communication and information exchange processes of businesses with IoT technology are quite different from those that do not use IoT. These differences can be summarised, as in Table 1:

Table 1. Differences Between Classical Information Process and IoT Information Process

Classical Information Process	loT Information Process
-There is information and customer relationship management based on data obtained from the intranet. -Data is saved on local servers. -Local time and limited personal access, -Organisation limited networks, -Sharing information and discussion via e-mail or intranet.	-Data is obtained directly from objects and customers. It is analysed and saved in the cloud. -There is real-time. Content is available online. There are no restrictions for sharing information between people or objects. -Information sharing and collaboration between people, between people and objects, and between things are established through wireless communication networks.

Reproduced from source: Roblek, V., Meško, M. and Krapež, A. (2016). A complex view of industry 4.0. Sage Open, 6(2), 2158244016653987. p.5.

3D Printers' Vision: 3D manufacturing is how digital 3D design data is used to create layers with additives/materials and additive manufacturing. The term "3D printing" is increasingly used as a synonym for additive manufacturing. Instead of milling a workpiece from a one-piece partition block, additive manufacturing forms sheet-by-layer components using available material in fine powder form. A range of different metals, plastics and composite materials can be used. 3D printed objects are an additive manufacturing process that produces layer by layer.

One of the most significant advantages of 3D printers is flexible production. If we keep it together with mass production, we can obtain independent and unique products from each product we produce. Of course, it will save us the cost of high paid moulds (Chong et al., 2018, p. 1). For instance, Vestel, a company that operates in the durable consumer goods industry and has an essential place in the industry, processed products using three-dimensional printers instead of using a separate mould for each product in its production lines. It started to use it in the process. In this way, the number of moulds used in Vestel decreased by 90%, and the complexity in processes decreased (Horenbeng, 2017, p. 59).

Big Data Implementations: Data acquisition constitutes the conceptual framework of the predictive production system. Various signals can be given, such as suitable sensor setups, vibration, pressure. Furthermore, historical data can be collected for further data processing. Communication protocols can help users record controller signals. In this way, all data are brought together, and this combination is called "Big Data" (Lee et al., 2014, pp. 4-5).

The rapid development of the internet has led to the production and collection of large amounts of information daily. The processing and analysis of these data are at a level far above the capabilities of traditional tools (Witkowski, 2017, p. 767). The collection, storage, management and analysis of big data is challenging for traditional database technology. From a management perspective, manufacturing companies need to instantly obtain personalised data of many consumers from the web and manage more appropriate data types. Big data technology is a technology that uses new modes of operation to provide in-depth information, provide insight, make the right decision, make discoveries, and quickly extract valuable information from various types of data (Zhou et al., 2015, p. 2147).

Contribution of Cloud Systems: Cloud-based manufacturing is a networked production model that can be used to access diversified and distributed production resources from on-demand access to create temporary, reconfigurable cyber-physical production lines that increase efficiency, reduce product lifecycle costs, and allow optimal resource allocation (Wu et al., 2013, p. 564). Nowadays, data is produced through many technological products, production facilities, sensors and many other factors. Furthermore, problems may arise due to the diversity and incompatibility of direct, real-time, bidirectional communication protocols between these machines and devices (Georgakopoulos et al.,2016, p. 66). Cloud systems are an essential component for Industry 4.0 as they eliminate this problem and enable the use of the same data on different devices, data can be transferred quickly without any software or hardware problems, and machines and devices can communicate without any protocol restrictions (Wu et al., 2013, p. 564). Besides, cloud systems, which are in close relations with other

components of the Industry 4.0 process, when combined in the most compatible way with IoT, allow real-time computing and delivering high-value information everywhere.

Furthermore, the data can be integrated and stored reliably (Thames and Schaefer, 2016, p. 12). These benefits can enable manufacturing facilities worldwide to gain unprecedented operating efficiency, increase profits and reduce costs (Xu, 2012, p. 75). Other technological groups and applications, together with the cloud system, are given in Table 2 below (Zimmermann et al., 2019, p. 1757):

Table 2: Technological tools with implementations

Technological tools	Implementation
Mobile actuators	AGV, UAV…
Stationary actuators	Industrial robot…
Sensors	Temperature, humidity…
Identifiers	RFID/NFC, Quick Response-Code…
Mobile devices	Smartphone, handheld…
Wearables	Data glasses, data gloves…
Human-machine-interface	Touchpad, motion capture…
Machine-machine-interface	Bluetooth/BLE, WLAN, 3G…
Cloud computing	Private/Public cloud…
Software solutions	ERPS, MES, dashboards…
(Big) data	Analytics, data mining…
Additive manufacturing	Selective laser sintering…

Reproduced from source: Zimmermann, M., Rosca, E., Antons, O., & Bendul, J. C. (2019). Supply chain risks in times of Industry 4.0: Insights from German cases. IFAC-PapersOnLine, 52(13), 1755-1760. (p., 1757).

Digital Transformation Strategies

The digital transformation decision is a strategic decision for companies and supply chains. If a company and its supply chain want to survive in a competitive environment, innovation must encourage itself. In this context, it should implement a digital transformation strategy (Albukhitan, 2020, p. 664).

There are two methods to implement new technology or a new workflow in companies. The first of these is the gradual transition. The second is the direct transition. In the gradual transition, users are given time to integrate into the new system. The old application and the new application work together for a while, and eventually, the new application is started. Gradual transition enables users to adapt without any shock process. However, it also has disadvantages. If the application does not receive sufficient attention from the users, it may be that the application cannot be used (Hammer and Stanton, 1995, p. 28).

The direct transition method applied in the realisation of new applications, on the other hand, is a method that switches to new applications by altogether terminating old applications without allowing a gradual transition period for applications. This method creates tension in users as it changes the way users are used to doing business. However, if the new application is well-designed, then the complaints decrease over time. The main advantage of this management is that users are forced to the new system. The direct transition method can pose severe risks for the entire system in an organisation. Therefore, it is necessary to be careful while applying this method (Koch, 2005; Gartner, 2019).

After the digital transformation decision is made, what needs to be done in order for the transformation to be successful is another strategic decision in digital transformation in the supply chain. Managers' interest in technology and the impact of information are also significant in digital transformation projects' success. Company executives must believe in and support the added value that transformation will provide in company success (Polites and Karahanna, 2012, pp. 21-42; Hartley and Sawaya, 2019, p. 713).

Another strategic decision is the choice of the right technology choice. In this process, companies need to find answers to many questions, such as which technologies meet the company's needs, which technologies they should invest in, and how to distribute their resources to these technologies. Apart from deciding on the technologies to be applied, the organisation's strategy, capabilities, business models, and organisational structure must be suitable. Apart from deciding on the technologies to be applied, it has been brought to the agenda that the strategy, capabilities, business models, and even the institution's organisational structure should be suitable for this. The selection, implementation, and use of these technologies that come with Industry 4.0 require a transformation process that affects all enterprise units and resources (Hanley et al., 2018). In this context, it is imperative to understand the difference between traditional business strategies and digital transformation strategies on the agenda today for companies that are members of the supply chain. The difference between traditional firm strategies and firms' digital transformation strategies is shown in Table 3 (Mäkinen, 2017, p. 20):

Table 3: The difference between digital transformation strategies and traditional company strategies

	Traditional Company Strategy	**Digital Transformation Strategy**
Focus	Optimisation of individual technologies and individual units	Focus on implications for products, services and business models as a whole
Scope	The detailed content of the strategy	How to realise the organisational vision
Goal	Operational efficiency	Business transformation, customer experience, operation and rescheduling of business models
Period	Several years	Continuous
Source of Innovation	Talented individuals and competencies within the organisation	Collaboration and effort, and knowledge sharing between industries and different business units
The Cycle of Business Model	Slow to the average speed	Quick
Method	Forecast and plan	Experience and respond
Business Model	Service provider, asset creator	Creating technology and synchronising networks
Competitive Advantage	Proprietary assets	The ability to transform and adapt

Reproduced from Source: Mäkinen, T., (2017). Strategising for Digital Transformation: A Case Study of Digital Transformation Process in the Construction Industry. p.20.

A digital strategy should monitor and evaluate digital transformation initiatives and test their impact consistently in addition to the above. Furthermore, responsibilities should be determined in the planning and implementing digital transformation projects (Westerman et al., 2011).

Qualitative Analysis

The Aim of Research

It is to guide companies that have not yet made a digital transformation decision by presenting digital transformation applications in the supply chain, the contributions of these applications and the challenges of digital transformation from a scientific perspective. This context categorises the problems that companies in different industries encounter in their digital transformation based on the questions asked.

The Importance of Research

Industry 4.0 is expressed as the digitalisation of industrialisation or integrating physical production and cyber through new technologies (Vasin et al., 2018, p. 64). These technologies enable Industry 4.0 to create a transformation that will change the entire supply chain and business models (Lee et al., 2018: 2754). Digital Transformation suggests that factories should be made bright, but the entire supply chain structure should be intelligent (Müller and Voigt, 2018, p. 122). The internal dynamics consist of business models, processes, professionals and resources (Kotarba, 2017, p. 123). Transformational changes in any of these affect both companies' performance and supply chains (Ashurst et al., 2008, p. 352).

With digital transformation contributions, a significant change has occurred in the business world and continues to occur. Industry 4.0 technologies, which give confidence with their increasingly low costs, are now available for businesses of all sizes. The Fourth Industrial Revolution has created unlimited opportunities for businesses and their connected supply chains with new technologies (Hanley et al., 2018). Some companies have started a digital transformation in the supply chain, and some companies have not started. Some companies have not switched to digital transformation, and their applications are still at the digitalisation level.

Many companies in the supply chain cannot make a digital transformation decision due to many reasons such as cost, implementation difficulties and the difficulty of choosing the right technology. This study handles the digital transformation as a whole regarding its contributions to companies that will start the digital transformation with current applications, the company itself and its customers, suppliers, investors and employees, and the transformation process's challenges. In this respect, it serves as a guide for companies that have not yet started a transformation. The fact that current applications are not addressed and the contributions and challenges of transformation in the studies conducted so far reveals its significance.

The Method of Research

Since quantitative research does not generally reflect the targeted result in qualitative research, answers to research questions have been sought by the basic methodology on which the research is based (Denzin, 1994, p. 15; Mcleod, 2011, p. 279). Interviewing is one method of gathering information in which individuals or groups of individuals are questioned personally (Qu and Dumay, 2011, pp. 238-264). For this purpose, interviews were conducted with companies. In this case, the data collection tool of current digital transformation practices in supply chains, their contributions and challenges, was an in-depth interview. For this purpose, it was decided to collect the necessary data in consultation with the companies' supply chain managers. Interviews were conducted face-to-face by making an appointment with the company. The answers for current applications are grouped by industry. The contributions and challenges are taken as common across all industries. Since the research was conducted before 2020, there was no need for an ethics committee permission document. While the applications differ according to industries, the contributions and challenges are common to all industries. This study has targeted to find answers to the following four research questions (R.Q.):

RQ1: What are the successful applications and new business models that your company has implemented in the digital transformation process of supply chain management?

RQ2: How did you contribute to your company with your successful applications in supply chain management?

RQ3: With successful applications, you implement in supply chain management

a) What kind of contributions did you make to your "customers"?

b) What kind of contributions did you make to your "suppliers"?

c) What kind of contributions did you make to your "investors"?

d) What kind of contributions did you make to "employees"?

RQ4: What are the challenges of digital transformation in the supply chain?

The Universe and Sample of the Research

Within the study's scope, the supply chain managers of 180 different companies were requested to interview, 28 companies accepted to answer the interviews.

Findings of Research

The Current Applications in Different Industries

In this part of the study, digital transformation current applications in the different industry from the findings of interview applied to companies are grouped by industries, and these applications for digital transformation in the supply chain are given below in Table 4:

Table 4: The Current Applications

INDUSTRY	**Electronics and I.T. Industries**					
NAME OF COMPANY	**C1**	**C2**	**C3**	**C4**		
CURRENT APPLICATIONS						
Online tracking of internal processes	✓	✓	✓	✓		
Online tracking of sales and stocks	✓	✓	✓	✓		
Developing new sales plans by creating a customer portfolio	✓	✓		✓		
Supplier management with SAP SNC and SAP SLC software programs		✓	✓			
Logistics management with inbound and outbound applications and SAP TMS		✓				
Sales, supply and operation planning with S&OP project and CTP (Capable to Promise)		✓				
Production planning with integrated planning and advanced scheduling		✓				
Warehouse management with SAP EWM	✓					
Electronic demand management			✓			
Using robots		✓				
Open-source technologies				✓		
ERP TMS and ERP WMS software				✓		
INDUSTRY	**FMCG Industry**		**Food Industry**		**Medical Pharmaceutical Industry**	
NAME OF COMPANY	**C1**	**C2**	**C1**	**C2**	**C1**	**C2**
CURRENT APPLICATIONS						
Supply chain planning processes with machine learning	✓					
Co-robots in production	✓					
Robotic process automation (RPA) in office processes	✓					
3PL automatic transmission of information		✓				
SAP customer data system integration		✓				
Online tracking of internal processes		✓				
Integrated supply chain planning project			✓			
Planning the transportation processes of the factory with TMS			✓			
Route optimisation with dynamic rooting			✓			
Consolidation between purchasing, production and logistics units				✓		
E-Tender					✓	
SAP APO Module					✓	
ERP software such as SAP SRM, SAP SLC, SAP BO software				✓	✓	✓

INDUSTRY	Retail Industry		Retail Food Industry		Transportation Industry		
NAME OF COMPANY	C1	C2	C1	C2	C1	C2	C3
CURRENT APPLICATIONS							
Digital routing, Digital POD (Proof of Delivery), Digital replenishment	✓						
E-commerce	✓						✓
CRM	✓						
Master data repository		✓					
3d measuring device		✓					
High processor capacity for data processing		✓					
Automatic goods picking and sorting development systems			✓				
ERP and WMS software			✓				
Supply chain and logistics data warehouse			✓				
Tablet-based cockpit reporting system			✓				
Use of Scrum methodology from agile software			✓				
Communication software			✓				
Store order management and warehouse order management				✓			
Live container tracking					✓		
Routing engine for maritime transport					✓		
Practices that enable the parties to meet their information needs					✓		
Online pricing and online reservation tracking						✓	
Performing necessary documentation corrections on a digital platform						✓	

INDUSTRY	Logistics Industry						
NAME OF COMPANY	C1	C2	C3	C4	C5	C6	C7
CURRENT APPLICATIONS							
Technologies for tracking vehicles with satellite tracking systems	✓						
Intelligent systems where vehicles communicate with other vehicles, traffic road status information, vehicle and load-related sensor data	✓						
Device design, process and software development projects	✓						
Establishing communication networks for tow trucks, containers and trailers	✓						
Storage technologies equipped with automation technologies	✓						
Face recognition technologies to increase human-machine interaction	✓						
Voice or light guidance systems	✓						
Automatically guided stocking tools	✓						
Intelligent shelf and storage units	✓						
Automation components that decide their routes	✓						
One-order shipping management	✓						
A new and modern corporate data warehouse environment with the new Transportation Management System (TMS)	✓				✓		
Integrating own technological software and systems		✓					
Facilitating the delivery process		✓					
Detailed tracking status updates of consumers and tracking of shipments		✓					
Electronic separation system		✓					
E-clearance		✓					
Customers can call a courier with the WhatsApp line		✓					

Choosing the optimum route in daily business plan with Android handheld terminals software		✓				
More automated handling system		✓				
Use of new software			✓	✓		
Sorting systems			✓		✓	
New generation warehouse management system (WMS)					✓	
E-trade logistics					✓	
Robot systems					✓	
24/7 online vehicle tracking						✓
Online distance and route tracking						✓
Fuel tracking system						✓
E-freight						✓
Online booking						✓

		Other Industries				
	Aluminium Industry	**Consumer Health Industry**	**Software Industry**	**Defense Industry**	**Furniture Industry**	**Management Consulting Industry**
NAME OF COMPANY	**C1**	**C1**	**C1**	**C1**	**C1**	**C1**
CURRENT APPLICATIONS						
RFID systems as stock and inventory tracking system	✓					
The digitalisation of all supply chain processes	✓					
ERP software	✓					
Reducing manual processes		✓				
Demand planning, inventory and KPI analysis with Microsoft Power BI Tool		✓				
Lead time reduction projects		✓				
S&OP process improvement Project		✓				
Product development model			✓			
Subscription system that offers customers continuous renewal			✓			
Thanks to the application called Logosphere, the business partners of the company can carry out all processes in a digital environment			✓			
The digital realisation of approval mechanisms			✓			
Customer portal where end users can use many features together				✓		
Artificial intelligence applications				✓		
The digitalisation of all processes				✓		
Software investments				✓		
Optimisation of business processes					✓	
Software purchases					✓	
Developing information technology infrastructure					✓	
Optimising the workload					✓	
Demand perception management by taking advantage of internet search trends						✓

When the findings are examined on a company basis, some companies that have completed their digital transformation are still at the level of digitalisation. While software such as ERP is widely used, open-source technologies are also used. In terms of ERP software, it is seen that the most used software is SAP. In general, it is possible to say that there are studies that will integrate processes in the supply chain and that there are applications that allow online monitoring of internal processes. Advanced technologies such as Industry 4.0 based robot applications and artificial intelligence are not widely used, but they have current applications.

Considering the industries, the industry that uses the most advanced technologies and has the highest digital transformation level is the logistics industry. The logistics industry is ahead in digital transformation because logistics is a process in which multiple business processes are carried out, planned and controlled at the same time. One of the significant issues when examining current applications is the necessity of evaluating the industries, together with their digital transformation needs.

The Contributions and Challenges of Digital Transformation in the Supply Chains

In this part of the study, companies' contributions that carry out digital transformation to their companies through transformation and the challenges encountered in this transformation process and after the transformation are given below with the interview answers' findings.

The Contributions of Digital Transformation to Companies

Considering the contributions it provides to companies that have completed their digital transformation, all companies' contributions to the digital transformation process are expected. Therefore, the contributions of companies from digital transformation were not grouped according to industries. The contributions of the companies participating in the research to their companies and supply chains through digital transformation are as follows in Table 5:

Table 5: The Contributions to Companies

✓ Planning sales correctly and increasing sales efficiency, and organising marketing activities according to sales plans and real-time reporting of sales and stocks at the point of sale,	✓ Increasing in the product availability and Transfer of processes such as freight, confirmation of bill of lading, offer approval to a digital platform,
✓ Real-time order communication and shortening order preparation and delivery times,	✓ Prevention of selling out and recommending alternative models and reduction in stocks and an increase in production efficiency,
✓ Making data analysis easier, analysing more data with less processing,	✓ Obstructing stock quantities that seemed as incorrect and due to this case, decreasing number of cancelled orders,
✓ Increasing the level of information sharing with integration and being able to make predictions or confirm orders for future periods and increase the accuracy of demand estimation,	✓ Improvement of customer experience and increasing customer service level and increase in the number of customers and turnover per customer,
✓ When raw material stock quantities and supplier delivery times are considered through software, stock costs are minimised by keeping a safety stock,	✓ Operational lean in the company due to providing system integration to the suppliers and more transparent, traceable and measurable logistics processes,
✓ The decrease in labour capacity, waste rates and product damage and the number of expired products,	✓ Increasing competitiveness and brand value of the firm and strengthening the image of the firm,
✓ Increasing efficiency at the point of source planning and operation management,	✓ World-class execution of the work and higher quality,
✓ Doing away with the bottlenecks in the operations and improvement of planning activities,	✓ Managing the supply chain more accurately by making the company's process easier, more visible and manageable,
✓ Making predictions more consistent and inventory and resource optimisation,	✓ Saving in costs at a significant level,
✓ Making better business decisions in a short time.	

The most significant contributions companies make in terms of the supply chain are making more accurate sales plans, shortening order preparation and delivery times, reducing errors, increasing demand accuracy, decreasing workforce capacity, increasing quality and productivity. Furthermore, companies made their processes more transparent, traceable and measurable, increased customer service level and company profitability, and achieved significant savings in production and logistics processes. Undoubtedly, the levels of contribution provided differ according to the levels of transformation.

The Contributions Provided by the Company to Its Customers, Suppliers, Investors and Employees

The contributions of the company to its customers by performing digital transformation are as follows in Table 6:

Table 6: The Contributions Provided by the Company to Its Customers

✓ Improving existing communication with customers,	✓ Increased speed and quality of supply,
✓ Customers reach the product they want,	✓ Finding solutions to customer problems with a more agile approach,
✓ Opportunity to give correct order to customers,	✓ Meeting customers with timely, economical and freshest products,
✓ Traceability and measurability to customers.	

Table 7: The Contributions Provided by the Company to Its Suppliers

✓ Improving the suppliers themselves, decreasing their costs and acquiring new customers,	✓ Providing that the suppliers have information about the company's current technologies on an institutional basis,
✓ Supplier integration,	✓ Improvement in suppliers' corporate culture,
✓ Order automation for suppliers and easier ways of doing business of suppliers,	✓ Access to the company by all suppliers in the relevant markets thanks to transparency and accessibility,
✓ Delivery appointment management optimisation and payment traceability for suppliers,	✓ Progress to suppliers without breaking their business plans by keeping urgent orders at a minimum,
✓ With correct demand and sales forecasts, suppliers can plan their resources correctly. It can correctly manage the suppliers' sub-suppliers and provides the advantage of transparency,	✓ Providing the suppliers with the opportunity to make transactions over a single system without the need for a single system and without being affected by the time difference between countries,
✓ The advantage of an increase in processes that can be measured and reported to suppliers and a significant reduction in emergency management,	✓ Improving cooperation with suppliers, making their work visible and increasing the trust in the company by moving forward systematically,
✓ Supplier shipments and production are more planned thanks to stable production opportunity	✓ Providing volume due to suppliers shipping and manufacturing advantage and increased capacity,
✓ Opportunity for suppliers to participate in the tenders of companies, to implement these practices in their own suppliers' companies,	✓ To be able to anticipate the needs of the company to its suppliers and to make their production plans healthily,
✓ Domestic market suppliers can see the future in a longer-term,	✓ Easier identification of suppliers' operational efficiency areas,
✓ Suppliers can do correct planning as they work with a more optimised demand plan,	✓ Informing suppliers and subcontractors how you plan to open orders in the coming years with the projections that emerge,
✓ Availability on shelves to suppliers.	

The fact that the suppliers can plan their resources correctly with the proper demand and sales forecasts can manage their sub-suppliers correctly, and the contribution of transparency is a significant contribution that the company provides to its suppliers. Other significant contributions include supplier integration, availability on shelves, and order automation.

The contributions of the company to its investors by performing digital transformation are as follows in Table 8:

Table 8: The Contributions Provided by the Company to Its Investors

✓ Increasing the number of business partners of investors,	✓ Providing investors with more effective cost management and positive EBITDA contribution,
✓ More profits for its investors in parallel with rapid growth,	✓ Advantages for investors in terms of financial and reputation,
✓ Delivering projects to investors without delay in the determined business plan,	✓ Sustainable competitive advantage for its investors,
✓ Budgeting convenience for investors.	

The contributions of the company to its investors by performing digital transformation are as follows in Table 9:

Table 9: The Contributions Provided by the Company to Its Employees

✓ Transferring a large part of the non-value-added operational workloads of the employees to the systems and ensuring that the employees focus on more value-added jobs,	✓ A working environment where everyone can speak the same language with leaner and standard business processes for employees,
✓ Developing the employees' competencies and focusing on the areas that should be focused in line with the employees' skills. Motivation and training opportunities for employees, the participation of employees in projects at various levels,	✓ The opportunity to create standard processes and ways of doing business thanks to measurable and reportable systems for its employees. With the generated reports, it becomes possible to determine the resource needs of the department strategy more clearly,
✓ Organising employee shifts according to the work volumes of employees,	✓ Employees can follow the processes more closely and systematically,
✓ A safer working environment with systems that minimise errors for employees,	✓ Flexible working opportunity, clear definition of a job, authority and responsibilities and making processes more transparent,
✓ A significant reduction in employee turnover,	✓ Elimination of rework.

The Challenges that Companies Encounter in Digital Transformation

The challenges companies encounter in digital transformation are as follows in Table 10:

Table 10: Challenges that Companies Encounter in Digital Transformation

✓ Resistance to change by employees,	✓ It is challenging to guarantee the accuracy of the data collected,
✓ Companies do not know where to start digitalisation and need help in this regard,	✓ It is tough to control and ensure the accuracy of the data to be processed in many different ways, and it takes time,
✓ Difficulty working of different actors such as company employees, suppliers, customers, system development companies at the same time and difficulty of providing expected benefits for all actors,	✓ Increase in need for education and management support in the transformation process,
✓ The difficulty of finding the right consultants and solution partners,	✓ Difficulties in integrating low-tech subcontractors into the process,
✓ If the project requires software, the software to be selected should be investigated thoroughly,	✓ Trying to transition before the processes become apparent and the processes do not support each other,
✓ The necessity of cultural and mental	✓ Adapting customers to this process,

transformation necessity,	
✓ The necessity of proper management of projects and programs, insufficiencies and deficiencies in project and program management,	✓ Difficulty keeping the system operational. If disruptions occur, this directly leads to operational efficiency,
✓ The necessity to make digital transformation an integral part of company strategies,	✓ Difficulty creating appropriate budgets for digital transformation and the need to analyse the return costs of investments well,
✓ The necessity for digital transformation to cover the entire corporate structure,	✓ Integration of the systems used with each other,
✓ The necessity of constantly monitoring all issues based on the road map,	✓ With the low number of companies that can do API integration,
✓ Keeping the applications updated constantly,	✓ Not having enough top management sponsorship,
✓ Not enough qualified workforce for digital transformation and the necessity for all employees to embrace transformation,	✓ Technological maturity is not enough in some fields yet,
✓ With the continuous change of technologies and difficulty adapting technology to your own business,	✓ Too much information pollution from consultants and digital suppliers,
✓ Anxiety in employees due to reduced dependence on employees,	✓ The financial return of the solutions found by consulting firms is not clear,
✓ Problems of establishing a systemic infrastructure due to not being at the same level of technological maturity as the partner companies,	✓ The high cost of ready-made digital solutions and digital solutions are not suitable for every company model. The necessity of companies to turn to tailor-made software in digital transformation,
✓ Legislation,	✓ Shipping problems,
✓ Uncertainty of management and strategy,	✓ Security concern,
✓ Not knowing which technology to adopt,	✓ Master data problems,
✓ Cooperation level of the ecosystem,	✓ Lack of know-how.

Digital transformation brings many challenges, along with its contributions. For this reason, before starting the transformation, it is necessary to create a road map according to the challenges. First of all, you should be prepared for resistance against change in the company. In the digital transformation process, the cultural and mental transformation of the employees should also be realised. As well as the challenge of creating an appropriate budget, the lack of a sufficient qualified workforce after the transformation is another challenge.

Conclusion

When the current applications of the companies included in the study are examined, open-source software and ERP software such as SAP are used in the software part. In terms of ERP software, it is seen that the most used software is SAP. The first industry with the highest transformation level among the companies that have made digital transformation is the logistics industry. Many technologies such as robots, sensors, face recognition technologies that increase human-machine interaction, automatic handling and stocking systems, and satellite tracking systems are used in the logistics industry. The logistics industry is ahead in digital transformation because logistics is a process in which multiple business processes are carried out, planned and controlled at the same time. Two companies included in the study could not start the digital transformation in logistics. The reason for this is that both firms are national scale SMEs. Each of the other firms is a large-scale, international and corporate firms.

In digital transformation, the electronics and I.T. and fast-moving consumer goods (FMCG) industry follows logistics. Since each of the three electronics industry companies is large-scale, international, corporate and leading companies, it has completed the digital transformation process. The same is true for the fast-moving consumer goods industry. Similarly, large-scale companies in the food industry have completed the digital transformation process, while SMEs remain in the digitalisation phase. Although the medical-pharmaceutical industry companies are large, it can be concluded that the reason for staying in the digitalisation phase requires this much of the industry's needs. In the retail and transportation industries, it can be said that applications are in the digitalisation stage. Artificial intelligence applications have been used in the defence industry. Based on these results, it would be appropriate to say that the two most important factors affecting digital transformation decisions are the company's size and the industry's digital transformation requirement.

Considering the benefits it provides to companies that have completed their digital transformation, all companies' contributions that have started the digital transformation process are expected. At this point, the contribution changes depending on the digital conversion rate, not the type of contribution.

In the study, the contributions companies make to their customers, suppliers, and investors through digital transformation and their difficulties in the digital transformation process are also explained. All the tips are presented in detail for the company that will make a digital transformation decision to evaluate its situation, what kind of contributions it can make to itself, and to what extent the industry needs digital transformation. Technology advances by pushing all boundaries in order to facilitate SCM. Only when technology is used to the benefit of supply chains will it be successful. Therefore, a path should be followed in line with the industry's needs and the supply chain. The company should choose the technology that best suits the needs of the supply chain and the industry.

Contrary to all the conversations of change in the business world, the digital transformation level is limited. Considering the study results, companies and their supply chains have used one or more Industry 4.0 technologies. The significant point is that the firm chooses a technology area that it wants to develop or use. With digital transformation, supply chains are transforming, not companies. However, supply chains have not been transformed completely, as few companies have fully implemented digital transformation.

Discussing how to mentioned overcome these challenges in digital transformation above is recommended for future research. Besides, digital transformation contributions can be investigated with quantitative analysis, from what level of contribution it contributes. Governments worldwide view digital transformation as a strategic imperative to improve service performance, improve customer experience, streamline operations and create new business models (Curtis, 2019, pp. 322-324). Therefore, as suggestions for future studies, digital transformation applications can be compared by considering the company's countries.

In the digital transformation process, it should be kept in mind that the transformation alone cannot be successful. Managers and employees must adopt new practices for all supply chain members. Therefore, managers have significant responsibilities in this regard.

Digital transformation decision is a strategic decision for companies. The managers of companies have crucial responsibilities in this sense. According to the study findings, if a few recommendations are given to the company's managers, one is the transition to new technology. Companies can use old and new technology at the same time until they adapt to new technology. This transition in businesses allows employees to adapt without any shock. However, new technologies and applications may not be used if users do not receive enough attention. The other method is to remove old technology and start new technology directly.

Another responsibility of managers is to be relevant and knowledgeable in digital transformation because this is one of the most critical factors affecting digital transformation success. Managers of companies must believe in and support the added value that transformation will provide in company

success (Polites and Karahanna, 2012, pp. 21-42; Hartley and Sawaya, 2019, p. 713). Another role for managers is the choice of technology. In this regard, the organisation's strategy, capabilities, business models and even organisational structure should be considered while making a choice. In addition to all these, digital transformation strategies should be adopted and implemented instead of traditional supply chain strategies.

Companies that carry out digital transformation in their supply chains have advanced rapidly and have made tremendous contributions (Westerman et al., 2011, p. 65). However, digital transformation brings many challenges, along with its contributions. For this reason, before starting the transformation, it is necessary to create a road map according to the challenges. The managers of the company should evaluate potential challenges both before and after transformation. Furthermore, supply chains will face some new risks with the digital transformation in supply chains. It can be concluded that, while making this digital transformation decision, it is vital for companies to carry out risk management studies. For further studies, it can also be recommended to collect much more data to compare the companies' before and after performances regarding digital transformation. It should always be kept in mind that nothing can be evaluated without being measured.

Peer-review:

Externally peer-reviewed

Conflict of interests:

The author(s) has (have) no conflict of interest to declare.

Grant Support:

The authors declared that this study has received no financial support

Acknowledgement:

We are grateful to all the supply chain and company managers who made the most significant contribution to this study.

References

Alexopoulos, K., Makrıs, S., Xanthakıs, V., Sıpsas, K. and Chryssolourıs, G. (2016). A concept for context-aware computing in manufacturing: The white goods case. *International Journal of Computer Integrated Manufacturing*, 29(8), 839-849.

Albukhitan, S. (2020). Developing Digital Transformation Strategy for Manufacturing. *Procedia Computer Science*, 170, 664–671. doi: 10.1016/j.procs.2020.03.173

Ashurst, C., Doherty, N. F. and Peppard, J. (2008). Improving the impact of I.T. development projects: the benefits realisation capability model. *European Journal of Information Systems*, 17(4), 352-370.

Atzori, L., Iera, A. and Morabito, G. (2017). Understanding The Internet Of Things: Definition, Potentials, And Societal Role Of A Fast Evolving Paradigm. *Ad Hoc Networks*, 56, 122-140.

Benlian, A. and Hess, T. (2011). Comparing the relative importance of evaluation criteria in proprietary and open-source enterprise application software selection – a conjoint study of ERP and Office systems. *Information Systems Journal*, iVol. 21, 503 – 525, doi: 10.1111/j.1365-2575.2010.00357.x

Billington, P. J., McClain, J. O. and Thomas, L. J. (1983). Mathematical Programming Approaches to Capacity-Constrained MRP Systems: Review, Formulation and Problem Reduction. *Management Science*, 29(10), 1126–1141. doi:10.1287/mnsc.29.10.1126

Bradley, J. M. and Atkins, E. M. (2015). Optimisation and control of cyber-physical vehicle systems. *Sensors*, 15(9), 23020-23049.

Brennen, J. S. and Kreiss, D. (2016). Digitalisation. *The international encyclopedia of communication theory and philosophy*, 1-11.

Chen, Y., Miao, W. M., Lin, Z. Q. and Chen, G. L. (2008). Adjusting MRP for dynamic differentiation of identical items for process customisation. *Production Planning and Control*, 19(6), 616-626.

Chong, S., Pan, G.T., Chin, J., Show, P.L., Yang, T.C.K. and Huang, C. M. (2018). Integration of 3D Printing and Industry 4.0 into Engineering Teaching. *Sustainability.* 10, 1-13.

Chopra, S. and Meindl, P. (2007). *Supply Chain Management: Strategy, Planning, and Operation*. New Jersey: Pearson Prentice Hall, p. 57.

Cichosz, M., Wallenburg, C. M. and Knemeyer, A. M. (2020). Digital transformation at logistics service providers: barriers, success factors and leading practices. *The International Journal of Logistics Management,* 31(2), 209-238.

Centobelli, P., Cerchione, R. and Ertz, M. (2020). Agile supply chain management: where did it come from and where will it go in the era of digital transformation? *Industrial Marketing Management*, 90, 324-345.

Coleman, D. C. (1956). Industrial growth and industrial revolutions. *Economica*, 23 (89), pp. 1-22.

Curtis, S. (2019). Digital transformation—the silver bullet to public service improvement? *Public Money & Manageurtisment*, 39(5), 322-324.

Denzin, N. K. (1994). Romancing the text: The qualitative researcher-writer-as-bricoleur. *Bulletin of the Council for Research in Music Education*, 122, 15-30.

DePuy, G. W., Usher, J. S., Walker, R. L. and Taylor, G. D. (2007). Production planning for remanufactured products. *Production Planning & Control,* 18(7), 573–583. doi:10.1080/09537280701542210

Drath, R. and Horch, A. (2014). Industrie 4.0: Hit or hype?. *IEEE industrial electronics magazine*, 8(2), 56-58.

Edirisuriya, A., Weerabahu, S. and Wickramarachchi, R. (2018). Applicability of lean and green concepts in Logistics 4.0: a systematic review of literature. In *2018 International Conference on Production and Operations Management Society* (POMS) (pp. 1-8). IEEE.

Ellram, L. M. and Cooper, M. C. (1990). Supply chain management, partnership, and the shipper-third party relationship. *The International Journal of Logistics Management*, 1(2), 1-10.

Gartner, 2019. Retrieved from https://www.gartner.com/en/newsroom/press-releases/2019-10-21-gartner-identifies-the-top-10-strategic-technology-trends-for-2020 Accessed date 14.09.2020.

Goodwin, T. (2019). *Digital Darwinism: Survival of the Fittest in the Age of Business Disruption*. London: Kogan Page Publishers. pp.124-125.

Greengard, S. (2017). *Internet of Things (Nesnelerin İnterneti),* Çev: Müge Çavdar, Optimist Yayınları: İstanbul. pp.30-31.

Geisberger, E. and Broy, M. (Eds.). (2012). *agendaCPS: Integrierte Forschungsagenda Cyber-Physical Systems*. Vol: 1. Berlin: Springer-Verlag. p.314.

Georgakopoulos, D., Jayaraman, P. P., Fazia, M., Villari, M. and Ranjan, R. (2016). Internet of Things and Edge Cloud Computing Roadmap for Manufacturing. *IEEE Cloud Computing*, 3(4), 66-73.

Haddara, M. (2014). ERP selection: the SMART way. *Procedia Technology*, 16, 394-403. doi:10.1016/j.protcy.2014.10.105.

Hammer, M. and Stanton, S. A. (1995). *The reengineering revolution: A handbook.* New York: HarperBusiness. p.28.

Hammer, M. (2001). The superefficient company. *Harvard business review*, 79(8), 82-93.

Hartley, J. L. and Sawaya, W. J. (2019). Tortoise, not the hare: Digital transformation of supply chain business processes. *Business Horizons*, 62(6), 707-715.

Hanley, T., Daecher, A., Cotteleer, M. and Sniderman, B. (2018). The industry 4.0 paradox. Deloitte Insights, Retrieved from https://www2.deloitte.com/insights/us/en/focus/industry-4-0/challenges-on-pathto-digital-transformation/summary.html Accessed date 06.02.2019

Horenberg, D. (2017). Applications within Logistics 4.0 A research conducted on the visions of 3PL service providers. *9th IBA Bachelor Thesis Conference*, 5 July, University of Twente, Enschede. p.59.

Hofmann, E. and Rüsch, M. (2017). Industry 4.0 and the current status as well as future prospects on logistics. *Computers in Industry*, 89, 23–34.

Ivanov, D., Dolgui, A., Sokolov, B., Werner, F. and Ivanova, M. (2016). A dynamic model and an algorithm for short-term supply chain scheduling in the smart factory industry 4.0. *International Journal of Production Research* ,54(2): 386-402.

İlyasoğlu, E., Barbarosoğlu, G., Tanyaş, M. and Duruiz L. (1994). *MRP II Üretim Kaynak Planlaması Seminer Notları.* İstanbul: Trio Çözüm Evi, p. 28.

Johannson, L. (1994). How can a TQEM approach add value to your supply chain?. *Environmental Quality Management*, 3(4), 521-530.

Kupiainen, J. (2006). Translocalisation over the Net: digitalisation, information technology and local cultures in Melanesia. *E-learning and Digital Media*, Vol3. p.280.

Jänicke, M. and Jacob, K. (2009). A Third Industrial Revolution? Solutions to the crisis of resource-intensive growth. Solutions to the Crisis of Resource-Intensive Growth.

Junge, A. L. and Straube, F. (2020). Sustainable supply chains–digital transformation technologies' impact on the social and environmental dimension. *Procedia Manufacturing*, 43, 736-742.

Keil, M. and Tiwana, A. (2006). Relative importance of evalu- ation criteria for enterprise systems: a conjoint study. *Information Systems Journal,* 16, 237–262.

Kehoe, D. and Boughton, N. (2001). Internet based supply chain management: A classification of approaches to manufacturing planning and control. *Internatioal Journal of Operations & Production Management*, Vol 21, No.4, 516-524.

Khan, S. (2016). *Leadership in the digital age – A study on the effects of digitalisation on top management leadership*. (Master Thesis). Stockholm Business School. p.6.

Kersten W., Schröder M. and Indorf M. (2017). Potenziale der Digitalisierung für das Supply Chain Risikomanagement: Eine empirische Analyse. In: *Seiter M., Grünert L., Berlin S. (eds) Betriebswirtschaftliche Aspekte von Industrie 4.0. ZfbF-Sonderheft*, vol 71/17. Wiesbaden: Springer Gabler. https://doi.org/10.1007/978-3-658-18488-9_3, pp. 47–74.

Koch, C. (2005). The ABC of ERP, Retrieved from http://www.cio.com/research/erp/edit/erpbasics.html Accessed date 15.07.2005.

Koh, S. C. L., Saad, S. M. and Jones, M. H. (2002). Uncertainty under MRP-planned manufacture: Review and categorisation. *International Journal of Production Research*, 40(10), 2399–2421. doi:10.1080/00207540210136487

Kotarba, M. (2017). Measuring digitalisation–key metrics. *Foundations of Management*, 9(1), 123-138.

Lee, H.L. and Billington, C. (1992), Managing supply chain inventory: pitfalls and opportunities. *Sloan eManagement Review,* Vol.33 No.3, 65-73.

Lee, C. K. M., Lv, Y., Ng, K. K. H., Ho, W. and Choy, K. L. (2018). Design and application of internet of things-based warehouse management system for smart logistics. *International Journal of Production Research*, 56(8), 2753–2768.

Lee J,, Kao H. and Yang S. (2014). Service Innovation and Smart Analytics for Industry 4.0 and Big Data Environment. *Procedia CIRP*, 16, 3- 8.

Liboni, L. B., Cezarino, L. O., Jabbour, C. J. C., Oliveira, B. G. and Stefanelli, N. O. (2019). Smart industry and the pathways to HRM 4.0: implications for SCM. *Supply Chain Management: An International Journal*, 24(1), 124- 146.

Li, F. (2020). The digital transformation of business models in the creative industries: A holistic framework and emerging trends. *Technovation*, 92, 102012, 1-10.

McLeod, J. (2011). *Qualitative research in counselling and psychotherapy*. London: Sage, pp.279.

Mell, P. and Grance, T. (2011). Retrieved from A Nist Definition of Cloud Computing [WWW document] http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf Accessed date 28.04.2015.

Menon, S., Shah, S. and Courtoubis, A. (2019). An Overview of Smart Manufacturing for Competitive and Digital Global Supply Chains. In *2018 IEEE International Conference on Technology Management, Operations and Decisions (ICTMOD*) (pp. 178-183). IEEE.

Metz, P. J. (1998). Demystifying supply chain management. *Supply Chaın Management Review,* V. 1, No. 4, 46-55.

Müller, J. M. and Voigt, K. I. (2018). The Impact of Industry 4.0 on Supply Chains in Engineer-to-Order Industries – An Exploratory Case Study. *IFAC-PapersOnLine*, 51(11), 122–127.

Olhager, J. and Selldin, E. (2004). Supply Chain Management Survey of Swedish Manufacturing Firms. *International Journal of Production Economics*, Vol. 89, 2004, p. 353.

Orlicky, J. A. (1975). *Material Requirements Planning.* New York: McGraw-Hill Company: New York, 33-98.

Pagano, A. M. and Liotine, M. (2020). *Technology in Supply Chain Management and Logistics: Current Practice and Future Applications*. United States: Elsevier. p.9.

Plenert, G. (1999). Focusing material requirements planning (MRP) towards performance. *European Journal of Operational Research*, 119(1), 91–99. doi: 10.1016/S0377-2217(98)00339-7

Polites, G. L. and Karahanna, E. (2012). Shackled to the status quo: The inhibiting effects of incumbent system habit, switching costs, and inertia on new system acceptance. *MIS quarterly*, 36(1), 21-42.

Qu, S.Q. and Dumay, J. (2011). The qualitative research interview. *Qualitative Research in Accounting & Management*, Vol. 8 No. 3, pp. 238-264. https://doi.org/10.1108/11766091111162070

Redclift M., (2005). Sustainable development (1987–2005): An oxymoron comes of age. *Sustainable development*, 13 (4), pp. 212-227.

Rifkin J. (2015). *Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of Capitalism.* New York: St. Martin's Griffin Publisher.

Roblek, V., Meško, M. and Krapež, A. (2016). A complex view of industry 4.0. *Sage Open*, 6(2), 2158244016653987.

Singh, A., Klarner, P. and Hess, T. (2020). How do chief digital officers pursue digital transformation activities? The role of organisation design parameters. *Long Range Planning*, 53(3), 101890. pp.1-12.

Smartindustry. (2017). Retrieved from Smart Industry Dutch Industry Fit for The Future. http://smartindustry.nl/wp-content/uploads/2017/08/opmaaksmart-industry.pdf. Accessed date 02.10.2018.

Supulniece, I., Polaka, I., Berzisa, S., Meiers, E., Ozolins, E. and Grabis, J. (2015). Decomposition of Enterprise Application: A Systematic Literature Review and Research Outlook. *Information Technology and Management Science*, 18(1), 30-36. doi:10.1515/itms-2015-0005

Stolterman, E. and Fors, A. C. (2004). Information technology and the good life. In *Information systems research* (pp.687-689). Boston: Springer, MA.

Sawyer, S. (2001). Information systems development: a market-oriented perspective. *Communications of the ACM*, 44, 97–102.

Schneider, S., Wollersheim, J., Krcmar, H. and Sunyaev, A. (2018). How do requirements evolve over time? A case study investigating the role of context and experiences in the evolution of enterprise software requirements. *Journal of Information Technology*, 33(2), 151-170.doi: 10.1057/s41265-016-0001-y

Teng, S. Y., Li, X. J., Zhao, Z., Qin, P. L. and Lu, Y. Y. (2018). Countermeasure Analysis on Internet Logistics. In *E3S Web of Conferences* (Vol. 38, p. 01036). EDP Sciences. https://doi.org/10.1051/e3sconf/20183801036

Thames, L. and Schaefer, D. (2016). Software-defined cloud manufacturing for industry 4.0. *Procedia cirp*, 52, 12-17.

Tiersky, H. (2017). The 5 key drivers of digital transformation today. Retrieved from https://www.cio.com/article/3198121/it-industry/whats-now-indigitaltransformation.html Accessed date 9.11.2019.

Titze, C. and Barger, R. (2015). Evolving concepts in supply chain visibility. The Gartner Group, ID G, 270855. Retrieved from http://hughfinerty.com/wp-content/uploads/2015/03/Gartner-Evolving-Concepts-in-Supply-Chain-Visibility.pdf Accessed date 30.11.2016.

Themistocleous, M., Irani, Z. and Love, P. E. (2004). Evaluating the integration of supply chain information systems: A case study. *European Journal of Operational Research*, 159(2), 393-405. pp. 395–396

Usländer, T. (2016). Agile service-oriented analysis and design of industrial internet applications. *Procedia CIRP*, 57, 219-223.

Vasin, S., Gamidullaeva, L., Shkarupeta, E., Palatkin, I. and Vasina, T. (2018). Emerging trends and opportunities for industry 4.0 development in Russia. *European Research Studies Journal*, 21(3), 63–76.

Verville, J. and Halingten, A. (2003). A six-stage model of the buying process for ERP software. *Industrial Marketing Management*,32(7), 585-594. doi:10.1016/s0019-8501(03)00007-5

Ward, M., Halliday, S., Uflewska, O. and Wong, T.C. (2016). Three dimensions of maturity required to achieve future state, technology-enabled manufacturing supply chains, *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, 232, 605–620.

Westerman, G., Calméjane, C., Bonnet, D., Ferraris, P. and McAfee, A. (2011). Digital Transformation: A roadmap for billion-dollar organisations. *MIT Center for Digital Business and Capgemini Consulting*, 1, 1-68.

Witkowski K. (2017). Internet of Things, Big Data, Industry 4.0–Innovative Solutions in Logistics and Supply Chains Management. Procedia Engineering, Vol: 182, *7th International Conference on Engineering, Project, and Production Management*, pp.763-769.

Wu, D., Greer, M. J., Rosen, D. W. and Schaefer, D. (2013). Cloud manufacturing: Strategic vision and state-of-the-art. *Journal of Manufacturing Systems*, 32(4), 564-579.

Xu, X. (2012). From cloud computing to cloud manufacturing. *Robotics and computer-integrated manufacturing,* 28(1), 75-86.

Yu, F. and Schweisfurth, T. (2020). Industry 4.0 technology implementation in SMEs–A survey in the Danish-German border region. *International Journal of Innovation Studies*, 4(3), 76-84.

Zhou, K., Liu, T. and Zhou, L. (2015). Industry 4.0: Towards future industrial opportunities and challenges. In *2015 12th International conference on fuzzy systems and knowledge discovery (FSKD)* (pp. 2147-2152). IEEE. pp. 2147- 2152.