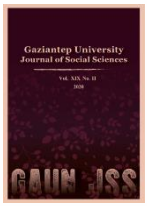

GAZİANTEP UNIVERSITY
JOURNAL OF SOCIAL SCIENCES

Journal homepage: http://dergipark.org.tr/tr/pub/jss

Araştırma Makalesi ● Research Article

Historical Evolution of Supply Chain Management in The VUCA Age: Sustainable, LARG and Digital Supply Chain Managements

VUCA Çağında Tedarik Zinciri Yönetiminin Tarihsel Evrimi: Sürdürülebilir, LARG ve Dijital Tedarik Zinciri Yönetimleri

Nuri Özgür DOĞAN[a] Serkan DERİCİ[b]*

[a] Prof. Dr., İstanbul Medeniyet Üniversitesi, Sağlık Bilimleri Fakültesi, İstanbul / TÜRKİYE
ORCID: 0000-0002-7892-1550
[b] Dr. Öğr. Üyesi, Nevşehir Hacı Bektaş Veli Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, Nevşehir / TÜRKİYE
ORCID: 0000-0003-2581-6770

ARTICLE INFO

Article History:
Received: April 26, 2024
Accepted: December 10, 2024

Keywords:
Digital Supply Chain Management,
Sustainability,
LARG,
VUCA Age.

ABSTRACT

The increasing impact of technology is differentiating the business processes from the classical meaning. In this study, based on the fact that business processes in the world now include components such as Volatility, Uncertainty, Complexity, Ambiguity (VUCA) under the influence of different factors, new approaches in supply chains are discussed under the concept of VUCA as a flow process. Different important developments affecting the world such as political developments, digital transformation, epidemics and natural disasters make the classical supply chain dysfunctional. A review of the literature shows that the historical development of lean, agile, flexible and green (LARG) supply chains and digital supply chains under the VUCA era are not addressed in relation to each other. In today's studies on supply chains, the lack of knowledge of the new components of supply chains causes studies to be carried out in the classical chain understanding and this prevents applications that reflect the real world. In this respect, within the scope of the study, the historical development of supply chain management, industrial revolutions and their interaction with each other were revealed. Thus, it will contribute to new studies to understand the development of supply chain management from past to present and to focus on the right issues. The historical integrity has been preserved and developments have been obtained by reviewing the literature on supply chain management and industrial revolutions and these developments have been associated with each other and the historical development process has been presented in tables. In addition, all concepts are explained with the support of the literature and each development is expressed as a temporal flow in stages in this direction. It has been determined that there is a lack of theoretical explanation of this evolutionary development in the literature. The information presented in the article reveals the development of supply chain management as a whole with industrial revolutions and will contribute to the development of a professional perspective.

MAKALE BİLGİSİ

Makale Geçmişi:
Başvuru tarihi: 26 Nisan 2024
Kabul tarihi: 10 Aralık 2024

Anahtar Kelimeler:
Dijital Tedarik Zinciri Yönetimi,
Sürdürülebilirlik,
LARG,
VUCA Çağı.

ÖZ

Teknolojinin giderek etkisinin artması ile beraber iş süreçleri klasik anlamdan farklılaşmaktadır. Bu çalışmada, dünyadaki iş süreçlerinin artık farklı faktörlerin etkisi altında Volatilite, Belirsizlik, Karmaşıklık, Belirsizlik (VUCA) gibi bileşenleri içerdiği gerçeğinden hareketle, tedarik zincirlerindeki yeni yaklaşımlar bir akış süreci olarak VUCA kavramı altında ele alınmaktadır. Politik gelişmeler, dijital dönüşüm, salgın hastalıklar ve doğal afetler gibi dünyayı etkileyen farklı önemli gelişmeler klasik tedarik zincirini işlevsiz hâle getirmektedir. Literatür incelendiğinde yalın, çevik, esnek ve yeşil (LARG) tedarik zincirlerinin tarihsel gelişimi ile VUCA dönemi altında dijital tedarik zincirlerinin birbiriyle ilişkili olarak ele alınmadığı görülmektedir. Günümüz şartlarında tedarik zincirlerinin ele alındığı çalışmalarda, tedarik zincirlerinin sahip olduğu yeni bileşenlerin bilinmemesi klasik zincir anlayışında çalışmalar yapılmasına neden olmakta ve bu durumda gerçek dünyayı yansıtan uygulamaların yapılmasına engel olmaktadır. Bu bakımdan çalışma kapsamında tedarik zinciri yönetiminin tarihsel gelişimi, endüstriyel devrimler ve bunların birbirleriyle olan etkileşimi ortaya konulmuştur. Böylece yeni çalışmaların geçmişten günümüze tedarik zinciri yönetiminin gelişimini anlaması ve doğru konulara odaklanmasına katkıda bulunulacaktır. Tarihsel bütünlük korunarak tedarik zinciri yönetimi ve sanayi devrimleri ile ilgili literatür taraması yapılarak gelişmeler elde edilmiş ve bu gelişmeler birbirleri ile ilişkilendirilerek tarihsel gelişim süreci tablolar hâlinde sunulmuştur. Ayrıca tüm kavramlar literatür desteği ile açıklanmış ve her bir gelişme bu doğrultuda aşama aşama zamansal bir akış olarak ifade edilmiştir. Bu evrimsel gelişimin teorik olarak açıklanmasında literatürde bir eksiklik olduğu tespit edilmiştir. Makalede sunulan bilgiler, tedarik zinciri yönetiminin endüstriyel devrimlerle birlikte bir bütün olarak gelişimini ortaya koymaktadır ve profesyonel bir bakış açısının gelişmesine katkı sağlayacaktır.

* *Sorumlu yazar/Corresponding author*.
e-posta: serkanderici@nevsehir.edu.tr

Introduction

Today, the effects of economic crises, epidemics such as covid-19, political crises between countries and natural disasters such as fire, flood and earthquake are effective worldwide. On the other hand; rapid technological developments, internet-based applications and developing transportation opportunities have revealed dynamic and highly competitive markets. These situations, which appear suddenly in these markets and where businesses need to must respond quickly, reveal the fact that supply chains does not suffice in the classical structure. In addition, supply chains are in a digital transformation which contain to high-tech applications such as sensors, cloud computing and big data. As supply chains undergo digital transformation, incorporating technology, lean working principles, flexibility and environmentally friendly practices into this transformation process is important to achieve sustainable chain success.

The basis of today's artificial intelligence applications is based on associating logic propositions with mathematics (Martin-Löf, 1982). In this process, there have been many developments from the invention of simple calculators to today's smart technological tools. Within the scope of these developments; Business processes have become quite complex due to many factors such as the increase in the human population, the change in expectations and demands, the development of technology, internet-based applications and sensors. This complexity; uncertain processes have revealed a flexible and ever-changing dynamic structure. This emerging new structure required businesses to change their management policies and philosophies. This new way of thinking involving risks and changes, is defined the VUCA era. (Mack et al., 2015).

The concept of *VUCA* is a new age of thought created by combining the first letters of terms (*V*olatility, *U*ncertainty, *C*omplexity and *A*mbiguity) expressing uncertain and variable situations experienced in business processes (Mohanta et al., 2020) and first introduced by the US military after the cold war period (Murugan et al., 2020).

The concept of supply chain, on the other hand, is the structure in which the links between the units involved in the process of revealing the products produced by the enterprises and offered to the consumers are established (Christopher, 1992). When considered as a process, the supply chain is the whole of the transportation and storage activities in the process of producing products by processing the raw materials, combining the parts and delivering the created products to the markets (Zijm et al., 2019).

In 2011, Industry 40 was announced at the Hannover Fair (Kagermann et al., 2011). The technology that was developing before industry 4.0 started to be applied to all sectors with this announced. The expansion of the scope of application, the whole world has started to talk about digital transformation. In this context, concepts such as sensors, the internet of things, cloud computing and big data which are the components of the last industrial revolution in all sectors (Yang et al., 2019), have become the main working point of enterprises (Soto-Acosta, 2020). This development, which has caused us to enter the digital age, has affected many sectors. In this direction, supply chain management is at the beginning of the works where the most important developments are experienced (Ivanov et al., 2019). The digital age we entered with the announcement of the last industrial revolution, communication in-chain in supply chain management has transformed into digital communication by moving from real environments to virtual environments via sensors (McIvor and Humphreys, 2004). The concept of digital supply chain management is a new phenomenon in which emerging digital components are integrated. In this context, digital supply chain management is defined as the structure in which separate applications and different facilities are systematically connected to each other through virtual networks throughout the supply chain network (Abdel-Basset et al., 2018).

In supply chains, which have become a flexible structure and transformed into a dynamic form with digitalization, the problems and workflows within the network have become quite complex, including uncertainties. Even companies operating around the world are now software-linked to each other via virtual networks. In this direction, supply chains have become a digital chain where there is a simultaneous flow of information and information about the products produced, sold and stored between different places (Bhargava et al., 2013). With the use of advanced technology, the development of the transportation routes of raw materials, the sending of products to any part of the world, and online sales have transformed the supply chains from national to a global structure. A development that occurs at any stage of the supply chain is now transmitted instantly to the actors in the chain via virtual networks (Manthou et al., 2014). In this direction, situations such as the continuous data flow, the purchase of products by consumers online, the tracking of instant product movement, the continuous forecasting, the integration of developing technological tools into the supply chain network have brought businesses face to face with the problem of big data analysis (Hung and Hsieh, 2017). Big data analysis is carried out at all stages supply chain management which of including planning, purchasing, production, shipping, sales, delivery and feedback (Zekhnini et al., 2020).

In digital supply chain management, the analysis of the large data obtained is only possible with artificial intelligence supported algorithms. The most used techniques in big data analysis are machine learning techniques (Athmaja et al., 2017). Machine learning techniques are basically classified into four groups as supervised, unsupervised, semi-supervised and reinforcement learning (Saravanan and Sujatha, 2018). The most widely used machine learning techniques in big data analytics applications in supply chain management (Bousqaoui et al., 2017): regression (Goldstein et al., 2017; Jagielski et al., 2018; Maulud and Abdulazeez, 2020), artificial neural networks (Chen et al., 2017; Kim et al., 2018; Chen et al., 2019), support vector machines (Burbidge et al., 2001; Rodriguez-Galiano et al., 2015; Battineni et al., 2019). The mentioned classification and the techniques to be used in the classes are shown in Figure 1.

Not just a business anymore, every business in the supply chain has to regularly analyze big data and share it with other actors. Only in this way will supply chains achieve sustainable success. Another important point understood here is that digital supply chain management covers the business processes carried out in the VUCA era, and the processes of Lean, Agile, Resilient and Green (Carvalho et al., 2011), which are effective in sustainable supply chain management.

In this study, the relationships between current issues in supply chain management such as digital, lean, agile, resilient, green and sustainable approaches are revealed. In doing so, the historical evolution of the concept of supply chain management, from its primitive form to its current advanced structure are presented. The rest of the paper is organized as follows: Section 2 reviewes literature and describes the theoretical background in a detail way. Section 3 gives methodology and finally Section 4 presents the results.

Theoretical Background

As this study includes digital, LARG and sustainable supply chain managements in the VUCA era, theoretical background of these concepts were presented separately within the following sub-headings.

Digital Supply Chain Management

Nowadays, digital supply chains, which are frequently the subject of scientific studies and expressed as a special field of study by industry experts, are the connections between the actors in the chain are carried out online with internet-based systems instead of cables, all information is transmitted and stored simultaneously and at low cost. are structures.

Transmitting and sharing the information in the chain with virtual networks is the most important feature that distinguishes digital supply chains from their classical structure and makes the chain a whole (Oh and Jeong, 2019). Digital supply chains and optimization make it necessary to develop new management approaches apart from classical management approaches (Büyüközkan and Göçer, 2018). In this respect, the digital supply chain is expressed as a process in which advanced information technologies are integrated into the chain in order to provide a sustainable performance, it is transformed into an agile structure, activities are carried out for customer needs with the new technologies (such as augmented reality, big data, sensors) used, and it provides more added value by reducing costs (Ageron et al., 2020).

There are many scientific studies on digital supply chain in the literature. Many of these studies were in the form of theoretical reviews or literature reviews (Wu et al., 2016; Büyüközkan and Göçer, 2018; Agrawal and Narain, 2018; Iddris, 2018; Zhao et al., 2020; Farajpour et al., 2022). Although many theoretical studies have been done on digital supply chains, it has been determined that there is limited work on how these chains work. It has been determined that there is estimation (Rajesh, 2016; Vairagade et al., 2019) and modeling on a part of the chain (Gunasekaran et al., 2017; Scuotto et al., 2017; Ivanov and Dolgui, 2021) in all of the identified scientific studies.

Lean, Agile, Resilice and Green Supply Chain Management

Today, businesses operate under highly competitive and highly variable market conditions (Kumar and Bhat, 2014). In this direction, it should have lean processes that will minimize its costs and wastes and maximize activities with high added value (Womack et al., 1990). On the other hand, businesses should have a supply chain that can respond to their activities in a flexible and agile way in the face of constantly changing and uncertain market demand (Baramichai et al., 2007). In addition, supply chain structures should be designed in a structure that is resistant to sudden situations and focuses on minimizing environmental risks, contributing to ecological efficiency (Cabral et al., 2012). These four supply chain approaches, which are mentioned in the literature as *L*ean, *A*gile, *R*esilient and *G*reen, are named as *LARG* supply chain by using their initials (Ghotbabadi et al., 2016).

In the literature review, it has been determined that there are many studies on these four methods (LARG), which are related to each other, and their relations with each other. In this context, lean supply chain management (Lamming, 1996; Jasti and Kodali, 2015; Tortorella et al., 2017; Garcia-Buendia et al., 2022), agile supply chain management (Power et al., 2001; Tarafdar and QRunfleh, 2017; Chowdhary, 2022; Hamdani et al., 2022; Oliveira-Dias et al., 2022), resilient supply chain management (Mensah and Merkuryev, 2014; Lee and Rha, 2016; Purvis et al., 2016; Shokouhifar and Ranjbarimesan, 2022) and green supply chain management (Hervani et al., 2005; Srivastava, 2007; Zhu et al., 2012; Tseng et al., 2019). On the other hand, the relationship between lean and agile supply chain managements (Qrunfleh and Tarafdar, 2013; Ciccullo et al., 2018; Kawa and Maryniak, 2019) and the relationship between agile and resilient supply chain managements (Carvalho et al., 2012; Taseer et al. Ahmed, 2022) and the relationship between lean and green supply chain management (Duarte et al., 2011; Cherrafi et al., 2018) and there are scientific studies that deal with four approaches (Carvalho and Cruz-Machado, 2011; Cabral et al., 2012; Sharma et al., 2021).

Sustainable Supply Chain Management

Today, the success of supply chains, which include many actors and are affected by many factors, depends on their sustainability. In this context, the chains, efficient virsual communication network, big data analysis and developed policies should be designed in a sustainable structure based on perfect communication and data transfer (Ki Fiona Cheung & Rowlinson, 2011). Sustainable supply chain management; that businesses operate in line with

the objectives they have developed for the environmental, social and economic dimensions of sustainability; there is cooperation in the chain in the management of material, information and capital flows; these are chains that aim to increase long-term performance in chains operating in an effective integration (Kumar et al., 2017; Stroumpoulis and Kopanaki, 2022).

In the literature review, it has been determined that there are many studies on different topics related to sustainable supply chain management. Some of these studies are as follows: literature review (Clift, 2003; Seuring and Müller, 2008; Abidi et al., 2017), sustainable supply chain management with multi-criteria decision making (Kumar et al., 2017; Matić et al., 2019; Alshehri et al., 2022), green supply chain management and sustainable supply chain management (Ahi and Searcy, 2013; Yildiz Çankaya and Sezen, 2019), agile supply chain management and sustainable supply chain management (Digalwar et al., 2020; Yusuf et al., 2020), theoretical studies (Vermeulen and Seuring, 2009; Galal and Moneim, 2016; Sauer and Seuring, 2018; Bubicz et al., 2019), sustainability relationship with digital supply chain (Jabbour et al., 2020; Liu et al., 2020; Akbari ve Hopkins, 2022; Beltagui et al., 2022; Zekhnini et al., 2022).

Research Methodology

The historical development of supply chain management shows that it has developed together with the industrial revolutions (Balon, 2020). The development of national economies and industries has directly influenced the development of supply chain management, as the forward and backward flow of products in a chain network is the subject of supply chain management. Frazon et al. (2019) compiled the evolution of the concept of supply chain management. In this study, the key events in the development of supply chain management (1980 to the present) are integrated into the table and shown in Table 1.

According to Table 1, the following points were determined: logistics 2.0 begins almost a century after Industry 2.0, phase 3.0 started almost simultaneously for all areas (Industry 3.0, 1969; Logistics 3.0, 1980; SCM 3.0, 1985), the features and techniques of SCM 3.0 (the first stage of SCM) are more compatible with industry 3.0 and logistics 3.0, SCM 1.0 and SCM 2.0 stages are absent, SCM 4.0 still has not reached its ideal maturity (Frazzon et al., 2019). Before mentioning the development of supply chain management in the historical process from its primitive state to its digital state, it would be meaningful to show all the developments on a chart and explain it afterwards. In this respect, the historical development of digital supply chain management is shown in Table 2 chronologically (1950s to the present).

Table 1: The Relationship of Supply Chain Management and Logistics with Industrial Revolutions

Period	The industrial Revolution	Logistics Age	Supply Chain Management
1780 -1870	**Industry 1.0** (1784 – 1870) *Mechanical loom, water, steam power*	**Logistics 1.0** (late 19th - early 20th century) *Mechanization of Transport* *Sedentary Period* *Unit Load*	
1870 - 1980	**Industry 2.0** (1870 – 1969) *Mass production with electrical energy*	**Logistics 2.0** (1960 – 1980) *Automation of the Transport System* • Physical Distribution Period • Establishment of the National Physical Distribution Management Council • Beginning of Road Transport • 1961 Whip Effect • Material Requirements Planning (MRP) • Textbooks and Scientific Journals	*In this period, the concept of supply chain was not used.*
1980 - 2010	**Industry 3.0** (1969 - 2000'ler) *Microprocessors, First Programmable Logic Controller (PLC), Use of Electronics and Information Technology*	**Logistics 3.0** (1980 – 2010) *Logistics Management System* • Personal Computers • Logistics Planning • Quick Response System • Third Party Logistics • Logistics, SCM Separation	**SCM 3.0** (early 1980s) *Integration between two channels* • Supply Chain Management Concept • Enterprise Resource Planning (ERP) • First Robot Cobot • Effective Customer Response • Logistics, SCM Separation • LARG SCM • VUCA Era
2010 - …	**Industry 4.0** (2010 - ...) *Strong product customization under production conditions with great flexibility* • *Digitalization* • *Cloud Computing* • *Internet Of Things* • *Big Data* • *Machine Learning* • *Sensors*	**Logistics 4.0** (2010 - ...) *Intelligent Transportation Systems (ITS), Real Time Detection Systems (RTLS)* • Digitalization • Risk management • Reverse Logistics • Big Data Analysis • Artificial Intelligence Innovation • Internet of Things	**SCM 4.0** (2010 - ...) *Total Network Integration* • Digitalization • Risk Management • Reverse Logistics • Big Data Analysis • Artificial Intelligence Innovation • Internet Of Things • Sensors • Smart Systems

Table 2. Historical Evolution of Supply Chain Management (Habib ve Jungthripanich, 2008; Rodrigue, 2020; Scmdojo, 2023)

PERIOD	**1950s**	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**2010s - …**
	Transportation Period Partial Processes	**Physical Distribution Period**	**Physical Supply Period** Deregulation Logistics	**Physical Distribution Period** Business Logistics Deregulation Transport Consolidation	**Integration Period**	**Value Capture Period** Teaching Supply Chain Management as a Course in Universities (2007)	**Automation and Digitization Era**
EVENTS	***Birth of Logistics Concept***	• Demand Forecast • Sourcing • Buy • Requirements Planning • Production planning • Stock and Storage • Transport • Packaging • Distribution Planning • Order Process • Customer relationship ➢ National Physical Distribution Management Councils ➢ The Whip Effect (1961-Jay Forrester) ➢ first textbook ➢ (Smykay et al. 1961 - Logistics Management: Logistics Problems) ➢ American Transportation Association - Transportation Journal (1961)	***Maturation of the Logistics Concept*** Establishment of the first real-time warehouse system (1971) Journal of Business Logistics was founded (1978)	***The Birth of Supply Chain Management (1980)*** *Material Management* • Storage • Handling • Packaging **Physical Distribution Beginning to Use SCM in Manufacturing Industry (1985)** **Supply chain management is a process**	Enterprise Resource Planning (ERP) started to be used. Supply chain actors have begun to be seen as a whole. Optimization techniques have been used. The first robot cobot was invented. VUCA Concept Lean SCM Green SCM **The Use of Supply Chain Management in the Service Industry (1995)**	**In SCM:** • Information Technologies • Marketing • Sales • Process Planning • Finance Agile SCM	**Industry 4.0** • Digitalization • Digital Finance • Digital SCM
					Resilience SCM (the mid-to-late 1990s and early 2000s)		

Supply chain management is a very old discipline in practice, but the concept was first expressed in the twentieth century. Supply chains, which were initially thought to be quite simple, as a single line, are structured from raw material suppliers to consumers. Supply chains have changed from a simple line form with the effects of factors such as the development of technology, transportation and production areas in the historical process, as well as the changes in consumer needs; It has become an advanced network of multiple raw material suppliers, multiple production areas and different distribution channels, which are transmitted to a wide variety of markets. However, with this development and change and the digital transformation that entered our lives in the twenty-first century, the existence of digital supply chains is now mentioned. We are living in an era that was officially ushered in with the announcement of the last industrial revolution in 2011, enabling the use of high-tech components in the supply chain. One of the most important fields of activity for businesses in the digital age is supply chain management. Now, as in all areas of our lives, activities are planned, coordinated and carried out by using the internet, artificial intelligence and sensors in supply chain management.

In the early stages of supply chain management, the bringing together of different manufacturers in order to respond to customers in supply chains formed the basis of today's supply chains. Workshop type production, which is based on labor, started to leave its place to machines with the invention of steam machines. The use of steam engines in industry has made iron processing possible (Rosen, 2012). In addition to the increasing population and migration movements in the 1800s, the development of railway transportation with the beginning of the processing of iron made it possible to transport the products produced (Rodrigue, 2020).

In the 1900s, we see that the biggest innovation in the field of transportation was the invention of pallets. With the pallets, the transporters started to transport the products in a single shipment. This development in the field of transportation has led to the development of planning and transportation methods. The fact that supply chains became the main target by competitors during the Second World War led to the development of maritime transport (Mangan and Lalwani, 2016). The beginning of the development of maritime transport in a way that can be primitive first and then the efforts to optimize the carrying capacity by using containers have formed the basis of today's global supply chains (Song and Panayides, 2012).

The 1950s pass as the era of transportation in the field of logistics and supply chain. This period, which is also defined as the sedentary period in the field of logistics and supply chain (Ballou, 1978), is when computers and pocket calculators are not used, courses on logistics and supply chain are not given even in universities (Southern, 2011), the main actor is governments, almost no This is the period when there is no optimization in the field. In this period, when the concept of unit load was used in transportation, logistics and supply chain issues were used predominantly in the military. In this period, the main point of thought was to deliver the materials needed during the war to the places needed with a thinking style similar to the just-in-time production philosophy. The concept of logistics, which was referred to as a military term in this period (Ballou, 1978); the establishment of military facilities, the procurement of personnel, the transportation of materials (Habib, 2014).

By the 1960s, which was the period of physical distribution (Heskett et al., 1973), the use of computers in the field of supply chain made it possible to address optimization problems. During this period, textbooks and journals began to be published. In this period, the book “Logistics Management: Logistics Problems” was written by Smykay et al. (1961) and the Journal of Transportation was published (1961) by the American Transportation Association.

In the 1970s, when physical supply was at the forefront, the issue of physical contact came to the fore in addition to physical distribution, and studies were carried out to combine

these two behaviors. At the same time, lectures were started at universities and scientific journals, books and professional organizations were established (Southern, 2011).

In the 1980s, with the introduction of personal computers, there were revolutionary developments in the field of supply chain. In this period, the concept of supply chain management was used for the first time by Keith Oliver and started to be used by professionals working in the field of logistics (Oliver and Webber, 1992). Electronic systems began to be implemented. The concept of logistics has begun to be used instead of the term physical distribution (Rodrigue, 2020). The concept of supply chain has started to be considered as a process that is given importance as a result of the studies carried out in this period (La Londe, 1997).

In the 1990s, when business logistics began, Enterprise Resource Planning (ERP) started to be used and businesses realized that the whole process from the supply of inputs to the delivery of products to consumers should be seen as a whole in businesses (Handfield and Nicholas, 1998). Optimization methods have started to be used in the field of supply chain. Again in this period, the introduction of the internet into our lives and the beginning of electronic data transfers caused a complete integration to begin (Rodrigue, 2020). At the end of this period, the first robot Cobot, which is used in the field of supply chain, was invented (Dossou, 2018). In the 2000s, logistics was defined as a process within the supply chain management and these two concepts, which were used in the same sense, were separated from each other (Mukhamedjanova, 2020).

Digitalization has started to make its impact felt more in all sectors with the fourth industrial revolution. In this respect, there have been significant developments in supply chains since the start of the last industrial revolution in 2011. Risk management, reverse logistics, big data analysis, artificial intelligence innovation, the use of the internet of things in processes and finally robotic applications have been implemented. These developments have caused supply chain management to be one of the most influential factors in our daily lives and industries.

The last industrial revolution has revealed developments that cause us to enter the digital age and affect not only production but also many areas (Hofmann and Rusch, 2017). With this industrial revolution called Industry 4.0, innovations such as augmented reality, cloud computing, big data, sensors and the internet of things have begun to be used both in production areas and in other areas (Radivojević & Milosavljević, 2019). In this sense, digitalization has been reflected in the field as an important development that reduces costs by providing integration within supply chains (Raj et al., 2020). Production areas that emerged from the classical structure with Industry 4.0; smart factories by integrating these components; smart or digital supply chains have emerged with the integration of supply chains. Supply chains and logistics activities have been the most affected by digitalization in enterprises. In digital transmission chains, there is an optimally organized virtual connection between raw materials, materials, products and the duration of the equipment used in the chain network and the sensors integrated into the machines (Luthra & Mangla, 2018). This virtual connection allows information to be transmitted simultaneously and quickly. Thanks to this structure, supply chains gain a durable and plastic structure in the face of rapid final situations such as sudden changes preferred by consumers and problems in production. It is also a fact that control audits cannot be operated effectively thanks to this structure.In this period, the development of smart production systems and tools brought about radical changes in production and business processes, necessitating digitalization in the field of supply chain (Büyüközkan and Göçer, 2018). With this development, the necessity for businesses to have digital supply chains in order to compete has become an accepted reality. In addition, digitalization and the facilitation of the use of the internet have become an important part of logistics and supply chain training, leading to the development of distance education opportunities. Supply chains now include flexible,

agile and advanced intelligent systems, with the development of educational content and educational paths, the introduction of new approaches and the impact of digitalization (Rodrigue, 2020).

The digital supply chain as a value chain: developed based on the components of industry 4.0. In this context, digital supply chains: autonomous control systems, intelligent logistics and distribution, 3D printing, robots and quality control, artificial intelligence, augmented reality, real-time systems, machine learning algorithms, big data, mobile computing, home collect, digital reality social media, pick up points, e-commerce, information integration and sharing, self-driving vehicles, autonomation warehousing, flexibility, IoT, IoS, monitor and drive customers behaviour, human computing interaction and horizontal and vertical integration. In digital supply chains, material, product and service flows form a cycle depending on these components. In digital supply chains, industry 4.0 components are connected to supply chains with cyber physical systems. The chain is protected by minimizing the data protection problem caused by the Internet of Things in cyber physical systems. In the light of all these components, digital supply chains consist of 2PL, 3PL, Wholesaler distributor, Retailer, Customers, Final Costomer, Service Partner (4PL, 5PL), suppliers, smart factories (Garay-Rondero et al., 2020).

In the digital supply chain, the entire process from raw material suppliers to the end consumer within this entire structure is interconnected with virtual networks thanks to IoT technology. The information flow problem in classical supply chains is eliminated thanks to these virtual networks. In this way, a development occurring in any link of the chain is shared simultaneously with the entire chain. This allows all stakeholders along the chain to have full information and thus achieve a flexible structure. The flexible structure of the chain members, together with digital supply chains, enables supply chains to be more resilient by preparing themselves in case of an unplanned negativity or development at any stage. In this respect, it can be said that digital supply chains are chains where the disconnect between stakeholders, as in the classical supply chain, is eliminated with digital components. Now, supply chains are seen as a single company thanks to the virtual networks and digital components they contain. This increases resilience, flexibility and efficiency in every link of the chain.

The application of the innovations brought by the last industrial revolution in supply chain management, the entire network has become a source of big data. The storage, storage, separation and analysis of the huge data produced within the supply chain network has become the main focus of supply chain managers. Contrary to classical methods, these operations can be performed on the large data obtained, with artificial intelligence-based systems that require the use of advanced technology. These practices differentiate digital supply chains from the traditional structure. Now, networks with lower cost, faster and minimizing uncertainties are designed compared to conventional supply chains. Analyzing the data produced by digital supply chains is possible with machine learning techniques. Machine learning also includes the most widely used techniques for analyzing big data shared between stages by being produced in a new and digital network designed. It has become a very important issue for supply chain management to make the analyzes made with computers using machine learning techniques correctly with reliable data and to make the results useful. The digital age, on-chain communications have moved from real environments to virtual environments and have turned into digital communications (McIvor ve Humphreys, 2004).

The amount of information about the process of supply chain managers has increased with these developments. New technologies used in the chain have caused supply chains to become a flexible structure that provides real and simultaneous data to all members in the network (Cavalcante vd., 2019). Consumers' purchase of products online, integrating developing technological tools into the supply chain network, and the constantly provided big

data analysis have forced businesses to do big data analytics on chains (Hung and Hsieh, 2017). With this necessity, there has been a rapid evolution from traditional supply chain management to digital supply chain; In this sense, the analyzes to be made and the use of big data have become an important process that creates sustainable value for businesses and provides a significant competitive advantage against businesses operating in the same sector. The digital supply chain is an agile structure in which the central management approach is eliminated, advanced information technologies are integrated into the chain in order to provide a sustainable performance, activities are carried out for customer needs together with the new technologies used and costs are reduced. It is expressed as a process that provides more added value (Ageron et al., 2020).

Results

The VUCA era that emerged in the post-Cold War era and the development of technology, business processes have become quite complex. Flexible and agile supply chains play a vital role in new business processes involving sudden changes, where uncertainties and risks are high. On the other hand, with digitalization, not only supply chains, but the whole world has entered into a virtual network. Under VUCA conditions, it is important for businesses to have a sustainable supply chain management, to survive under intense competition conditions.

In today's digital world, the entire supply chain is followed by virtual networks. For example, when an individual purchases a product through a web page, information flows throughout the supply chain network. Against this flow of information, suppliers are preparing for raw materials, manufacturers are preparing for production, and distributors realize that new transportation is required. On the other hand, businesses can predict which product is in demand across the product range and what they should produce in the future. It has a flexible structure by using digital tools in the face of uncertainty, risk and volatility; Businesses with lean, agile, resilient and environmentally friendly practices provide competitive advantage. It will continue to exist with an intelligent supply chain designed in this way. Digital supply chains also consist of the four main actors (supplier, producer, distributor and consumer) that classical supply chains have. The difference from classical chains is that the entire forward and backward process is connected by virtual networks, regardless of the number of all these actors, vertical or horizontal structure. In digital supply chain applications, the big data obtained at every stage of the supply chain is analyzed by machine learning methods, and useful results are obtained and shared with the related actors. Thanks to this simultaneous, accurate and fast information flow, businesses can operate sustainably in lean production principles and in case of a possible sudden demand, they can respond to the demand thanks to the flexible structure of all stages of the chain.

In the face of globalization reaching gigantic dimensions with digitalization; Covid-19 outbreak; Businesses and countries with digital supply chains can gain serious advantages in the face of major natural disasters such as earthquakes, floods and fires, and economic and political crises. In the face of the recent covid-19 epidemic, while countries with businesses with the specified characteristics of supply chains do not have problems; In many developed countries, there have been major problems in the supply of pharmaceuticals and consumer goods. From another point of view, having a digital and sustainable supply chain will make it possible to use every stage of the supply chain effectively in case of a major natural disaster. In this direction, the needs arising in the natural disaster area will be determined and distribution will be provided with different alternative transportation methods. Based on all the aforementioned; The sustainable development, economic and social development of both businesses and countries depend on the existence of an effective and sustainable digital supply chain.

In this study, research has been conducted on the lack of full expression of the development flow in the literature on supply chain management. In this context, a literature review on supply chain management and industrial revolutions was conducted while maintaining historical integrity. As a result of this literature review, important developments were obtained and these developments were associated with each other and the historical development process was presented in tables. Furthermore, all concepts are explained with the support of the literature and each development is expressed as a temporal flow in this direction. In this respect, a study has emerged in which the historical development of the supply chain is fully expressed in the literature. This study will enable future researchers to make sense of current problems by considering the historical development of the supply chain. Again, in this way, they will focus on the right issues. As a result of the examinations, scientific studies in the literature and developments in the field of supply chain management show that research and sectoral investments should be different from a classical perspective. In this study, the process of transformation of the supply chain from primitive to modern has been revealed. In this direction, it is known that the SCM sector must now be resilient and flexible. The ability to carry out processes without disruptions as a result of changes and sudden developments depends on the design of supply chains in the modern sense. On the other hand, the era of green, agile, lean and resilient supply chains is now referred to as the VUCA era. Today, when scarce resources are becoming scarcer, supply chains need to be lean and green as a social responsibility and profitability item. On the other hand, agile and resilient structures need to be created in order to eliminate the impact of sudden crises such as epidemics or wars and to minimize the damages of uncertainties experienced in the sectors. Research and orientations should now be in this direction. In order to analyze this structure, digital components such as sensors and the Internet of Things should be analyzed and integrated into processes. This will create big data at each stage and big data can only be analyzed with appropriate algorithms such as machine learning. The literature on big data analysis and machine learning algorithms has started to develop. In addition, the existence of an effective digital system on the supply chain network makes all this possible. As governments support and emphasize green, lean and digital transformation, both companies and scientific studies should be designed with a focus on these issues.

References

Abdel-Basset M., Manogaran G., Mohamed M. (2018). *Internet of Things (IoT) and its impact on supply chain: A framework for building smart, secure and efficient systems*. Future Generation Computer Systems, 86(9), 614-628.

Abidi, N., Bandyopadhayay, A., Gupta, V. (2017). Sustainable supply chain management: A three dimensional framework and performance metric for Indian IT product companies. *International Journal of Information Systems and Supply Chain Management (IJISSCM), 10*(1), 29-52.

Ageron B., Bentahar O., Gunasekaran A. (2020). Digital supply chain: challenges and future directions. *In Supply Chain Forum: An International Journal* (Vol. 21, No. 3, pp. 133-138). Taylor & Francis.

Agrawal, P., Narain, R. (2018). Digital supply chain management: An Overview. In *IOP Conference Series: Materials Science and Engineering* (Vol. 455, No. 1, p. 012074). IOP Publishing.

Ahi, P., Searcy, C. (2013). A comparative literature analysis of definitions for green and sustainable supply chain management. *Journal of cleaner production, 52*, 329-341.

Akbari, M., Hopkins, J. L. (2022). Digital technologies as enablers of supply chain sustainability in an emerging economy. *Operations Management Research*, *15*(3-4), 689-710.

Alshehri, S. M. A., Jun, W. X., Shah, S. A. A., Solangi, Y. A. (2022). Analysis of core risk factors and potential policy options for sustainable supply chain: an MCDM analysis of Saudi Arabia's manufacturing industry. *Environmental Science and Pollution Research*, 1-31.

Athmaja, S., Hanumanthappa, M., Kavitha, V. (2017, March). A survey of machine learning algorithms for big data analytics. *In 2017 International conference on innovations in information, embedded and communication systems (ICIIECS)* (pp. 1-4). IEEE.

Ballou RH (1978). *Basic business logistics: transportation, materials management, physical distribution* (No. 2). Prentice Hall.

Balon, V. (2020). Green supply chain management: Pressures, practices, and performance-An integrative literature review. *Business Strategy & Development*, *3*(2), 226-244.

Baramichai, M., Zimmers Jr, E. W., Marangos, C. A. (2007). Agile supply chain transformation matrix: an integrated tool for creating an agile enterprise. *Supply Chain Management: An International Journal*, 12(5), 334-348.

Battineni, G., Chintalapudi, N., Amenta, F. (2019). Machine learning in medicine: Performance calculation of dementia prediction by support vector machines (SVM). *Informatics in Medicine Unlocked*, *16*, 100200.

Beltagui, A., Nunes, B., Gold, S. (2022). Sustainability and the digital supply chain. In *The Digital Supply Chain* (pp. 397-417). Elsevier.

Bhargava B, Ranchal R., Othmane LB (2013). Secure information sharing in digital supply chains. *In 2013 3rd IEEE international advance computing conference (IACC)* (pp. 1636-1640). IEEE.

Bousqaoui, H., Achchab, S., Tikito, K. (2017). Machine learning applications in supply chains: An emphasis on neural network applications. In *2017 3rd International Conference of Cloud Computing Technologies and Applications (CloudTech)* (pp. 1-7). IEEE.

Bubicz, M. E., Barbosa-Póvoa, A. P. F. D., Carvalho, A. (2019). Incorporating social aspects in sustainable supply chains: Trends and future directions. *Journal of Cleaner Production*, *237*, 117500.

Burbidge, R., Trotter, M., Buxton, B., Holden, S. (2001). Drug design by machine learning: support vector machines for pharmaceutical data analysis. *Computers & chemistry*, *26*(1), 5-14.

Büyüközkan, G., Göçer, F. (2018). Digital Supply Chain: Literature review and a proposed framework for future research. *Computers in Industry*, *97*, 157-177.

Cabral, I., Grilo, A., Cruz-Machado, V. (2012). A decision-making model for lean, agile, resilient and green supply chain management. *International Journal of Production Research*, *50*(17), 4830-4845.

Carvalho, H., Cruz-Machado, V. (2011). Integrating lean, agile, resilience and green paradigms in supply chain management (LARG_SCM). *Supply chain management*.

Carvalho, H., Duarte, S., Machado, V. C. (2011). Lean, agile, resilient and green: divergencies and synergies. *International Journal of Lean Six Sigma*, 2(2), 151-179.

Carvalho, H., Azevedo, S. G., Cruz-Machado, V. (2012). Agile and resilient approaches to supply chain management: influence on performance and competitiveness. *Logistics Research*, *4*, 49-62.

Cavalcante IM, Frazzon EM, Forcellini FA, Ivanov D (2019). A supervised machine learning approach to data-driven simulation of resilient supplier selection in digital manufacturing. *International Journal of Information Management*, 49, 86-97.

Chen, M., Challita, U., Saad, W., Yin, C., Debbah, M. (2017). Machine learning for wireless networks with artificial intelligence: A tutorial on neural networks. arXiv preprint arXiv:1710.02913, 9.

Chen, M., Challita, U., Saad, W., Yin, C., Debbah, M. (2019). Artificial neural networks-based machine learning for wireless networks: A tutorial. *IEEE Communications Surveys & Tutorials*, 21(4), 3039-3071.

Cherrafi, A., Garza-Reyes, J. A., Kumar, V., Mishra, N., Ghobadian, A., Elfezazi, S. (2018). Lean, green practices and process innovation: A model for green supply chain performance. *International Journal of Production Economics*, *206*, 79-92.

Chowdhary, C. L. (2022). Agile Supply Chain: Framework for Digitization. In *Innovative Supply Chain Management via Digitalization and Artificial Intelligence* (pp. 73-85). Singapore: Springer Singapore.

Christopher, M. (1992). *Logistics and supply chain management*, FT Prentice Hall, London.

Clift, R. (2003). Metrics for supply chain sustainability. *Clean Technologies and Environmental Policy*, *5*, 240-247.

Ciccullo, F., Pero, M., Caridi, M., Gosling, J., Purvis, L. (2018). Integrating the environmental and social sustainability pillars into the lean and agile supply chain management paradigms: A literature review and future research directions. *Journal of cleaner production*, *172*, 2336-2350.

Digalwar, A., Raut, R. D., Yadav, V. S., Narkhede, B., Gardas, B. B., Gotmare, A. (2020). Evaluation of critical constructs for measurement of sustainable supply chain practices in lean-agile firms of Indian origin: A hybrid ISM-ANP approach. *Business Strategy and the Environment*, *29*(3), 1575-1596.

Dossou, P. E. (2018). Impact of Sustainability on the supply chain 4.0 performance. *Procedia Manufacturing*, *17*, 452-459.

Duarte, S., Cabrita, M. D. R. D. M. F., Machado, V. A. C. (2011). Exploring lean and green supply chain performance using balanced scorecard perspective. In *Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management (IEOM)* (pp. 520-525). IEOM Research Solutions Pty Ltd.

Farajpour, F., Hassanzadeh, A., Elahi, S., Ghazanfari, M. (2022). Digital supply chain blueprint via a systematic literature review. *Technological Forecasting and Social Change*, *184*, 121976.

Frazzon EM, Rodriguez CMT, Pereira MM, Pires MC, Uhlmann I. (2019) Towards supply chain management 4.0. *Brazilian Journal of Operations & Production Management*, 16(2), 180-191.

Ghotbabadi, A. R., Gandaee, S., Gandaee, M. T. (2016). Making LARG supply chain management smart and identification of its conditions with management tools of SWOT, BI, and RFID technology. *International Journal of Academic Research in Business and Social Sciences*, *6*(9), 321-333.

Galal, N. M., Moneim, A. F. A. (2016). Developing sustainable supply chains in developing countries. *Procedia Cirp*, *48*, 419-424.

Garay-Rondero, C. L., Martinez-Flores, J. L., Smith, N. R., Caballero Morales, S. O., Aldrette-Malacara, A. (2020). Digital supply chain model in Industry 4.0. *Journal of Manufacturing Technology Management*, 31(5), 887-933.

Garcia-Buendia, N., Moyano-Fuentes, J., Maqueira-Marín, J. M. (2022). A bibliometric study of lean supply chain management research: 1996–2020. *Total Quality Management & Business Excellence*, *33*(15-16), 1872-1895.

Goldstein, B. A., Navar, A. M., Carter, R. E. (2017). Moving beyond regression techniques in cardiovascular risk prediction: applying machine learning to address analytic challenges. *European Heart Journal*, 38(23), 1805-1814.

Gunasekaran, A., Papadopoulos, T., Dubey, R., Wamba, S. F., Childe, S. J., Hazen, B., Akter, S. (2017). Big data and predictive analytics for supply chain and organizational performance. *Journal of Business Research*, 70, 308-317.

Habib MM, Jungthirapanich C (2008). An integrated framework for research and education supply chain for the universities. *In 2008 4th IEEE International Conference on Management of Innovation and Technology* (pp. 1027-1032). IEEE.

Habib, M. (2014). Supply chain management (SCM): Its future implications. Open Journal of Social Sciences, 2(09), 238.

Hamdani, F. E., Quintero, I. A. Q., Enjolras, M., Camargo, M., Monticolo, D., Lelong, C. (2022). Agile supply chain analytic approach: a case study combining agile and CRISP-DM in an end-to-end supply chain. In *Supply Chain Forum: An International Journal* (pp. 1-15). Taylor & Francis.

Handfield RB, Nıcholas EL (1999). *Introduction to Supply Chain Management*, Prentice-Hall, Inc., New Jersey.

Hervani, A. A., Helms, M. M., Sarkis, J. (2005). Performance measurement for green supply chain management. *Benchmarking: An international journal*, *12*(4), 330-353.

Heskett JL, Glaskowsky NA, Ivie RM (1973). *Business logistics: Physical distribution and materials management* (Vol. 1). New York: Ronald Press Company.

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

Hung CC, Hsieh CC (2017). Big data management on wireless sensor networks. *In big data analytics for sensor-network collected intelligence* (pp. 99-116). Academic Press.

Iddris, F. (2018). Digital supply chain: survey of the literature. *International Journal of Business Research and Management*, *9*(1), 47-61.

Ivanov, D., Dolgui, A., Sokolov, B. (2019). The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. *International Journal of Production Research*, 57(3), 829-846.

Ivanov, D., Dolgui, A. (2021). A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0. *Production Planning & Control*, *32*(9), 775-788.

Jabbour, C. J. C., Fiorini, P. D. C., Ndubisi, N. O., Queiroz, M. M., Piato, É. L. (2020). Digitally-enabled sustainable supply chains in the 21st century: A review and a research agenda. *Science of the total environment*, *725*, 138177.

Jagielski, M., Oprea, A., Biggio, B., Liu, C., Nita-Rotaru, C., Li, B. (2018). Manipulating machine learning: Poisoning attacks and countermeasures for regression learning. In 2018 IEEE symposium on security and privacy (SP) (pp. 19-35). IEEE.

Jasti, N. V. K., Kodali, R. (2015). A critical review of lean supply chain management frameworks: Proposed framework. *Production Planning & Control*, *26*(13), 1051-1068.

Kagermann, H., Lukas, W., Wahlster, W. (2011). Industrie 4.0 –Mit dem Internet der Dinge auf dem Weg zur 4. Industriellen Revolution. VDI Nachrichten, Berlin.

Kawa, A., Maryniak, A. (2019). Lean and agile supply chains of e-commerce: empirical research. *Journal of Information and Telecommunication*, *3*(2), 235-247.

Ki Fiona Cheung, Y., Rowlinson, S. (2011). Supply chain sustainability: a relationship management approach. *International journal of managing projects in business*, *4*(3), 480-497.

Kim, J. S., Merrill, R. K., Arvind, V., Kaji, D., Pasik, S. D., Nwachukwu, C. C., ... Cho, S. K. (2018). Examining the ability of artificial neural networks machine learning models to accurately predict complications following posterior lumbar spine fusion. *Spine*, *43*(12), 853.

Kumar, D., Rahman, Z., Chan, F. T. (2017). A fuzzy AHP and fuzzy multi-objective linear programming model for order allocation in a sustainable supply chain: A case study. *International Journal of Computer Integrated Manufacturing*, *30*(6), 535-551.

Kumar DP, Amgoth T, Annavarapu CSR (2019). Machine learning algorithms for wireless sensor networks: A survey. *Information Fusion*, 49, 1-25.

Kumar Sharma, S., Bhat, A. (2014). Modelling supply chain agility enablers using ISM. *Journal of modelling in management*, *9*(2), 200-214.

La Londe BJ (1997). Supply Chain Management: Myth or Reality?. *Supply Chain Management Review*, Vol. 1, Spring, pp. 6-7.

Lamming, R. (1996). Squaring lean supply with supply chain management. *International Journal of Operations & Production Management*.

Liu, Y., Zhu, Q., Seuring, S. (2020). New technologies in operations and supply chains: Implications for sustainability. *International journal of production economics*, *229*, 107889.

Luthra S, Mangla SK (2018). *Evaluating challenges to Industry 4.0 initiatives for supply chain sustainability in emerging economies*. Process Safety and Environmental Protection, 117, 168-179.

Mack, O., Khare, A., Krämer, A., Burgartz, T. (Eds.). (2015). *Managing in a VUCA World*. Springer.

Mangan, J., Lalwani, C. (2016). *Global logistics and supply chain management.* John Wiley & Sons.

Manthou, V., Vlachopoulou, M., Folinas, D. (2014). Virtual e-Chain (VeC) model for supply chain collaboration. International Journal of Production Economics, 87(3), 241-250.

Martin-Löf, P. (1982). Constructive mathematics and computer programming. In *Studies in Logic and the Foundations of Mathematics* (Vol. 104, pp. 153-175). Elsevier.

Matić, B., Jovanović, S., Das, D. K., Zavadskas, E. K., Stević, Ž., Sremac, S., Marinković, M. (2019). A new hybrid MCDM model: Sustainable supplier selection in a construction company. *Symmetry*, *11*(3), 353.

Maulud, D., Abdulazeez, A. M. (2020). A review on linear regression comprehensive in machine learning. *Journal of Applied Science and Technology Trends*, 1(4), 140-147.

McIvor R, Humphreys P (2004). Early supplier involvement in the design process: lessons from the electronics industry. *Omega*, 32(3), 179-199.

Mensah, P., Merkuryev, Y. (2014). Developing a resilient supply chain. *Procedia-Social and behavioral sciences*, *110*, 309-319.

Mohanta, B., Nanda, P., Patnaik, S. (2020). Management of VUCA (Volatility, Uncertainty, Complexity and Ambiguity) Using machine learning techniques in industry 4.0 paradigm. *New Paradigm of Industry 4.0: Internet of Things, Big Data & Cyber Physical Systems*, 1-24.

Mukhamedjanova, K. A. (2020). Concept of supply chain management. *Journal of Critical Reviews*, *7*(2), 759-766.

Murugan, S., Rajavel, S., Aggarwal, A. K., Singh, A. (2020). Volatility, uncertainty, complexity and ambiguity (VUCA) in context of the COVID-19 pandemic: challenges and way forward. *International Journal of Health Systems and Implementation Research*, *4*(2), 10-16.

Lee, S. M., Rha, J. S. (2016). Ambidextrous supply chain as a dynamic capability: building a resilient supply chain. *Management Decision*.

Oh, J., Jeong, B. (2019). Tactical supply planning in smart manufacturing supply chain. *Robotics and Computer-Integrated Manufacturing*, 55, 217-233.

Oliveira-Dias, D., Maqueira, J. M., Moyano-Fuentes, J. (2022). The link between information and digital technologies of industry 4.0 and agile supply chain: Mapping current research and establishing new research avenues. *Computers & Industrial Engineering*, 108000.

Oliver RK, Webber MD (1992). Supply chain management: Logistic catches up with strategy. 1982. *Outlook cit. Christopher, M., Logistics, the Strategic Issues*.

Power, D. J., Sohal, A. S., Rahman, S. U. (2001). Critical success factors in agile supply chain management-An empirical study. *International journal of physical distribution & logistics management*.

Purvis, L., Spall, S., Naim, M., Spiegler, V. (2016). Developing a resilient supply chain strategy during 'boom'and 'bust'. *Production Planning & Control*, *27*(7-8), 579-590.

Qrunfleh, S., Tarafdar, M. (2013). Lean and agile supply chain strategies and supply chain responsiveness: the role of strategic supplier partnership and postponement. *Supply Chain Management: An International Journal*, *18*(6), 571-582.

Radivojević G., Milosavljević L. (2019). The concept of logistics 4.0. *In 4th Logistics International Conference* (pp. 23-25).

Raj A, Dwivedi G, Sharm, A, de Sousa Jabbour ABL, Rajak S (2020). Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: An inter-country comparative perspective. *International Journal of Production Economics*, 224, 107546.

Rajesh, R. (2016). Forecasting supply chain resilience performance using grey prediction. *Electronic Commerce Research and Applications*, *20*, 42-58.

Rodrigue JP (2020). *The geography of transport systems*. Routledge.

Rodriguez-Galiano, V., Sanchez-Castillo, M., Chica-Olmo, M., Chica-Rivas, M. J. O. G. R. (2015). Machine learning predictive models for mineral prospectivity: An evaluation of neural networks, random forest, regression trees and support vector machines. *Ore Geology Reviews*, *71*, 804-818.

Rosen, W. (2012). *The most powerful idea in the world: A story of steam, industry, and invention.* University of Chicago Press.

Saravanan, R., Sujatha, P. (2018). A state of art techniques on machine learning algorithms: a perspective of supervised learning approaches in data classification. In *2018 Second international conference on intelligent computing and control systems (ICICCS)* (pp. 945-949). IEEE.

Sauer, P. C., Seuring, S. (2018). A three-dimensional framework for multi-tier sustainable supply chain management. *Supply Chain Management: An International Journal*, *23*(6), 560-572.

Scmdojo (2023) Evolution of Supply Chain Management and Logistics https://www.scmdojo.com/history-and-evolution-of-supply-chain-and-logistics/

Scuotto, V., Caputo, F., Villasalero, M., Del Giudice, M. (2017). A multiple buyer–supplier relationship in the context of SMEs' digital supply chain management. *Production Planning & Control*, 28(16), 1378-1388.

Seuring, S., Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of cleaner production*, *16*(15), 1699-1710.

Sharma, V., Raut, R. D., Mangla, S. K., Narkhede, B. E., Luthra, S., Gokhale, R. (2021). A systematic literature review to integrate lean, agile, resilient, green and sustainable paradigms in the supply chain management. *Business Strategy and the Environment*, *30*(2), 1191-1212.

Shokouhifar, M., Ranjbarimesan, M. (2022). Multivariate time-series blood donation/demand forecasting for resilient supply chain management during COVID-19 pandemic. *Cleaner Logistics and Supply Chain*, *5*, 100078.

Song, D. W., Panayides, P. (2012). *Maritime logistics: a complete guide to effective shipping and port management*. Kogan Page Publishers.

Soto-Acosta, P. (2020). COVID-19 pandemic: Shifting digital transformation to a high-speed gear. *Information Systems Management*, 37(4), 260-266.

Southern RN (2011). *Historical perspective of the logistics and supply chain management discipline*. Transportation Journal, 50(1), 53-64.

Srivastava, S. K. (2007). Green supply-chain management: a state-of-the-art literature review. *International journal of management reviews*, *9*(1), 53-80.

Stroumpoulis, A., Kopanaki, E. (2022). Theoretical perspectives on sustainable supply chain management and digital transformation: a literature review and a conceptual framework. *Sustainability*, *14*(8), 4862.

Smykay EW, Bowersox DJ & Mossman FH (1961). *Physical DistributionManagement,* New York: Macmillan Publishing Co, 1961.

Tarafdar, M., Qrunfleh, S. (2017). Agile supply chain strategy and supply chain performance: complementary roles of supply chain practices and information systems capability for agility. *International Journal of Production Research*, *55*(4), 925-938.

Taseer, M. I., Ahmed, A. (2022). The most effective leadership style in pursuit of resilient supply chain: Sequential mediation of flexibility and agile supply chain. *Pakistan Journal of Commerce and Social Sciences (PJCSS)*, *16*(3), 387-423.

Tortorella, G. L., Miorando, R., Marodin, G. (2017). Lean supply chain management: Empirical research on practices, contexts and performance. *International Journal of Production Economics*, *193*, 98-112.

Tseng, M. L., Islam, M. S., Karia, N., Fauzi, F. A., Afrin, S. (2019). A literature review on green supply chain management: Trends and future challenges. *Resources, Conservation and Recycling*, *141*, 145-162.

Vairagade, N., Logofatu, D., Leon, F., Muharemi, F. (2019). Demand forecasting using random forest and artificial neural network for supply chain management. In *Computational Collective Intelligence: 11th International Conference, ICCCI 2019, Hendaye, France, September 4–6, 2019, Proceedings, Part I 11* (pp. 328-339). Springer International Publishing.

Vermeulen, W. J., Seuring, S. (2009). Sustainability through the market-the impacts of sustainable supply chain management: introduction. *Sustainable Development*, *17*(5), 269-273.

Yang, H., Kumara, S., Bukkapatnam, S. T., Tsung, F. (2019). The internet of things for smart manufacturing: A review. *IISE transactions*, 51(11), 1190-1216.

Yildiz Çankaya, S., Sezen, B. (2019). Effects of green supply chain management practices on sustainability performance. *Journal of Manufacturing Technology Management*, *30*(1), 98-121.

Yusuf, Y., Menhat, M. S., Abubakar, T., Ogbuke, N. J. (2020). Agile capabilities as necessary conditions for maximising sustainable supply chain performance: An empirical investigation. *International Journal of Production Economics*, *222*, 107501.

Womack JP, Jones DT, Roos D (1990) *The Machine that Changed the World*, Mandarin Books, London.

Wu, L., Yue, X., Jin, A., Yen, D. C. (2016). Smart supply chain management: a review and implications for future research. *The International Journal of Logistics Management*.

Zekhnini, K., Cherrafi, A., Bouhaddou, I., Benghabrit, Y., Garza-Reyes, J. A. (2020). Supply chain management 4.0: a literature review and research framework. *Benchmarking: An International Journal*, *28*(2), 465-501.

Zekhnini, K., Cherrafi, A., Bouhaddou, I., Chaouni Benabdellah, A., Bag, S. (2022). A model integrating lean and green practices for viable, sustainable, and digital supply chain performance. *International Journal of Production Research*, *60*(21), 6529-6555.

Zhao, J., Ji, M., Feng, B. (2020). Smarter supply chain: A literature review and practices. *Journal of Data, Information and Management*, *2*, 95-110.

Zhu, Q., Sarkis, J., Lai, K. H. (2012). Examining the effects of green supply chain management practices and their mediations on performance improvements. *International journal of production research*, *50*(5), 1377-1394.

Zijm H., Klumpp M., Heragu S., Regattieri A. (2019). Operations, logistics and supply chain management: definitions and objectives. *Operations, logistics and supply chain management*, 27-42.

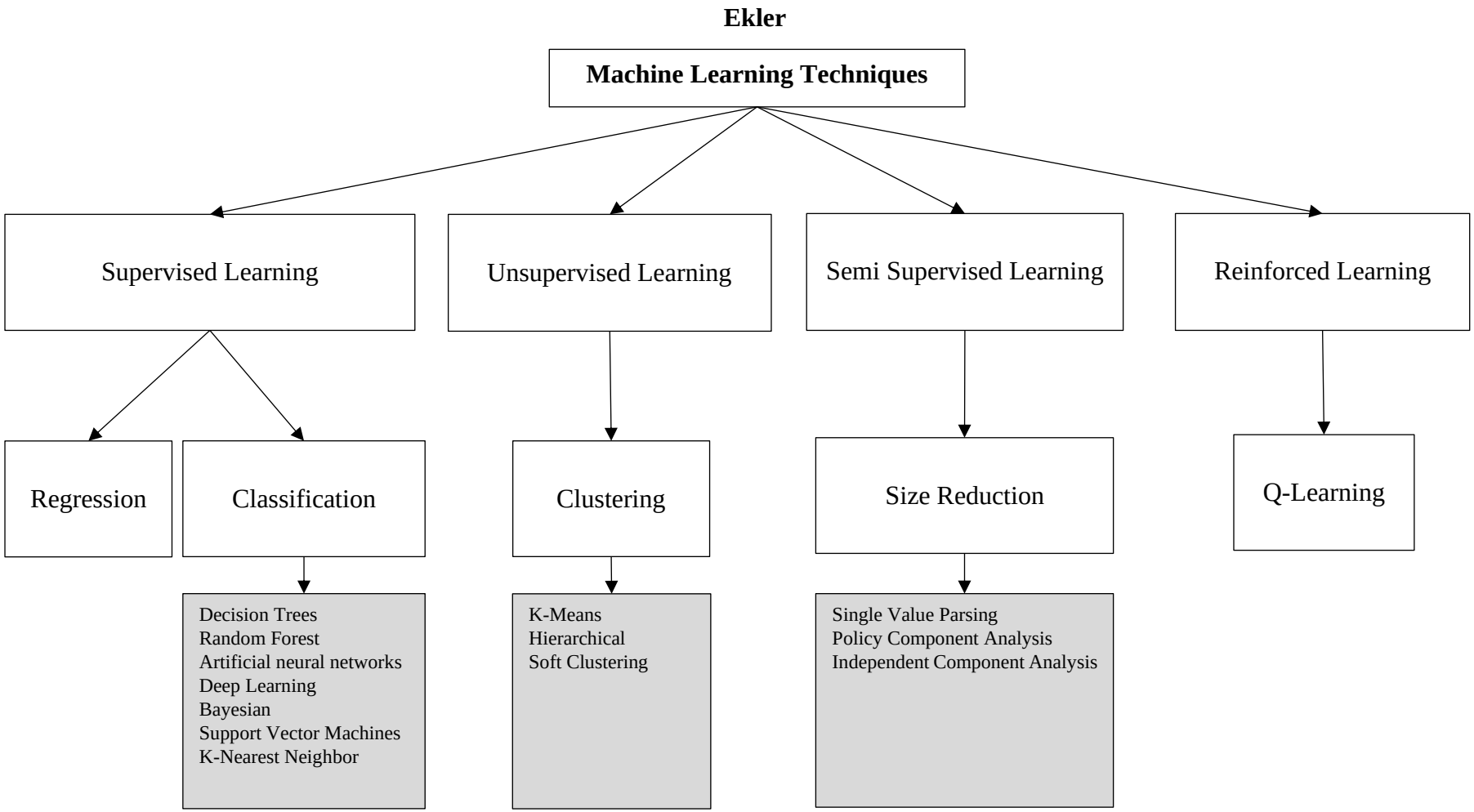

Figure 1: Classification of Machine Learning Techniques (Kumar et al., 2019)

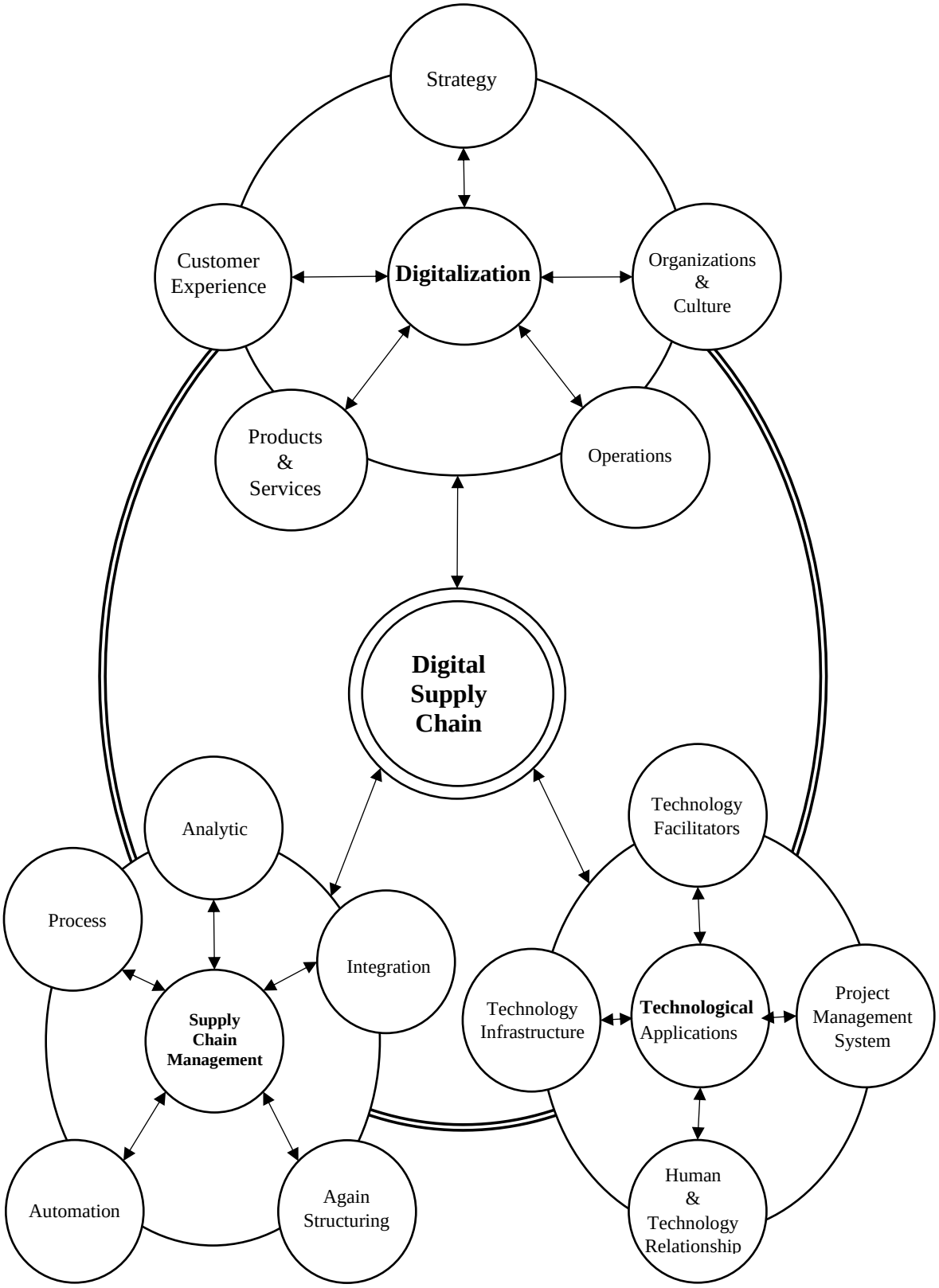

Figure 2. Disciplines and Components of the Digital Supply Chain (Büyüközkan ve Göçer (2018)