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**THE IDENTIFICATION AND PRIORITIZATION OF
LOGISTIC DIGITAL TRANSFORMATION BARRIERS:
A NEW INTEGRATED DELPHI-SWARA METHOD**

Kevser YILMAZ

Supervisor
Assoc. Prof. Dr. Aşkın ÖZDAĞOĞLU

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APPROVAL PAGE



DECLARATION

I hereby declare that this doctoral thesis titled as “The Identification and Prioritization of Logistic Digital Transformation Barriers: A New Integrated Delphi-Swara Method” has been written by myself in accordance with the academic rules and ethical conduct. I also declare that all materials benefited in this thesis consist of the mentioned resources in the reference list. I verify all these with my honour.

Date

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Keyser YILMAZ

Signature

ABSTRACT
Doctoral Thesis
Doctor of Philosophy (PhD)
The Identification and Prioritization of Logistic Digital Transformation
Barriers: A New Integrated Delphi-Swara Method
Kevser YILMAZ

Dokuz Eylül University
Graduate School of Social Sciences
Department of Business Administration
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There is no doubt that digitalization is one of the most significant technological trends facing the world today, and it has a profound impact on the logistics sector, among others. As logistics operations become more digital, companies can allocate resources more accurately and cost-effectively, increase communication between supply chain members, and increase flexibility. However, there are still gaps in the literature, and a need to clarify digitalization barriers to logistic operation remains. Therefore, this study aims to address this research gap by examining digitalization barriers to a logistic operation based on a systematic literature review (SLR) study. The investigation followed a mixed-methods approach, which included the Delphi method and SWARA. The twenty-seven obstacles and seven themes were identified using the SLR approach. The six barriers and one theme were eliminated as unsuitable for Türkiye conditions. Later, the SWARA method was used to prioritize and determine the weights of the synthesized obstacles. The findings show that "uncertainty about customers' needs and wants" comes out on top within the digitalization barriers to logistic operation in Türkiye. This is followed by a "lack of a digital vision and strategy" and "lack of a leader with appropriate skills, competencies, and experience". Besides, "inadequate organizational structure" is ranked as the fourth barrier, whereas "high investment/ implementation costs" is ranked as fifth barrier. Moreover, "organizational barriers" is identified as the most important digitalization barrier theme. The goal of this research is to aid managers and

practitioners in prioritizing, finding solutions, and developing strategies to overcome the distinctive digitalization barriers that are most important for firms desiring to transform business digitally.

Keywords: Logistic, Operation, Process, Digitalization, Barrier, Challenge, Obstacle, Systematic Literature Review, Delphi, SWARA.



ÖZET
Doktora Tezi
Lojistik Dijital Dönüşüm Engellerinin Belirlenmesi ve Önceliklendirilmesi: Yeni
Bir Entegre Delphi-SWARA Yöntemi
Kevser YILMAZ

Dokuz Eylül Üniversitesi
Sosyal Bilimler Enstitüsü
İngilizce İşletme Anabilim Dalı
İngilizce İşletme Yönetimi Doktora Programı

Dijitalleşme, günümüz dünyasının karşı karşıya olduğu en önemli teknolojik trendlerden biri olduğuna ve diğer sektörlerin yanı sıra lojistik sektörünü de derinden etkilediğine hiç şüphe yoktur. Lojistik operasyonları daha dijital hale geldikçe, şirketler kaynakları daha doğru ve uygun maliyetli bir şekilde tahsis edebilmekte, tedarik zincirinin üyeleri arasındaki iletişim artmakta ve daha esnek hale gelmektedir. Ancak, lojistik operasyonlarının önündeki dijitalleşme engellerini açıklığa kavuşturmak için literatürde hala boşluklar bulunmaktadır. Bu nedenle, bu çalışma, sistematik literatür taraması (SLT) çalışmasına dayalı olarak lojistik operasyonlarının önündeki dijitalleşme engellerini inceleyerek bu araştırma boşluğunu gidermeyi amaçlamaktadır. Bu araştırma, Delphi yöntemini ve SWARA'yı içeren karma yöntemler yaklaşımını izlemiştir. SLT yaklaşımı kullanılarak yirmi yedi engel ve yedi tema belirlenmiştir. Türkiye şartlarına uygun olmayan altı engel ve bir tema elenmiştir. Daha sonra, sentezlenen engellerin önceliklendirilmesi ve ağırlıklarının belirlenmesi için SWARA yöntemi kullanılmıştır. Bulgular, Türkiye'de lojistik operasyonların önündeki dijitalleşme engellerinin başında “müşterilerin ihtiyaç ve istekleri konusundaki belirsizliklerin” geldiğini göstermektedir. Bunu “dijital vizyon ve strateji eksikliği” ve “uygun beceri, yetkinlik ve deneyime sahip bir lider olmaması” takip etmektedir. Ayrıca “yetersiz organizasyon yapısı” dördüncü engel olarak, “yüksek yatırım/uygulama maliyetleri” ise beşinci engel olmuştur. Dahası, “örgütsel engeller” en önemli dijitalleşme engeli teması olarak bulunmuştur. Bu araştırma, yöneticilerin ve uygulayıcıların, işlerini dijital

olarak dönüştürmek istediklerinde, şirketleri için en önemli olan ayırt edici dijitalleşme engellerini aşmak için öncelikler belirlemelerine, çözümler bulmalarına ve stratejiler geliştirmelerini amaçlamaktadır.

Anahtar Kelimeler: Lojistik, Operasyon, Süreç, Dijitalleşme, Bariyer, Zorluk, Engel, Sistematiik Literatür Taraması, Delphi, SWARA.



THE IDENTIFICATION AND PRIORITIZATION OF LOGISTIC DIGITAL TRANSFORMATION BARRIERS: A NEW INTEGRATED DELPHI-SWARA METHOD

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ABBREVIATIONS

AGV	Automatic Guided Vehicle
AHP	Analytical Hierarchy Process
ANFIS	Adaptive Neuro-Fuzzy Inference System
AR	Augmented Reality
ARAS	Additive Ratio Assessment
COPRAS	Complex Proportional Assessment
COPRAS-G	Complex Proportional Assessment of Alternatives with Grey Relations
CPS	Cyber-Physical Systems
DEMATEL	Decision-Making Trial and Evaluation Laboratory
e-IRP	Efficient Interpretive Ranking Process
FPII	Fuzzy Performance Important Index
IQR	Interquartile Range
IT	Information Technology
NLP	Natural Language Processing
PSALSAR	Protocol, Search, Appraisal, Synthesis, Analysis and Report
R&D	Research and Development
RFID	Radio Frequency Identification Devices
ROI	Return on Investment
SALSA	Search, Appraisal, Synthesis, Analysis
SAP-LAP	Situation-Actor-Process and Learning-Action-Performance
SEM	Structural Equation Modeling
SLR	Systematic Literature Review
SMART	Simple Multi Attribute Ranking Technique
SWARA	Step-Wise Weight Assessment Ratio Analysis
TISM	Fuzzy total interpretive structural modelling
TODIM	Acronym in Portuguese of Interactive and Multi-Criteria Decision-Making

VR	Virtual Reality
WASPAS	Weighted Aggregates Sum Product Assessment
WHO	World Health Organization
WoS	Web of Science database



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INTRODUCTION

Industrial revolutions have been fueled by technological changes since the dawn of industrialization. The progress of modern technology has brought about a new industrial revolution, which can be referred to as "Industry 4.0." Rapid and disruptive changes are occurring in the production fields due to Industry 4.0 technology. This new revolution has also triggered changes in logistics. Logistics is being transformed by Industry 4.0 in response to its development and requirements.

In parallel with the industrial revolution, logistics has undergone four phases: Logistics 1.0, Logistics 2.0, Logistics 3.0, and Logistics 4.0. "Logistic 4.0" is the last phase of the logistic process evaluation, and Logistics 4.0 was first introduced in 2011. The logistics field responds to Industry 4.0's requirements by introducing Logistics 4.0.

Logistics 4.0 is a self-organizing and autonomous system that integrates with other systems and uses smart technologies to increase value chain management and enable highly personalized products and services. The main focus area of Logistic 4.0 is the value chain.

Digital transformation has received increasing attention as a technology trend transforming society and business. Digitalization primarily involves automating business processes and operations, as well as processing data. A digital transformation can be defined as leveraging new digital technologies to improve business processes and transform business models from a strategic, tactical, and operational standpoint.

Many industries and societal domains are experiencing the effects of digital transformation today. It is possible to create new types of organizations through digital transformation, which goes beyond changes in business processes. Digital transformation allows businesses to innovate new business models, increasing their revenue and competitive edge.

The right good, right quantity, right quality, right time, right place, right condition, and the right price are well-known requirements of logistics (Wang, 2016: 68). However, these requirements are becoming more and more difficult to meet in a constantly changing and uncertain logistic environment. Highly dynamic and uncertain logistic markets require new products, methods, and services. In order to

satisfy logistic markets, new intelligent technologies must be integrated. Thus, new intelligent technologies help logistic companies acquire benefits from the expected impact of digital transformation and its characteristics. For example, digitalization transformation will reduce overall costs by 34.2% and increase total revenue by 33.6% in logistics. However, most logistic firms are still in the beginning phases of digital transformation.

Organizations should begin the digital transformation process by understanding what they should include and avoid. Although several publications exist on the topic, there are still gaps to be filled to clarify how logistics companies can navigate the digitalization journey and how to overcome the barriers to digitalization.

The logistics sector is seeking guidance in order to prepare for the implementation of Industry 4.0 principles and to prepare themselves to deal with the changes and opportunities that come with the digitization of their operations.

This study clarifies logistic digitalization barriers, determines which obstacles are crucial for Türkiye Logistic firms, and prioritizes and weighs them. Therefore, this thesis is vital to filling this research gap and providing a more thorough understanding of logistics' digitalization barriers.

This research has three objectives. The first objective of this study is to analyze the existing knowledge on the barriers logistic firms face in adopting digitalization in their operation process in depth and generating comprehensive barrier classifications by theme. Therefore, firms can gain awareness of logistics' digitalization barriers.

The second objective is determining crucial digitalization barriers firms face operating in Türkiye (cultural, economic, political, geographical, etc. factors). As a result, Türkiye logistic companies can have more detailed knowledge about how they will adopt digital technologies successfully.

The last objective of the thesis is to prioritize and determine the weights of the digitalization barriers for Türkiye logistic operation. Consequently, if the firms discern which barriers are imperative for digital transformation, they can move forward to find solutions and develop strategies to overcome them.

CHAPTER ONE

DIGITALIZATION AND DIGITAL TRANSFORMATION

1.1. EVALUATION OF PRODUCTION SYSTEM: INDUSTRIAL REVOLUTIONS

Four industrial revolutions have occurred in the history of mankind. These four stages of industrial revolutions can be seen in the Figure 1. The first industrial revolution (also called as Industry 1.0) began with the invention of machines in the late 1700s. Using new inventions and machines, production could be done faster and cheaper than before. Small workshops morphed into factories, and production areas expanded (Allen, 2006: 29; Drath and Horsch, 2014: 1). Productivity increased as steam and waterpower were used in manufacturing. The first industrial revolution was characterized by mechanization (Kagermann et al., 2013).

Industry 1.0 began in manufacturing, but their effects soon reached beyond production areas and extended to society at large. Even the structure of the population was affected. As factories began to open in urban areas, citizens began moving there to work. The population, living standard, and welfare of the people increased as a result (Blinder, 2006; Tezge, 2010; Topleva, 2018).

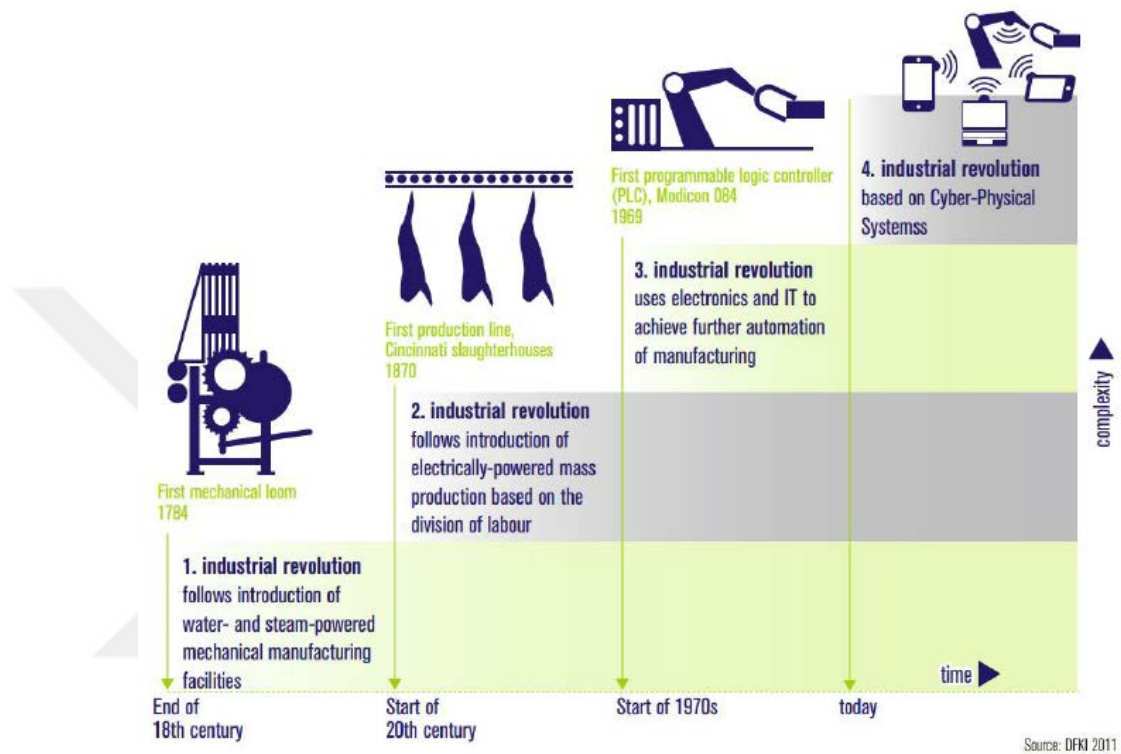
As manufacturers began to use electricity in the mass production, Industry 2.0 was born (Atkeson and Kehoe, 2001). In this era, the usage of steel in the production area reduced production costs and ultimately improved product quality (Mokyr, 1998). Moreover, in this time, as goods were shipped directly across the Atlantic to America, new markets were opened for global trading. The construction of additional railroads made long-distance transportation easier, thereby reducing costs, time and expenses (Engelman, 2015).

Furthermore, manufacturing factories adopted Taylorism principles. There was an important breakthrough in manufacturing with the assembly line, mass production, and labor division (Blanchet et al, 2014).

As a result of the second industrial revolution, costs fell, productivity increased, and production increased (Boyd and Crawford, 2012; Kagermann et al.

2013). The core characteristic of second industrial revolution was usage of electric in mass production.

Figure 1: Industrial Revolutions: Industry 1.0, Industry 2.0, Industry 3.0 and Industry 4.0



Source: DFKI 2011 (adopted from Kagermann et al 2013: 13)

The third industrial revolution began in the 1970s. The core elements of Industry 3.0 were automation and information technologies (IT) (Blanchet et al. 2014; Jazdi, 2014). A programmable logic controller was invented in 1969, allowing employees to program automation systems digitally (Kagermann et al. 2013). There were many inventions during the third industrial revolution, including railway systems, high-speed internet, fiber optics, satellites, cellular phones, etc (Jänicke and Jacob, 2009).

The third industrial revolution brought positive outcomes to manufacturing just as the first two did. The application of automation (Kagermann et al. 2013) and control of robots in production (Qin et al. 2016) allowed for more efficient and flexible

production systems. Moreover, in transportation and warehousing, radio frequency identification devices (RFID) have allowed manufacturers to track and control products remotely (Brettel et al., 2014). Besides, additive manufacturing has made it easier for companies to develop prototypes of products (Gibson et al., 2015). The services have continued to grow and develop as a result of the use of information technologies (Blinder, 2006).

The last industrial revolution is called as "Industry 4.0". Several German researchers, such as Henning Kagermann, Wolf-Dieter Lukas, and Wolfgang Wahlster, developed the concept of Industry 4.0 to develop smart manufacturing and a strong competitive presence. A public introduction to the term "Industry 4.0" took place at the Hannover Fair in April 2011 (Kagermann et al., 2011).

The Industry 4.0 philosophy has been accepted by different countries and companies under different names, such as the term "Industrie 4.0" is mainly used in Germany and the European Union prefer the term "Internet of Things" (Kagermann et al. 2013). Moreover, "Made in China 2025" is a strategic plan developed by China to keep up with Industry 4.0 technological developments (Liu, 2016). In Japan, the term Industry 4.0 has evolved into "Society 5.0" which integrates technological advancements into society's values (Wang et al., 2016b). The Turkish government gives great importance to Industry 4.0 as well. In 2016, TÜSİAD (Türk Sanayicileri ve İşinsanları Derneği) published a report to explain position and vision of Türkiye.

In addition, digital transformation is also known as "smart manufacturing", or "fourth industrial revolution"(Culot et al., 2020). The core of Industry 4.0 is built on Internet of Things (IoT) principles, along with other latest technologies (Beier et al., 2020; Verma et al., 2022). Besides, Cyber-Physical Systems (CPS) are referred to as the basis of the Industry 4.0 concept (Kagermann, 2015). In CPS, real and computerized worlds are connected, and all systems and devices are supervised, coordinated, and controlled without the need for centralized control (Rajkumar et al., 2010: 731).

Industry 4.0 technology presents fast and disruptive changes in the production fields (Blanchet et al., 2014: 7). This revolution assists in the control, arrangement, and optimization of manufacturing systems, as well as the development of flexible, dynamic, and real-time systems (Kagermann et al. 2013).

Industry 4.0 has nine core technologies which are cyber physical system, smart factory, cyber security, integration, autonomous system, internet of things, big data, augmented reality and cloud system. These technologies are explained in the following heading (1.4.) in detail.

These new technologies improve the predictability, control, and planning of production systems, and provide a more customized product. Also, they allow for last-minute changes during the production and delivery phases, which makes factories and systems more flexible (Kagermann et al., 2013). Additionally, same communication mechanisms can be used between various facilities. As a result, companies face fewer defects and repairs because the entire value chain can communicate and change information in real time. (Varghese and Tandur, 2014: 636).

In this part, four various industrial revolutions were defined briefly. In the following headings, firstly digitalization term is defined, later benefits and challenges of operation system's digitalization is clarified with perspective on usage of latest technologies. After that, nine pillars of digitalization and digital transformation are defined. Lastly, digital transformation and drivers, success factors and barriers of it are explained.

1.2. DIGITALIZATION DEFINITION

Digitalization is the most impactful technological trend that is transforming society and business (Leviäkangas, 2016; Parviainen et al., 2017). Digital technologies are constantly requiring firms to adapt their business models to these new realities, and firms are constantly being pushed to adopt new digital technologies (Chauhan et al., 2021; Kohli and Melville, 2019; Shahi and Sinha, 2020; Reis et al., 2020). However, literature on digitalization appears to be ambiguous regarding the precise definition of the term, partly due to its elusiveness.

According to Gobble (2018) digitalization is the use of digital technologies and likely digitized information to create new value, whereas, based on Wei and friends, digitalization is the use of digital technologies for revenue generation, improvement of business processes, and creation of a digital business environment (Wei et al., 2019).

Furthermore, digitalization is identified by Maxwell and McCain (1997) as digital technology breaks down information into its smallest components. Information, graphics, code etc. can all be manipulated digitally in ways never before thought possible, thus having an informative, transforming effect. Moreover, in Machekhina's (2017) definition, digitalization refers to the transformation of all types of information such as text, visual etc. into a digital format.

In addition that, by Castells (2009), digitalization is defined as the widespread use of information and communication technologies in all spheres of life. According to Crittenden et al. (2019), digitalization introduces new channels of communication between companies and their customers, whereas Lenka et al. (2017) defines digitalization as an intelligent connected machine powered by information and digital technologies.

In conclusion, the researcher's view: digitization is the transfer of analog data to digital form using the newest technologies, such as computers, smartphones, and tablets, to improve business relationships between companies and customers, adding value to the economy and society at large.

1.3. DRIVING FORCES AND CHALLENGES OF OPERATION SYSTEM DIGITALIZATION

It is essential to explain factors that may encourage companies to adopt digitalization, as well as to understand the concept of digitalization. As competition grows, companies are required to improve their productivity, as well as reduce their time-to-market to survive in the competitive landscape (Bauer et al., 2015; Lasi et al., 2014). Additionally, consumers' expectations and needs are changing, markets are becoming more diverse, and product life cycles are decreasing (Adolph et al., 2014; Karre et al., 2017). A company's competitive advantage can be improved by investing in new digital technologies (Kagermann et al., 2013: 15-16; Manyika et al., 2011: 13). The firms can therefore draw on digitalization and digital technologies to receive benefits.

Therefore, Horváth and Szabó (2019) conducted a study to identify the main barriers to Industry 4.0, as well as the driving forces behind introducing new

technologies. They recognized driving forces, factors and barriers that support or inhibit the introduction of digitalization that is shown in the Figure 2.

Figure 2: Barriers and Driving Forces of Digitalization

<i>Driving force</i>	<i>Factor</i>		<i>Barrier</i>
Increasing labour shortages Reducing human work Allocating workforce to other areas (higher added value)	Human resources		Lack of appropriate competences and skilled workforce Longer learning time (training of staff)
Reducing costs e.g. human resources, inventory management and operating costs	Financial resources and profitability		Lack of financial resources Return and profitability Shortcomings in tendering systems Long evaluation period for tenders
Market competition Follow market trends Increasing pressure from competitors Business model innovation	Market conditions and competitors	Management reality	Lack of a leader with appropriate skills, competencies and experience Lack of conscious planning: defining goals, steps and needed resources
Demand for greater control (from top management) Continuous monitoring of company performance	Management expectations		
Reducing the error rate Improving lead times (compliance with market conditions) Improving efficiency Ensuring reliable operation (e.g. less downtime)	Productivity and efficiency	Organizational factors	Inadequate organizational structure and process organization Contradictory interests in different organizational units Resistance by employees and middle management
		Technological and process integration, cooperation	Lack of a unified communication protocol Lack of back-end systems for integration Lack of willingness to cooperate (at the supply chain level) Lack of standards incl. technology and processes Lack of proper, common thinking Unsafe data storage systems The need for large amounts of storage capacity

Source: Horváth and Szabó (2019: 127)

The shortage of labour is increasing, a reduction in the amount of work done by humans and a better use of workforce are the main driving forces of human

resources (Horváth and Szabó, 2019: 127; Kagermann et al., 2013: 15-16; Stock and Seliger, 2016: 539; Rüßmann et al., 2015: 11). Furthermore, there are numerous financial benefits associated with increasing digitization of production processes, such as reducing costs associated with human resources, inventory management, and operations (Herrmann et al., 2014: 288; Horváth and Szabó, 2019: 127; Kagermann, 2015: 34; Stock and Seliger, 2016: 540).

A substantial reduction in the costs of human resources, inventory management, and operations are some of the benefits of digitizing production processes (Horváth and Szabó, 2019: 127; Kagermann, 2015: 34-35; Stock and Seliger, 2016: 539).

Competitive pressure and intense market competition are also driving forces for digital transformation. With the help of digital transformation and new technologies, companies can gain a competitive advantage, increase their market share and develop new business models (Jazdi, 2014: 2; Kagermann et al., 2013: 26; Rüßmann et al., 2015: 9; Schuh et al., 2014). Increasing control over company performance and continuous monitoring can also encourage digital transformation (Jazdi, 2014: 1-2; Kagermann, 2015: 23).

New technologies can also reduce lead times, error rates and increase production efficiency (Ganzarain and Errasti, 2016; Kagermann et al., 2013; Rüßmann et al., 2015; Schmidt et al., 2015). Further, flexibility of companies will increase with usage of new technologies, thus, companies will be able to respond more quickly to individual customer needs (Jazdi, 2014: 2; Kagermann, 2013: 15-16; Rüßmann, et al., 2015: 9).

However, the firms face to many obstacles when implementing new technologies. Practicing Industry 4.0 technologies can not be possible without skilled workers with the competencies necessary (Bag et al., 2021; Cichosz et al., 2020; Horváth and Szabó, 2019; Machado et al., 2021; Raj et al., 2020; Stornelli et al., 2021; Tijan et al., 2021). . Thus, this is one of the major challenges companies face when trying to implement digitalization. Moreover, retraining employees can be very challenging, as it takes a long time, which leads to higher costs overall (Arora and Rath, 2019; Gupta et al., 2022; Kumar et al., 2021; Machado et al., 2021; Ozkan-Ozen and Kazancoglu, 2021).

It is important to note, however, that implementing digitalization also requires important financial resources, which may be a barrier for some companies. In the early days of digitalization, a major concern for many companies was whether digitalization will be profitable and provide a return on investment (Cichosz et al., 2020; Horváth and Szabó, 2019; Karakas et al., 2021; Kumar et al., 2021; Tijan et al., 2021). Another obstacle is the lack of financial resources (Fruth and Teuteberg, 2017; Gupta et al., 2022; Nguyen, 2013; Shahi and Sinha, 2020; Sumrit, 2021; Verma et al., 2022; Wei et al., 2019).

Increasingly digitized production processes require a leader with the right skills and experience to lead Industry 4.0 initiatives. However, having such a leader is primarily an issue in businesses (Bag et al., 2021; Horváth and Szabó, 2019; Verma et al., 2022).

An inflexible organizational structure and inadequate management of it can be a major obstacle to digitalization (Bag et al., 2021; Kessler et al., 2022; Machado et al., 2021; Sumrit, 2021). Moreover, organizational resistance is another big obstacle to digital transformation which can be seen in both lower level workers and middle managers (Arora and Rathi, 2019; Ghadge et al., 2020; Gupta et al., 2022; Raj et al., 2020; Verma et al., 2022). As digitization increases, employees may fear losing their jobs and lagging behind in terms of technological competency.

1.4. NINE PILLARS OF DIGITALIZATION

Nine digital domains are currently affected by digitalization which are; (1) cyber physical system (CPS), (2) smart factory, (3) cyber security, (4) integration, (5) autonomous system, (6) internet of things (IoT), (7) big data, (8) augmented reality and (9) cloud system.

A cyber-physical system is essentially an interface connecting the real and virtual worlds through the use of internet of things technologies, computer and communication infrastructure (Baheti and Gill, 2011: 161; Kagermann et al., 2013; Rajkumar et al., 2010: 731; Schmidt et al., 2015: 17). Through sensors, embedded computers and networks, CPS is capable of automatically collecting a large amount of data from the real world (Kagermann, 2015: 26; Lee, 2008: 363). The information is

then transformed into virtual form by CPS using computer technologies. Then data is stored in cloud-based systems (Kagermann, 2015: 26).

It has been common practice to use embedded systems to connect physical systems with computing for a long time. The current embedded system, however, is not capable of connecting to other devices. CPS will gain networking skills with the advent of industry 4.0 (Lee, 2008: 366).

Despite the Internet of Things providing special ID codes, products cannot communicate or connect with each other without a CPS. Thus, rather than just connecting the virtual and real worlds, CPS will allow goods to communicate, coordinate, and autonomously make decisions on their own (Jazdi, 2014; Schmidt et al., 2015: 17).

The second pillar of digitalization is smart factory. The term "smart factory" refers to a factory that incorporates cyber-physical systems. A smart factory uses CPS cyber-physical systems to communicate between employees, machines, sources, and systems (Kagermann, 2015: 33; Wang et al., 2016a: 159).

As part of the smart factory, machines and employees can be supported while they perform their tasks. In a smart factory, flexible and agile manufacturing is combined with and real-time management (Lucke et al., 2008: 1; Wang et al., 2016a: 159). The smart factory concept also provides remote control of the factory, as well as real-time access to manufacturing information everywhere and anytime (Lucke et al., 2008: 2; Shrouf et al., 2014: 700). Moreover, the smart factory allows for better management of complexity, more efficient production, and fewer failures in production (Kagermann et al., 2013: 19). Besides, the smart factory requires a minimal amount of workers and eliminates repetitive tasks from the daily routine of workers (Kagermann et al., 2013: 21; Shrouf et al., 2014: 699-700).

"Cyber security" is the third pillar of digitalization. Industry 4.0 can only be successfully implemented if secure and reliable communications and connections to cloud systems are assured, as well as unique identities of devices (Kagermann et al., 2013: 23; Rüßmann et al., 2015: 4). The cloud will connect devices, machines, and factories, but these open networks may also be vulnerable to cyber-security threats (Byres and Lowe, 2004: 1; Rüßmann, et al., 2015: 4). The industry 4.0 era will

therefore require greater attention to ensuring the safety of all system components (Kagermann et al., 2013: 48-50).

There are two ways in which cyber-attacks can be conducted: either by exploiting vulnerabilities in the system or by utilizing the availability and connectivity of the system (Xie et al., 2010: 213). People also tend to focus on financial results when analyzing cyber-attack conclusions. The effects of cyber-attacks do not only affect factories or production, but also negatively affect the company's image, reputation, and ability to control processes (Byres and Lowe, 2004: 4). As the above illustrates, cyber-security is of utmost importance. Moreover, security architectures are necessary to detect misused acts in real time, to react appropriately to problems and to protect digital knowledge, smart devices, systems, and factory data from hackers (Kagermann et al., 2013: 48-50; Kagermann, 2015: 38).

The next pillar is “integration” Today, three types of integration exist: vertical, horizontal, and end-to-end. This integration function can be explained as follows. Horizontal integration facilitates intercompany cooperation using value networks, vertical integration creates hierarchical subsystems within an organization, ensuring an elastic and reconfigurable manufacturing system, and end-to-end integration enables customized production by connecting the entire value chain (Wang et al., 2016a).

Horizontal integration provides a global solution and optimizes manufacturing processes from end-to-end (Brettel et al., 2014; Kagermann et al., 2013: 20). As a result, real-time information about products and services, finances, and materials can be easily exchanged between these corporations, as well as within factories, in a more efficient manner (Wang et al., 2016a; Kagermann et al., 2013: 20; Zhou et al., 2015).

Vertical integration is defined as linking a variety of IT systems across different hierarchical levels in order to provide an end-to-end service Kagermann et al., (2013: 2). Vertical integration allows smart devices to self-organize, collect, send and receive data via sensors, as well as change production systems to produce different and customized products immediately. In addition, vertical integration ensures a seamless flow of communication and information between processes and technologies (Wang et al., 2016a).

“Autonomous systems” are the fifth pillar of digitalization. In the factory, robots are already in use, however their capabilities, skills, and some functions are severely limited (Rüßmann et al., 2015: 3). The Industry 4.0 redefines autonomous systems as cooperative, flexible and self-configuring (Blanchet et al., 2014: 8; Kagermann et al., 2013; Rüßmann et al., 2015: 3).

The autonomous systems determine its own actions based on sensors, justifying those actions according to the circumstances (Redfield and Seto, 2017:103; Kagermann et al., 2013: 20). Moreover, autonomous systems can use artificial intelligence to deal with some problems and can adapt themselves to different situations and other systems (Blanchet et al., 2014: 8; Rüßmann, et al., 2015: 3). As well as communicating with other systems, receiving and sending messages via cloud system, they operate in real time under real world conditions (Redfield and Seto, 2017:103; Kramer and Scheutz, 2007: 101). Consequently, the factory's structure and production system will undergo major changes. Due to the fact that these systems are more efficient, more intelligent, and more practical than human, and can be controlled remotely without the need for human intervention (Blanchet et al., 2014: 8; Pfeiffer, 2016: 1).

Internet of Things (IoT) is the next pillar. The term internet of things is defined by Morandi et al. (2012: 1497) as the extension of the internet and web into physical world. Internet Protocol will be used to network physical objects globally (Blanchet et al., 2014: 8-9; Miorandi et al., 2012: 1497). A further benefit of the Internet of Things connect between not only objects, but also machines, sensors, and people (Zuehlke, 2010). By using IoT, it will be possible to locate, track, monitor, and manage devices (Zhou et al., 2015). Moreover, machines will be able to identify customers' unique needs and wants, which will immediately regulate the production process to meet those needs and wants. In addition, when the product is completed, it will send a wireless message to the machines and communicate with other machines (Blanchet et al., 2014: 8-9).

Unstructured, complicated, heterogeneous, and large in volume is called Big Data. The 3Vs model has been widely used to define big data, which refers to volume, velocity, and variety. Volume refers to the amount of data created and collected. The idea of velocity is defined as the speed of big data, which means that the collection

and evaluation of data is quick. Lastly, the use of different types of data sources, including video, pages, and web pages, has been described as variety (Chen et al., 2014b: 171; Wu et al., 2014: 97).

Sensor prices are dropping, which leads to almost all machines, goods, and things becoming smart. The sensors are designed to collect data from machines, goods, and the environment all the time (Zhou et al., 2015: 2150). Thus, multi-source data is automatically collected. Moreover, data is not controlled by any central authority, and it supports the managers in making real-time decisions (Rüßmann et al., 2015: 2-3; Wu et al., 2014: 97).

In the age of big data, data collection, storage, management, and analysis will undergo dramatic changes (Manyika et al., 2011: 1). The main difference between big data and traditional datasets is that big data can collect and query whole datasets autonomously without requiring any control mechanism (John Walker, 2014: 183). Another difference is that the data volume is not stable, it changes and expands constantly as smart items receive data (Chen et al., 2014b: 173).

Data can also be transformed using two methods. First method is dynamic circuit network. Data is transmitted from the data source to the data center using it. Another method is to create a connection between data centers to allow them to communicate with each other and networked. This is called an intra-dynamic circuit network transmission (Chen et al., 2014b: 182-184).

A lot of information collected and held in the big data, but it is clear that data need to be analyzed according to their importance levels. In order to increase data quality, some pre-processing techniques can be used. Also, data that is inaccurate, incomplete, or illogical should be identified and changed or deleted. Moreover, datasets should be cleansed of excess or repetitive data (Chen et al., 2014b: 182-184).

The next pillar is “augmented reality” technology. It's possible to think of virtual and augmented reality as being similar terms, but they have different meanings from certain perspectives. Through virtual reality (VR), users can access synthetic platforms with real objects added. In spite of this, users can't see the real world when they use the virtual reality technology (Azuma, 1997: 355). Augmented reality (AR) enhances the real world and improves user experience by creating a bond between virtual and real worlds. It is possible for users to continue linking to the real world

while using it (Azuma et al., 2001: 34; Paelke, 2014: 1). Additionally, this technology provides 3D virtual objects that are created by computers, running interactively and in real time (Azuma, 1997: 355; Paelke, 2014: 1).

As a result of augmented reality, users will be able to access information on the new tasks, such as which parts need to be selected, where they are located, and how to repair them directly. So that, adapting to the dynamic production environment will be easier for users (Paelke, 2014: 1; Rüßmann et al., 2015: 5). Also, with this technology, new plants and products can be simulated virtually before they're launched, once all requirements are met (Blanchet et al., 2014: 9). Consequently, firms can decrease costs and earn time.

The last pillar is the “cloud system”. This technology is defined as;

“Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction” (Mell and Grance, 2011).

Cloud systems are essentially platforms through which users can manage, reconfigure, and access resources easily within minutes or seconds. Several modes of cloud computing have been identified in the literature, these are private, public, community and hybrid. Private clouds are systems that are used, managed, and operated by only one organization. The organization manages and processes of its own data, regardless of the volume of network traffic and security risks (Botta et al., 2016: 687; Mell and Grance, 2011; Rimal et al., 2009: 45).

By contrast with private clouds, public clouds are open resources that are based on the Internet for general public use that are owned and operated by businesses, academics, and governments (Botta et al., 2016: 687; Mell and Grance, 2011; Rimal et al., 2009: 45). The third type of cloud is the community cloud, which is used by consumers with shared interests such as missions, policies, etc.. The community cloud can be managed by one or more organizations, third parties, or a combination of them all (Botta et al., 2016: 687). The last cloud systems is hybrid that combines two or more distinct cloud connected via proprietary or standardized technology (Mell and Grance, 2011).

In this part, nine pillars of digitalization (cyber physical system, smart factory, cyber security, integration, autonomous system, internet of things, big data, augmented reality and cloud system) were explained, in the following part, digital transformation is defined.

1.5. DIGITAL TRANSFORMATION

Information processing, business process automation, and operations automation are the most prevalent aspects of digitalization. However, in literature on digital transformation, the term appears to be unclear. It lacks consensus with respect to its definition, despite increasing interest in both academia and practice in the concept of digital transformation (Morakanyane et al., 2017: 428; Osmundsen et al., 2018).

Thus, Morakanyane and colleagues made a systematic literature review study to conceptualize digital transformation phenomenon. The researchers conducted a scholarly literature search to collect credible peer-reviewed academic and peer-reviewed research articles and found 11 articles. Table 1 shows the definitions of digital transformation that were obtained from these articles.

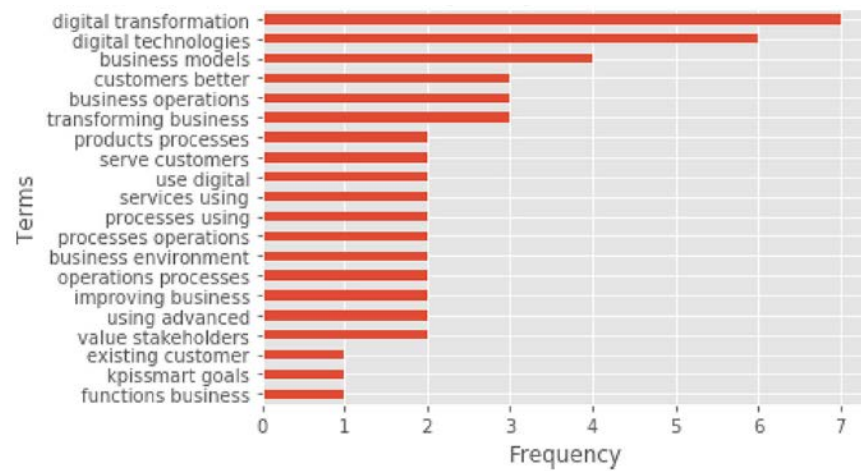
Table 1: Digital Transformation Definitions

Authors	Definition
Liu et.al. (2011);	"the integration of digital technologies into business processes"
Bharadwaj et.al. (2013);	"an organizational strategy formulated and executed by leveraging digital resources to create differential value"
Fitzgerald et.al. (2013);	"the use of digital technologies to enable major business improvements"
Lucas et.al (2013);	"fundamentally altering traditional ways of doing business by redefining business capabilities, processes and relationships"
Mithas et.al. (2013);	"the extent to which an organization engages in any activity of IT"
Westerman et.al. (2014b);	"the use of technology to radically improve performance or reach of enterprises"
Henriette et.al. (2015);	"a business model driven by the changes associated with the application of digital technology in all aspects of human society"
Piccinini et.al. (2015);	"characterized by the use of new digital technologies to enable significant business improvements"
Schuchmann & Seufert (2015);	"realignment of technology and new business models to more effectively engage digital customers at every touchpoint in the customer experience life cycle"
Chanas & Hess (2016);	"reflect the pervasiveness of changes induced by digital technologies throughout an organization"
Hess et.al. (2016)	"concerned with the changes digital technologies can bring about in a company's business model, which result in changed products or organizational structures or in the automation of processes"

Source: Morakanyane et al. (2017: 434).

However, there are many definitions of digital transformation and different meanings are attached to it depending on how the organization uses it. There are a lot of buzz words in the industry today, and many of them are misused. Therefore, Shahi and Sinha (2020) conducted a study to define "Digital Transformation" clearly. They asked the experts the meaning of digital transformation and analyzed the result with using the Bi-gram frequency. They generated themes explained the meaning of the term, these themes are shown in the Figure 3. There was agreement among the participants that digital transformation includes the use of digital technology to facilitate business operations. Moreover, they agreed upon digital transformation should transform business processes and operations and create value for for customers and all stakeholders.

Figure 3: Meaning of Digital Transformation



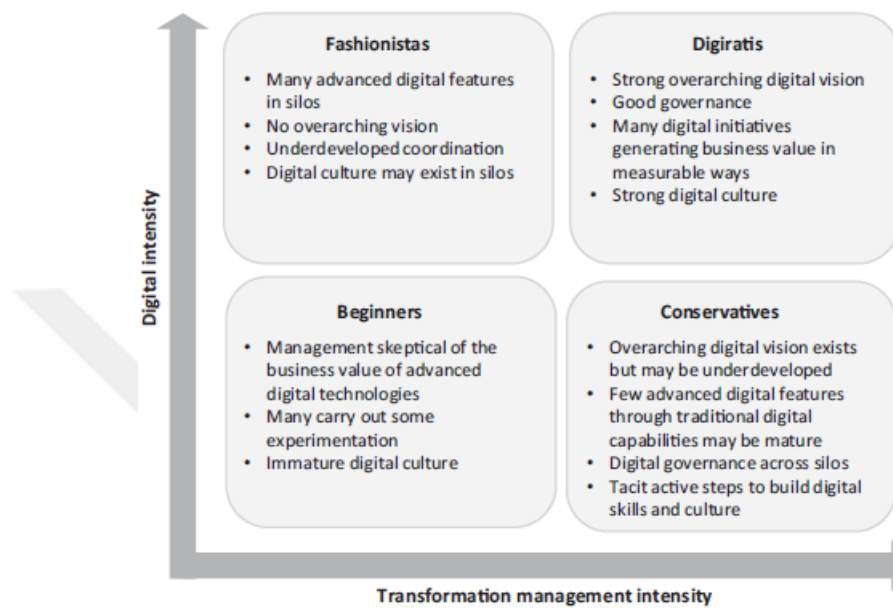
Source: Shahi and Sinha (2020: 24)

Moreover, the term digital transformation can refer to the process of using new digital technologies to enhance business processes, improve customer experiences, and innovate business models (Kovynyov & Mikut, 2018; Morakanyane et al., 2017). Besides, digital transformation has been described as a strategic transformation of all aspects of the business by some authors (Newman, 2017; Ross, 2019; Unruh and Kiron, 2017). Furthermore, the digital transformation is defined by Kane and friends (2017:3) as the degree to which an organization has adapted itself to a digital business environment.

According to Cichosz et al. (2020: 211), the digital transformation can be defined as an evolutionary process that can differ according to how much maturity an organization has in digital transformation. Westerman and colleagues (2014) used the “digital maturity” term in their study. A higher level of digital maturity is associated with better performance by firms, according to Westerman and colleagues’ (2014) research. The researchers divide the concept of digital maturity into two categories: (1) the intensity of digital initiatives, and (2) the capability of managing transformations. The intensity of digital initiatives mean that digital capabilities of the firms, whereas management capabilities mean culture, leadership, change management etc. of the companies. Cichosz and colleagues modified findings of

Westerman et al. (2014) and created a digital maturity matrix for companies which is shown in the Figure 4.

Figure 4: The Digital Maturity Matrix of Company



Source: Cichosz et al. (2020: 212)

There are four main digital maturity categories which are beginners, fashionistas, conservatives and digiratis. When the firm has weak digital and transformation management capabilities, it is called as beginners, whereas, when the firm has strong digital and transformation management capabilities, it is called as digiratis. Moreover, if the digital capabilities of the firm are strong but transformation management capabilities of the firm is weak is named as fashionistas, while if the digital capabilities of the firm is weak but transformation management capabilities of the firm is strong is named as conservatives.

Finally, the researcher's view: the digital transformation reshapes business processes and operations by using new digital technologies, also, it improves customer experiences, innovates business models and creates value for customers and all stakeholders.

1.6. DRIVERS, SUCCESS FACTORS, AND CHALLENGES BEHIND DIGITAL TRANSFORMATION

Organizations are focusing on digital transformation as one of their top priorities. The organization structure is being changed, and new positions are being created by digitalization (Singh et al., 2019). There is no doubt that digitalization will change the dynamics of the workforce. Job functions will be driven by algorithms, and the gap between top- and bottom-level employees will widen. As a result, the shared economy will become the new normal and businesses of tomorrow must be prepared to handle these changes in a positive way (Degryse, 2016).

The study of Ezeokoli et al. (2016) indicates that digital transformation is accompanied by several drivers, including increased profitability and revenue growth, improved customer service, convenience, and high-quality technical standards, improved operational efficiency, as well as improved business agility, employee productivity, and competitiveness.

Furthermore, Morakanyane and coworkers (2017: 432) conducted a systematic literature review study. In their review, they define digital transformation term, describe its characteristics, drivers and impacts. End of the study, they found 5 digital transformation's drivers which are digital technologies, digital capabilities, strategies, business models and value chain. These drivers and their references are shown in the Figure 5.

Figure 5: Drivers of Digital Transformation

What are the Drivers of Digital Transformation?	
Digital Technologies	Agarwal, et.al. (2010); Berman (2012); Bharadwaj, et.al. (2013); Bharosa, et.al. (2013); Janowski (2015); Kreutzer (2014); Luna-Reyes & Gil-Garcia (2014); Mithas, et.al. (2013); Lucas, et.al. (2013); Stieglitz & Brockmann (2012); Setia, et.al. (2013); Wang, et.al. (2016); Berman & Marshall (2014); Loebbecke & Picot (2015); Westerman et.al. (2011);
Digital Capabilities	Berman & Marshall (2014); Loebbecke & Picot (2015); Matt, et.al. (2015); Schuchmann & Seufert (2015); Tamm, et.al. (2015); Wang, et.al. (2016); Westerman et.al. (2011);
Strategies	Berman & Marshall (2014); Bharadwaj, et.al. (2013); Matt, et.al. (2015); Stieglitz & Brockmann (2012); Tamm, et.al. (2015); Mithas, et.al. (2013);
Business Models	Agarwal, et.al. (2010); Berman & Marshall (2014); Bharadwaj, et.al. (2013); Janowski (2015); Loebbecke & Picot (2015); Luna-Reyes & Gil-Garcia (2014); Matt, et.al. (2015); Mithas, et.al. (2013); Schuchmann & Seufert (2015); Tamm, et.al. (2015); Stieglitz & Brockmann (2012);
Value Chain	Agarwal, et.al. (2010); Berman & Marshall (2014); Bharosa, et.al. (2013); Janowski (2015); Stieglitz & Brockmann (2012); Tamm, et.al. (2015); Wang, et.al. (2016);

Source: Morakanyane et al. (2017: 432).

In addition, Osmundsen et al. (2018: 4) discussed digital transformation drivers, objectives, success factors, and implications based on empirical studies in their research paper. The result of this study can be seen in the Figure 6. They found 4 digital transformation drivers which are customer behavior and expectations, digital shifts in the industry, changing competitive landscape and regulative changes. Moreover, increase customer satisfaction and dialogue were identified as objectives of digital transformation. Furthermore, if the firm has a supportive organizational culture, manages transformation activities efficiently, leverages external and internal knowledge, engages managers and employees, grows is information systems capabilities, aligns business and information systems, develops dynamic capabilities and digital business strategy, the firm succeed in the digital transformation.

Figure 6: Drivers, Objectives and Success Factors of Digital Transformation

Drivers and Objectives
<i>Drivers</i>
Customer behavior and expectations
Digital shifts in the industry
Changing competitive landscape
Regulative changes
<i>Objectives</i>
Ensure digital readiness
Digitally enhance products
Embrace product innovation
Develop new business models
Improve digital channels
Increase customer satisfaction and dialogue
Success factors
A supportive organizational culture
Well-managed transformation activities
Leverage external and internal knowledge
Engage managers and employees
Grow IS capabilities
Develop dynamic capabilities
Develop a digital business strategy
Align business and IS

Source: Osmundsen et al. (2018: 4)

Digital transformation enables companies to develop more innovative business models and help them hold their ground. Moreover, stakeholders will be able to create value from this (Shahi and Sinsa, 2020). Furthermore, digital transformation enhances business processes, improves customer experience, and innovation business models by some authors (Hausberg et al., 2018; Kovynyov & Mikut, 2018; Morakanyane et al., 2017).

Besides, by leveraging digital transformation, a business can create new business models, increasing revenue and gaining a competitive edge. Moreover,

digital transformation should transform business processes and operations and create value for customers and all stakeholders (Shahi and Sinsa, 2020: 24).

Product and service digitalization reduces distances between people and things and mobility is increased as a result. This technology allows businesses and consumers to utilize specific data in order to satisfy individual customer needs. Creating new businesses and jobs is possible as a result of it, as it provides ample scope for innovation, investment, and job creation (Devereux and Vella, 2018; Reis et al., 2020: 447)

A manager's role during the digital transformation is to make the workplace open to change by introducing innovative content, providing in-house training, supporting performance, and encouraging collaboration and information sharing (Vey et al., 2017).

Moreover, the companies can provide a better employee experience as a result of changes in technology, organizational structure, and workplaces. This, however, results in an unstable, flexible, and short-lived workforce (Connelly et al., 2020). So that, digital transformation is not only bring positive result also bring some challenges for the companies.

There has been an increasing amount of attention paid to digital transformation as a technology trend that is changing society and business (Leviäkangas, 2016; Parviainen et al., 2017). Although going digital has many benefits, it does require investments and associated costs as well (Ahmad and Murray, 2019). Some organizations may find digitalization difficult because they must replace all methods of operating with new ones (Rad et al., 2015).

Shahi and Sinsa (2020) conducted a study to examine the digital transformation challenges faced by organizations and potential solutions to these challenges. They found 7 main challenges themes, which are; lack of vision, culture, skillset, infrastructure, limited budget, teams working in silos and data security. First theme is lack of vision, authors found that organizations have not clear strategy, objective and vision about how they apply digital transformation. Culture is the second theme and it is related to an organizations' culture and the mindset of its employees. Thus, systems and processes that have been in place for a long time are difficult to let go of for the organizations. Next digital transformation challenge is skillset. The lack of necessary

technical expertise and difficulties to find right talent have been identified as the major challenges for this theme. Following, lack of digital infrastructure of the companies and insufficient budget for the digital transformation are the another challenges. Another obstacle is that there is no integration between teams in different departments or functions of the organization. The last challenge for the organizations is about data security and management system. Unfortunately, the organizations have not efficient and effective data security and data management system.

Furthermore, Ozkan-Ozen and Kazancoglu (2021: 314) made a study to examine workforce development challenges in the digital age. They found out 13 various workforce development challenges that is shown in the Figure 7. First barrier is lack of internal digital culture. According to researchers, organizations must adopt digitalization from top to bottom, starting with their company culture in order to implement Industry 4.0 and for Industry 4.0 workforce development to be successful, digital culture must be accepted by all internal stakeholders. However, the result showed that there is a lack of digital culture at the organization level. Inadequate organizational structure and management system is the second digitalization barrier for the organizations, because dynamic industry 4.0 requirements cannot be met by existing organizational structures.

Figure 7: Challenges Associated with Workforce Development

C1	Lack of internal digital culture
C2	Inadequate organizational structure and management system for digitalization
C3	Lack of ability in decentralized decision-making
C4	Lack of system thinking/knowledge
C5	Cost of training for the digital systems
C6	Requirements for longer learning time and specialized training
C7	Lack of IT/digital skills
C8	Lack of analytical thinking and dealing with complexity
C9	Lack of interdisciplinary thinking and acting
C10	Shortage of workforce with adequate skillset within the labour market
C11	Lack of learning readiness/ability
C12	Lack of understanding of the interplay between human and machine, and related exchange of knowledge
C13	Employee resistance to change

Source: Ozkan-Ozen and Kazancoglu (2021: 314).

Next barrier is about the decision-making mechanism of the firms. In Industry 4.0, centralization is being replaced by decentralization and digital transformation doesn't require central planning or control. However, the lack of ability to make decentralized decisions is a limiting factor in the development of a trained workforce in Industry 4.0.

It is important to adopt system thinking throughout all processes and business procedures in Industry 4.0 in order to ensure successful workforce development. System thinking and knowledge are, however, challenges that organizations should overcome. Moreover, the next barrier for the organization is the cost. It is expensive

for organizations to develop industry 4.0 infrastructure due to high implementation costs.

Other challenges are learning time and digital skills. Training and education practices in Industry 4.0 are increasingly important due to the complexity of digital systems and the need for new skillsets. However, increasing knowledge requires more training and learning time, which leads to a longer learning process.

Eight and ninth challenges are related to skillset of the employees. In the era of Industry 4.0, advanced technologies and multidimensional interactions between partners make the process more complex. Therefore, problem-solving capabilities and data management become more important than usual. Moreover, industry 4.0 infrastructure requires cross-disciplinary interactions, and workers must be capable of thinking and acting in an interdisciplinary manner. As a result, the lack of analytical thinking and dealing with complexity and lack of interdisciplinary thinking and acting are therefore a challenge to Industry 4.0 workforce development.

Employees will need a new skill set to succeed in Industry 4.0. There, however, is a mismatch between the skills of the current workforce and the requirements of the new jobs as a result of new digital technologies. Due to this, organizations can face significant challenges due to the shortage of workers with adequate skillsets within the labour market. Furthermore, since Industry 4.0 requires continuous learning to adopt new technologies, learning ability is a critical competency for a workforce in Industry 4.0. Thus, Industry 4.0 workforce development is challenged by a lack of learning readiness/ability.

The interaction between employees and machines is an essential part of Industry 4.0, which facilitates knowledge exchange and improves system efficiency. Despite this, the lack of understanding of the interaction between humans and machines is an important challenge. The last workforce challenge is employee resistance to change. Employees are concerned about the possibility of being replaced by machines and robots as a result of Industry 4.0.

Eventually, the digital transformation is a long-term process requiring a lot of investment and several years before seeing results (Davenport and Westerman, 2018). If hastily implemented, the transformation process can negatively impact the core business of the organization (Davenport and Westerman, 2018). In order to transform

business into a digital ecosystem, new arrangements, infrastructure, and building blocks will be required. These changes can be challenging for organizations at times (Hinings et al., 2018). As a result, it is crucial that the transformation process is clearly defined. Digital transformation should be begun with an understanding of what should be included and what should be avoided by organizations.



CHAPTER TWO

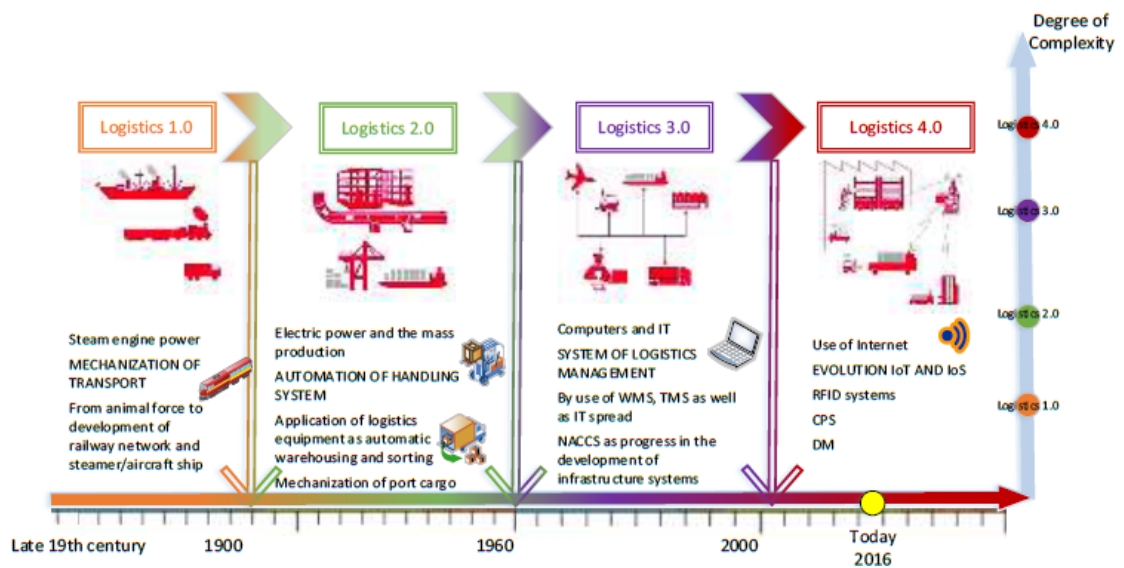
DIGITALIZATION IN LOGISTIC SECTOR

2.1. HISTORY OF THE LOGISTIC SECTOR DIGITALIZATION

Industrial revolutions have been driven by technological changes from the dawn of industrialization. There is a new industrial revolution underway today. The new industrial revolution can be referred to as "Industry 4.0." (Kagermann et al., 2011; Kagermann et al., 2013). Logistics will be changed and improved by Industry 4.0.

Logistics has gone through four phases, from Logistics 1.0 to Logistics 4.0, in parallel with the industrial revolutions. A timeline of logistics evolution from Logistic 1.0 to Logistic 4.0 can be seen in Figure 8. Moreover, focus area of every logistic processes are different and focus areas of each phases can be seen in the Figure 9.

Figure 8: Digitization of Logistics Systems: The Evolution Process



Source: Wang (2016: 69).

Prior to the industrial revolution, logistics relied on push delivery flows and supply chain management was at a local level. Material was kept on the ground in warehouses and moved by hand carts in these simple buildings. Production and

logistics were organized by the owners of factories and shops (Radivojević and Milosavljević, 2019).

In the 19th century, logistics term was introduced by the military and defined as the process of planning and coordinating troop movements (Bartodziej, 2017). At the point in time, the logistics discussed only centered around the physical distribution of materials, not addressing any other aspects of the business. As a result, logistics focused mainly on optimizing the three Ps; place (location and destination), period and pace (time value) and pattern (forms of order) (Ballou, 2006).

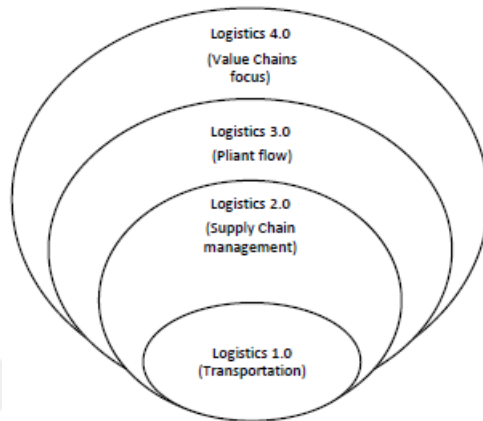
By the 18th century, the steam engine had been invented and manual production had been replaced by machine production. This was considered the first industrial revolution (Drath and Horch, 2014: 1; Kagermann et al., 2013). The logistics industry has undergone several transformations as a result of these industrial revolutions. In the late 19th and early 20th centuries, steam machines that led to the first industrial revolution resulted in the mechanization of transportation systems. Logistics 1.0 refers to this period (Demirdöğen, 2020: 495; Radivojević and Milosavljević, 2019: 284; Wang, 2016: 67). Logistics 1.0 was able to satisfy the industrial needs that were primarily brought about by the customers themselves (Wang, 2016: 67).

In Logistic 1.0 period, to transport large amounts of goods and containers over long distances and at large quantities, ships and trains with steam engines were used instead of humans and animals. A significant increase has been made in transportation capacity. There can be no doubt that logistics in the 20th century marked the dawn of mass transportation (Wang, 2016: 67). As a result, transportation of goods and passengers became a massive industry (Radivojević and Milosavljević, 2019: 284). During the 60s, logistics 1.0 was primarily associated with military applications, but now is more prevalent among businesses (Amr et al., 2019: 47).

Mass production and production lines were the hallmarks of the second industrial revolution in the 19th and 20th centuries (Radivojević and Milosavljević, 2019: 284). The importance of mass production was recognized by Industry 2.0 during the 1960s. However, cargo handling had to be automated in order to meet the demands of mass production. Because, neither the physical flow of traffic on roads nor the

automation of cargo were examined in the previously reviewed state (Amr et al., 2019: 47)

Figure 9: Focus Area of Logistic Processes



Source: Amr et al. (2019: 48).

Cargo handling was automated which is a result of the invention of electric power and mass production in manufacturing (Wang, 2016:67). Automation of cargo handling was considered an evolution in the Logistics field and was called "Logistics 2.0" (Demirdöğen, 2020: 496-497; Radivojević and Milosavljević, 2019: 284; Wang, 2016: 67).

As a result of Logistic 2.0, companies began to coordinate physical flow within and outside of their organizations by interacting with each other. Coordination among parties in a chain was the one of focus of Logistics 2.0. Thus, "Supply Chain Management" was born (Eljazzar et al., 2018; Lummus and Vokurka, 1999). In addition, Port loading systems have also changed due to the common use of container ships in harbors (Wang, 2016:69).

Besides, with the Logistic 2.0, it became more and more important to handle goods automatically, new forms of transportation were developed and specialized transport means were created. A global supply chain management system was developed, logistic networks expanded. Also, New industries and companies specializing in particular logistic activities and processes emerged as supply chain

management became global, logistics networks developed (Radivojević and Milosavljević, 2019: 284).

Finally, Logistics 2.0 focused on how to increase optimization levels so that more improvements can be achieved in addition to carrying goods as the focal point of Logistics 1.0 (Amr et al., 2019:5).

Numerically controlled (NC) machines and their application in manufacturing are what led to the emergence of Industry 3.0 at the end of the 20th century (Radivojević and Milosavljević, 2019: 284). As early as 1968, industrial robots were manufactured, marking the beginning of industry 3.0. This new industrial revolution triggered the Logistic 3.0 and "Systems of logistics management" brought about the third logistical revolution on the logistics side (Amr et al., 2019:5; Galindo, 2016:26).

In Logistics 2.0, operations were divided into three categories: supply chain management, product development and operations. Moreover, these operations were strengthened by business functions. However, the grouping of activities led to coordination problems in companies. Thus, companies began to pay attention to the flow management issue as a result of those new problems (Demirdöğen, 2020: 497). As a result, "Flow Management" was added as a new "P" in Logistic 3.0 era. Pliancy, or agility, is the new "P", which focused on more than just physical flow (Amr et al., 2019:5; Sheffi and Klaus, 1997). Due to the invention of computers and information technology in the 1980s, logistics management has been systemized (Wang, 2016:69)

As a result of logistic 3.0, IT systems such as Warehouse Management System and Transport Management System have used. Moreover, Logistics management, inventory management, and dispatch have been significantly improved and automated as a result of this logistic revolution (Wang, 2016:69). Managing supply chains globally, coordinating with buyers, suppliers, business partners, and users, applying advanced business models, and competing with their competitors were some features of Logistic 3.0 (Christopher and Holweg, 2011).

The last phase of the evaluation of logistic process is called as "Logistic 4.0". "Industry 4.0" is the name given to the last industrial revolution. In April 2011, the term "Industry 4.0" was introduced to the public (Kagermann et al., 2011). Rapid and disruptive changes are occurring in the production fields due to Industry 4.0 technology. Manufacturing systems can be controlled, arranged, optimized, and

developed in a flexible, dynamic, and real-time manner with the help of this revolution (Blanchet et al., 2014: 7; Kagermann et al. 2013).

This new revolution also has triggered the changes in logistic and Logistics 4.0 was first introduced in 2011. The logistics field responds to Industry 4.0's requirements by introducing Logistics 4.0. The Logistics 4.0 approach assists Industry 4.0 in analysis of market requirements, planning production, and delivering smart products to consumers (Kayikci, 2018; Radivojević and Milosavljević, 2019: 285-286; Wang, 2016: 69). Main focus area of Logistic 4.0 is value chain (Amr et al., 2019: 48). Definition and technical components of Logistic 4.0 is explained in the following heading in detail.

2.2. LOGISTIC 4.0 DEFINITION

Suppliers, manufacturers, and retailers have all recognized the importance of logistics. In order to be competitive on the market, suppliers, manufacturers, and retailers must have the 7(R) (right good, right quantity, right quality, right time, right place, right condition, right price). These are well-known requirements of logistics (Wang, 2016: 68).

However, these requirements are becoming more and more difficult to meet in a constantly changing and uncertain logistic environment. New products, methods, and services are required to satisfy highly dynamic and uncertain logistic markets. Integrating new intelligent technologies is the only way to satisfy logistic markets. It is possible to trigger major and even radical changes using technology-driven approaches (Radivojević and Milosavljević, 2019: 285-286).

As a result of today's technological advancements, industrial production is currently at the threshold of a new industrial revolution, which can be called "Industry 4.0." (Kagermann et al. 2013). The advent of Industry 4.0 will transform traditional logistics and improve it. Moreover value chains and networks are already being transformed by the fourth industrial revolution (Wang, 2016: 68).

The Industry 4.0 technology makes it possible to manufacture small batches at a low cost and to offer a large number of variant (Brynjolfsson et al., 2010; Shrouf et al., 2014: 697). Among the main promises of this revolution are complete

transparency, decentralized management, and networked processes (Kagermann et al., 2013; Stock and Seliger, 2016: 537). Moreover, Industry 4.0 is enabling machines, supply chains, warehousing systems and logistics products to exchange information with each other, triggering autonomous actions to be initiated and making these machines able to coordinate their actions with one another (Jazdi, 2014; Schmidt et al., 2015: 17). Furthermore, through the fourth industrial revolution, it is possible to strengthen the value chain by connecting products and processes (Kagermann et al., 2013: 15-16; Schmidt et al., 2015: 18; Stock and Seliger, 2016: 558). It has also triggered changes in logistics, resulting in Logistics 4.0 being introduced (Kayikci, 2018; Radivojević and Milosavljević, 2019: 285-286; Wang, 2016: 69).

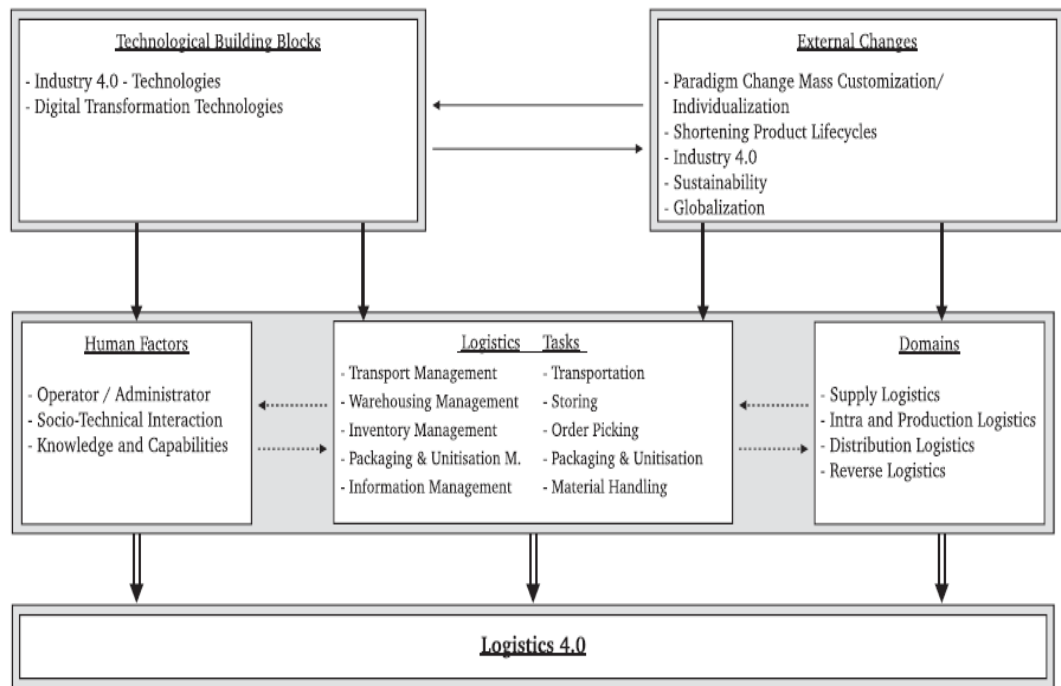
Industry 4.0 is transforming logistics in response to its development and requirements. Logistic 4.0 has responded to industry 4.0's demands by developing this term (Wang, 2016: 69). The logistics 4.0 revolution is regarded as an integral component of Industry 4.0. As part of this approach, Logistics 4.0 helps Industry 4.0 to analyze market requirements, plan production, and deliver smart products to consumers in line with Consumer 4.0 (Kayikci, 2018; Radivojević and Milosavljević, 2019: 285-286).

There are some authors who define logistics 4.0 as a new paradigm that is interconnected with Industry 4.0. Logistics 4.0 was conceptualized by Jeschke (2006) in terms of short- and medium-term perspectives. The short-term definition of logistics 4.0 is a system that uses huge amounts of data to connect independent systems in a cooperative manner. Whereas, the medium-term definition of logistics 4.0 is an self-organizing and autonomous system that integrates with other systems. Additionally, Timm and Lorig (2015) defined logistics 4.0 as a set of independent subsystems whose behavior is influenced by other subsystems around them.

Moreover, Wang (2016: 69) defined logistics 4.0 as a concept and set of technologies related to value chain management. Besides, according to Khan et al. (2022: 3), logistics 4.0 explained as; smart technologies are integrated with logistics through logistic 4.0 to enable highly personalized products and services. Also, the term explained by Strandhagen et al. (2017) based on five various characteristics: Big Data analytics in real-time, reduction in storage requirements, autonomous robots, real-time information exchange and no information disruption. Furthermore, according to

Hompel and Kerner (2015) the term also refers to processes that are automated and coordinated, as well as the support of Industry 4.0. In addition, Winkelhaus and Grosse (2020) conducted a systematic literature review to examine Logistic 4.0 and they created three dimensional conceptual framework to define Logistic 4.0. This conceptual framework can be seen in the Figure 10. The external changes are the first dimension of this framework, whereas technological building blocks are the second dimension. The last dimension concentrates on logistics and human factors, task and domains are the aspects of this dimension.

Figure 10: Three Conceptual Framework of Logistics 4.0



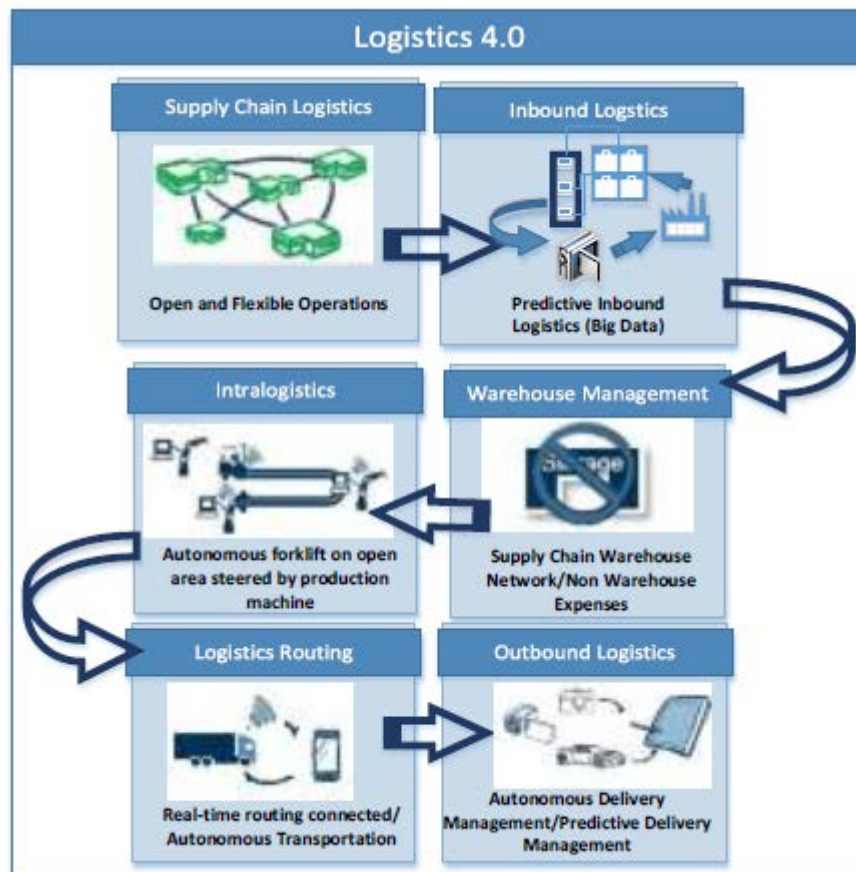
Source: Winkelhaus and Grosse, (2020: 4)

As a conclusion, the researcher's view: logistics 4.0 is the an self-organizing and autonomous system that integrates with other systems, usage of smart technologies to increase value chain management and to enable highly personalized products and services.

2.3. TECHNICAL COMPONENTS OF LOGISTIC 4.0

It is imperative that logistics 4.0 will be supported by rapid technological advancements, such as smart sensors, big data, wireless sensors networks, cloud computing, 3D printing, mobile internet technologies, and augmented reality. Wang (2016) summarizes the supply chain activities within the Logistics 4.0 concept (Figure 11).

Figure 11: Activities of Logistics 4.0 in Supply Chain Management

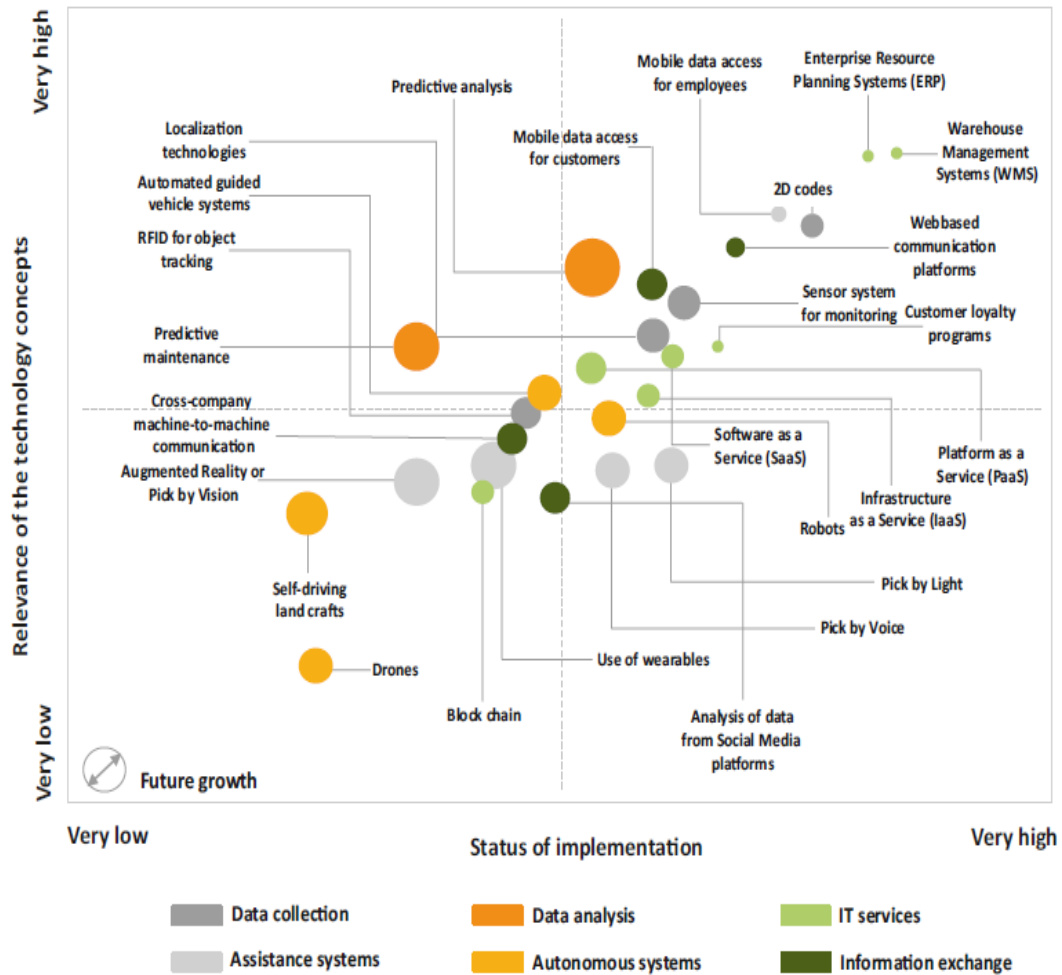


Source: Wang (2016: 70).

Moreover, Lehmacher et al. (2017) prepared a graphic to show digital applications usage in logistics. Figure 12 illustrates how technology can be used to contribute to digital transformation in logistics and supply chain management. This

figure not only highlights the relevance of the technologies mentioned, but also the state of their implementation.

Figure 12: Digital Applications Usage in Logistics



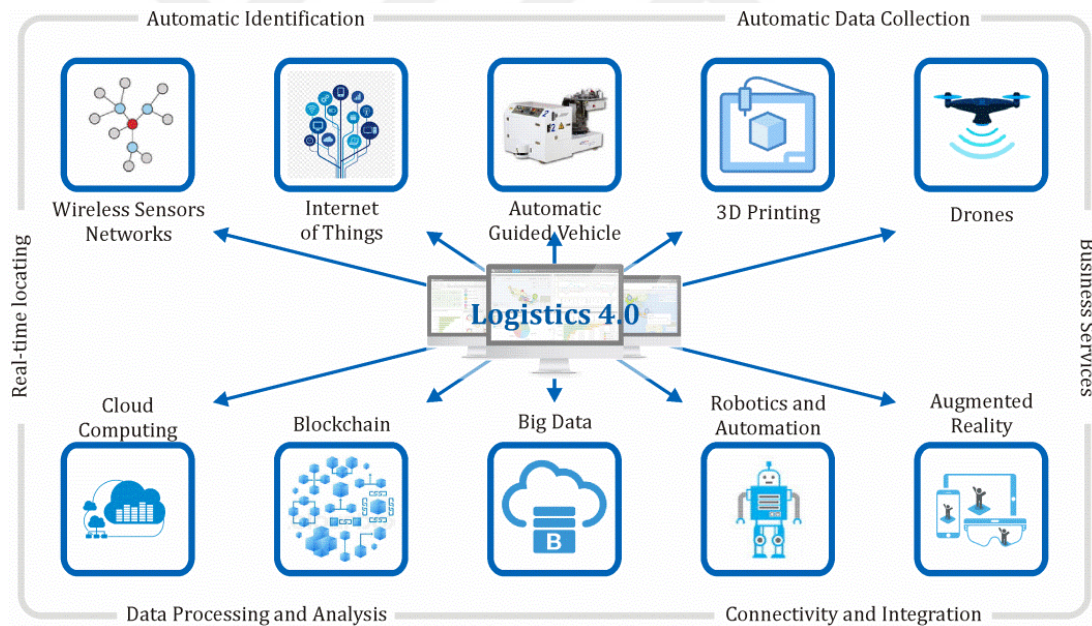
Source: Lehmacher et al. (2017: 6)

Furthermore, Radivojević and Milosavljević (2019: 287) defined core technical components of Logistic 4.0 and these components can be seen in the Figure 13. First technical component is Internet of Things (IoT). Things can be identified, communicated, and managed intelligently with IoT (Kagermann, 2015: 26). As a result of this concept, things are intelligent objects that can identify, communicate, and interact with one another (Miorandi et al., 2012: 1497). Logistics has developed smart

products (ex: smart containers, smart packaging, smart forklifts etc.) thanks to identifying technologies applied to different objects (Radivojević et al., 2017).

Cloud Computing is the second technical component and it is an Internet-based computer service. Logistics companies benefit from cloud computing. For example, logistic companies can access IT services and innovative supply chain solutions faster, more efficiently, and more flexible thanks to cloud computing (Rimal et al., 2009: 45-46; Mell and Grance, 2011). The next technical component is Big data. Large amounts of data can be stored, transmitted, processed, and analyzed using Big Data technologies. Businesses can create additional value and apply new business models using Big Data and Data Mining analytical methods (Chen et al., 2014b: 171; Wu et al., 2014: 97).

Figure 13: Technical Components of Logistic 4.0



Source: Radivojević and Milosavljević (2019: 287).

Fourth technical component is Blockchain technology, that is a distributed and decentralized system that manages all transactions related to a particular field of work. With blockchain technologies in logistics, global trade can be moved more efficiently and reliably; the supply chain can be monitored and visible more effectively

(Kückelhaus and Chung, 2018). The next is Wireless Sensor Networks and sensor and wireless communication networks are the components of them. Thus, data can be collected and transferred between sensors and objects and their physical characteristics can be identified using these sensors (ex: transshipment means, locations in warehouses, traffic infrastructure) (Radivojević and Milosavljević, 2019). The following technology is Robotics and Automation, that can be use in the production processes to enhance quality of products, reduce of errors and decrease cost (Blanchet et al., 2014: 8; Kagermann et al., 2013; Redfield and Seto, 2017:103; Rüßmann et al., 2015: 3).

Seventh component is Augmented Reality, that it is combine the digital and physical worlds and allows users to see reality as a composite of both. Logistic companies can take advantages from this tecnology by using smart glasses in sorting and packing operations, delivery of goods to the customers so on (Azuma et al., 2001: 34; Van Krevelen and Poelman, 2010: 1; Paelke, 2014: 1). Drone is the next technology that can be used deliver products to potentially dangerous locations. Following this, 3D is the ninth technical component and the development of 3D printing can allow companies to provide new logistical services related to spare parts supply (Radivojević and Milosavljević, 2019: 289-290). The last component is Automatic Guided Vehicle (AGV) and automated handling of equipment and freight is possible thanks to it. In logistic processes, the use of AGVs reduces costs and labor, increases productivity and quality, as well as reducing risks of human error (Kückelhaus and Chung, 2018; Radivojević and Milosavljević, 2019: 290).

2.4. BENEFITS AND CHALLENGES BEHIND LOGISTIC SECTOR DIGITALIZATION

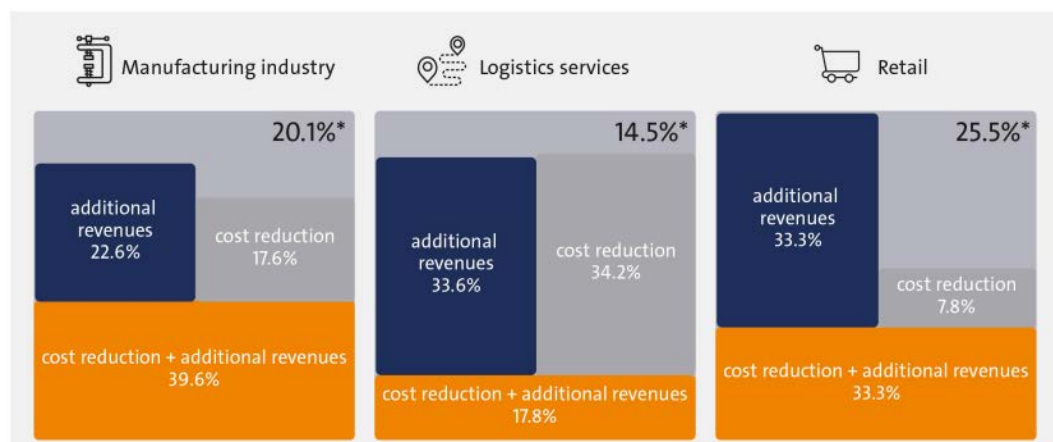
The use of digital technologies has become commonplace in almost all industries in the past few years. Organizational structures, management concepts, products, services and processes are frequently transformed in this process (Matt et al., 2015). Through the implementation and use of digital technology, digital transformation causes radical changes to traditional business practices (Dehning et al., 2003). DT goes beyond changes in business processes and enables new types of organizations to be create. Aside from this, DT also changes the culture of the

organization, the relationships, the value creation process, as well as the reach and position of the company on the market (Lucas et al., 2013; Tijan et al., 2021).

An organization in the process of digital transformation intends to respond to the changing environment in which it operates by implementing technological innovations that will transform the way it does business, its processes, and its relationships (Dehning et al., 2003). Businesses are experiencing changes in their business models, in their value creation, delivery, and capture processes (Pucihar, 2020).

Moreover, logistics and supply chain get benefits from the expected impact of the Industry 4.0 (or digital transformation) and its characteristics. Lehmacher et al. (2017) conducted a study to examine the impact of digitalization on supply chains and logistics. Figure 14 shows the how digital transformation is expected to affect companies' cost situation. Thus, the research revealed that the digitalization transformation will reduce overall costs by 17.6% and 34.2% in the manufacturing and logistics sectors, respectively. Furthermore, retail business operating costs will be reduced by 7.8%. Besides, the manufacturing sector, logistics services sector, and the retail business, are the three sectors that benefit the most when it comes to revenue streams, with increases of 22.6%, 33.6%, and 33.3%, respectively, with the manufacturing sector increasing the most.

Figure 14: Digital Transformation's Impact on Company Costs and Revenues

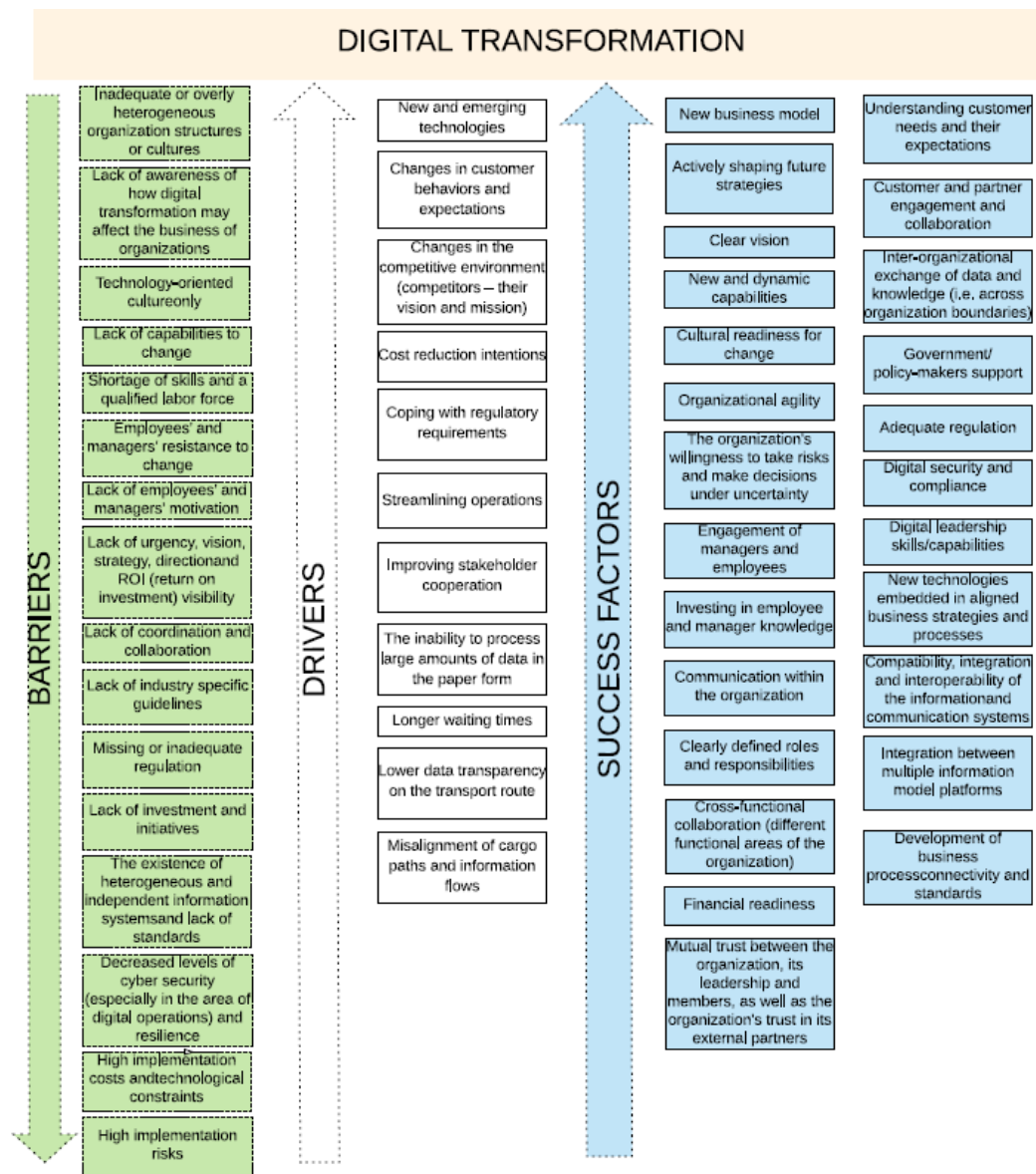


Source: Lehmacher et al. (2017: 5)

Furthermore, Tijan and coworkers reviewed the literature in order to determine the drivers, success factors, and barriers to digital transformation in the maritime transport industry. Researchers have identified 139 sources and based on the literature review, they found 16 digital transformation barriers, 11 drivers of digitalization and 25 success factors of digitalization. These all the drivers, success factors, and barriers to digital transformation in the maritime transport industry can be seen in the Figure 15.



Figure 15: Digital Transformation in Maritime Transport: Drivers, Success Factors, and Barriers



Source: Tijan et al. (2021: 11).

Moreover, researchers categorized the drivers under the three themes which are organizational (3 drivers), technological (3 drivers), and external environmental (5 drivers). There are three key drivers identified: new and emerging technologies, changes in customer expectations and behaviors, and the competitive environment. New digital technologies (ex: IoT, big data, blockchain) have radically changed the

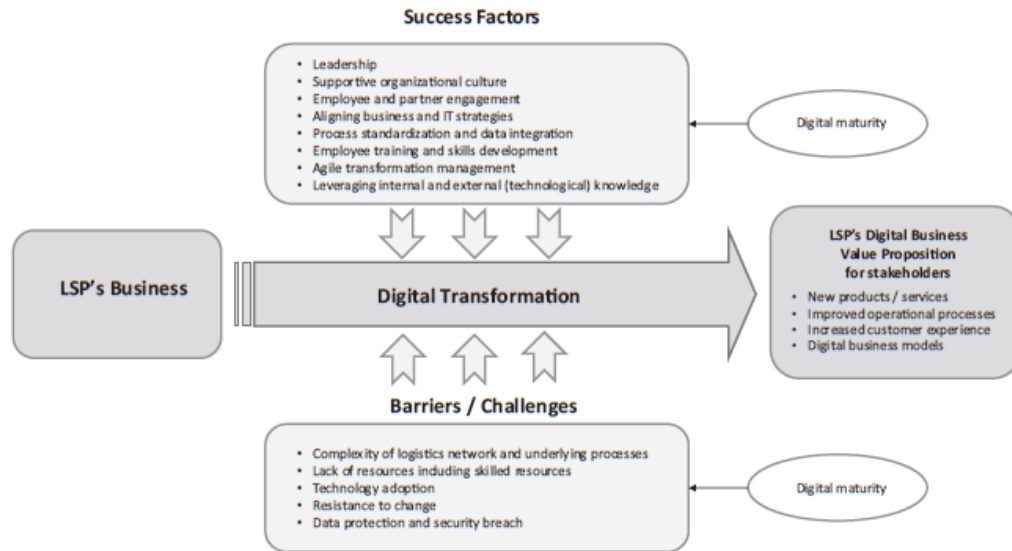
competitive landscape and customer expectations in the maritime transport sector (Verhoef et al., 2019).

Besides, three groups of success factors have been identified in this study: organization-related success factors, environmental success factors, and technology success factors. New business models, clear vision and new and dynamic capabilities are the some of the organization-related success factors. “Smart ports” can be example of new business model and the operation and transportation of seaports are closely interconnected through various digital networks in smart ports (Jović, 2019). An important part of digital transformation success is clear vision. Maritime transport organizations need to put in digitalization in their vision. (Larjovuori et al., 2018). As employees' knowledge and incentives influence the organizational agility of companies, senior managers in maritime transport organizations must effectively motivate and encourage them (Mohammad and Mollaei, 2014)

In addition, researchers identified 16 barriers that categorized as organizational (10 barriers), technological (2 barriers), and external environmental (2 barriers). Heterogeneous organizational structures and the lack of cultural integration have been identified as barriers. Having a weak organizational culture affects performance and productivity negatively (Tijen et al., 2021).

Furthermore, Cichosz and coworkers conducted a literature review to examine the barriers and success factors for digital transformation success at logistics service providers. They identified 5 core barriers which are complexity of the logistics system and underlying processes, lack of resources including skilled resources, technology adoption, resistance to change and data protection. Moreover, the study revealed 8 success factors which are leadership, supportive organizational culture, employee and partner engagement, aligning business and IT strategies, process standardization and data integration, employee training and skills development, agile transformation management and leveraging internal and external (technological) knowledge. These all barriers and success factors shows in the Figure 16.

Figure 16: Success Factors and Barriers of Logistics Service Providers



Source: Cichosz et al. (2020:220)

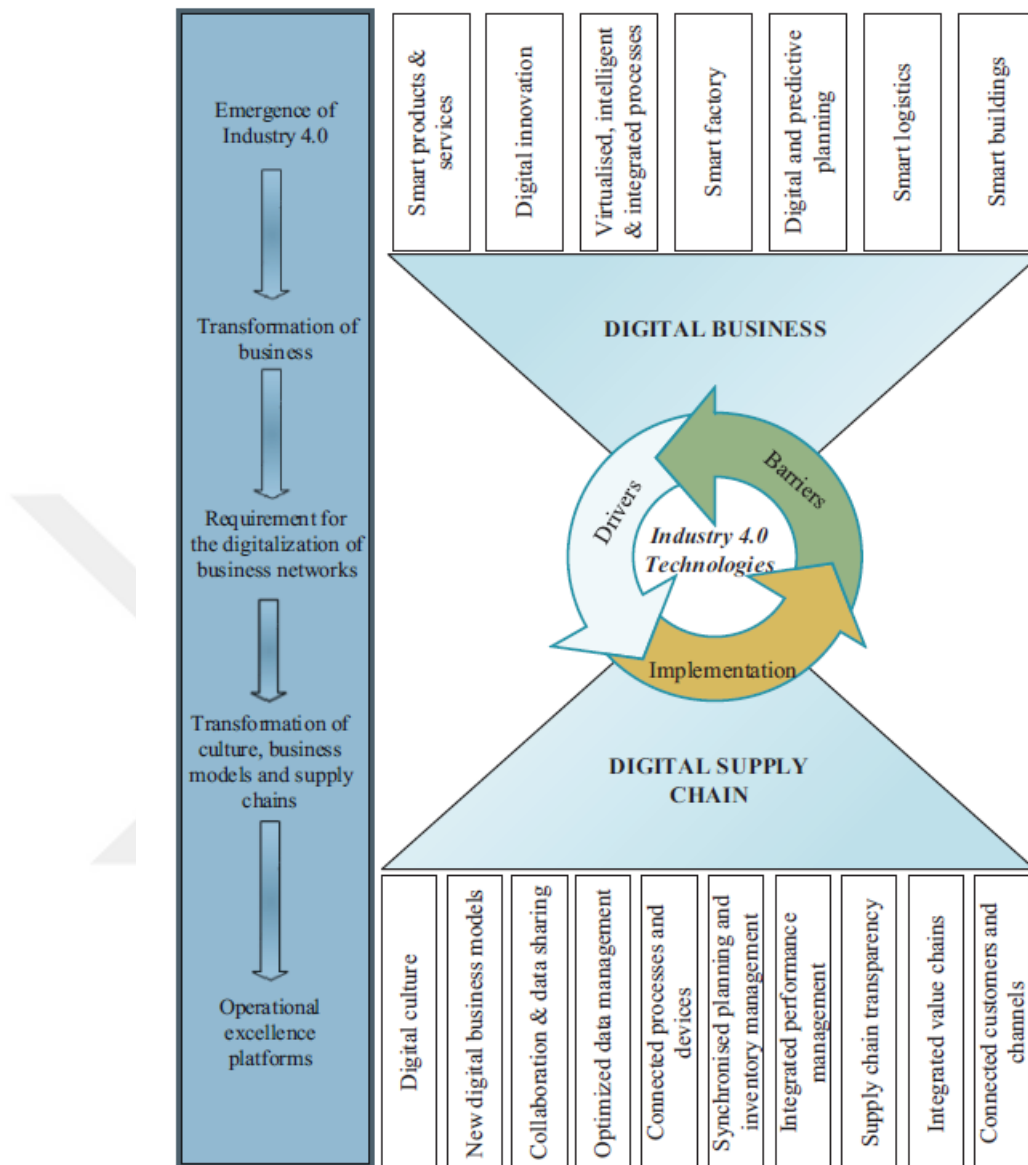
Aside from these contributions to the literature on the field of digital transformation, the researchers also provide a list of success factors that are crucial to DT's success that synthesizes and expands previous findings in the field. The list of success factors and leading practises of logistics service providers can be seen in the Table 2.

Table 2: Success Factors and Leading Practises of Logistics Service Providers

Success factors	Associated leading practices
Leadership	(1) Leaders monitor market trends, seize technological opportunities and translate them into business opportunities (2) Leaders develop and communicate the DT vision (3) Leaders inspire and motivate employees to be part of the DT (4) Leaders shape supportive organizational culture for the DT (5) Leaders empower employees and cascade DT decisions down (6) Leaders, supported by system and procedures, execute and govern the DT
Supportive organizational culture	(1) Communicating and sharing company's norms, values, beliefs and attitudes via meetings, presentations and workshops (2) Creating a supportive work environment with trust, empowerment (3) Building agile organization structure via project management, fluid teams, flexible processes, people's openness to collaboration and change (4) Bottom-up initiatives proactively improving processes and services (5) "Questioning attitude" of employees (6) Acceptance for mistakes
Employee and partner engagement	(1) Programs communicating DT vision and goals (2) Programs to get the right level of management sponsorship (3) Programs to bring-in new ideas (4) Programs encouraging cross-boundaries collaboration (5) Workshops building strengthening "growth mindset"
Aligning business and IT strategies	(1) DT vision and goals as a part of digital business strategy (2) Pursuing aligning actions to reconfigure resources and redefine the strategy (3) "Dynamic synchronization" of business and IT strategies and resources (4) Building agile organization for fast adaptation to changing environment (5) Communicating aligned strategy to the public in a comprehensive way
Process standardization and data integration	(1) PMO – Project Management and Organization (2) Lean management (3) Simplification and standardization programs (4) Best Practice Library (5) Establishing KPIs (6) Real-time data and applications integration
Employee training and skills development	(1) Workshops building digital awareness and enhancing digital skills (2) Workshops strengthening "growth mindset" (3) "Training the trainer" programs (4) Developing business cases to present reference practices (5) Creating environment for "on-the-job" learning
Agile transformation management	(1) Building agile organization for fast adaptation to changing environment (2) Small cross-functional teams (3) Iteration during innovation development process (4) Communication and collaboration with clients (5) Pilot projects for checking barriers and gaining know-how in innovation (6) Mixing methods if applying only agile method is impossible
Leveraging internal and external (technological) knowledge	(1) Using big data repositories as a source of knowledge (2) Programs stimulating collaboration with technological suppliers (3) Programs stimulating collaboration with startups, e.g. corporate accelerators, speed-dating summits (4) Pilot projects for checking barriers and gaining know-how in innovation

Source: Cichosz et al. (2020:220)

Figure 17: Industry 4.0 Implementation in Supply Chains



Source: Ghadge et al. (2020: 681)

Moreover, Ghadge et al. (2020) made a study to examine the impact of digital transformation on supply chains and create a framework by considering potential drivers and barriers of digital transformation. They found 10 drivers for the adoption of Industry 4.0 (digitalization) in supply chains which are; reduction of monotonous work, reduction of environmental impact, increased efficiency, cost reduction, higher quality, agility, load balancing and stock reduction, new value offers for enhanced competitiveness, new business models and transparency. Furthermore, the researchers

identified 16 barriers which are lack of management support, lack of digital vision and strategy, financial constraints, lack of expertise, resistance to change, complex network systems, problems related with coordination and collaboration, legal issues, data privacy and security issues, profiling and complexity issues, unclear economic benefits, lack of digital culture, lack of policies and support from the government, lack of research and development, poor data quality and management and lack of digital infrastructure. Furthermore, the authors listed ten important components of Industry 4.0. These components and the digital supply chain triangle can be seen in the Figure 17.

Finally, supply chains and logistics were transformed by Industry 4.0. As the industry continues to undergo digital transformation, new opportunities for innovative business models are being created as well. In the manufacturing and logistics industries, the majority of companies see positive outcomes from digital transformation (79.9% and 85.5%, respectively) (Lehmacher et al. (2017: 5). For example, Logistic 4.0 improves labor efficiency and standardize supply chain management through labor savings. In addition, throughout the supply chain and logistic operation, the Internet of Things and big data usage greatly reduce the amount of work people have to perform (Wang, 2016:69). As a result of new technologies such as automated guide vehicles and warehouse robots, people are no longer needed to handle operations or make decisions.

Besides, by using blockchain technology in logistics and supply chains, companies can ensure their data is protected and tracked, communicate with their partners and users more effectively, save money with smart contracts, and develop new business models (Radivojević and Milosavljević, 2019). As a result of logistics 4.0, products and services are more customized and intelligently integrated with smart technologies (Khan et al., 2022).

2.5. DIGITALIZATION PERFORMANCE OF LOGISTIC SECTOR

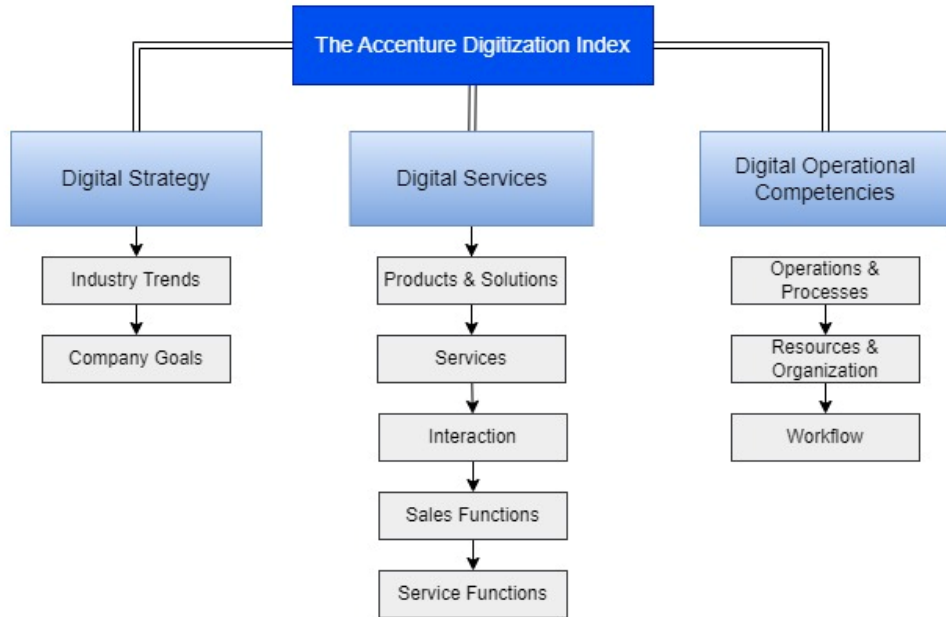
The progress of modern technology has brought about a new industrial revolution, which can be referred to as "Industry 4.0." (Kagermann et al. 2013). Logistics is being transformed by Industry 4.0 in response to its development and

requirements. Digital transformation has received increasing attention as a technology trend that is transforming society and business (Leviäkangas, 2016; Parviainen et al., 2017).

The right good, right quantity, right quality, right time, right place, right condition, right price are well-known requirements of logistics (Wang, 2016: 68). However, these requirements are becoming more and more difficult to meet in a constantly changing and uncertain logistic environment. Highly dynamic and uncertain logistic markets require new products, methods, and services. In order to satisfy logistic markets, new intelligent technologies must be integrated. Thus, new intelligent technologies helps logistic companies get benefits from the expected impact of the digital transformation and its characteristics. For example, digitalization transformation will reduce overall costs by 34.2% and increase total revenue by 33.6% in the logistics sectors (Lehmacher et al., 2017). However, most of the logistic firms are in the beginning phases of the digital transformation. Therefore, some of the studies and report are created to discover the digitalization index of countries and sectors.

In 2016, Accenture developed an indexing methodology that called as the Accenture Digitization Index to help companies identify where they are in their digitalization journey, analyze their digital capabilities. The Accenture Digitization Index examines the digitalization levels of companies under three main categories: Digital Strategy, Digital Services and Digital Operational Competencies. There are 10 different criteria under these three themes and when these three titles come together, the company's "digital maturity" profile emerges. These three main categories and 10 sub-criteria can be seen in the Figure 18.

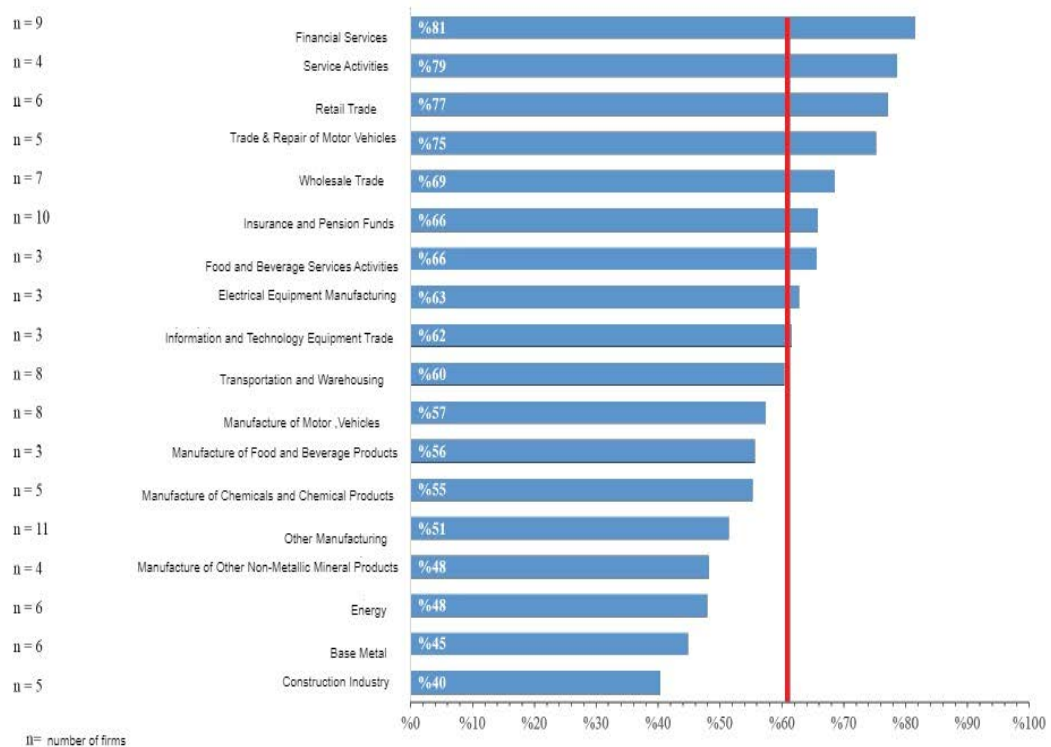
Figure 18: Components of the Accenture Digitization Index



Source: Accenture (2016: 10).

The study result showed that the average Accenture Digitization Index score of 106 companies in Turkey is 61%. The total score of 61 percent indicates that Turkey still has a long way to go in the field of digitalization. Moreover, companies participating in the Accenture Digitization Index study were grouped by sector and the digitalization index was calculated in these sectors. A total of 18 sectors were found and the digitization index of each sector is shown in the Figure 19. According to the results of this research, the sectors with the highest digitization scores were financial services, service activities, retail trade and the trade and repair of motor vehicles, respectively. The transportation and warehousing sector grade is 60, thus, the logistics industry has more steps to take to digitalize its processes.

Figure 19: Accenture Digitization Index Scores of Industries



Source: Accenture (2016: 12).

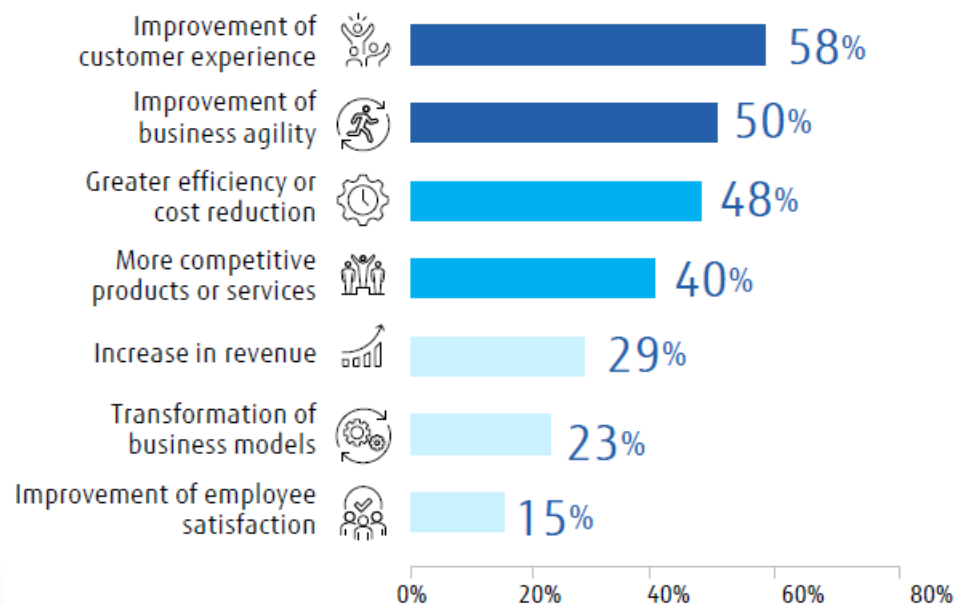
The Fujitsu Group also conducted a survey across 15 countries in 2017 to assess businesses' responses to the digital transformation process. Based on the results of this study, nearly 90% of businesses are working on multiple digital transformation projects in different stages: some are planning, some are testing, and some are implementing phases. Furthermore, some of these digital initiatives are already yielding positive results. (Fujitsu, 2017: 3). Revenues of firms increased by 46%, customer relationships improved by 44% as a result of their digital transformation projects. Other outcomes included improving efficiency, reducing costs, strengthening product competitiveness, and transforming business models and processes.

Furthermore, in 2021, Fujitsu conducted another survey and approximately 1,200 business leaders from nine countries participated in Fujitsu's survey. Purpose of this survey to examined how organizations respond to the pandemic and what kind of digital features are crucial to effective response to the changes that the pandemic

caused. The results showed that revenues of the half of the organizations that provide products and services completely offline or partially online decreased. On the other hand, the firms provide products and services purely online increased their revenues.

Moreover, the results show that agility, digitalization and employee well-being helped the organizations respond the pandemic effectively. According to a survey, 82% of organizations have accelerated digital transformation as a result of the pandemic. Besides, the research found that digital transformation requires six organizational capabilities which are leadership, culture of agility, data value, ecosystem, business integration and empowered people. In addition, the report revealed the positive outcomes of the digital transformation, these outcomes are shown in the Figure 20.

Figure 20: Results of Digital Transformation



Source: Fujitsu (2021: 10).

Additionally, DMCC (2021) published a report to evaluate the future of trade with focusing on trade growth, the digitalization of trade and trade finance and infrastructure. This report recommends the company to increase investment in digital technologies to deal with the post-pandemic impacts.

Therefore, the digital transformation and pandemic are not only affecting just one sector, but all sectors are also affected, and the logistic industry is one of them. However, the logistics industry has more steps to take to digitalize its processes.



CHAPTER THREE

METHODOLOGICAL FRAMEWORK

3.1. AIM OF THE RESEARCH

Digital transformation is clearly a part of our future, based on literature and feedback from practitioners (Fujitsu, 2017: 3; Fujitsu, 2021; DMCC, 2021; Holzhauser and Schalla, 2017; Kessler et al., 2022; Machado et al., 2021). The concept of digital transformation has been embraced by companies in all sectors in recent years (Kessler et al., 2022; Cichosz et al., 2020). The digital transformation of businesses is the way to go. It is essential that companies adapt to the rapid advances in technology, not just to take advantage of the opportunities it offers but even to remain relevant in this volatile, uncertain, complicated, and ambiguous environment.

In 2016, Accenture conducted a study to determine the digitalization index of Turkey, and the average digitalization grade of the 18 sectors was 61 out of 100. According to the report, the transportation and warehousing sector scored a 60. Moreover, the Digitalisierungsindex Mittelstand 2021/2022“ (Digitalization Index for SMEs) identified the logistic sector as a leading pioneer with a score of 65%, well above the index average of 59% (Deutsche Telekom, 2022). As a result, the logistics industry still has a long way to go in digitalization. Moreover, many logistics companies are still in the early stage of implementing digital technologies in their process, and there is not enough information about how companies are adopting digital technologies successfully (Bley et al., 2016; Moeuf et al., 2018; Van den Bossche, 2016). Therefore, this study's objective is threefold:

(1) analyzing the existing knowledge on the obstacles logistic firms face in adopting digitalization in their operation process in depth and generating comprehensive barrier classifications by theme.

(2) identifying important digitalization barriers that firms face operating in Türkiye with taking care of cultural, economic, political, geographical, etc. factors

(3) determining weights of the digitalization barriers to Türkiye logistic operation and prioritizing them

3.2. SIGNIFICANCE OF THE RESEARCH

Advancements in new technologies, information, and communication systems such as the internet of things, artificial intelligence, cyber-physical systems, and reduction of technology costs (Monostori et al., 2016; Thoben et al., 2017) have caused an explosion in the digitalization of the system. Moreover, the successful implementation of digital technologies in systems has brought various benefits to logistic firms enhancing production performance (Buer et al., 2020) while protecting competitive advantage (Liao et al., 2017), optimizing information flow (Hoellthaler et al., 2019), and enhance the agility ability to manufacture systems through the flexibility of systems (Kagermann et al., 2013; Rüßmann et al., 2015). Thus, logistic companies must deploy digital technologies in operations to stay ahead of the competition. However, it is unknown how companies are adopting digital technologies successfully, as many logistic companies are still in the early stages of implementing digital technologies (Bley et al., 2016; Moeuf et al., 2018; Van den Bossche, 2016). Moreover, a serious lack of research and scientific papers examining the barriers to digitalization in the logistics sector. While there are numerous publications available on digitalization, there are still gaps in the knowledge of the digitalization barriers faced by logistic companies and how companies can navigate the digital transformation journey effectively. Moreover, as logistics companies seek guidance regarding preparing and organizing themselves to implement Industry 4.0 principles, they are unprepared for the changes and opportunities that digital transformation will bring.

Thus, this thesis aims to fill this research gap and provide a better understanding of digitalization barriers in the logistics sector. One contribution of this thesis is identifying digitalization barriers in the logistics sector by conducting a comprehensive literature review. Therefore, firms can be aware of logistics' digitalization barriers and evaluate them.

The second contribution of this thesis is identifying digitalization barriers to Türkiye logistic operation. Digitalization barriers are determined based on the systematic literature review. However, these barriers should be adapted to Türkiye conditions and learning which items are actual digitalization barriers or not. Hence, in

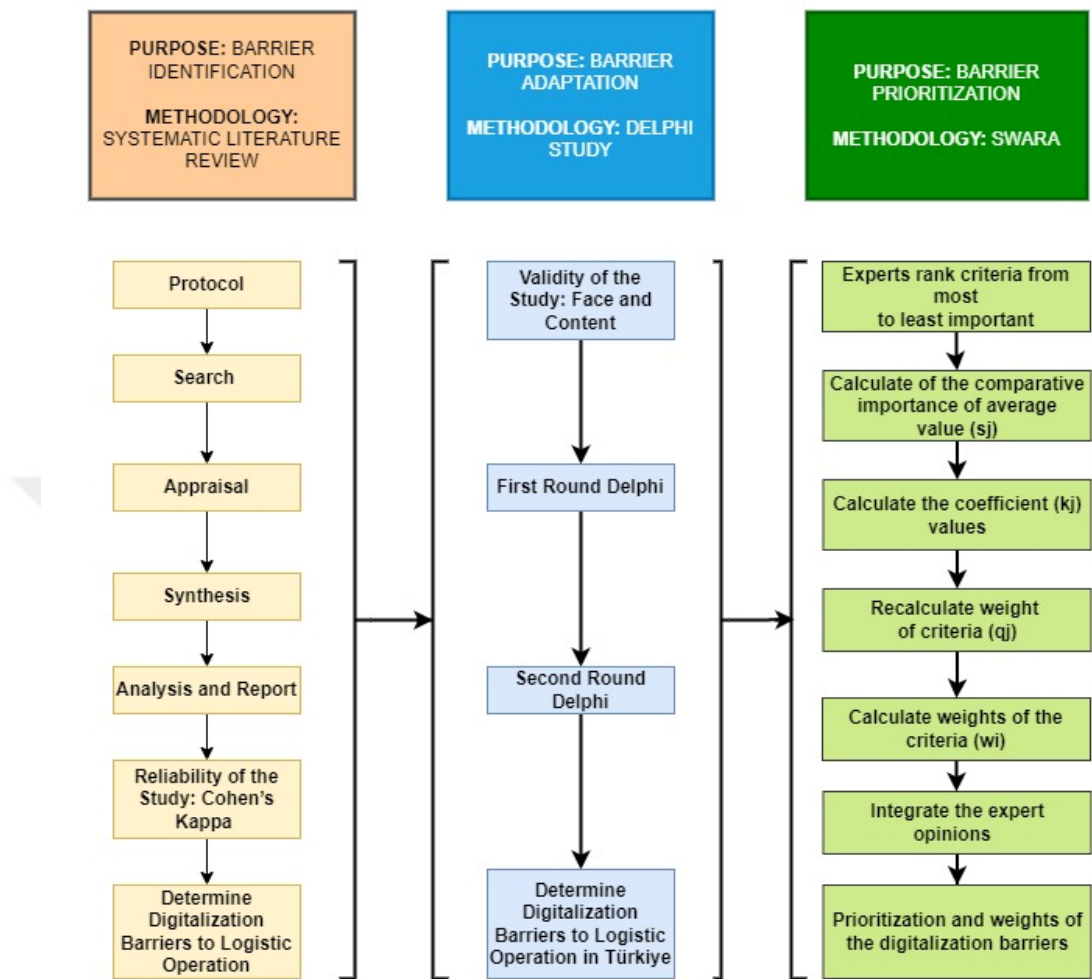
this thesis, the Delphi method eliminates unrelated items and determines real and important barriers for Türkiye. Thus, the logistic companies operating in Türkiye can have more detailed knowledge about how they will adopt digital technologies successfully.

The final contribution of this thesis is to rank each digitalization barrier and theme to Türkiye logistic operation and determine their weight values of them. Hence, the companies will gain knowledge of which barriers and themes are essential. Therefore, they can take steps to the invention and find solutions and strategies to overcome them.

3.3. THE METHODOLOGY OF THE RESEARCH

This study's approach is based on SLR, Delphi, and SWARA methods with a focus group of logistic industry experts. The main motive behind selecting three methodologies is identifying, evaluating, and prioritizing digitalization barriers for logistic companies in Türkiye. The research purposes, methodologies, and application steps applied to this work are illustrated in Figure 21.

Figure 21: Purposes, Methodologies and Application Steps of the Study



Source: Author's own compilation

The systematic literature review was selected as the first methodology to analyze the knowledge of barriers logistic firms face in adopting digitalization in their operation process in depth and to generate comprehensive barrier classifications based on the theme. Besides, the Delphi method is applied as a second methodology to identify digitalization barriers to logistic operation in Türkiye. Lastly, the SWARA methodology was used to rank each digitalization barriers and determine their weight values of them.

Meaning, steps, and methods of the systematic literature review, Delphi, and SWARA are explained in the following headings 3.4 (Systematic literature review),

3.5 (Delphi method), and 3.6 (SWARA). Application phases of this thesis are explained under “Chapter Four” and “Chapter Five.”

3.4. SYSTEMATIC LITERATURE REVIEW

When examining the literature, it is seen that there are three different ways to conduct review studies; these are traditional (narrative) review, systematic review, and meta-analysis.

The first review type is a traditional review generally made by relevant experts who examine two or more studies published on a topic without following a specific method (Karaçam, 2013). However, this review is not accepted as a scientific method because results can be subjective and cannot be reproducible, the literature review may not be sufficiently done, the criteria for the selection of the literature are not clear, and the method used in the review is not defined. Thus, the study's results can be accepted as an "expert opinion." (Burns and Grove, 2009; Hemingway and Brereton, 2009; Karaçam, 2013).

The second type of review is a systematic review, which is a comprehensive search of all the studies published on a specific topic using various inclusion and exclusion criteria considering the quality of the studies to answer a question or create a solution to a problem. In this review, researchers use specific and scientific criteria to determine which studies to include in the reviews and synthesize the studies' findings. Moreover, it is accepted as a scientific method because the results are objective, and the literature review is much more comprehensive than a specific method. Furthermore, the methods used for the literature review and the criteria used in selecting the studies are clearly defined in the study, the quality of the studies included in the review is evaluated, and other researchers can repeat the results (Fink, 2005; Burns and Grove, 2007; Moule and Goodman, 2009; Okoli and Schabram, 2010).

A meta-analysis, the last type of review, is a statistical method used to combine the findings of studies included in the systematic review. In the meta-analysis, statistical analysis of the research findings is obtained by combining the findings of more than one independent study on a specific topic. Meta-analysis cannot be done for

all systematic reviews. In order to obtain accurate results from the meta-analysis, the researchers should take care of these situations; meta-analysis should be done after systematic review, low-quality research, studies done in very different periods, and studies whose results are not adequately presented should not be included in the meta-analysis, the heterogeneity of the studies should not be ignored, and there should be no bias in the selection of the studies (Rosenthal and DiMatteo; 2001; Karaçam, 2013; Pezeshkanet et al., 2016; Kim and Peterson, 2017; Paul and Mas, 2020; Dhaliwal et al., 2020).

Systematic literature review methodology is firstly developed and used by Tranfield et al. (2003). Fink (2005) specifies a literature review as

“a systematic, explicit, and reproducible method for identifying, evaluating and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners. (Fink, 2005)”

Moreover, researchers can conduct a literature review to explore the theoretical background of the research topic, to learn the explanation of practical questions or to understand the breadth of the research subject (Okoli and Schabram, 2010; p. 1).

A systematic literature review comprises an organized, reproducible, and structured method for identifying, evaluating and interpreting academic research on a particular topic (Fink 2014). This approach aims to bring together as many relevant studies as possible, regardless of where they were published or their disciplinary background (Thorpe et al., 2004: 258; Rhoades, 2011; Mengist et al., 2020). This review approach provides transparency by maintaining a record of researchers' decisions, procedures, and conclusions (Tranfield et al., 2003). So that readers can judge the suitability of the studies included and the robustness of the conclusion (Denyer and Neely, 2004; Tranfield et al., 2003).

In recent years, there has been a marked increase in the number of systematic review studies in the literature because these kind of studies are made based on objective and evidence-based scientific knowledge instead of being based on knowledge, experience, and priorities. For example, Pereira and Romero (2017) investigated the meaning of Industry 4.0 and clarified the importance and implications of this new technological system. The researchers selected ISI Web of Knowledge, Elsevier (Science Direct), Scopus, Emerald Insight and Springer databases to find

relevant articles. They found four key areas addressing the future manufacturing vision; smart products, business models, smart factories and customers. Furthermore, end of the study, Cyber-Physical Systems, Internet of Things and Internet of Services were determined as key technologies enablers for industry 4.0.

Moreover, Liao et al. (2017) used a systematic literature review methodology to investigate the enabling features of Industry 4.0, the main research directions and current research on the topic, which researchers are working on and the existing Industry 4.0 application fields. Additionally, Kamble and colleagues (2018) published an article to explore current research on Industry 4.0 topics and find out what various research methods are used in Industry 4.0 topics. This research used a systematic literature review methodology to analyze eight-five articles. Results showed that the sustainable industry 4.0 framework has three primary components: process integration, industry 4.0 technologies and sustainable results. Furthermore, Luthra and Mangla (2018) identified key challenges in implementing Industry 4.0 initiatives for sustainable supply chains by applying a literature review methodology. This study revealed 18 key challenges and later categorized them under the four groups based on explanatory factor analysis. This research revealed that the top challenge is organizational, followed by technological, strategic, and legal and ethical challenges.

Agrawal et al. (2015) focused on the reverse logistic topic to provide a comprehensive review of the topic. The authors selected 242 published papers, then categorized and analyzed them to found out gaps in the reverse logistic literature and provide guidance for future research. In conclusion, implementing legislation, environmental concerns, corporate imaging, sustainable competitiveness, and economic benefits were necessary for companies to adopt reverse logistics practices.

Research by Smith et al. (2008) investigated elements influencing corporate innovation management. They examined more than 100 papers using a systematic literature review method and identified nine key elements: resources, management style and leadership, corporate strategy, organizational structure, employees and innovation process, knowledge management, and technology.

Furthermore, Sandberg and Aarikka-Stenroos used a systematic literature review method to find radical innovation barriers. Another study on innovation made by Ratajczak and Szutowski (2016). They focused on summarizing the relationship

between a firm's corporate social responsibility and its innovation performance using Search, Appraisal, Synthesis, Analysis (SALSA), and backward-snowballing methods. This research found that innovation performance is assumed to be influenced by CSR, and inversely, CSR is assumed to influence innovation performance. However, many aspects of the relationship were not scientifically agreed upon.

Besides that, systematic literature review methodology is mostly preferred by researchers to conduct a study about operation management topics. For example, Paschou et al. (2020) focused on digital servitization in the manufacturing concept. Firstly, they defined the digital servitization phenomenon and later examined how digital technology promotes servitization. Furthermore, Abdirad and Krishnan (2021) examined the current literature about Industry 4.0 based on the supply chain management perspective by applying a systematic literature review method.

Additionally, Verma et al. (2022) focused on identifying and prioritizing the barriers to sustainable digital manufacturing in the era of industry 4.0. The authors used mixed methods. Firstly, they used a systematic literature review method to reveal all barriers and 30 various impediments found. Secondly, the researchers used Analytical Hierarchy Process (AHP) to prioritize and categorize the barriers. The study categorized barriers under six dimensions which are; organizational, environmental, technological, economic, societal, and institutional. Moreover, Ali and Phan (2022) preferred to use the systematic literature review method to explore current literature about the various Industry 4.0 technologies and sustainable warehousing and focus on research and methodology of studies to reveal research gaps in the topic.

3.4.1. Data Collection Process and Tool: PSALSAR Review Framework

The systematic literature review approach differs from traditional narrative reviews because, firstly, it maps relevant literature that fits pre-defined inclusion criteria and figures out potential gaps in the specific research question. Secondly, multiple quantitative and qualitative studies have been produced due to this review approach (Mengist et al., 2020; Verma et al., 2022; Tranfield et al., 2003). Thirdly, this method is reproducible, scientific, and transparent. Fourthly, this review approach minimizes bias when searching, identifying, assessing, summarizing, analyzing, and

synthesizing studies because it follows the specific review procedure (Mengist et al., 2020, Antman et al., 1992; Verma et al., 2022; Oxman & Guyatt, 1993; Tranfield et al., 2003; del Amo et al., 2018).

The researchers must use a review framework to reach reproducible, scientific, and transparent results for systematic literature review. The Search, Appraisal, Synthesis, and Analysis (SALSA) framework is the most common and preferred methodology (Grant and Booth, 2009; Moher et al., 2009; Vicente-Saez and Martinez-Fuentes, 2018; Verma et al., 2022). Some of the researchers added Protocol and Reporting phases to the Search, Appraisal, Synthesis, and Analysis framework, which is called PSALSAR (Protocol, Search, Appraisal, Synthesis, Analysis, and Report) method to determine the search protocols to be followed by the systematic literature review and publish a report end of the study (Mengist et al., 2020; Del Amo et al., 2018; Verma et al., 2022). Figure 22 shows the PSALSAR method steps.

Figure 22: Systematic Literature Review Framework based on PSALSAR method

	Steps	Outcomes	Methods
PSALSAR Framework	Protocol	Defined study scope	Only the mountain ecosystem and its various ecosystem services
	Search	Define the search strategy	Searching strings
		Search studies	Search databases
	Appraisal	Selecting studies	Defining inclusion and exclusion criteria
		Quality assessment of studies	Quality criteria
	Synthesis	Extract data	Extraction template
		Categorize the data	Categorize the data on the iterative definition and ready it for further analysis work
	Analysis	Data analysis	Quantitative categories, description, and narrative analysis of the organized data
		Result and discussion	Based on the analysis, show the trends, identify gap and result comparison
	Report	Conclusion	Deriving conclusion and recommendation
		Report writing	PRISMA methodology
		Journal article production	Summarizing the report result for the larger public

Source: Mengist et al. (2020:3)

The protocol is the first stage of the systematic literature review process. In this stage, the researchers must carefully plan their literature review procedure and formulate a search technique before the start of to review. Therefore, the authors firstly establish a clear research question for the study, secondly, set explicit and reproducible

objectives, thirdly create searching string to include all studies relevant to the research, fourthly decide which databases are used by giving reasons for selecting these databases and lastly determine the other searching criteria by explaining reasons such as which document type, subject area, and index are selected and why.

Search is the second phase of the systematic literature review methodology. In this phase, the selected databases are searched using various combinations of the terms, determined in a searching string by researchers to reach all studies relevant to the research objectives. Boolean operators (“AND” and “OR”) are the most popular and common use method (Kitchenham and Charters, 2007; Maphosa and Maphosa, 2020; Ratajczak and Szutowski, 2016). The researchers use “AND” to combine the keywords and “OR” to join the identified keywords. Later, researchers filter the delivered documents based on the document types, subject area, index, and other criteria determined in the search protocol.

The appraisal is the next phase of the review process and is divided into two parts: a technical and substantial appraisal. In the technical step, researchers eliminate the duplicates and papers written in various languages (for example: if the researchers decided to include studies published in English, they delete the papers written non-English language). In the substantial step, the researchers perform three different siftings (title, abstract and full text) to determine related studies. Firstly, writers read all the titles of the papers to eliminate researches that are not related to their research objectives, secondly, the abstract of the remaining papers are read and evaluated by the writers to find papers that really concentrate on the research objectives, and lastly, after eliminated unrelated papers, the full text of the remaining papers are read and reached the final publications that are a valuable information source for the researchers (Ratajczak and Szutowski, 2016; Armitage and Keeble-Allen, 2008; Luthra and Mangla, 2018; Bridges et al., 2020)

The fourth phase is Synthesis, and this procedure involves extracting and categorizing certain content from chosen publications into extracted knowledge and conclusions. Thus, this process involved extracting and classifying data from chosen publications. The data extraction method entailed identifying and extracting data relevant to the research objectives from the selected publications. The coder extracts information from the selected published papers using the provided criteria. Moreover,

the general characteristics and the specific parameters of the selected publications, such as years of publication, the focus of study, and analysis types, are assessed (Verma et al., 2022; Mengist et al., 2020; Ratajczak and Szutowski, 2016).

The Analysis is the next stage of the PSALSAR method. As part of the analysis phase, the synthesized data and selected articles are evaluated, meaningful information is extracted, and concluding the selected publications. In this phase, researchers would have answers to the research questions they had formulated earlier. Moreover, the analysis stage includes qualitative and quantitative explanations of the results, a discussion, upcoming research directions, and conclusions. Based on the final list of selected articles, the researchers use descriptive and inferential statistics to summarize the data (Mengist et al., 2020; Verma et al., 2022; Shelby and Vaske, 2008; Maphosa and Maphosa, 2020).

The Report phase is the last phase of the PSALSAR method. In this stage, the researchers explain the methods they followed and present results from the selected literature (Mengist et al., 2020; Verma et al., 2022). The report phase involves two steps; the first is to describe the procedure followed, and the second is to publish the results as a journal article, thesis so on (Del Amo et al., 2018).

3.5. DELPHI METHOD

Delphi is a qualitative method that gathers expert opinions to obtain a reliable group opinion (Dalkey and Helmer, 1963; Landeta et al., 2011; Parente et al., 1984). RAND Corporation researcher Norman Dalkey developed the Delphi method as part of a US-sponsored military project in the 1950s (Eggers and Jones, 1998; Franklin and Hart, 2007; Skulmoski et al., 2007).

The Delphi method can be used when there are no prior research and knowledge, when there is no agreement, when ideas must be generated, facts must be established, or decisions must be reached and consensus reached on a broad subject (Delbecq et al., 1975: 83; Powell, 2003: 379; Landeta et al., 2011: 1630). As part of its process, the anonymous experts conduct a number of questionnaire rounds to reach a consensus on the topic (Rodriguez-Mañas, et al., 2012). The Delphi method is therefore ideal for enhancing the overall understanding of multifaceted problems, as

well as for solving problems that require multiple solutions (Skinner et al., 2015: 35; Şahin, 2001: 216).

The method is characterized by five key features: expert, panel, anonymity, rounds, iteration, and controlled feedback. The use of experts is the first feature of the Delphi study. Experts have technical knowledge in their field and also understand the connection between present and future developments (Lilja et al., 2011; Skinner et al., 2015: 33). Moreover, using heterogeneous experts is recommended by Rowe and Wright (2001). The panel is the second feature of this method, and there should be no limit to the size of the panel of selected experts. However, most authors recommend smaller group size, and in most cases, the panel consists of 10 to 30 experts (Delbecq et al., 1975; Keil et al., 2002: 106; Daniel and White, 2005; Worrell et al., 2013: 198). The next characteristic of this study is anonymity. This characteristic of anonymity helps panelists maintain independence by preventing the effect of their official position status on others' opinions, expression problems, loss of face fears, or attitudes that might be inappropriate to express publicly.

Furthermore, it protects panelists from competing with each other by removing the potential for mimicry. In this way, objective answers and results are guaranteed (Lilja et al., 2011; Skinner et al., 2015: 33). Fourth characteristic of the Delphi study rounds. In the data collection period, there is a series of rounds, and data collection rounds finish when all experts receive a consensus about the topic (Von der Gracht, 2012). Moreover, two rounds are recommended as a minimum (Bradley and Stewart, 2003: 275; Custer et al., 1999). Finally, the last feature of the Delphi study is iteration and controlled feedback. Opinions and answers of experts are collected and analyzed; later, the panelists receive feedback on the answers as a basis for comments and the next round. Each panelist must evaluate their choices based on the feedback, and the information is built round by round (Skinner et al., 2015: 33; Şahin, 2001).

Delphi Method has many advantages for the researchers, such as bringing various experts who live in different geographic locations together, consensus building between experts, and the limited time required for data collection. However, as with all studies, this study also has some disadvantages, such as group pressure for consensus can happen, participant commitment required for data collection, and may

lead to hasty. All advantages and disadvantages of the Delphi Method are explained by Hung et al. (2008: 192) and showed in Figure 23.

Figure 23: Advantages and Limitations of Delphi Method

Advantages/strengths	Limitations/weaknesses
Consensus-building	Group pressure for consensus—may not be true consensus
Future forecasting	Feedback mechanism may lead to conformity rather than consensus
Bring geographically dispersed panel experts together, overcoming spatial limitations	No accepted guidelines for determining consensus, sample size and sampling techniques
Anonymity and confidentiality of responses	Outcomes are perceptual at best
Limited time required for respondents to complete surveys	Requires time/participant commitment
Quiet, thoughtful consideration	Possible problems in developing initial questionnaire to start the process
Avoids direct confrontation of experts with one another (encourages honest opinion, free from group pressure)	May lead to hasty, ill-considered judgments
Structured/organized group communication process	Requires skill in written communication
Decreasing somewhat a tendency to follow the leader	Potential danger of bias—surveys are open to manipulation by researchers
Focused, avoids unnecessary side-tracking for panelists	Selection criteria for panel composition
Ties together the collective wisdom of participants	Time delays between rounds in data collection process
Possibly motivational and educational for participants	May force a middle-of-the-road consensus
Cost effective and flexible/adaptable	Concerns about the reliability of the technique
Validity, as the content is driven by panelists	Drop-outs, response rates
Fairly simple to use	
Beneficial for long-range educational planning and short-term decision making	
Applicable where there is uncertainty or imperfect knowledge, providing data where little exists before	
Best used as establishing the basis for future studies	
Accommodates a moderately large group	

Source: Hung et al. (2008: 192)

The researchers should consider whether Delphi is the most effective method for the study. In the evaluation phase, the researchers should check the advantages and disadvantages of the Delphi Method, explained in Figure 23. Moreover, they should consider the questions shown in Table 3 to assess whether their study is suitable for this study or not.

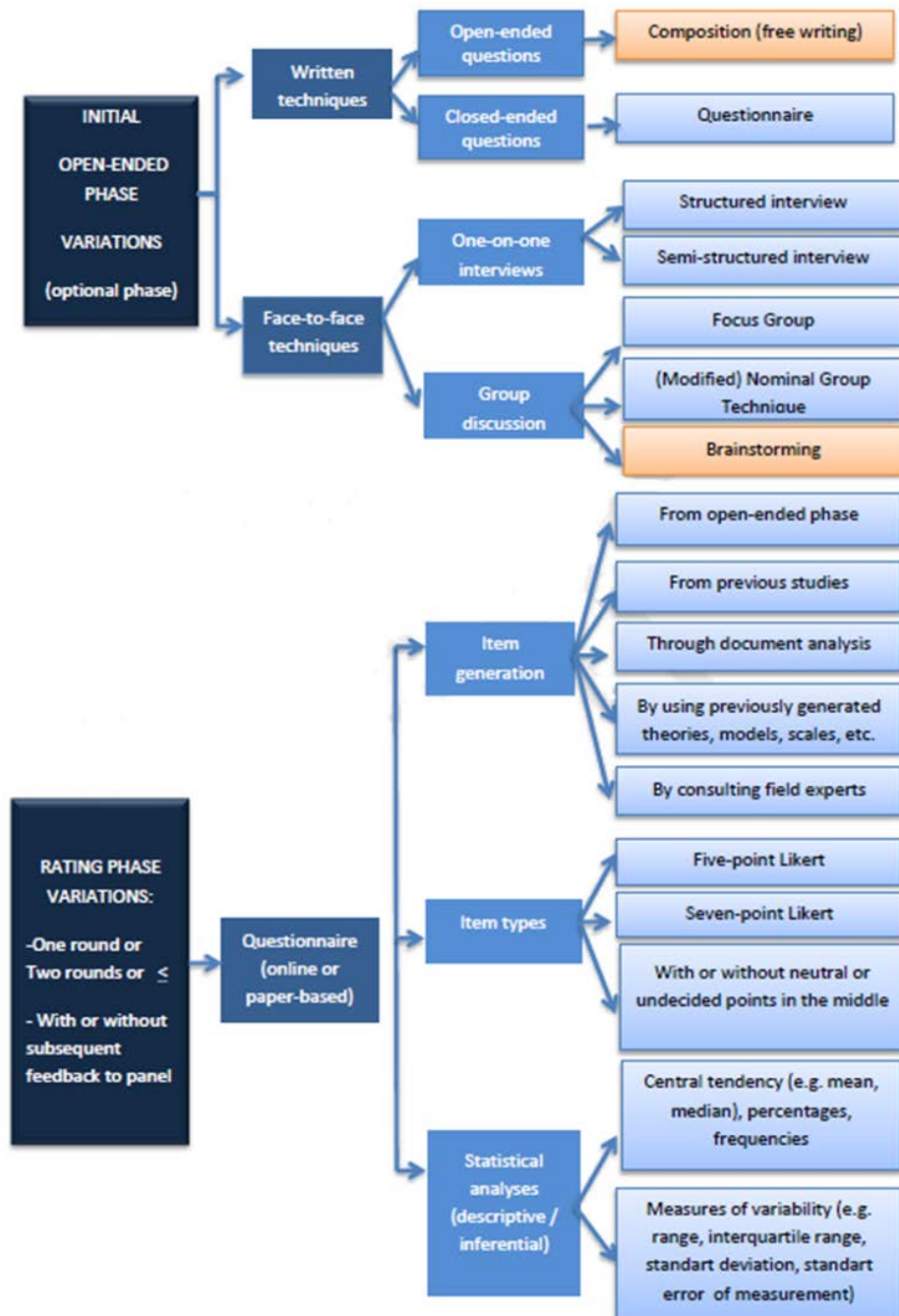
Table 3: Research Feasibility of Using the Delphi Method

-Is the phenomenon of interest able to be evaluated by a panel of experts?
-Are a sufficient (minimum) number of experts available to make up the panel?
-Is anonymous feedback from the panel of experts feasible?
-Are experts able to dedicate sufficient time to assess the phenomenon over multiple iterations of feedback and evaluation?
-In the absence of precise analytical techniques, is gathering subjective judgments moderated through group consensus the only approach possible?
-Is personal contact not possible due to time and cost constraints or is it not desirable due to concerns about the difficulty of ensuring democratic participation?

Source: Skinner et al. (2015:35).

After the researchers decide the Delphi Method is suitable for the study, they select experts and collect data and analyze them. An appropriate analysis technique depends on the collected data type, so qualitative and quantitative data may need to be considered when analyzing data. Unfortunately, there needs to be a consensus in the literature for data analysis. In Delphi method studies, Hasson et al. (2000) suggest that central tendency, standard deviation, and interquartile range are the most effective statistical techniques to assess the collective judgment of respondents. On the other hand, Lang (1994) recommends using a data median based on a Likert-type scale. Furthermore, Mullen (2003) offers Bayesian weighting to integrate the Delphi method replies, whereas Schmidt (1997) advises using Kendall's coefficient of concordance to evaluate the consensus level of the experts.

Figure 24: Variations in the application of Delphi method



Source: Keser, A. D. (2018: 35).

There are some variations in the application of the Delphi study. These variations are shown in Figure 24. There are two phases in Delphi; the first one is open-ended phases, and the second one is the rating phase. The open-ended phase is

optional for the researchers, and this phase can be excluded from the study. The open-ended phase collects experts' ideas about one topic or question, which is mostly preferred when research or theory needs to be revised. In the open-ended phase, there are two ways to collect ideas; written and face-to-face techniques. All detailed information about these two techniques is given in Figure 24. The rating phase is the second phase of the Delphi method. In this phase, researchers create a questionnaire and send items to experts for the vote to reach a consensus on them. In order to prove this consensus, the researchers usually use a quantitative methodology. In the rating phases, the researchers generate items and later decide which item types and statistical analyses are used.

3.6. SWARA

Kersulienė et al. (2010) proposed the Step-Wise Weight Assessment Ratio Analysis (SWARA). This method relies on experts' implicit knowledge, experience, and information (Kersulienė et al., 2010; Zolfani and Saparauskas, 2013). Thus, experts are crucial to this method's evaluations and weight calculations. Moreover, this method is not considered time-consuming or complicated (Zavadskas et al. 2011; Hashemkhani Zolfani et al. 2012).

The SWARA consists of five steps which are;

Step 1: Experts rank each evaluation criterion from most to least important. Thus, the most significant criteria are in the first spot, the least significant is in the last position, and the criteria in between are ranked in significance.

Step 2: Experts grade criteria based on the previous one to determine their relative importance levels. According to Kersulienė et al. (2010), this calculation is named “the comparative importance of average value (s_j).”

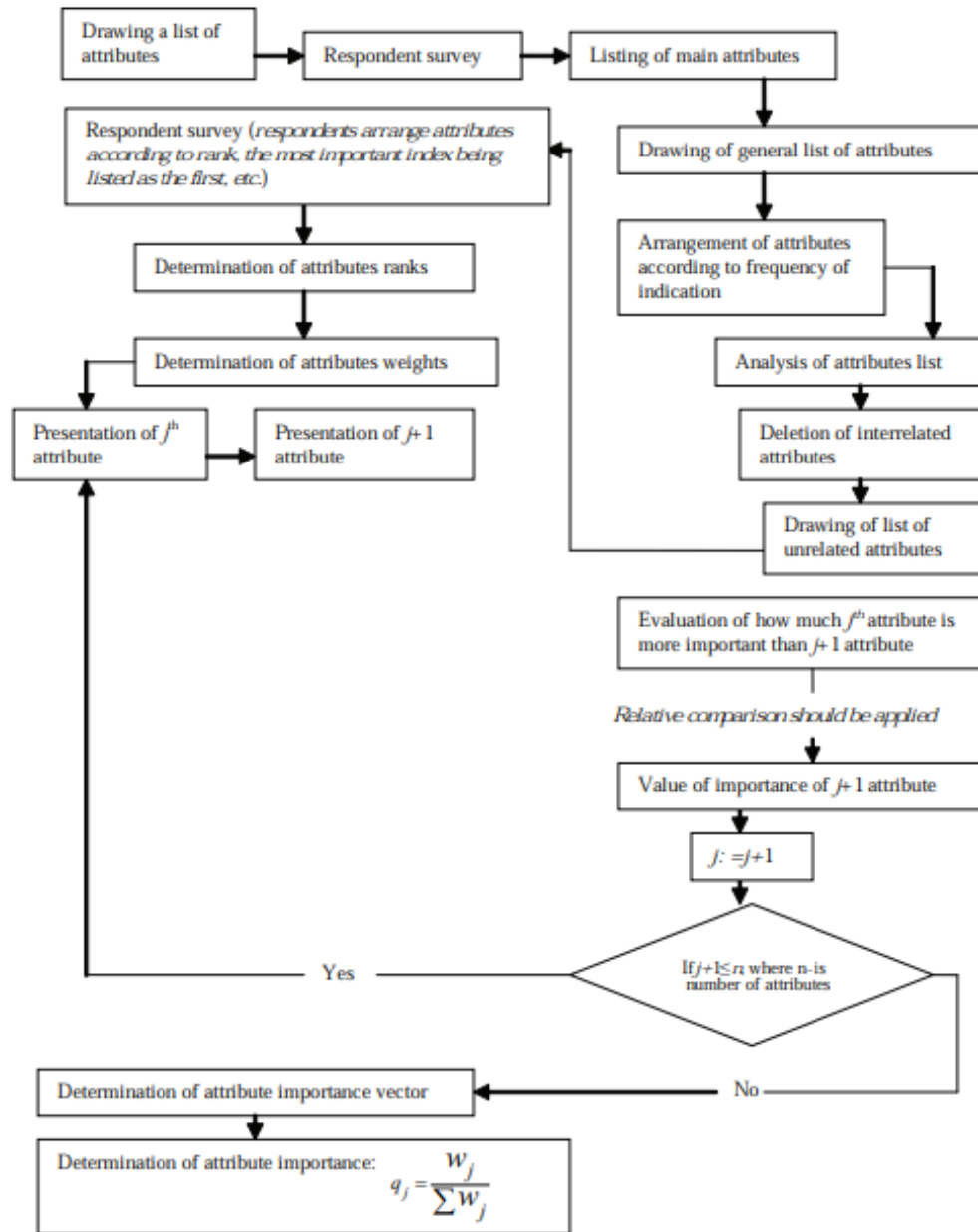
Step 3: The researcher calculate the coefficient (k_j) values.

Step 4: The researcher recalculated weight of criteria (q_j).

Step 5: Relative weights of the evaluation criteria (w_j) is calculated as last step by the researcher.

In conclusion, the final rankings are calculated by averages of the team of experts' evaluation. Figure 25 explains the process of determining the weights of the attributes in SWARA in detail.

Figure 25: The process of determining the weights of the attributes in SWARA



Source: Keršuliene et al. (2010: 250)

Even though SWARA is a newly proposed method, researchers highly prefer it and use it extensively. Some of the studies used the SWARA method presented in Table 4.

Table 4: SWARA Research Examples

Authors	Methods	Research Problem
Dehnavi et al. (2015)	SWARA and Adaptive Neuro-Fuzzy Inference System (ANFIS)	A new hybrid approach incorporating SWARA and ANFIS to assess landslide-prone areas has been proposed by the researchers.
Hashemkhani Zolfani and Bahrami (2014)	SWARA and Complex Proportional Assessment (COPRAS)	This study focuses on rank the high tech industries in Iran. The researchers use SWARA to evaluate and weight the criteris, while use COPRAS evaluate and weight the alternatives. The study result shows that Nano Technology and Biotechnology are the best two high tech industry to develop in Iran.
Jamali et al. (2015)	SWARA and The Complex Proportional Assessment of	The researchers use SWARA and COPRAS grey approaches to evaluate and analysis five

	Alternatives with Grey Relations (COPRAS-G)	advance manufacturing systems, and operating cost is found as the most important criterion.
Karabasevic et al. (2015)	SWARA and The Multi-Objective Optimization by Ratio Analysis plus Full Multiplicative Form (MULTIMOORA)	This research focuses on recruitment and personal selection in mining industry. The researchers use SWARA to determine weights of criteria and MULTIMOORA to rank the alternatives.
Karabasevic et al. (2016)	SWARA and Additive Ratio Assessment (ARAS)	Researchers combine SWARA, and ARAS approaches to select candidates in the recruitment process.
Keršulienė et al. (2010)	SWARA	SWARA method is used by the authors to evaluate and select the best method of dispute resolution.
Nakhaei et al. (2016)	SWARA and Simple Multi Attribute Ranking Technique (SMART)	The writers assesses the building's vulnerability to explosions. Thus, they integrate SWARA and SMART to estimate and calculate index and subindex weights.
Ruzgys et al. (2014)	SWARA and An Acronym In Portuguese Of Interactive And Multi-	The researchers integrate SWARA-TODIM methods to evaluate

	Criteria Decision-Making (TODIM)	criteria of thermal insulation systems.
Shukla et al. (2016)	SWARA and Preference Ranking Organisation Method for Enrichment of Evaluations (PROMETHEE)	In order to select the best ERP system for the company, the researchers use SWARA and PROMETHEE approaches.
Stanujkic et al. (2015)	SWARA and Group Decision Making	In order to select the best packaging design for customers, researchers utilize SWARA approach and group decision making.
Vafaeipour et al. (2014)	SWARA and Weighted Aggregates Sum Product Assessment (WASPAS)	In this research, SWARA and WASPAS techniques are applied to assess 29 quantitative and qualitative solar projects criteria and rank the solar projects.
Zolfani et al. (2015)	SWARA	This paper uses SWARA approach in high level decision making to evaluate technology foresight criteria.

Source: Author's own compilation

CHAPTER FOUR

IDENTIFYING DIGITALIZATION BARRIERS TO LOGISTIC OPERATION

4.1. STRUCTURED LITERATURE REVIEW: DIGITALIZATION BARRIERS IDENTIFICATION

Systematic review studies have increased significantly in the literature in recent years, since these studies draw upon objective and evidence-based scientific knowledge, rather than relying on knowledge and experience (Agrawal et al., 2015; Fink 2005; Smith et al., 2008).

With this research method, the findings of more than one research topic are brought together and the best evidence is created by making a critical analysis (Mengist et al., 2020; Rhoades, 2011; Thorpe et al., 2004: 258). However, systematic review studies are an important research project and should be done within a specific protocol. In addition, researchers should examine all the studies on a particular subject to conduct a systematic review research (Antman et al., 1992; Del Amo et al., 2018; Mengist et al., 2020; Verma et al., 2022).

Various technological advancements, such as the internet of things, artificial intelligence, cyber-physical systems, and the reduction of technology costs have led to rapid digitalization of the systems. The digitalization process is not only affect manufacturing and operation sector but also logistics companies affected. The successful implementation of digital technologies in systems has provided various benefits to logistic firms such as improving production performance while maintaining competitive advantage, optimizing information flow, and increasing system flexibility (Hoellthaler et al., 2019; Kagermann et al., 2013; Liao et al., 2017; Rüßmann et al., 2015). Thus, logistic companies must deploy digital technologies in operations to stay ahead of the competition. However, many logistic companies are still in the early stage of implementation of digitalization in their process, and there is not enough information about what barriers logistics firms face in adopting digitalization in their operation process.

Therefore, in order to analyze the extant knowledge on barriers logistic firms face in adopting digitalization in their operation process in depth and to generate

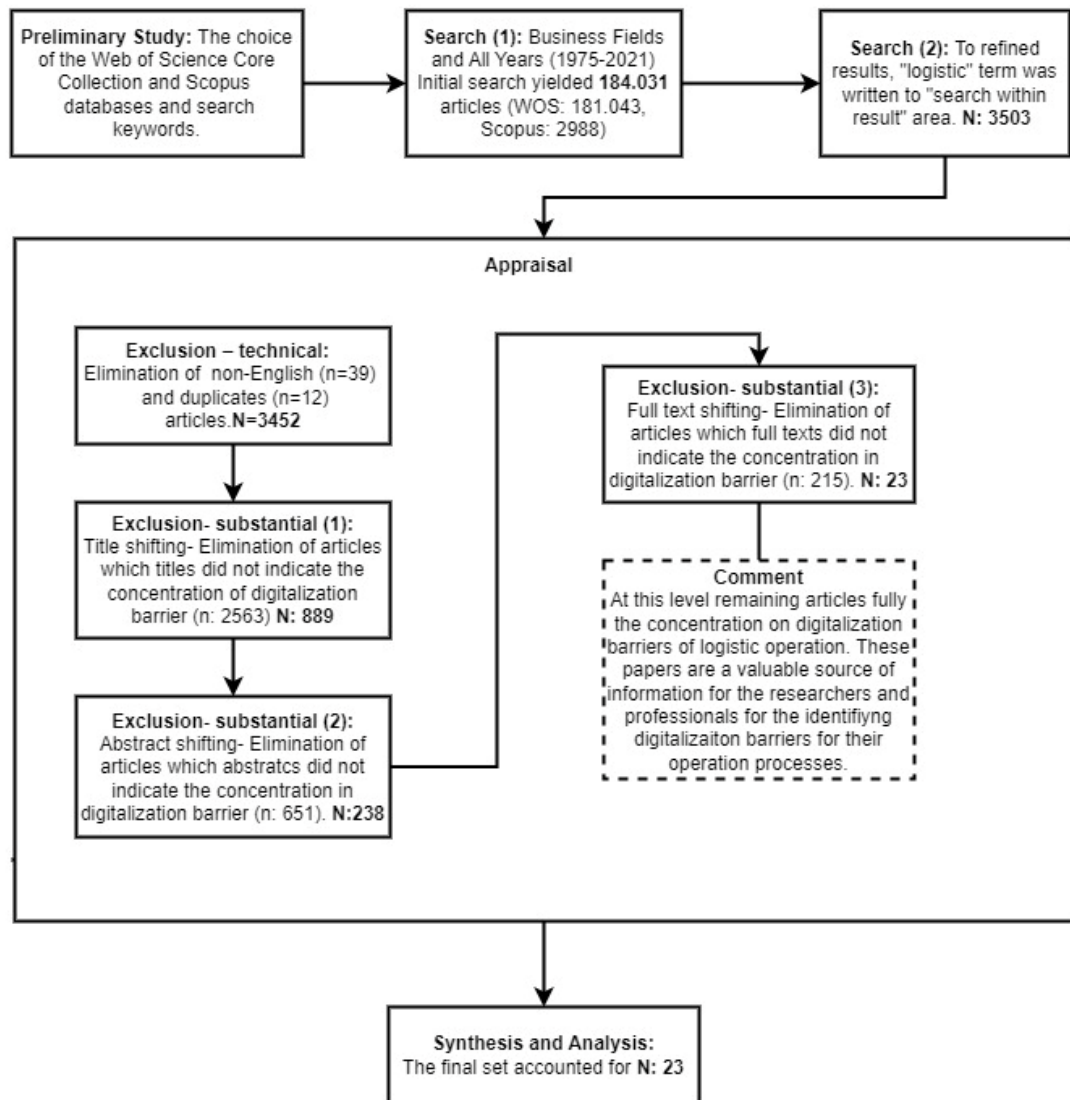
comprehensive barrier classifications based on the theme, this study followed an established research procedure for systematic literature reviews. The PSALSAR method was selected as the research protocol to review specific and reproducible search methods to identify, appraise, synthesize, and analyze all research related to the topic. The PSALSAR method was designed based on Mengist et al. (2020) approach. In the following parts, each step of the PSALSAR framework is explained.

4.1.1. PSALSAR Framework

PSALSAR (Protocol, Search, Appraisal, Synthesis, Analysis and Report) is a data method to determine the review protocols, search, appraise, synthesize, and analyze the results to be followed by the systematic literature review and publish a report end of the study. The detailed information about the PSALSAR method was explained under the “3.3.1. Data Collection Process and Tool: PSALSAR (Protocol, Search, Appraisal, Synthesis, Analysis and Report) Review Framework” title.

This method ensures reproducible, scientific, and transparent results and minimizes bias for systematic literature review. Thereby, the PSALSAR framework was selected as a research protocol for this systematic literature review study.

Figure 26: The PSALSAR Methodology Application for the Systematic Literature Review



Source: Author's own compilation

Figure 26 explains the PSALSAR methodology application for this part of the study. The strategy of the literature review consisted of 8 steps, including preliminary study, search (1), search (2), technical exclusion, substantial exclusion (1), substantial exclusion (2), substantial exclusion (3) and synthesis and analysis. At the end of the study, 23 articles were selected because they fully concentrate on digitalization barriers of logistic operation and are valuable sources of information for this research to define digitalization barriers for their operational processes. The following sections will

explain each step of the PSALSAR framework and how they were used during the search.

4.1.1.1. Protocol

One of the purposes of this study is to extensively investigate the literature using a structured literature review protocol to explore what barriers logistic firms face in adopting digitalization in their operation process. The summary of the methodology used for the research is shown in Table 5. For this analysis, the PSALSAR method was selected as the research protocol. All data of this study was collected on 25 May 2022 from the Web of Science database (WoS) and Scopus databases. These two databases are one of the most reputed and widely accepted databases, covering high-impact articles and journals, and are accepted as an essential sources for the literature review (Chen et al., 2014a; Mongeon and Paul-Hus, 2016; Skute, 2019; Van Leeuwen, 2006). Thus, WoS and Scopus were selected as the databases.

Table 5: Protocol of the Research

Type of analysis	Systematic Literature Review based on PSALSAR framework
Date Collection Time	25.05.2022
Search engines	Web of Science and Scopus
Keywords	Barrier, Challenge, Obstacle, Operation, Operation Process, Digitalization, Logistic
Index	WoS Database: Social Sciences Citation Index, Science Citation Index Expanded and Emerging Sources Citation Index Scopus Database: There is not any constraint.
Unit of analysis	Peer-reviewed journal articles, reviews and early accesses articles
Language	English

Source: Author's own compilation

Later, “barrier, challenge, obstacle, operation, operation process, digitalization, logistic” terms were determined as keywords to enter the search areas. This research aims to find out articles about digitalization challenges in logistics operation; thus, these keywords were directly related to the research objective. After that, “Social Sciences Citation Index, Science Citation Index Expanded and Emerging Sources Citation Index” were selected as the Web of Science index in the WoS database. There was no index in the Scopus database, so that there was not any constraint.

Next, peer-reviewed journal articles, reviews, and early accesses were selected as document types because the information in these documents passed the evaluation processes. Lastly, English was chosen as the language. The researcher has only the ability to read English language articles so that, other language articles were excluded from the sample.

4.1.1.2. Search

One of the purposes of this study was to explore what barriers logistic firms face in adopting digitalization in their operation process. Thus, based on the search protocol, two well-known databases, Web of Science Core Collection and Scopus, were selected to narrow down the research and find articles related to the research aim. This process started with keywords and search terms. Based on the research questions, “barrier”, “challenge”, “obstacle”, “operation”, “operation process” and “digitalization” terms were selected as keywords.

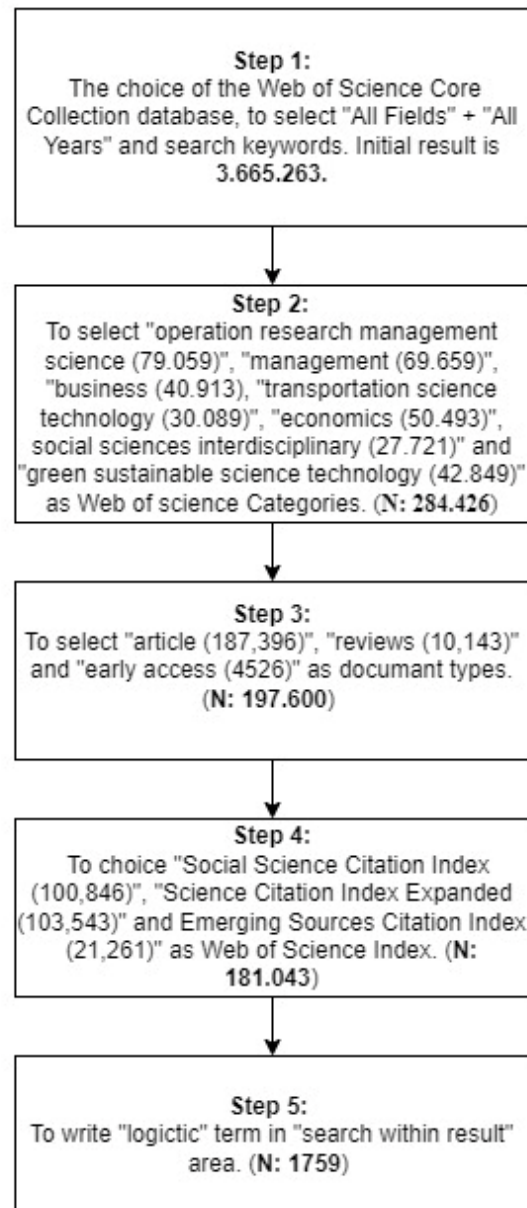
In line with this, most of the writers used a special search technique that is called Boolean operators (“AND” and “OR”). This method was proposed by Kitchenham and Charters in 2007, and the researchers used various combinations of keywords by adding “AND” and “OR” terms to optimize the searches. Thus, the following keywords with the “Boolean operators” method were selected to define the articles related to this study.

The following keywords were used with the “Boolean operators” method to find articles related to the research aim:

“barrier” OR “barriers” OR “challenge” OR “challenges” OR “obstacle” OR “obstacles” OR “operation” OR “operations” OR “operation process” OR “operations process” OR “operation processes” OR “operations processes” AND “digitalization”.

Firstly, these research terms were entered into Web of Science Core Collection database using “All Fields” in advance research of it. 3,665,263 studies were found, “operations research management science, management, business, transportation science technology, economics, social sciences interdisciplinary and green sustainable science technology” web of science categories were selected to acquire studies that were related to business fields. Later than, peer-reviewed journal articles, reviews and early accesses were selected as document types, because peer-reviewed journals contains more reliable studies than the others and studies published on them are going to double blind review processes. Social Sciences Citation Index, Science Citation Index Expanded and Emerging Sources Citation Index were chosen as Web of Science index as articles are published in other research. Initial search yielded 181.043 articles. So that to narrow down to studies, “logistic” keyword was written to “search within result” area to get the studies to related to logistic. Based on this refining, initial research result achieved 1759 articles from WoS database, including works from 1975 to May 2022. Figure 27 shows the all WoS searching process.

Figure 27: The Final Search Sample in WoS

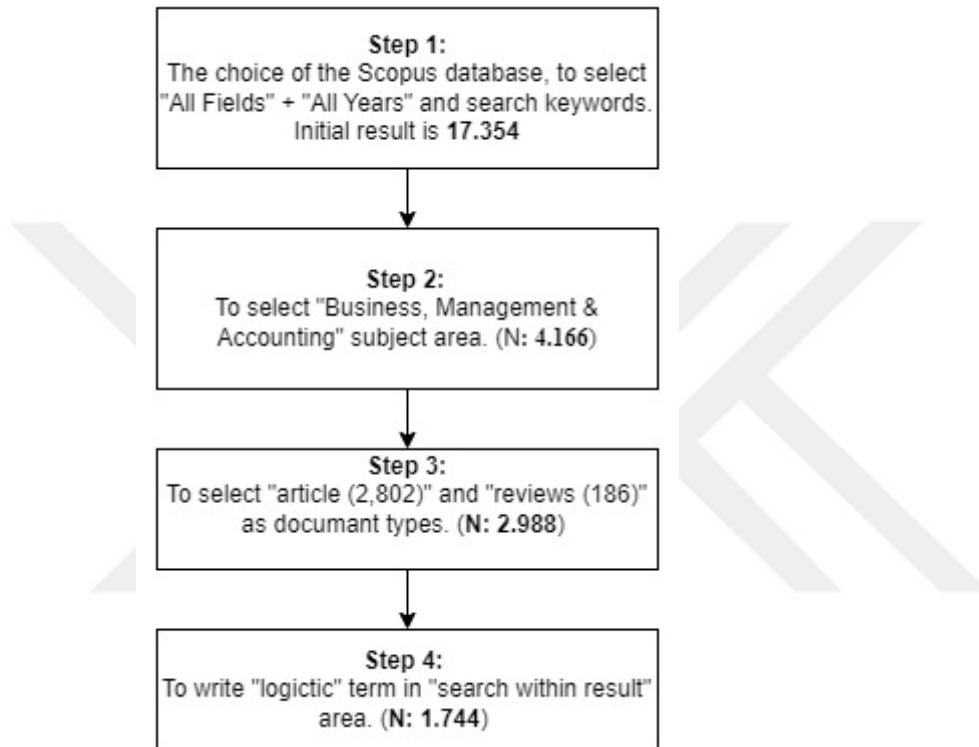


Source: Author's own compilation

Secondly, the formal search keywords were entered into the Scopus database. The "Business" subject area was selected to find studies related to the research question subject area, then articles and reviews were selected as document types and 2988 studies were found. Later than, reaching logistic related studies, the "logistic"

keyword was written on search within the result field. Finally, the initial research result achieved 1744 articles from the Scopus database, including works from 1975 to May 2022. Figure 28 shows the all Scopus search process.

Figure 28: The Final Search Sample in Scopus



Source: Author's own compilation

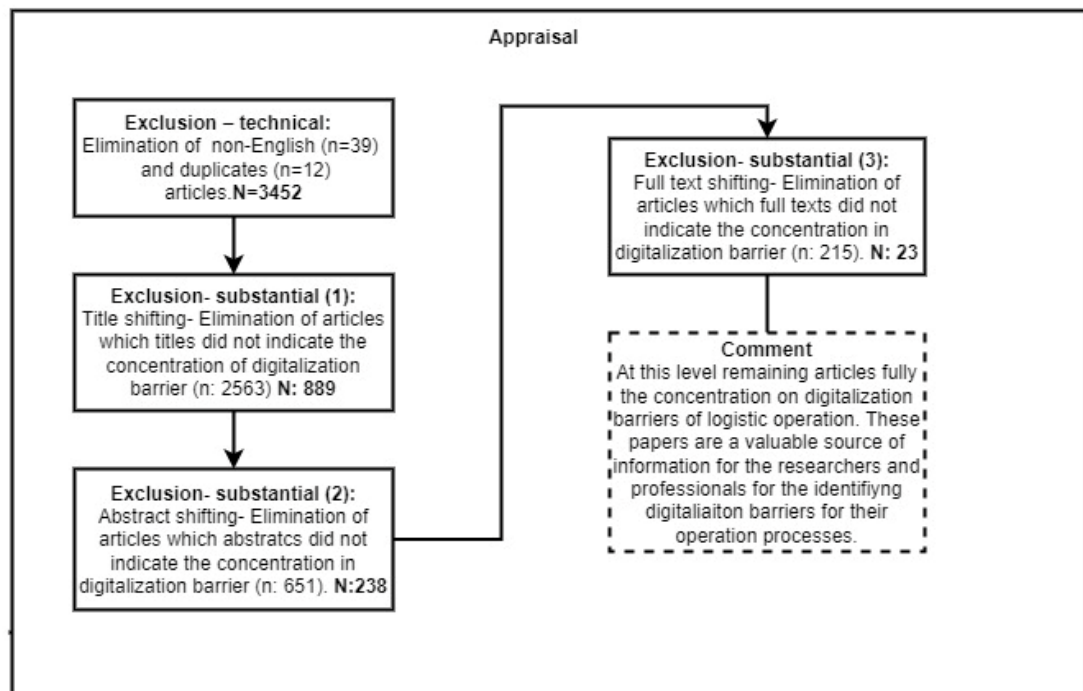
Consequently, the Web of Science Core Collection search led to 1759 and The Scopus search to 1744 articles. The final sample of this research was 3503. All the articles were downloaded on 25 May 2022 to an Excel sheet, and literature searches were finalized.

4.1.1.3. Appraisal

The appraisal is the next stage in the PSALSAR method, and the researchers analyze the articles to determine the most relevant articles for the study. This step is divided into two categories, the first one is technical, and the second one is substantial appraisal.

In the search part of this study, 3503 articles were found and all the articles were downloaded to an Excel sheet. The first category of the appraisal is the technical part, so that duplicated (12 papers) and non-English (39 papers) were eliminated from the sample, resulting in 3452 articles for further research.

Figure 29: Technical and Substantial Appraisal Process



Source: Author's own compilation

Later, the researcher followed three various substantial shifting appraisal processes. Firstly, all titles of the papers were read and analyzed between 26 May- 4 June 2022 to find related research topics and eliminate papers that do not concentrate on the digitalization barrier. In all, 2563 papers were identified as not concentrating on

the research topic. Thus they were eliminated from the sample, leaving 889 for further analysis.

Secondly, all abstracts of the remaining publications were carefully read between the 6th and 19th of June 2022, and 651 papers were found that do not concentrate on digitalization barriers; 238 papers remained for further analysis.

The last part of the substantial shifting is full-text elimination. All 238 articles were read and evaluated by the researcher between 20 June-28 July 2022 to find directly related papers to the research topic. 215 papers were identified were eliminated; thus, 23 articles were found as a final set. These papers were directly related to digitalization barrier and contained valuable information for the research. The whole refining procedure is explained in Figure 29.

4.1.1.4. Synthesis

The synthesis step involves extracting relevant data and classifying it to develop knowledge and conclusions. The coder/s extract/s information from selected published articles according to the prepared criteria. Thus, two coders identified and extracted related information from the selected papers in this step.

As a result of performing all of the searches mentioned above strings, including and excluding decision criteria, content quality, and extraction, 23 articles were found to identify digitalization barriers. Based on the relevant information, selected papers were categorized based on the author/s' name, years of the published articles, the focus of study, research approach (study types), research scale, and finally, findings from the papers connected to digitalization barriers. Table 6 (shown in the following part) displays the author/s, year of publication, the focus of study, research approach, and findings of these 23 articles. Finally, the data for each selected publication was retrieved and entered into an Excel spreadsheet for processing.

4.1.1.5. Analysis and Report

The analysis step involved evaluating and extracting information from synthesis data, as well as examining the conclusions from selected publications. The 23 publications selected for this study were reported according to the author/s list, year

of publication, the focus of study, research approach (methodology) and findings, and classification category, as shown in Table 6.

As shown in the table below, some researchers used two methods to reach results. For example, Verma et al. (2022) combined a systematic literature review and Analytical Hierarchy Process methods to find sustainable digital manufacturing, whereas Bag et al. (2021) selected Decision-Making Trial and Evaluation Laboratory (DEMATEL) and Fuzzy Performance Important Index (FPPI) technique to find out barriers to digital manufacturing in the circular economy.

Findings part gives information about the study results of the selected papers. For example, Stornelli et al. (2021) use a systematic literature review method to find the obstacles and enablers of the adoption process of advanced manufacturing technology. They identify five main types of barriers and four main types of enablers to adoption. In addition that, Cichosz et al. (2020) recognize five barriers, eight success factors and associated leading practices for digital transformation.

Table 6: Systematic Literature Review

No	Author/s	Focus of study	Research Approach	Findings
1	Verma et al. (2022)	barriers of industry 4.0 to sustainable digital manufacturing	Systematic literature review (SLR) method and Analytical Hierarchy Process (AHP) method	The thirty sustainability barriers relating to technological, organizational, economic, environmental, social, and institutional factors were identified, and organizational barriers of Industry 4.0 are the most prominent impediment to sustainability measures for digital production.
2	Tijan et al. (2021)	the drivers, success factors and barriers to digital transformation in the maritime transport sector	Comprehensive literature review	Based on the literature review, in total 10 drivers, 25 success factors and 16 barriers were identified. The study reveals that one of the main drivers is cost reduction, the engagement of managers and employees, investing in employee and manager knowledge are the main success factors and technology-oriented culture is the main barrier of digital transformation in the maritime transport sector.
3	Stornelli et al. (2021)	the obstacles to and enablers of adoption process of advance manufacturing technology, and how these factors relate to various types of innovation	Systematic literature review	Five main types of barriers and four main types of enablers to adoption were identified, and clarified relationship between categories of barriers and enablers related to different forms of innovation types outcomes: product, process, service or business model innovations.

4	Chauhan et al. (2021)	to examines how the intrinsic and extrinsic barriers to digitalisation affect firms' adoption of Industry 4.0 and assess how these barriers effect the the linkage between digitalisation and firms' operational performance and supply chain competency.	The Structural Equation Modeling (SEM)	There is a negative relationship between digitalization and intrinsic and extrinsic barriers, and Industry 4.0 adoption increases operational performance and supply chain competency of the firms.
5	Shahi and Sinha (2020)	to define the means of digital transformation, and to identify barriers that a firm face during digital transformation and potential solutions to those challenges.	Open-Ended Questions, Natural language processing (NLP) and text mining techniques	Digital Transformation was defined as transforming various business aspects to create value for all the stakeholders and bringing in measurable targets and vision by utilizing current digital technologies. Lack of vision and culture were defined as major challenge, and putting the end goal and creating culture of innovation gave as solutions.
6	Machado et al. (2021)	to define the conditions of organisational readiness for digital transformation in manufacturing companies.	In-depth interviews and Case Study	The transformation process must beled by a cross-functional team that is assisted and empowered by the top management.

7	Bag et al. (2021)	Barriers to digital manufacturing initiatives in a circular economy and a methodological model for prioritizing the identified challenges.	Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique and Fuzzy Performance Important Index (FPPI)	The "risk of data security and information privacy" was found the most significant barrier as well as technological challenges appeared as the most significant category of barrier.
8	Ozkan-Ozen and Kazancoglu (2021)	Analyzing and identifying workforce development barriers in a digital age presents the relationship between challenges, categorizes them, and proposes suggestions for managers.	Fuzzy total interpretive structural modelling (TISM)	Thirteen different workforce development challenges were defined, "lack of IT/digital skills" which was the essential barrier, had a critical role in workforce development, and affected other challenges.
9	Jedynak et al. (2021)	Analyzing the development of literature on digital transformation	The systematic literature review	The study revealed that developing a digital organization theory or a theory of digitally transformed organizations is a major problem for management researchers.

10	Cichosz et al. (2020)	Identifying barriers and organizational elements and associated leading practices for digital transformation success at Logistics service providers.	Literature review and Multiple case studies analysis	Five barriers, eight success factors and associated leading practices for digital transformation were defined, "the complexity of the logistics network and lack of resources" was main obstacle and "a leader having and executing a digital transformation vision, and creating a supportive organizational culture" was main success factor for digital transformation at logistics service providers.
11	Raj et al. (2020)	Investigating barriers to the implementation of Industry 4.0 technologies in the manufacturing sector in the context of developed as well as developing economies	Comprehensive literature review and Grey Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach	15 barriers were identified and the 'lack of a digital strategy alongside resource scarcity' which was determined as the essential barrier in both developed and developing economies.
12	Ghadge et al. (2020)	To examine effect of Industry 4.0 implementation on supply chains	Critical literature review	The most common drivers and barriers were identified and categorised to Industry 4.0 adoption based on four dimensions: organizational, legal, ethical, and strategic.
13	Horváth and Szabó (2019)	To examine theory and practice of digitalization in the logistics and transportation sector.	Structured evaluation approach	Influences and Requirements of Digitization Along Strategical, Tactical, and Operational Planning Levels were Identified

14	Wei et al. (2019)	Identifying driving forces and barriers of Industry 4.0 for multinational and small and medium-sized companies	Qualitative case study and Semi-structured interviews	The study found that increasing control and enabling real-time performance measurement was a significant driving force for, on the other hand organizational resistance was important challenge for Industry 4.0 applications. Moreover, small and medium-sized businesses face higher barriers and lower driving forces to industry 4.0 than multinational companies.
15	Fruth and Teuteberg (2017)	Analyses the current state of digitization in maritime logistics, highlighting opportunities for improvement, and discussing current issues	Systematic literature review	In the digitization of maritime logistics, artifacts such as big data and simulations and models played a crucial role. Moreover, the study found that using digital technologies will reduce ship waiting times and speed up terminal processing, but these technologies also will bring some challenges such as hacker attacks, difficulty of the real-time data transmission etc.
16	Gupta et al. (2022)	Identifying barriers to innovative digitalisation technology for supply chain logistics during a pandemic and offering strategies to deal with these barriers.	Bayesian best-worst method	22 barriers were identified and “lack of monetary resources”, “high cost of investment”, “lack of Information Technology infrastructure”, “inadequate internet connectivity”, and “unclear economic benefit of digital investment” were found as the top five barriers
17	Kumar et al. (2021)	Investigating the Industry 4.0 implementation for the Indian manufacturing firms	Situation-actor-process and learning-action-performance (SAP-LAP) and Efficient interpretive ranking process (e-IRP)	Government policymakers, research and academic institutions, industry associations, manufacturers and customers were found as five important stakeholders to implement Industry 4.0.

18	Kessler et al. (2022)	Examining the relationship between Industry 4.0 technologies and supply chain risks	Case analysis and Semi-structured Interviews	The adoption of digital technologies is frequently used to address existing supply chain risks, but their implementation introduces new risks as well.
19	Karakas et al. (2021)	Investigating enablers, barriers, and risks of blockchain adoption in logistics and supply chain	Systematic literature review and the Narrative network analyses	Blockchain adoption increased efficiency across the supply chain and the adoption barriers fall into four categories: governance and regulation, economics, technology, and business ecosystems.
20	Ancillo et al. (2021)	Examining weaknesses and strengths of Spanish Small and Medium-Sized Enterprises' implementation of Industry 4.0	Documentation analysis, the companies visits, interviews and Delphi methodology	Four major barriers were identified: (1) Technical, (2) Training, (3) Economic, and (4) Contextual.
21	Sumrit (2021).	Investigating barriers to the digital transformation of Thailand small and medium-sized enterprises in the freight sector	Literature review, panel of experts, Interpretive Structural Modelling and Matrix Impact of Cross Multiplication Applied to Classification approach	"lack of digital culture", "lack of support and commitment from top management" and "lack of risk taking initiative" were found as the top three barriers.

22	Arora and Rath (2019).	Examining of Implementation of Digitalisation in Small and Medium-Sized Enterprises in India	Logistic regression, T-Test and Descriptive Statistics	The study revealed that there is a positive relationship between the size of the firm and the adoption of digitalisation. Moreover, "increased sales", "profitability", "competitive capability", and "brand awareness" were found to be the most motivating factors for digitalization, on the other hand, while adopting digitalisation, the most important challenges faced by organizations were "dissatisfaction with the current system", "high costs", "lack of appropriate technology", and "lack of top management support".
23	Nguyen (2013).	The critical factors in adopting e-business	Factor Analysis and Logistic Regression	"Higher level of competitiveness", "service differentiation", "value adding", "improved customer services" and "supply chain integration" were found as e-business adoption benefits, while "financial obstacles" and "technical issues" were found as the obstacles to e-business adoption in Australian transport and logistics companies.

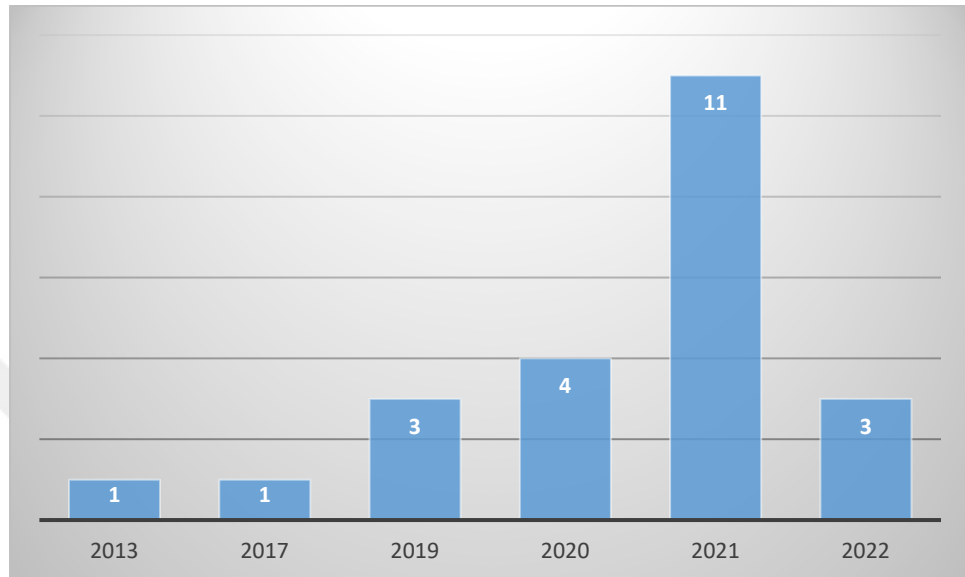
Source: Author's own compilation

When to the analyzed year of publication of selected papers, the first publication about digitalization barriers started in 2013 and reached a peak level in 2021 (11 articles). Figure 30 shows the number of articles published about the digitalization barrier based on year. These results indicate a few studies about digitalization barriers between 2013 and 2017. After 2017, the number of publications increased incrementally between 2019- 2022 and peaked in 2021.

These results are consistent with the time of the Industry 4.0 revolution announcement (Kagermann et al., 2013). Fourth Industrial Revolution that was introduced by the German government in 2011 is defined as flexible control of manufacturing systems using Cyber-Physical Systems (CPS) technology (Kagermann,

2015: 24). Thereby, Industry 4.0 triggers the digitalization of the systems, and it has not only grabbed the attention of businesses but also researchers.

Figure 30: Number of Publications about Digitalization Barrier based on Year



Source: Author's own compilation

After these selected papers were reported according to the author/s list, year of publication, the focus of study, research approach and findings, the coding process was started. Two different coders followed a code protocol and extracted information from the selected papers between 29 July and 2 September 2022. End of the coding process, Cohen's Kappa was calculated to learn inter-rater agreement. The results showed that this analysis were reliable. Cohen's Kappa and inter-rater agreement are explained in the following part.

End of the coding process, 27 various digitalization barriers to logistic operation were defined. These barriers are as follows:

- Lack of technological infrastructure
- Complex network systems and Lack of System Integration
- Data Complexity
- Insufficient R&D

- Lack of information about potentialities of newer digital technologies
- Lack of effective cybersecurity mechanisms
- Data Privacy Concerns
- Threat to intellectual property
- High investment/ implementation costs
- Return on investment (ROI) concerns
- Lack of financial resources
- Lack of digital culture
- Lack of a Digital Vision and Strategy
- Inadequate organizational structure
- Lack of training and training facilities
- Lack of communication, coordination and collaboration across different units or departments
- Resistance to change- employees
- Lack of necessary skillset and qualified labor force for adopting new technologies
- Resistance to change- managers
- Lack of a leader with appropriate skills, competencies and experience
- Lack of supply chain integration between partners
- Lack of trust and support among stakeholders
- Uncertainty about customers' needs and wants
- High energy consumption
- Lack of proper Waste Management (Electronic waste and Emission risk)
- Lack of industry specific guidelines, regulations and standardization
- Lack of legal and ethical policies

In the main theme categorization phases, two coders categorized the 27 barriers based on Verma et al. (2022) articles because they applied explanatory factor analysis to categorize the sustainable digital manufacturing barriers in their study. Moreover, after the main themes were determined, three academicians and two experts working in logistics evaluated this categorization between 5-18 September. Finally, all feedback was collected and evaluated by the writer, and the final version of the main

themes was determined. These 27 barriers were categorized under the seven themes as follows:

- Technological Barrier
- Data Security Barrier
- Financial Barrier
- Organizational Barrier
- Extrinsic Barrier
- Environmental Barrier
- Legal & Industry Barriers.

The twenty-seven barriers and seven themes are shown in Table 8. In the following part, reliability of the study is explained.

4.1.2. Reliability of the Study: Cohen's Kappa

A variety of statistics have been developed to assess inter-rater and intra-rater reliability. If there are two raters, Cohen's kappa statistic is used; if there are three or more raters, the Fleiss kappa statistic is used (McHugh, 2012: 277).

Cohen's Kappa represents the overall agreement between two coders in classifying items (Kvålseth, 1989: 223; Warrens, 2015: 4). Cohen introduced the kappa statistic in 1960 to measure inter-rater agreement (Cohen, 1960). Raters' agreement can be used to indicate the quality of rating categories and the raters' ability to apply them. Having high agreement between coders indicates that the diagnoses are in agreement, and the ratings can be used interchangeably. Cohen's Kappa is commonly used to evaluate the nominal agreement between two raters. This statistic measures the level of agreement between the inter-raters to reduce bias. (Brennans and Prediger, 1981; Sim and Wright, 2005; Warrens, 2011). Most of the authors are used to the guidelines of Landis and Koch (1977: 165), which guidelines are shown in Figure 31.

Figure 31: Kappa Statistic and Level of Agreement Based on the guidelines of Landis and Koch

<i>Kappa Statistic</i>	<i>Strength of Agreement</i>
<0.00	Poor
0.00–0.20	Slight
0.21–0.40	Fair
0.41–0.60	Moderate
0.61–0.80	Substantial
0.81–1.00	Almost Perfect

Source: Landis and Koch (1977: 165)

Cohen's Kappa statistic is used in this study to measure the level of agreement between the two coders responsible for categorizing digitalization barriers. Therefore, in this systematic literature review process, firstly, all barriers were recorded in an Excel sheet, and two different coders read all barriers several times. Secondly, they first coded several barriers together to get the logic of the coding process. Thirdly, they coded barriers separately and categorized them between the 29th of July and the 2nd of September 2022. Fourthly, all results were downloaded to Excel, and data were prepared for SPSS 24 program to measure Cohen's Kappa.

Table 7: Cohen's Kappa Result

		Symmetric Measures			
		Value	Asymptotic Standard Error ^a	Approximate T ^b	Approximate Significance
Measure of Agreement	Kappa	.711	.035	17.161	.000
N of Valid Cases		291			

Source: Author's own compilation

After that, SPSS 24 program was used to calculate Cohen's Kappa statistic. The results of the Kappa statistic are shown in Table 7. The results were evaluated based on the guidelines of Landis and Koch (1977:165). A kappa statistic of between

0.61–0.80 indicates there is a general agreement between two coders and there is a good level of significance inter-rater agreement. Moreover, in this table, the Approximate Significance column was evaluated to determine whether the agreement is due to chance or not. If the p-value is less than 0.001, there is significant agreement between the coders and agreement is not due to chance (Landis and Koch, 1977).

The interrater reliability for this study was found to be Kappa = 0.71 ($p < 0.001$). Thus, the Kappa result ($K = 0.711$) showed that there is a substantial agreement between the two raters and the inter-rater reliability for this study was good and significance.

Lastly, the differences between the two raters were discussed and the barriers categorizations were revised until a full agreement was reached. To sum up, 27 different digitalization barriers and 7 main themes were found and in the following part, all barriers and themes are explained with given detailed definition.

4.1.3. Research Findings: Digitalization Barriers to Logistic Operation

In the analysis part, two coders read, evaluated, and analyzed 23 selected articles carefully; later, they identified 27 different digitalization barriers and seven main themes from relevant literature. After that, a list of barriers and main themes was shared with the three academicians and two experts to receive feedback. All academicians and experts have comprehensive knowledge in the area of logistics. Finally, the list of barriers and main themes was edited based on experts' discussions and feedback, and the final barriers list and main themes were determined.

Based on the systematic literature review study, coding and categorized phases, key digitalization barriers of logistic operation were finalized and shown in Table 8. In this table, main themes part show seven various themes (technological, data security, financial, organizational, extrinsic, environmental, legal & industry). Under the each themes, there are several barriers that are directly related the themes. Moreover, contents shows which scopes are related to the barrier. For example, "Complex network systems and Lack of System Integration" barrier covers all these scopes; "the existence of heterogeneous and independent information systems; the complexity of system design; lack of integration among it networks; countries with

different infrastructures; the integration of legacy systems”. Thus, if a manager thinks “lack of integration among firm’s networks” is a problem for digitalization, the manager should think “Complex network systems and Lack of System Integration” barrier.

In addition that, “High investment/ implementation costs” barrier covers all these contents; “high investment in industry 4.0 implementation; high financial investment requirements; high investment cost (the high setup fee+ investment costs+ the costs of transition to the new system+ time cost); cost of training for the digital systems”. Thereby, if a firm thinks that digitalization requires “high financial investment” and it is a huge problem for digitalization, the owner of the firm should think “High investment/ implementation costs” barrier. So that, these barriers are kind of umbrella that comprise all scopes written in their related contents area.

Table 8: Digitalization Barriers of Logistic Operation with Main Theme, Content and References

Main Theme	Barriers	Contents	References
1)Technological Barriers	1.1. Lack of technological infrastructure	Real-Time Data Analysis; Challenge in transforming current infrastructure; Insufficient digital and physical infrastructure for Industry 4.0; inability to choose IT technology; The very long implementation process; Poor broadband network and connectivity; Speed of internet connection; Inadequate internet connectivity; The need for unique, faster, and cheap identification process	Ancillo et al. (2021); Arora and Rath (2019); Bag et al. (2021); Chauhan et al. (2021); Cichosz et al. (2020); Fruth and Teuteberg (2017); Ghadge et al. (2020); Gupta et al. (2022); Karakas et al. (2021); Kumar et al. (2021); Machado et al. (2021); Nguyen (2013); Raj et al. (2020); Shahi and Sinha (2020); Sumrit (2021); Verma et al. (2022); Wei et al. (2019).
	1.2.Complex network systems and Lack of System Integration	The existence of heterogeneous and independent information systems; The complexity of system design; Lack of integration among IT networks; countries with different infrastructures; the integration of legacy systems	Bag et al. (2021); Chauhan et al. (2021); Cichosz et al. (2020); Ghadge et al. (2020); Gupta et al. (2022); Horváth and Szabó (2019); Jedynek et al. (2021); Karakas et al. (2021); Kessler et al. (2022); Machado et al. (2021); Raj et al. (2020); Stornelli et al. (2021); Tijan et al. (2021); Verma et al. (2022).

	1.3.Data Complexity	Lack of data, hard to collect, analyses, and storage of data; Process optimization; The need for large amounts of storage capacity; data quality	Bag et al. (2021); Fruth and Teuteberg (2017); Ghadge et al. (2020); Gupta et al. (2022); Horváth and Szabó (2019); Kessler et al. (2022); Machado et al. (2021); Raj et al. (2020).
	1.4.Insufficient R&D Budget	Lack of having enough budget or allocate enough budget for research and development activities.	Ghadge et al. (2020).
	1.5.Lack of information about potentialities of newer digital technologies	lack of understanding of the principles of Industry 4.0; The lack of technological knowledge; The lack of awareness and knowledge towards digitization	Ancillo et al. (2021); Arora and Rath (2019); Karakas et al. (2021); Kessler et al. (2022); Machado et al. (2021); Nguyen (2013); Tijan et al. (2021).
2)Data Security Barriers	2.1.Lack of effective cybersecurity mechanisms	Unsolved questions around data security and data privacy in connection with use of external data; Decreased levels of cyber security (especially in the area of digital operations) or Data security constraints; Lack of Information security	Bag et al. (2021); Chauhan et al. (2021); Cichosz et al. (2020); Fruth and Teuteberg (2017); Ghadge et al. (2020); Gupta et al. (2022); Horváth and Szabó (2019); Jedynak et al. (2021); Kessler et al. (2022); Kumar et al. (2021); Machado et al. (2021); Raj et al. (2020); Shahi and Sinha (2020); Stornelli et al. (2021); Sumrit (2021); Tijan et al. (2021); Verma et al. (2022); Wei et al. (2019).

	2.2.Data Privacy Concerns	Unsolved questions around data privacy in connection with use of external data; privacy concerns	Arora and Rathi (2019); Bag et al. (2021); Ghadge et al. (2020); Gupta et al. (2022); Kessler et al. (2022); Machado et al. (2021); Sumrit (2021).
	2.3.Threat to intellectual property	Concerns around lack of control over your company's intellectual property	Bag et al. (2021); Stornelli et al. (2021).
3)Financial Barriers	3.1.High investment/ implementation costs	High investment in Industry 4.0 implementation; High financial investment requirements; High investment cost (the high setup fee+ investment costs+ The costs of transition to the new system+ time cost); Cost of training for the digital systems	Ancillo et al. (2021); Arora and Rathi (2019); Bag et al. (2021); Chauhan et al. (2021); Gupta et al. (2022); Karakas et al. (2021); Nguyen (2013); Ozkan-Ozen and Kazancoglu (2021); Raj et al. (2020); Shahi and Sinha (2020); Stornelli et al. (2021); Sumrit (2021); Tijan et al. (2021); Wei et al. (2019).
	3.2.Return on investment (ROI) concerns	Return and profitability; Uncertain financial Return; The uncertainty of return on investment; Unclear economic benefits	Bag et al. (2021); Cichosz et al. (2020); Ghadge et al. (2020); Gupta et al. (2022); Horváth and Szabó (2019); Karakas et al. (2021); Kessler et al. (2022); Kumar et al. (2021); Raj et al. (2020); Tijan et al. (2021); Verma et al. (2022).



	3.3.Lack of financial resources	Lack of monetary resources; financial constraints; Limited budget; Lack of economic of scale; Lack of suitable and adequate funding options; Lack of financial supports in governmental policies and private and government fundings	Cichosz et al. (2020); Fruth and Teuteberg (2017); Ghadge et al. (2020); Gupta et al. (2022); Horváth and Szabó (2019); Machado et al. (2021); Nguyen (2013); Shahi and Sinha (2020); Sumrit (2021); Tijan et al. (2021); Verma et al. (2022); Wei et al. (2019).
4)Organizational Barriers	4.1.Lack of digital culture	Lack of internal digital culture; Lack of Technology-oriented culture	Bag et al. (2021); Ghadge et al. (2020); Jedynak et al. (2021); Kumar et al. (2021); Machado et al. (2021); Ozkan-Ozen and Kazancoglu (2021); Raj et al. (2020); Shahi and Sinha (2020); Sumrit (2021); Tijan et al. (2021); Verma et al. (2022).
	4.2.Lack of a Digital Vision and Strategy	Lack of a digital strategy alongside resource scarcity; Lack of digital vision and strategy; Lack of policy framework; Lack of a clear digital operations vision and support; Lack of clear digital strategy	Bag et al. (2021); Chauhan et al. (2021); Ghadge et al. (2020); Horváth and Szabó (2019); Jedynak et al. (2021); Karakas et al. (2021); Machado et al. (2021); Raj et al. (2020); Shahi and Sinha (2020); Stornelli et al. (2021); Sumrit (2021); Tijan et al. (2021); Verma et al. (2022).



	4.3.Inadequate organizational structure	Organization Rigidity; Heterogeneous organization structures; lack of cultural integration; Inadequate organizational structure and process organization for digitalization; Lack of ability in decentralized decision-making; Lack of digital flexibility; Organization resistance; Lack of capabilities to change; Lack of risk management tool in place concerning the digital transformation; Lack of risk taking initiative; change management; Overconfidence, poor procedure enforcement and lack of control; Uncertainty, feedback cycles and dynamics	Bag et al. (2021); Horváth and Szabó (2019); Karakas et al. (2021); Kessler et al. (2022); Kumar et al. (2021); Machado et al. (2021); Ozkan-Ozen and Kazancoglu (2021); Sumrit (2021); Tijan et al. (2021); Verma et al. (2022).
	4.4.Lack of training and training facilities	Requirements for longer learning time and specialized training; Lack of training facilities; Inadequate training for digital competencies; Lack of internal digital training	Arora and Rathi (2019); Bag et al. (2021); Gupta et al. (2022); Horváth and Szabó (2019); Kumar et al. (2021); Machado et al. (2021); Ozkan-Ozen and Kazancoglu (2021); Raj et al. (2020).



	4.5.Lack of communication, coordination and collaboration across different units or departments	Contradictory interests in different organizational units; Lack of proper, common thinking; Coordination problem across different units or departments; Teams working in silos; Lack of lean and flexible communication structure within organization	Bag et al. (2021); Chauhan et al. (2021); Horváth and Szabó (2019); Machado et al. (2021); Shahi and Sinha (2020); Tijan et al. (2021).
	4.6.Resistance to change- employees	Resistance by employees and middle management; Reluctance to changes; Employees within my organization lack enough resources and capacities for the digital transformation; Resistance from employees due to fear of job loss; Uncertainties and fears among employees in implementation of digitization; Satisfied with the current system; Lack of employees' motivation; Lack of rewards and recognition	Arora and Rathi (2019); Bag et al. (2021); Chauhan et al. (2021); Cichosz et al. (2020); Ghadge et al. (2020); Gupta et al. (2022); Horváth and Szabó (2019); Jedynak et al. (2021); Karakas et al. (2021); Kumar et al. (2021); Machado et al. (2021); Ozkan-Ozen and Kazancoglu (2021); Raj et al. (2020); Stornelli et al. (2021); Tijan et al. (2021); Verma et al. (2022); Wei et al. (2019).

	4.7.Lack of necessary skillset and qualified labor force for adopting new technologies	Lack of analytical, interdisciplinary thinking and dealing with complexity; Lack of understanding of the interplay between human and machine; Lack of analytical and predictive driven production thinking; Lack of digital skills and qualified labor force; Skills development issues; Shortage of workforce with adequate skillset within the labor market	Arora and Rathi (2019); Bag et al. (2021); Chauhan et al. (2021); Cichosz et al. (2020); Fruth and Teuteberg (2017); Ghadge et al. (2020); Gupta et al. (2022); Horváth and Szabó (2019); Jedynak et al. (2021); Karakas et al. (2021); Kumar et al. (2021); Machado et al. (2021); Nguyen (2013); Ozkan-Ozen and Kazancoglu (2021); Raj et al. (2020); Shahi and Sinha (2020); Stornelli et al. (2021); Sumrit (2021); Tijan et al. (2021); Verma et al. (2022); Wei et al. (2019).
	4.8.Resistance to change- managers	Absence of adequate management systems; Ineffective change management; Lack of management support; Lack of interest from authorities and regulators (Senior-level managers have a sceptical view of new technologies.+management's commitment and transactional level uncertainties)	Ancillo et al. (2021); Arora and Rathi (2019); Chauhan et al. (2021); Ghadge et al. (2020); Gupta et al. (2022); Karakas et al. (2021); Machado et al. (2021); Raj et al. (2020); Sumrit (2021); Tijan et al. (2021); Verma et al. (2022);
	4.9.Lack of a leader with appropriate skills, competencies and experience	Poor leadership style of top management, Lack of leadership management within organization that can support “creative freedom” for creativity and innovation	Bag et al. (2021); Horváth and Szabó (2019); Verma et al. (2022).



5)Extrinsic Barriers	5.1.Lack of supply chain integration between partners	Lack of willingness to cooperate (at the supply chain level); Difficulties in buyer-supplier relationship; Business partners are not able to collaborate around digital solutions; Reluctance from supply chain partners	Ancillo et al. (2021); Bag et al. (2021); Horváth and Szabó (2019); Jedynak et al. (2021); Karakas et al. (2021); Kessler et al. (2022); Stornelli et al. (2021); Sumrit (2021); Verma et al. (2022).
	5.2.Lack of trust and support among stakeholders	Difficulty to establish a culture of trust with business partners; Lack of support from supplier/customer and stakeholders; Need to find a suitable research partner	Bag et al. (2021); Chauhan et al. (2021); Gupta et al. (2022); Karakas et al. (2021); Kessler et al. (2022); Verma et al. (2022).
	5.3.Uncertainty about customers' needs and wants	Market uncertainty (Uncertain about customer needs); customers' uninterested in new services;	Nguyen (2013); Verma et al. (2022).
6)Environmental Barriers	6.1.High energy consumption	Focus on sustainability and energy efficiency in operations management	Machado et al. (2021); Verma et al. (2022).
	6.2.Lack of proper Waste Management (Electronic waste and Emission risk)	Disposal of the waste harmful to society	Gupta et al. (2022); Verma et al. (2022).



7)Legal and Industry Barriers	7.1.Lack of industry specific guidelines, regulations and standardization	Missing or inadequate regulations; Legal and contractual ambiguity; Culture and regional difference; Lack of institutional definition of digital transformation, theoretical framework, solutions and digitalization impact for sectors; Lack of Digital standardization, norms and certifications; The lack of globally viable and consistent technical standards and regulatory frameworks	Bag et al. (2021); Chauhan et al. (2021); Fruth and Teuteberg (2017); Gupta et al. (2022); Jedynak et al. (2021); Karakas et al. (2021); Kumar et al. (2021); Machado et al. (2021); Stornelli et al. (2021); Sumrit (2021); Tijan et al. (2021); Verma et al. (2022); Wei et al. (2019).
	7.2.Lack of legal and ethical policies	Inadequate legal and regulatory framework and lack of a standard legal infrastructure	Karakas et al. (2021).

Source: Author's own compilation

When examining these main themes, there are five barriers under the technological category; these barriers are 1) lack of technological infrastructure, 2) complex network systems and lack of system integration, 3) data complexity, 4) insufficient R&D budget and 5) lack of information about potentialities of newer digital technologies. The Data Security theme includes three barriers as follows; 1) lack of effective cybersecurity mechanisms, 2) data privacy concerns and 3) threat to intellectual property. In addition that, the Financial theme also comprises three barriers which are; 1) high investment/ implementation costs, 2) return on investment (ROI) concerns and 3) lack of financial resources.

Furthermore, the organization category has the highest number of barriers; nine different barriers are grouped under this theme. These nine barriers are; 1) lack of digital culture, 2) lack of a digital vision and strategy, 3) inadequate organizational structure, 4) lack of training and training facilities, 5) lack of communication, coordination and collaboration across different units or departments, 6) resistance to change- employees, 7) lack of necessary skillset and qualified labor force for adopting new technologies, 8) resistance to change- managers and 9) lack of a leader with appropriate skills, competencies and experience.

Additionally, there are three barriers under the extrinsic theme, which are; 1) lack of supply chain integration between partners, 2) lack of trust and support among stakeholders and 3) uncertainty about customers' needs and wants. Furthermore, the environmental barriers cover two barriers as follows; 1) high energy consumption and 2) lack of proper waste management (electronic waste and emission risk), whereas, the legal and industry themes comprise two barriers which are; 1) lack of industry specific guidelines, regulations and standardization and 2) lack of legal and ethical policies. In the following part, all themes and barriers are explained in detail.

4.1.3.1. Technological Barriers

There is no doubt that digital technologies are taking center stage in every organization. The adoption of Industry 4.0 technologies is essential for companies wishing to adopt digitalization processes. However, many companies have difficulty implementing new technology. The full adoption of digitalization requires companies to overcome several challenges (Bag et al., 2021; Gupta et al., 2022: 6; Verma et al.,

2022). Under this headline, five technological challenges that logistic firms face during the digitalization process are explained in Table 9.

Table 9: Explanation of Technological Barriers

Main Theme	Barriers	Explanation
Technological Barriers	1) Lack of technological infrastructure	Difficulties in transforming existing infrastructure and systems in line with digitization, insufficient digital and physical infrastructure for digitization, insufficient internet connection or slowdowns in connection speed, and difficult real-time data analysis.
	2) Complex network systems and Lack of System Integration	The necessity of designing heterogeneous and independent information systems, the complexity of system design, the lack of integration between systems, and the need to design different systems for countries with different infrastructures.
	3) Data Complexity	It is difficult for companies to collect, analyze and store high-quality data without missing it; companies need a large amount of storage capacity to store data and difficulties of process optimization.
	4) Insufficient R&D Budget	Companies do not have enough research and development budgets for new technologies and digitalization processes.
	5) Lack of information about potentialities of newer digital technologies	The lack of technological knowledge; the lack of awareness and knowledge about digitalization; the lack of understanding of Industry 4.0 principles by the company and its employees.

Source: Author's own compilation

4.1.3.2. Data Security Barriers

The digitalization process involves interaction with big data, so cyber protection and data privacy have become more crucial for companies since cybercrime poses a threat to companies' intellectual property and competitive advantages (Bag et al., 2021). Thus, companies must make arrangements with cyber security companies or create effective cyber security systems in order to protect high volumes of digital manufacturing data and private data in implementing of digitalization in their systems. Thus, data security is the second barrier theme in the digitalization process for logistic companies. This theme has three barriers; lack of effective cybersecurity mechanisms, data privacy concerns and threat to intellectual property. These barriers are explained in Table 10.

Table 10: Explanation of Data Security Barriers

Main Theme	Barriers	Explanation
Data Security Barriers	1)Lack of effective cybersecurity mechanisms	The existence of problems with data security, the reduction of cyber security levels with digitalization and system integration.
	2)Data Privacy Concerns	The existence of problems with data privacy and privacy concerns
	3)Threat to intellectual property	Concerns about a lack of control over companies' intellectual property.

Source: Author's own compilation

4.1.3.3. Financial Barriers

Companies now have more opportunities thanks to digitalization; however, the digitalization process requires a huge amount of capital expenditures for the firms. The firms should consider the high setup fee for a new system, investment costs for buying

new technologies and systems, transition costs to the new system from old systems, and training costs. Moreover, managers do not have certain financial returns and time, so that there are unclear economic benefits for managers. Furthermore, each firm has financial constraints to make new investments and digitalization processes, and there are not enough private and government funds to support the digitalization process. Thereby, financial barriers are found as a third main theme in this study. All barriers related to finance are explained in Table 11.

Table 11: Explanation of Financial Barriers

Main Theme	Barriers	Explanation
Financial Barriers	1)High investment/implementation costs	Industry 4.0 applications and digital technologies require high financial investment, the establishment of a new digital system causes various costs such as high setup fee + investment costs + the costs of transition to the new system + time cost, and training cost for digital systems.
	2)Return on investment (ROI) concerns	Investments in digitalization have uncertain financial returns, profitability and economic benefits.
	3)Lack of financial resources	Financial constraints and limited budgets of firms to digitize, the lack of appropriate and adequate financing options for firms, the lack of financial support in government policies for digitization, and the lack of private and government funds to support digitization for the sector.

Source: Author's own compilation

4.1.3.4. Organizational Barriers

Digital transformations have completely changed the business model of firms. The digitalization process is not only changes technological inputs but also the human assets of the companies. Companies that want to digitalize their process should be ready to create a digital culture inside the organization. Also, they should rebuild a more flexible organizational structure to accept new technologies and effective communication structure within the organization. Moreover, top managers must put digitalization in the firm's vision and create a digital strategy and framework to support the transformation process.

Furthermore, top managers must explain the reasons and benefits of digitalization to their managers and workers to deal with the resistance to change and provide training and training facilities for their managers and workers to receive the necessary skills, competencies, and experience for adopting new technologies. Companies should focus on organizational barriers to apply digitalization in their process effectively. Therefore, under this theme, nine organizational barriers logistic companies face during digitalization are explained in Table 12.

Table 12: Explanation of Organizational Barriers

Main Theme	Barriers	Explanation
Organizational Barriers	1)Lack of digital culture	The company's lack of a technology-oriented and digitized culture
	2)Lack of a Digital Vision and Strategy	The company's lack of digital vision, strategy and policy framework.
	3)Inadequate organizational structure	The company has an insufficient organizational structure for digitalization, the organization's flexibility for digitalization is low, the company is resistant to change, and the company does not have or lacks a risk management tool related to digital transformation.
	4)Lack of training and training facilities	The necessity of providing special training to the employees for the digitization of the company, the lack of in-house digital training and the lack or insufficient facilities for digitization training.
	5)Lack of communication, coordination and collaboration across different units or departments	Coordination problems and conflicts of interest in different organizational units, lack of common thinking, lack of a simple and flexible communication structure within the organization.

	6)Resistance to change- employees	The unwillingness of the employees to change, the resistance of the employees due to the fear of losing their job, the employees' lack of motivation for transformation, and employees do not have enough resources and capacity for digital transformation.
	7)Lack of necessary skillset and qualified labor force for adopting new technologies	The workforce lacks of analytical, interdisciplinary thinking and the ability to deal with complexity, a lack of digital skills and a skilled workforce, and a lack of understanding of the interaction between humans and machines.
	8)Resistance to change- managers	Managers' lack of interest in digitization, lack of management support for digitization, and lack of effective and appropriate management systems for digital transformation.
	9)Lack of a leader with appropriate skills, competencies and experience	Top management lacks an effective leadership style for digitalization and lacks effective leadership management to support digitalization and innovation within the organization.

Source: Author's own compilation

4.1.3.5. Extrinsic Barriers

Extrinsic barriers are caused by factors outside of the firm control or factors within the industry the firm belongs. Organizations are unable to deal with change due to extrinsic barriers (Chauhan et al., 2021). When the partners are unwilling to

cooperate with each other, they cannot collaborate around digital solutions or cannot establish a culture of trust, or receive any support from partners, and the firm faces extrinsic barriers. Moreover, market uncertainty and customers' uninterested in new services are the other extrinsic barriers for firms. Thus, extrinsic barriers are the next theme for this study, and there are three barriers under this theme which are explained in Table 13.

Table 13: Explanation of Extrinsic Barriers

Main Theme	Barriers	Explanation
Extrinsic Barriers	1)Lack of supply chain integration between partners	The unwillingness of suppliers to cooperate with digitalization, and the difficulties in the supplier management relationship
	2)Lack of trust and support among stakeholders	The difficulty of building a culture of trust among business partners and inadequate support from suppliers, customers, and stakeholders in the digitalization process.
	3)Uncertainty about customers' needs and wants	The uncertainty of customers' attitudes and desires towards the digitalization process and new technologies.

Source: Author's own compilation

4.1.3.6. Environmental Barriers

Environmental Barriers are the sixth theme. The digitalization process requires the replacement of old equipment with new ones; however, these replacement processes can increase electronic waste. Moreover, the transformation of old equipment increases the carbon emission of the firms and creates harmful waste for both environment and society. Consequently, logistic firms face three various environmental barriers during the digitalization phases that are explained in Table 14.

Table 14: Explanation of Environmental Barriers

Main Theme	Barriers	Explanation
Environmental Barriers	1)High energy consumption	The inadequacy of the waste management system in the use of digitalization process and new technologies, the difficulty of companies paying attention to emission reduction activities while managing electronic waste.
	2)Lack of proper Waste Management (Electronic waste and Emission risk)	Inadequate systems for the disposal of wastes harmful to society and the environment.

Source: Author's own compilation

4.1.3.7. Legal and Industry Barriers

The last theme is Legal and Industry. Unfortunately, there are no complete or adequate regulations about the digitalization process, so firms must deal with legal and contractual ambiguity. Moreover, there are no globally viable and consistent technical standards and regulatory frameworks and/or sectoral digital standardization, norms, and certifications about digitalization. Furthermore, companies not only deal with industry-specific guidelines, regulations, and standardization but also with legal and ethical policies because there is no adequate legal and regulatory framework for digitalization. Thus, this theme covers two barriers that are explained in Table 15.

Table 15: Explanation of Legal and Industry Barriers

Main Theme	Barriers	Explanation
Legal and Industry Barriers	1)Lack of industry specific guidelines, regulations and standardisation	Lack of institutional definition, theoretical framework, solutions, and impact of digitalization on the firm, and the lack of globally applicable and consistent technical standards, norms, certifications and regulatory frameworks for digitalization,
	2)Lack of legal and ethical policies	Lack of an adequate legal, regulatory framework and a standard legal infrastructure for digitalization.

Source: Author's own compilation

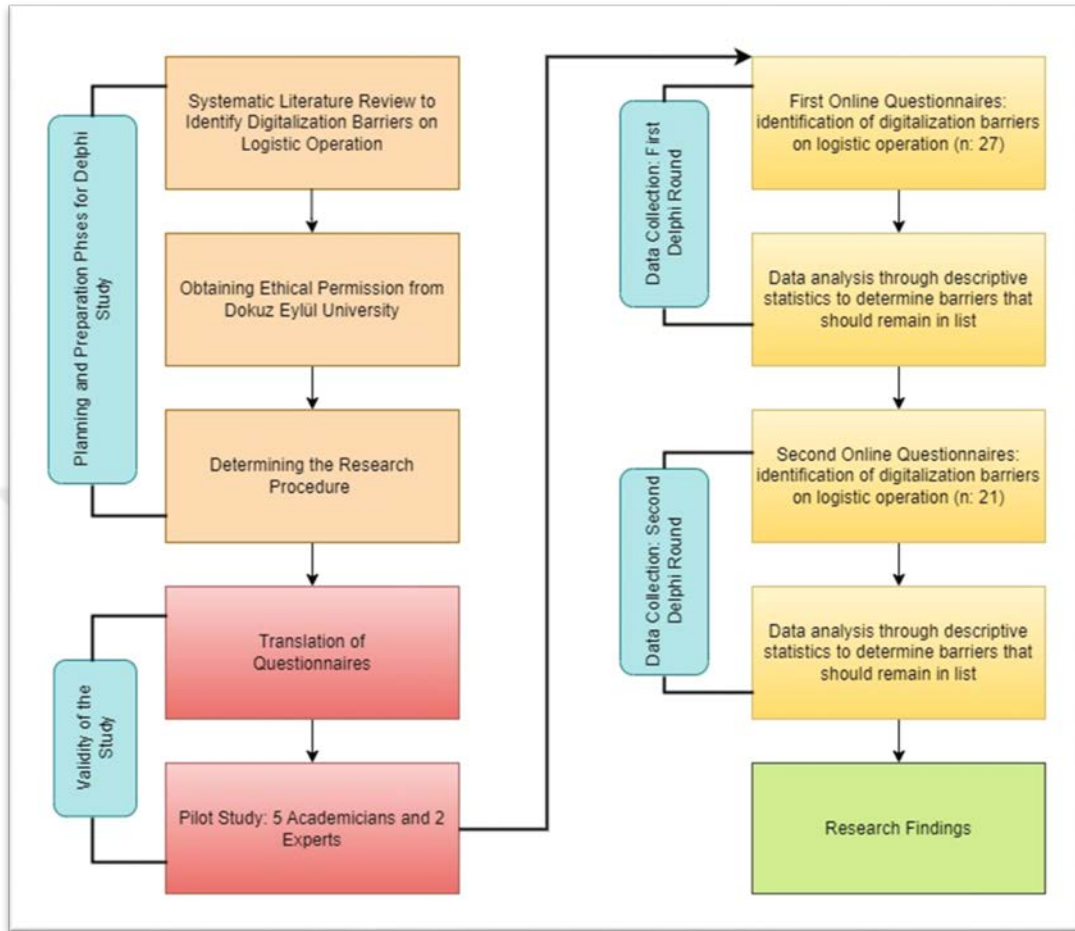
CHAPTER FIVE

ADOPTION AND PRIORITIZATION DIGITALIZATION BARRIERS TO LOGISTIC OPERATION

5.1. DELPHI METHOD: DIGITALIZATION BARRIERS ADAPTATION

Twenty-seven different digitalization barriers and seven main themes are identified from relevant literature in the systematic literature review study. These barriers cover all topics without considering cultural, economic, political, etc. differences. Thus, this thesis applies the Delphi method as a second methodology to identify digitalization barriers to logistic operation in Türkiye. This is a problem-solving technique to help researchers scientifically collect expert information to determine the existing digitalization barriers to logistics operations in Türkiye. Therefore, this method aims to identify important digitalization barriers that firms face operating in Türkiye by considering cultural, economic, political, geographical, etc. factors.

Figure 32: Delphi Research Process



Source: Author's own compilation

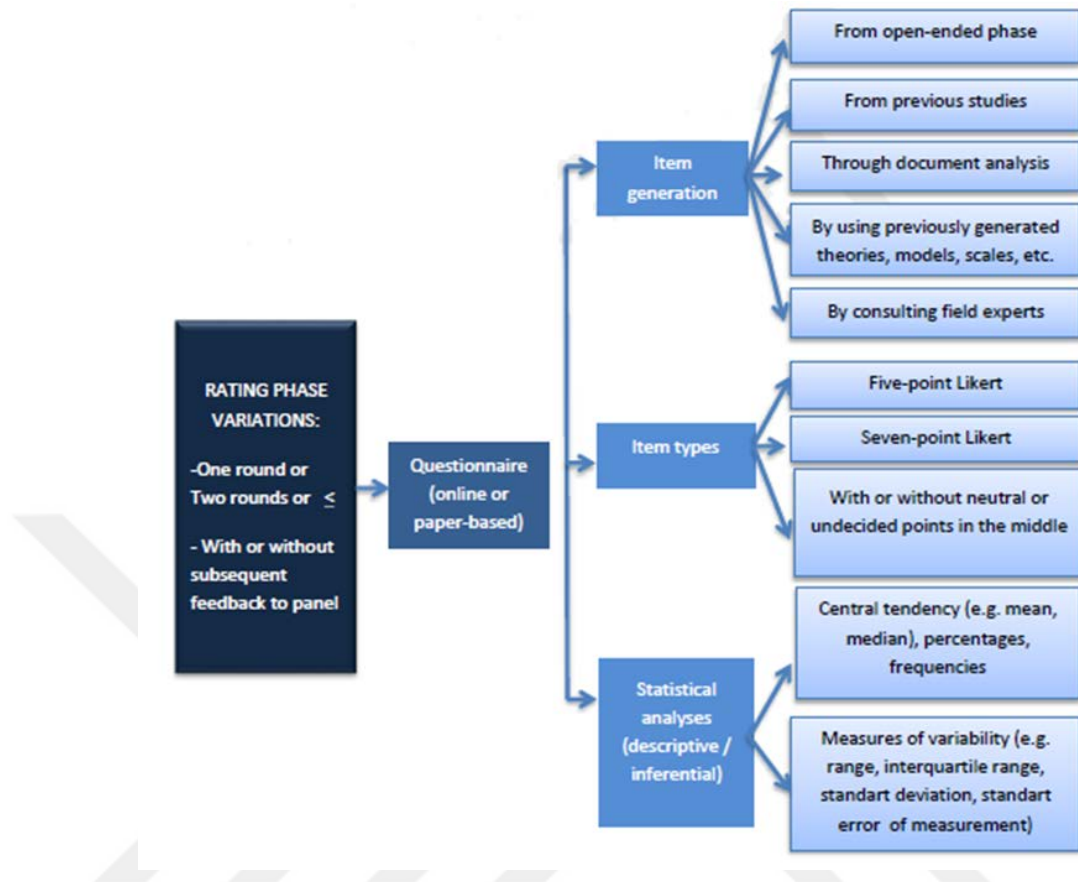
Delphi research process steps of this study are demonstrated in Figure 32. The planning and preparation phases for Delphi phases consist of 3 steps. Firstly, digitalization barriers and main themes were identified from relevant literature. Afterward, the researcher applied an ethical committee to get ethical permission to collect data from experts. Lastly, the researcher determined the research procedure that is explained in Figure 34.

The second step of the Delphi research process is the "Validity of the Study." Data are collected from experts who live in Türkiye, and the main language of these experts is Turkish. Thus, identified barriers have to be translated from English to Turkish. However, in this translation process, the researcher must follow some rules

to make certain validity of the study. Therefore, two bilingual academicians translated all identified barriers and themes into Turkish in this step. Later five academicians and two logistic managers attended to pilot study. In the following part, the study's validity is explained with detailed information.

The third and fourth steps of this research process are the data collection phases. After determining this study's sample (the study's sample is explained under the “5.1.2. Sampling” heading), data collection phases were started. The researcher reached out to a total number of 14 experts. The researcher sent the first Questionnaires to experts via emails, received answers, and analyzed the results to determine digitalization barriers. Six barriers were found as unimportant for the Turkish logistic sector in the first round. Later, the researcher sent a second Questionnaire to experts via email, received answers, and analyzed the results to determine digitalization barriers. In the second round, all remaining barriers (21) were considered important for the Turkish logistic sector. In this round, the experts reached a consensus about digitalization barriers to logistic operation, so the Delphi rounds and the data collection period ended. Details of the data collection process and data analysis are explained in the 5.1.3 and 5.1.4 headings, respectively. The final step of the Delphi research process is “Research Findings,” which is explained 5.1.5 heading.

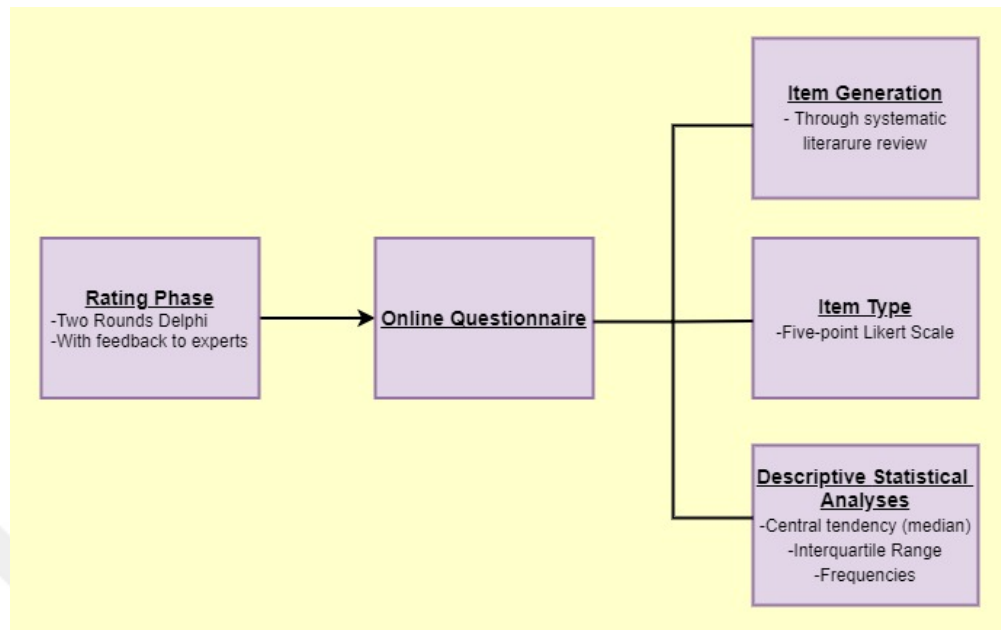
Figure 33: Delphi Rating Phase Variations



Source: Keser, A. D. (2018: 35).

Delphi research procedure of this study is demonstrated in Figure 34. In the Delphi study, the rounds of questionnaires are continued until experts reach a consensus on the topic (Rodriguez-Mañas et al., 2012). In this study, the experts reached a consensus end of the second round. In the Delphi study, two rounds are recommended as a minimum (Bradley & Stewart, 2003: 275; Custer et al., 1999). Thus, this study provides this two-round condition. In the rating phases, there are two rounds of Delphi, and at the end of each round, the researcher gives feedback to experts about the result of the study. In this study, an online questionnaire was preferred so that all surveys were sent to experts via e-mail.

Figure 34: Delphi Research Procedure



Source: Author's own compilation

In the Delphi study, there are five ways to identify items, three ways to determine item types, and two various statistics that can be used to determine whether there is a consensus. All these item generations, item types, and statistical ways are shown in Figure 33. Based on this figure, items can be identified from open-ended, previous studies, through document analysis, using previously generated theories, models, scales, etc., and by consulting field experts. In this study, digitalization barriers to logistic operation items are determined through document analysis (systematic literature review). Moreover, based on the same figure, the researchers can use one of the three item types: five-point Likert, seven-point Likert, or with or without neutral or undecided points in the middle. Liu and Anderson (2008: 169) state, "The initial round of the review is unstructured and consists of written answers to an open-ended question. A list of important points is generated from these answers. The second phase (Delphi) includes one or more opportunities to rate the importance or desirability of those items on a 5- or 7-point Likert-type scale until some pre-established consensus indicator is reached." Thus, this study selects a five-point Likert scale as the item type.

In the Delphi study, there are two types of statistical analysis to evaluate the consensus met; the first is the central tendency, and the second is the measures of variability. This study uses central tendency statistical analysis to determine whether consensus is met. So, the median, interquartile range, and frequency of the first and two-round results are evaluated to establish levels of agreement. Consensus evaluation criteria are explained in the “5.1.4. Data Analysis” heading.

5.1.1. Validity of the Study

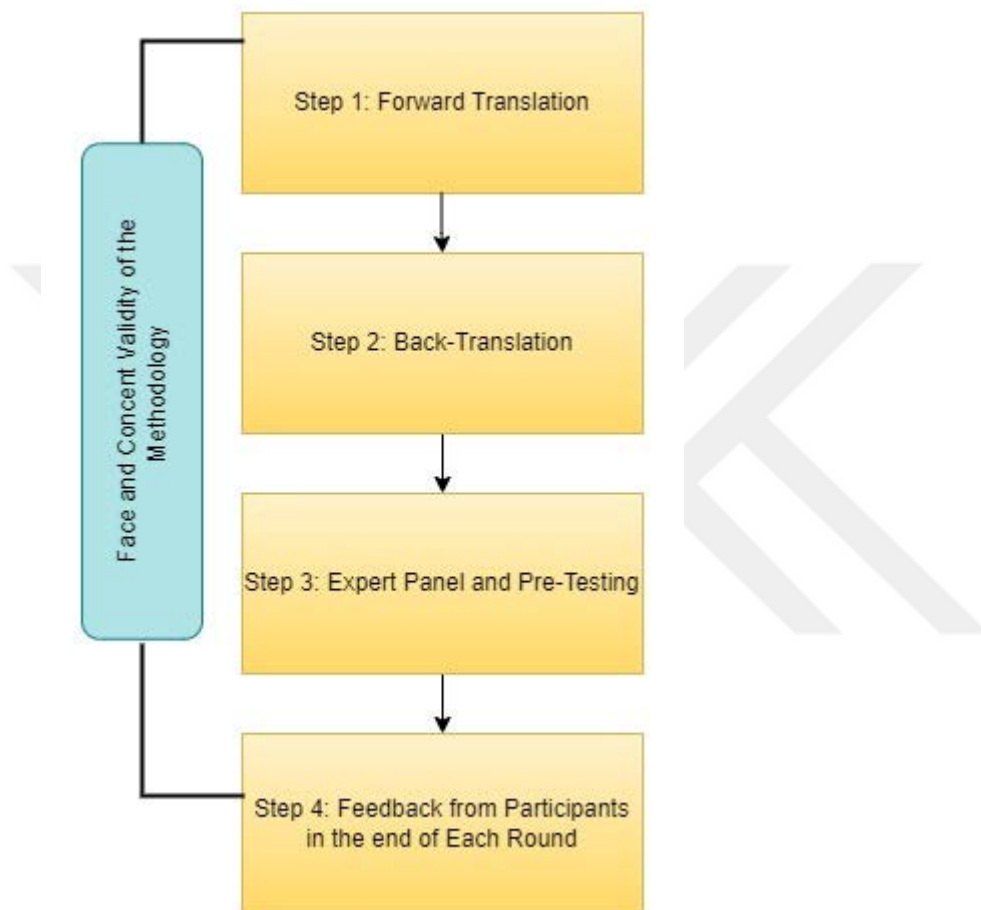
Validity was described by Kelly (1927: 14) as the ability to measure what a test claims to measure, whereas Creswell (2005) defines validity as the assurance that conclusions are based on accurate and appropriate instruments. The face validity of a test refers to whether it seems to measure what it claims to measure (Dronavalli and Thompson, 2015: 2; Privitera, 2015). An instrument's content validity determines whether it can effectively measure and represent the construct (Hecker and Violato, 2009: 272; Privitera, 2015). In the present study, it was a priority to ensure that the instruments used were both face and content validity. Thus, the researcher used four various steps (Figure 35) to assess the face and content validity of the methodology,

In the systematic literature review, 27 digitalization barriers and seven themes were determined, and each barrier was explained. However, in the Delphi process, these barriers and definitions must be translated from English to Turkish and adapted to Turkish culture because the main language of all participants is Turkish.

World Health Organization (WHO) defines a guideline for translating and adapting instruments from English to a different language. This guideline has five steps: forward translation; back-translation; expert panel; pre-testing and cognitive interviewing; final version (WHO, 2017). Moreover, most of the researchers use this guideline for instruments translation and adaptation (Bayık and Gürbüz, 2016; Çapık et al., 2018; Dronavalli and Thompson, 2015; Heggstad et al., 2019; Öztürk et al., 2015; Taşçi et al., 2016). Moreover, according to Hung et al. (2008: 192), the validity of Delphi is provided by participants because panelists drive the content.

Thus, in this study, the guideline of WHO and the study of Hung et al. (2008: 192) were used to ensure the face and content validity of the methodology. Figure 35 shows the face and content validity steps of the methodology.

Figure 35: Face and Content Validity of the Study



Source: Author's own compilation

The first step is forward translation. This task was performed by two academicians familiar with the terminology of digitalization. The mother languages of the two academicians are English and Turkish, so they are bilingual. In the translation, the focus was not solely on literal translation but also conceptual and cross-cultural adaptations and interpretations. The next step is back-translation. These two academicians converted the digitalization barriers back to English after giving two

weeks a break. Again, they were not only focused on literal translation but also on conceptual and cultural translation. The third step is the expert panel and pre-testing. After the translation process was finished, five academicians and two logistic managers read and evaluated the translated and original scales and gave feedback about them. Survey questions were modified based on this feedback, and the survey was prepared for the first round Delphi study. Lastly, the researcher received feedback from participants at the end of each round and again modified the survey.

5.1.2. Sampling

The Delphi method is ideal for enhancing the overall understanding of multifaceted problems and solving problems that require multiple solutions (Skinner et al., 2015: 35; Şahin, 2001: 216). As part of its process and one of the features of the Delphi method is to select experts as a participant. An expert group's collective ideas are particularly helpful when the problem does not require advanced or precise analysis. Moreover, a group's opinion will be more objective than an individual's (Critcher and Gladstone, 1998; Delbecq et al., 1975).

In addition, the expert selection is important for a successful Delphi application. Participants must be knowledgeable in their field. Thus, there is no random selection of experts or decision-makers in Delphi studies; instead, they are chosen based on their knowledge of the subject matter (Hasson et al., 2000: 1010; Melander, 2018:73). Furthermore, Skulmoski et al. (2007: 9) suggest purposive sampling combined with snowballing for expert recruitment.

Purposive sampling is one of the non-probability sampling techniques and is also called judgmental, subjective, or selective sampling. There are seven types of purposive sampling, which are; (1) maximum variation, (2) homogeneous, (3) typical case, (4) extreme (or deviant) case, (5) critical case, (6) total population and (7) expert sampling (Laerd Dissertation, 2022; Nikolopoulou, 2022; Rai and Thapa, 2015).

The purposive sampling method focuses on the characteristics of a population that are important for answering the research questions to maximize the results' accuracy. Therefore, in this study, two different sampling types were used to determine participants, which are purposive sampling and snowball sampling.

Expert sampling is preferred when the study needs the opinions of experts who have a high degree of knowledge in a specific area. In purposeful expert sampling, the researcher selects people most suitable for the purpose of the research (Yıldırım and Şimşek, 2011). Therefore, expert sampling was selected as the purposive type of sampling in this research because this thesis requires people with a high level of knowledge about the digitalization process in the logistics sector.

The size of the participant is the other criterion to determine the Delphi sample. There is no set standard for sample size exists in this method. Gordon (1994) observes that 15–35 people often participate in panels, whereas, according to Witkin and Altschuld (1995), panels should be less than 50 in size. Moreover, according to Şahin (2001), the ideal size of participants is between 10-20 people. Most of the authors recommend a smaller group size, and in most cases, the panel consists of 10 to 30 experts (Delbecq et al., 1975; Keil et al., 2002: 106; Daniel and White, 2005; Worrell et al., 2013: 198).

Various researchers determine different criteria to select experts; for example, Powell (2003) chooses experts based on work experience, and Skulmoski et al. (2007) decide on experts based on their knowledge, experience, capacity, willingness, and sufficient time to participate in the study. Therefore, in this study, experts were selected based on these criteria;

- experts have a min 3 years of work experience in the logistics area
- experts' willingness to participate in the study
- experts have sufficient time to participate in the study

Therefore, in this study, participants were selected among managers and academicians with experience in logistics. Firstly, three academicians and five logistic managers accepted to participate in this study. Later, the researchers asked them if they knew of another expert who may be interested in willing to participate in the study. Some experts recommended three new people, and some of them recommended two people. At the end of the sample selection process, 14 experts were selected as samples. They all had a minimum of 3 years of work experience in logistics, a willingness to participate, and sufficient time for this study. Thus, the selection of experts was finished on 9 November 2022 because this study reached the saturation point (14 experts).

Table 16: Delphi Respondent Profile

Respondent Code	Gender	Qualification	Occupation	Experience (years)
Expert 1	Man	PhD	Academician	23
Expert 2	Man	Graduated	Regional Director	30
Expert 3	Woman	PhD	Academician	21
Expert 4	Man	PhD	Academician	20
Expert 5	Man	Graduated	Logistic Sales Executive	3
Expert 6	Woman	Graduated	Logistic Sales Executive	3
Expert 7	Woman	Graduated	Logistics Operations Manager	3
Expert 8	Man	Master	Authorized Customs Broker	35
Expert 9	Woman	Graduated	Deputy Director General	21
Expert 10	Man	Graduated	Regional Director	18
Expert 11	Man	Graduated	General Director	23
Expert 12	Man	Master	General Director	17
Expert 13	Man	Graduated	Regional Director	28
Expert 14	Woman	Graduated	Logistics Manager	13

Source: Author's own compilation

Table 17: Characteristics of Selected Experts

Dimensions		Frequency	Percent
Gender	Man	9	64.29
	Woman	5	35.71
Qualification	Postgraduate	5	35.71
	Graduated	9	64.29
Occupation	lower level	3	21.43
	middle-level	3	21.43
	senior-level	8	57.14
Experience	Less than 10 Years	3	21.43
	10-20 Years	4	28.57
	More than 20 Years	7	50

Source: Author's own compilation

Delphi respondent profile and characteristics of selected experts are given in Table 16 and Table 17. The sample size is 14, and 9 (64.29%) are men, and 5 (35.71%) are women. Male respondents are approximately two times more than women. When evaluating the qualification of experts, it is seen that nine experts have a university degree, and five experts have a master's or doctoral's degree. Moreover, all of the experts are white-collar workers, three experts are the middle-level manager, and eight experts are the senior-level manager in their position. In addition, only three experts have less than ten years of work experience, and the remaining participants have more than ten years of experience in logistics. So the participants have qualified knowledge in their area because they graduated from a university, have more than three years of experience in the field, and are white-collar workers.

5.1.3. Data Collection Process

Twenty-seven digitalization barriers were identified by systematic literature review methodology. Later, these barriers were translated from English to Turkish, and the study sample was determined. The researcher reached out to a total number of 14 experts. After all, the items were arranged and turned into questionnaires for First and Second Round Delphi studies. The survey was divided into two parts. At the beginning of the survey, the purpose of the study was explained, and later, definitions of digitization and digital transformation were written. So that all participants had a common opinion about these terms. In the first part of the survey, the researcher asked the experts to evaluate items and whether they are important digitalization barriers to logistic operation. Again, the researcher wrote the definition of all barriers to create common knowledge about the barriers. In the second part of the survey, there were demographic questions such as age, gender, and work experience of the experts. The First and the Second round Delphi surveys can be seen in appendixes 1 and 2.

Moreover, this study selects a five-point Likert scale as the item type. The selected experts evaluated whether the questionnaires are important digitalization barriers to logistic operation. “1” means “I strongly disagree that this item is not digitalization barriers to logistic operation,” while “5” means “I strongly agree that this item is digitalization barriers to logistic operation.”

The researcher sent email instructions to participants before each round and a link to access each questionnaire. The experts answered the questionnaire in two different rounds using an online survey website (Google Forms). The online questionnaire was used because it was simpler to distribute surveys among the experts without physical restrictions.

Every round, panelists had one week to complete questionnaires. The researcher eliminated panelists who did not complete the instrument. In the first round, 14 selected experts completed questionnaires, and six barriers were found as unimportant for the Turkish logistic sector. Later, the researcher sent a second Questionnaire to experts via email, received answers, and analyzed the results to determine digitalization barriers. In this round, one expert (respondent code: expert 14) did not want to complete the survey, so she was eliminated from the second phase. 13 various experts attended and completed the second Delphi phase, and the response

rate was 95.85%. According to Keeney et al. (2001), the researcher reaches a sufficient number of participants if the response rate is more than 70%. So, one participant drop-out was not affected by this Delphi study and result.

In the second round, all remaining barriers (21) were found as important for the Turkish logistic sector. Delphi is a qualitative method that collects and gathers opinions from selected experts to build consensus (Dalkey and Helmer, 1963; Landeta et al., 2011; Parente et al., 1984). Therefore, in the second round, the experts reached a consensus about digitalization barriers to logistic operation. So, Delphi rounds and the data collection period ended between the 10th and 29th of October 2022.

5.1.4. Data Analysis

Delphi surveys do not have a universally agreed-upon consensus criterion. The researchers determine consensus criteria based on the sample size, the research objective, and available resources. For example, According to Loughlin and Moore (1979), respondents should have 51% agreement, whereas Sumsion (1998) recommends 70% and Green et al. (1999) opted for 80% agreement. Moreover, in their model, Hsu and Sandford (2007) suggest focusing on items that receive more than 70% positive ratings and where the median is higher than neutral. Other items can be eliminated as there is no consensus between panelists.

Furthermore, some researchers prefer to use the interquartile range (IQR) while determining the consensus (Clayton, 1997: 379). The interquartile range is the difference between the upper and lower quartiles. (IQR: Q3-Q1). Gracht (2012) suggests the researchers use the median and interquartile range together to determine whether consensus is met. Besides that, according to Zelif and Heldenbrand (1993), if an item's "IQR" is less than 1.2, then the expert panel has reached a consensus on the item.

Table 18: Consensus Evaluation Criteria

Consensus	Explanation
YES	Median ≥ 4 and IQR ≤ 1.2
	Median ≥ 4 , IQR > 1.2 and Frequency of 4-5 $\geq 70\%$

Source: Author's own compilation

In the Delphi study, there are two types of statistical analysis to evaluate whether consensus is met; the first is the central tendency, and the second is the measures of variability. This study uses central tendency statistical analysis to determine whether consensus is met. Data were analyzed through SPSS 24. So, the median, interquartile range, and frequency of the first and two-round results are evaluated to establish levels of agreement. Consensus evaluation criteria are explained in Table 18.

Hsu and Sandford (2007) suggest focusing on items with more than 70% positive ratings and where the median is higher than neutral. Moreover, Zeliff and Heldenbrand (1993) recommend using the "IQR" of items; this data should be less than 1.2. Therefore, based on these recommendations, two types of consensus criteria were determined. If the median of the items is equal to or more than four and the IQR of the items is equal to or less than 1.2, there is a consensus among panelists. However, if the IQR of the item is higher than 1.2, the median of the item must be equal or more than 4, and the item must have equal or more than 70% positive ratings to determine whether consensus is met.

5.1.4.1. First Delphi Round and Result

The researcher sent email instructions to participants before the first round, along with links to access each questionnaire. The first questionnaires were sent electronically to experts on October 10, 2022, and the experts had one week to complete the questionnaires. They answered the questionnaire in this round using an

online survey website (Google Forms). The first round was completed with 14 experts between the dates 10.10.2022 – 15.10.2022.

Furthermore, this study used a five-point Likert scale as the item type. The selected experts evaluated the questionnaire and whether they are important digitalization barriers to logistic operation. “1” means “I strongly disagree that this item is not digitalization barriers to logistic operation,” while “5” means “I strongly agree that this item is digitalization barriers to logistic operation.”

This study used the central tendency statistical analysis type to evaluate whether there is consensus. Thus, the whole answers were downloaded to an Excel sheet and organized, and later they were analyzed using the statistical software SPSS 24. Median, interquartile range (IQR), and frequency and percentage of 4-5 answers were calculated.

The results for the first round are shown in Table 19. This table indicates which barriers remained and which ones were eliminated based on the median, IQR, and frequency and percentage of 4-5 answers. There were 27 items in the first round survey, and when viewed from the logistic experts’ perspective, six were eliminated; thus, 21 were accepted as digitalization barriers.

Under the technological theme, “lack of technological infrastructure,” under the financial theme, “return on investment (ROI) concerns,” under the organizational theme, “lack of digital culture,” and “resistance to change- managers” items were eliminated due to the percentage of 4-5 less than 70%. Moreover, under the environmental theme, “high energy consumption” and “lack of proper waste management (electronic waste and emission risk)” were eliminated due to median values below 4. Therefore, these six items were removed from the second survey. Besides, all items under the environmental theme were eliminated, so this theme was also removed from the survey.

Table 19 shows that 21 items were accepted by experts as digitalization barriers on logistic operation for first round. These are;

- “Complex network systems and Lack of System Integration”,
- “Data Complexity”,
- “Lack of information about potentialities of newer digital technologies”,
- “Lack of effective cybersecurity mechanisms”,

“Data Privacy Concerns”,
 “Threat to intellectual property”,
 “High investment/ implementation costs”,
 “Lack of financial resources”,
 “Lack of a Digital Vision and Strategy”,
 “Lack of training and training facilities”,
 “Resistance to change- employees”,
 “Lack of necessary skillset and qualified labor force for adopting new technologies”,
 “Lack of a leader with appropriate skills, competencies and experience”,
 “Lack of supply chain integration between partners”,
 “Lack of trust and support among stakeholders”,
 “Uncertainty about customers' needs and wants”,
 “Lack of industry specific guidelines, regulations and standardization”,
 “Lack of legal and ethical policies”,
 “Insufficient R&D”,
 “Inadequate organizational structure”,
 “Lack of communication, coordination and collaboration across different units or departments”.

The first 18 items were accepted barriers due to their median were equal to or more than 4 and IQR were less than 1.2. The IQR of the last 3 items (insufficient R&D, inadequate organizational structure and lack of communication, coordination and collaboration across different units or departments) were more than 1.2; however, the median of them equal to 4 and a percentage of 4-5 was more than 70%. Therefore, these 3 items also accepted as digitalization barriers for the first round. Finally, end of the first Delphi round, 6 barriers and 1 theme were eliminated and 21 items remained and re-evaluated in the second Delphi round.

Table 19: Analysis of First Delphi Round Results

		Results						
Main Thema	Barriers	Q1	Median	Q3	IQR	Frequency of 4-5	Percentages of 4-5	Consensus
1) Technological Barriers	Lack of technological infrastructure	2.25	4	4	1.75	9	64	No
	Complex network systems and Lack of System Integration	4	4	4.75	0.75	12	86	Yes
	Data Complexity	4	4	5	1	11	79	Yes
	Insufficient R&D	3.25	4	4.75	1.5	10	71	Yes
	Lack of information about potentialities of newer digital technologies	4	4	4	0	11	79	Yes
2) Data Security Barriers	Lack of effective cybersecurity mechanisms	4	4	4	0	13	93	Yes
	Data Privacy Concerns	4	4	5	1	12	86	Yes
	Threat to intellectual property	3	4	4	1	8	57	Yes
3) Financial Barriers	High investment/ implementation costs	4	4.5	5	1	14	100	Yes
	Return on investment (ROI) concerns	2	4	4	2	9	64	No
	Lack of financial resources	3	4	4	1	8	57	Yes
4) Organizational Barriers	Lack of digital culture	2.25	4	4	1.75	9	64	No
	Lack of a Digital Vision and Strategy	4	4	4.75	0.75	12	86	Yes
	Inadequate organizational structure	3.25	4	4.75	1.5	10	71	Yes
	Lack of training and training facilities	3	4	4	1	9	64	Yes
	Lack of communication, coordination and collaboration across different units or departments	3.25	4	4.75	1.5	10	71	Yes
	Resistance to change- employees	4	4	5	1	11	79	Yes



	Lack of necessary skillset and qualified labor force for adopting new technologies	3	4	4	1	9	64	Yes
	Resistance to change- managers	2	4	4	2	9	64	No
	Lack of a leader with appropriate skills, competencies and experience	3.25	4	4	0.75	10	71	Yes
5) Extrinsic Barriers	Lack of supply chain integration between partners	4	4	5	1	13	93	Yes
	Lack of trust and support among stakeholders	4	4	4	0	12	86	Yes
	Uncertainty about customers' needs and wants	3.25	4	4	0.75	10	71	Yes
6) Environmental Barriers	High energy consumption	2	3	3.75	1.75	4	29	No
	Lack of proper Waste Management (Electronic waste and Emission risk)	2.25	3	4	1.75	6	43	No
7) Legal and Industry Barriers	Lack of industry specific guidelines, regulations and standardisation	4	4	4	0	13	93	Yes
	Lack of legal and ethical policies	4	4	4	0	12	86	Yes

Source: Author's own compilation

5.1.4.2. Second Delphi Round and Result

The researcher sent participants a second email and links to access each questionnaire. The second questionnaires were sent electronically to experts on October 20, 2022, and the experts had one week to complete the questionnaires. The second survey contained information about the first round result. The participant knew that all items found as important by the panelists. So, in this round, they re-evaluated these items, which are still important digitalization barriers to logistic operation. They answered the questionnaire in this round using an online survey website (Google Forms). One of the experts (code: expert 14) did not want to complete the second survey and was eliminated from the second phase. Thirteen experts attended and completed the second Delphi round, and the response rate was 95.85%. According to Keeney et al. (2001), the researcher reaches a sufficient number of participants if the response rate is more than 70%. Thus, one participant drop-out does not negatively affect the Delphi study and the results. This round was completed with 13 experts between the dates 20.10.2022 – 29.10.2022.

Besides, in the second phase, a five-point Likert scale was used as the item type. The selected experts evaluated the questionnaire to identify whether they are important digitalization barriers to logistic operation. “1” means “I strongly disagree that this item is not digitalization barriers to logistic operation,” while “5” means “I strongly agree that this item is digitalization barriers to logistic operation.”

In this round, again central tendency statistical analysis type was used to evaluate whether there was a consensus. Thus, the whole answers were downloaded to an Excel sheet and organized, and later they were analyzed using the statistical software SPSS 24. Median, interquartile range (IQR), and frequency and percentage of 4-5 answers were calculated.

The results for the second round are shown in Table 20. This table indicates which barriers remained and which ones were eliminated based on the median, IQR, and frequency and percentage of 4-5 answers. There were 21 items in the second round survey, and when viewed from the logistic experts’ perspective, all the items were accepted as digitalization barriers.

Table 20 shows that experts accepted 21 items as digitalization barriers on logistic operation for the second round because their median was equal to (or more than) 4 and IQR was less than 1.2.

Finally, end of the second Delphi round, the panelists reached a consensus about digitalization barriers to logistic operation. So, Delphi rounds and the data collection period ended between the 10th of and 29th of October. Digitalization barriers to logistic operation in Türkiye are as follows;

- “Complex network systems and Lack of System Integration”,
- “Data Complexity”,
- “Lack of information about potentialities of newer digital technologies”,
- “Lack of effective cybersecurity mechanisms”,
- “Data Privacy Concerns”,
- “Threat to intellectual property”,
- “High investment/ implementation costs”,
- “Lack of financial resources”,
- “Lack of a Digital Vision and Strategy”,
- “Lack of training and training facilities”,
- “Resistance to change- employees”,
- “Lack of necessary skillset and qualified labor force for adopting new technologies”,
- “Lack of a leader with appropriate skills, competencies and experience”,
- “Lack of supply chain integration between partners”,
- “Lack of trust and support among stakeholders”,
- “Uncertainty about customers' needs and wants”,
- “Lack of industry specific guidelines, regulations and standardization”,
- “Lack of legal and ethical policies”,
- “Insufficient R&D”,
- “Inadequate organizational structure”,
- “Lack of communication, coordination and collaboration across different units or departments”.

Table 20: Analysis of Second Delphi Round Results

Main Thema	Barriers	Results						
		Q1	Median	Q3	IQR	Frequency of 4-5	Percentages of 4-5	Consensus
1) Technological Barriers	Complex network systems and Lack of System Integration	4	4	4	0	13	93	Yes
	Data Complexity	4	4	5	1	11	79	Yes
	Insufficient R&D	4	4	5	1	11	79	Yes
	Lack of information about potentialities of newer digital technologies	4	4	4	0	11	79	Yes
2) Data Security Barriers	Lack of effective cybersecurity mechanisms	4	4	4	0	10	71	Yes
	Data Privacy Concerns	4	4	5	1	12	86	Yes
	Threat to intellectual property	4	4	4	0	10	71	Yes
3) Financial Barriers	High investment/ implementation costs	4	5	5	1	13	93	Yes
	Lack of financial resources	4	4	5	1	11	79	Yes
4) Organizational Barriers	Lack of a Digital Vision and Strategy	4	4	5	1	11	79	Yes
	Inadequate organizational structure	4	4	5	1	10	71	Yes
	Lack of training and training facilities	4	4	5	1	11	79	Yes
	Lack of communication, coordination and collaboration across different units or departments	4	4	5	1	11	79	Yes
	Resistance to change- employees	4	4	5	1	11	79	Yes
	Lack of necessary skillset and qualified labor force for adopting new technologies	3	4	4	1	9	64	Yes
	Lack of a leader with appropriate skills, competencies and experience	4	5	5	1	11	79	Yes



5) Extrinsic Barriers	Lack of supply chain integration between partners	4	4	5	1	12	86	Yes
	Lack of trust and support among stakeholders	4	4	4	0	11	79	Yes
	Uncertainty about customers' needs and wants	4	4	5	1	10	71	Yes
7) Legal and Industry Barriers	Lack of industry specific guidelines, regulations and standardisation	3	4	4	1	9	64	Yes
	Lack of legal and ethical policies	4	4	5	1	10	71	Yes

Source: Author's own compilation

5.1.5. Research Findings: Barriers Adoption and Determination for Logistic Companies

Twenty-seven different digitalization barriers and seven main themes are identified from relevant literature. These barriers cover all topics without considering cultural, economic, political, etc. differences. Thus, in this part of the study, Delphi was applied as a second methodology to identify digitalization barriers to logistic operation in Türkiye. This is a problem-solving technique to help researchers scientifically collect expert information to determine the existing digitalization barriers to logistics operations in Türkiye. Therefore, this method aims to identify important digitalization barriers that firms face operating in Türkiye by considering cultural, economic, political, geographical, etc. factors.

In this study, purposive and snowball sampling types were used to determine participants, and they were selected among managers and academicians with experience in the logistics field. Firstly, three academicians and five logistic managers accepted to participate in this study. Later, they recommended new participants. At the end of the sample selection process, 14 experts were selected as samples. They all have a minimum of 3 years of work experience in logistics, a willingness to participate, and sufficient time for this study. Thus, the selection of experts was finished on 9 November 2022 because this study reached the saturation point (14 experts).

Furthermore, a five-point Likert scale was selected as the item type in Delphi surveys. The participants evaluated the Questionnaire whether these 27 items are important digitalization barriers to logistic operation. “1” means “I strongly disagree that this item is not digitalization barriers to logistic operation,” while “5” means “I strongly agree that this item is digitalization barriers to logistic operation.”

The researcher sent email instructions to participants before each round and links to access each Questionnaire. The experts answered the Questionnaire in two different rounds using an online survey website (Google Forms). Every round, experts had one week to complete questionnaires. In the first round, 14 participants answered the survey, and six barriers were found as unimportant for the Turkish logistic sector. Later, the researcher sent a second Questionnaire to experts via email, received answers, and analyzed the results to determine digitalization barriers. In this round, one expert (respondent code: expert 14) did not want to complete the survey, so she

was eliminated from the second phase. 13 various experts attended and completed the second Delphi phase, and the response rate was 95.85%. In the second round, all remaining barriers (21) were found as important for the Turkish logistic sector. The experts agreed on digitalization barriers to logistic operations in the second round. So, the Delphi rounds and data collection period concluded between the 9th and 29th of October. The Delphi study used central tendency statistical analysis to determine whether consensus was met. Data were analyzed through SPSS 24. So, the median, interquartile range, and frequency of the first and two-round results were evaluated to establish levels of agreement.

Comparisons of the First and Second Delphi Round Results are shown in Table 21. The First Delphi result shows that “lack of technological infrastructure,” “return on investment (ROI) concerns,” “lack of digital culture,” and “resistance to change-managers” items were eliminated due to a frequency of 4-5 less than 70%. Moreover, “high energy consumption” and “lack of proper waste management (electronic waste and emission risk)” were eliminated due to median values below 4. Therefore, these six items were removed from the second survey. The Second Delphi result shows that experts accepted the remaining 21 items as digitalization barriers on logistic operation for the second round because their median was equal to (or more than) 4 and IQR was less than 1.2.

Finally, end of the second Delphi round, the panelists reached a consensus about digitalization barriers to logistic operation. So, Delphi rounds, and the data collection period ended.

Table 21: Comparisons of First and Second Delphi Round Results

Main Thema	Barriers	First Delphi Result	Second Delphi Result	Consensus	Final Result
1) Technological Barriers	Lack of technological infrastructure	Frequency of 4-5 less than 70%	Not included for second round	No	Eliminated
	Complex network systems and Lack of System Integration	Median and IQR- okey	Median and IQR- okey	Yes	✓
	Data Complexity	Median and IQR- okey	Median and IQR- okey	Yes	✓
	Insufficient R&D	Median, IQR and Frequency- okey	Median and IQR- okey	Yes	✓
	Lack of information about potentialities of newer digital technologies	Median and IQR- okey	Median and IQR- okey	Yes	✓
2) Data Security Barriers	Lack of effective cybersecurity mechanisms	Median and IQR- okey	Median and IQR- okey	Yes	✓
	Data Privacy Concerns	Median and IQR- okey	Median and IQR- okey	Yes	✓
	Threat to intellectual property	Median and IQR- okey	Median and IQR- okey	Yes	✓
3) Financial Barriers	High investment/ implementation costs	Median and IQR- okey	Median and IQR- okey	Yes	✓
	Return on investment (ROI) concerns	Frequency of 4-5 less than 70%	Not included for second round	No	Eliminated
	Lack of financial resources	Median and IQR- okey	4	Yes	✓

4) Organizational Barriers	Lack of digital culture	Frequency of 4-5 less than 70%	Not included for second round	No	Eliminated
	Lack of a Digital Vision and Strategy	Median and IQR- okey	Median and IQR- okey	Yes	✓
	Inadequate organizational structure	Median, IQR and Frequency- okey	Median and IQR- okey	Yes	✓
	Lack of training and training facilities	Median and IQR- okey	Median and IQR- okey	Yes	✓
	Lack of communication, coordination and collaboration across different units or departments	Median, IQR and Frequency- okey	Median and IQR- okey	Yes	✓
	Resistance to change- employees	Median and IQR- okey	Median and IQR- okey	Yes	✓
	Lack of necessary skillset and qualified labor force for adopting new technologies	Median and IQR- okey	Median and IQR- okey	Yes	✓
	Resistance to change- managers	Frequency of 4-5 less than 70%	Not included for second round	No	Eliminated
	Lack of a leader with appropriate skills, competencies and experience	Median and IQR- okey	Median and IQR- okey	Yes	✓
5) Extrinsic Barriers	Lack of supply chain integration between partners	Median and IQR- okey	Median and IQR- okey	Yes	✓
	Lack of trust and support among stakeholders	Median and IQR- okey	Median and IQR- okey	Yes	✓
	Uncertainty about customers' needs and wants	Median and IQR- okey	Median and IQR- okey	Yes	✓
6) Environmental Barriers	High energy consumption	Median less than 4	Not included for second round	No	Eliminated



	Lack of proper Waste Management (Electronic waste and Emission risk)	Median less than 4	Not included for second round	No	Eliminated
7) Legal and Industry Barriers	Lack of industry specific guidelines, regulations and standardisation	Median and IQR- okey	Median and IQR- okey	Yes	✓
	Lack of legal and ethical policies	Median and IQR- okey	Median and IQR- okey	Yes	✓

Source: Author's own compilation

5.2. SWARA: PRIORITIZING DIGITALIZATION BARRIERS TO LOGISTIC OPERATION

In this thesis, three various methodologies were applied. The first methodology is the systematic literature review. This is used for the researcher to determine digitalization barriers to logistic operation. End of the study, 27 different digitalization barriers and seven main themes were identified from relevant literature. However, these barriers covered all topics without considering cultural, economic, and political differences. So, as a second methodology, the Delphi method was applied to determine digitalization barriers to logistic operation in Türkiye. In the Delphi data collection period, the researcher applied two series of rounds to eliminate unrelated digitalization barriers for Türkiye. In conclusion, six barriers and one theme were eliminated, and 21 barriers were accepted as digitalization barriers to logistic operations in Türkiye. Lastly, the SWARA methodology was used to rank each digitalization barrier and determine the weight values of them.

This paper applies the SWARA method for several reasons. Firstly, using SWARA, managers, and academicians can select their priorities in light of the current logistic sector situation. Secondly, SWARA is not considered time-consuming and complicated compared to other methods. Lastly, this method calculates weights and the relative importance of criteria more logically.

The following parts explain the sample, data collection process, data analysis, and research findings in detail.

5.2.1. Sampling

In the Delphi study step, the sample of the study was explained. In this thesis, two different sampling types were used to determine participants, which are purposive expert sampling and snowball sampling. Expert sampling was preferred because this thesis requires people with a high level of knowledge about the digitalization process in the logistics sector. Moreover, the researcher set three criteria to select experts who are; experts must have a minimum of three years' work experience in logistic areas, be willing to take part in the study, and have sufficient time to do so. Consequently,

participants for this study were selected from managers and academics with experience in logistics.

At the end of the Delphi sample selection process, 14 experts were selected as samples. They all have at least three years of experience in logistics, are willing to participate, and have sufficient time to complete the study. The First Delphi round was completed by 14 experts; however, one of the experts wanted to withdraw from the study, so 13 experts completed the second round of the Delphi study. Later, the researcher asked participants whether they wanted to attend to SWARA study, and nine experts accepted to attend the study. Therefore, the sample of the SWARA study was nine, and the selection of experts was finished on 1 November 2022.

Table 22: SWARA Respondent Profile

Respondent Code	Gender	Qualification	Occupation	Experience (years)
Expert 1	Man	Graduated	Regional Director	30
Expert 2	Man	PhD	Academician	23
Expert 3	Woman	PhD	Academician	21
Expert 4	Man	PhD	Academician	20
Expert 5	Man	Graduated	Logistic Sales Executive	3
Expert 6	Woman	Graduated	Logistic Sales Executive	3
Expert 7	Woman	Graduated	Logistics Operations Manager	3
Expert 8	Man	Master	Authorized Customs Broker	35
Expert 9	Woman	Graduated	Deputy Director General	21

Source: Author's own compilation

Table 23: Summary of Respondents Characteristics- SWARA

Dimensions		Frequency	Percent
Gender	Man	4	44.44
	Woman	5	55.56
Qualification	Postgraduate	4	44.44
	Graduated	5	55.56
Occupation	lower level	3	33.33
	middle-level	0	0.00
	senior-level	6	66.67
Experience	Less than 10 Years	3	33.33
	10-20 Years	1	11.11
	More than 20 Years	5	55.56

Source: Author's own compilation

SWARA respondent profile and characteristics of selected experts are given in Table 22 and Table 23. The sample size is 9, and 4 (44.44%) are men, and 5 (55.56%) are women. Men and women respondents are approximately the same numbers. When evaluating the qualifications of experts, it is seen that five experts have a university degree, and four experts have master's or doctoral's degrees. Furthermore, all of the experts are white-collar workers, three experts are the lower level manager, and six experts are the senior level manager in their position. Moreover, only three experts have less than ten years of work experience, and the remaining participants have more than ten years of experience in logistics. So the participants have qualified knowledge in their area because they graduated from a university, have more than three years of field experience, and are white-collar workers.

5.2.2. Data Collection Process

Fourteen experts were selected as samples for the Delphi study. However, one wanted to quit the study in the second round. Thus, the second round of the Delphi was completed by 13 experts. Afterward, the researcher asked participants whether

they wanted to attend to SWARA study, and nine experts accepted to attend the study. Therefore, the sample of the SWARA study was nine, and the selection of experts was finished on 1 November 2022.

In the Delphi study, 21 barriers were identified as digitalization barriers to logistic operations in Türkiye. Later, these items were arranged and turned into a questionnaire for SWARA studies. At the beginning of the survey, the purpose of this study was explained, and later an example was given. This example explained the SWARA method and gave information to participants about how they should answer the survey. The SWARA survey can be seen in appendix 3.

Afterward, the researcher sent participants the SWARA survey via e-mail and access links. The experts had one week to complete the questionnaires. Three experts answered the survey by themselves. However, the remaining (6) experts found the survey complicated, so the researcher arranged online and face-to-face meetings with them to explain the survey. These six experts answered the SWARA survey. Therefore, the data collection period for the SWARA methodology ended between the 1st and 15th of November 2022.

5.2.3. Data Analysis

This part of the study aims to rank each digitalization barrier to logistic operation and determine their weight values. Therefore, SWARA was applied to evaluate and prioritize digitalization barriers in the logistics sector. In this study, the SWARA procedure is conducted following the steps;

Step 1: In this step, each evaluation criterion is ranked from most to least important. Thus, the nine experts sorted the digitalization barriers from the most important to the least important barriers.

j: the evaluation criterion from the most important criterion to the least important criterion

$j = 1, 2, 3, \dots, n$

l: the expert; $l = 1, 2, \dots, L$

Step 2: During this stage, the experts grade criteria based on previous criteria to determine their relative importance levels. The assessment is called “the comparative importance of average value (s_{jl}).”

s_{jl} : the importance of *j*. evaluation criterion according to (*j*+1). Evaluation criterion according to the expert *l*.

Step 3: The researcher calculate the coefficient (k_j) values. Equation 1 was used to calculation.

$$k_{jl} = \begin{cases} j = 1 \Rightarrow 1 \\ j > 1 \Rightarrow s_{jl} + 1 \end{cases} \quad \text{Equation 1}$$

Step 4: This is followed by recalculating the weight q_{jl} using Equation 2.

$$q_{jl} = \begin{cases} j = 1 \Rightarrow 1 \\ j > 1 \Rightarrow \frac{q_{j,l-1}}{k_{jl}} \end{cases} \quad \text{Equation 2}$$

w_{jl} : the importance level of j . evaluation criterion according to expert l ; $j = 1, 2, 3, \dots, n$

k : evaluation criterion; $k = 1, 2, 3, \dots, n$

Step 5: The weights of the evaluation criteria are calculated using Equation 3.

$$w_{jl} = \frac{q_{jl}}{\sum_{k=1}^n q_{kl}} \quad \text{Equation 3}$$

Step 6: Expert opinions are integrated as the last step of the SWARA method. Based on the average value of a group of experts, the final ranks are determined. Equation 4 is used to integrate expert opinions.

w_j : the integrated importance level of j . evaluation criterion; $j = 1, 2, 3, \dots, n$

$$w_j = \sqrt[L]{\prod_{l=1}^L w_{jl}} \quad \text{Equation 4}$$

First 5 steps of the SWARA method calculation is shown in the Table 24.

Table 24: Example of the SWARA Calculation

Criterion	Comparative importance of average value s_{jl}	Coefficient $k_{jl} = s_{jl} + 1$	Recalculated the weight (q_{jl})	The weights of the evaluation criteria (w_{jl})
X ₃		1	1	0.1534
X ₁	0.23	1.23	0.8130	0.1247
X ₄	0.22	1.22	0.6664	0.1022
X ₂	0.16	1.16	1.0000	0.1534

Source: Author's own compilation

5.2.4. Research Findings: Digitalization Barriers Prioritization and Weights

The first part of this study aimed to extensively investigate the literature by using a structured literature review protocol to explore the barriers logistic firms face in adopting digitalization in their operation process. The 23 publications were selected for this thesis, and this structured literature review methodology disclosed 27 various digitalization barriers and 7 Themes to logistic operation.

In addition, Delphi was applied as a second methodology to adapt digitalization barriers to logistic operations in Türkiye. This method aims to examine important digitalization barriers that firms face operating in Türkiye by taking care of cultural, economic, political, geographical, etc. factors. End of the study, six barriers and one theme were eliminated because they were unsuitable for Türkiye conditions.

Finally, SWARA was selected as this thesis's third and last methodology. This method was applied to determine weights and prioritize the digitalization barriers for Türkiye logistic sector. In this study, nine experts answered the survey, and the results were downloaded to an Excel sheet and organized. Later all data were analyzed using the Excel program. In the following tables, the results of each expert answer are shown with calculation. Rank, comparative (relative) importance, coefficient, recalculated weight, and final weights of each barrier's importance were calculated and shown between Table 25 to Table 33.

Table 25: SWARA Result of Expert 1

Rank	Barriers	s_{j1}	k_{j1}	q_{j1}	w_{j1}
1	Data privacy concerns		1.0000	1.0000	0.1534
2	Lack of effective cybersecurity mechanisms	0.2300	1.2300	0.8130	0.1247
3	High investment/implementation costs	0.2200	1.2200	0.6664	0.1022
4	Threat to intellectual property	0.1600	1.1600	0.5745	0.0881
5	Lack of training and training facilities	0.0900	1.0900	0.5270	0.0808
6	Lack of a digital vision and strategy	0.1500	1.1500	0.4583	0.0703
7	Lack of communication, coordination and collaboration across different units or departments	0.1400	1.1400	0.4020	0.0617
8	Data complexity	0.1100	1.1100	0.3622	0.0555
9	Insufficient R&D	0.2500	1.2500	0.2897	0.0444
10	Lack of legal and ethical policies	0.2000	1.2000	0.2415	0.0370
11	Inadequate organizational structure	0.2800	1.2800	0.1886	0.0289
12	Lack of financial resources	0.2700	1.2700	0.1485	0.0228
13	Lack of supply chain integration between partners	0.2900	1.2900	0.1151	0.0177
14	Lack of trust and support among stakeholders	0.0500	1.0500	0.1097	0.0168
15	Uncertainty about customers' needs and wants	0.0400	1.0400	0.1054	0.0162

16	Lack of industry specific guidelines, regulations and standardisation	0.0200	1.0200	0.1034	0.0159
17	Lack of a leader with appropriate skills, competencies and experience	0.0000	1.0000	0.1034	0.0159
18	Lack of necessary skillset and qualified labor force for adopting new technologies	0.0800	1.0800	0.0957	0.0147
19	Resistance to change- employees	0.1500	1.1500	0.0832	0.0128
20	Lack of information about potentialities of newer digital technologies	0.1600	1.1600	0.0718	0.0110
21	Complex network systems and lack of system integration	0.1800	1.1800	0.0608	0.0093

Source: Author's own compilation

It can be concluded from Table 25 that the “data privacy concerns” item is the most important barrier. The weight of this item is 15.34%. So, according to Expert 1, data privacy concerns caused a big digitalization barrier for the logistic sector, and the sector should focus on this barrier and develop a solution. Moreover, “lack of effective cybersecurity mechanisms” was ranked second, and its weight is 12.47%. Besides, when evaluating the comparative importance of the first and second barriers, the first barrier (data privacy concerns) is 23% more important than the second barrier (lack of effective cybersecurity mechanisms).

Table 26: SWARA Result of Expert 2

Rank	Barriers	s_{j2}	k_{j2}	q_{j2}	w_{j2}
1	Complex network systems and lack of system integration		1.0000	1.0000	0.0821
2	Lack of communication, coordination and collaboration across different units or departments	0.1000	1.1000	0.9091	0.0746
3	Lack of effective cybersecurity mechanisms	0.0500	1.0500	0.8658	0.0711
4	Data privacy concerns	0.1500	1.1500	0.7529	0.0618
5	Insufficient R&D	0.0200	1.0200	0.7381	0.0606
6	Lack of trust and support among stakeholders	0.0500	1.0500	0.7030	0.0577
7	Lack of supply chain integration between partners	0.0200	1.0200	0.6892	0.0566
8	Lack of a leader with appropriate skills, competencies and experience	0.1000	1.1000	0.6265	0.0514
9	Lack of necessary skillset and qualified labor force for adopting new technologies	0.0500	1.0500	0.5967	0.0490
10	Inadequate organizational structure	0.0100	1.0100	0.5908	0.0485
11	Lack of training and training facilities	0.0500	1.0500	0.5626	0.0462
12	Data complexity	0.0300	1.0300	0.5463	0.0448
13	Resistance to change- employees	0.1000	1.1000	0.4966	0.0408
14	High investment/ implementation costs	0.0400	1.0400	0.4775	0.0392

15	Lack of financial resources	0.0300	1.0300	0.4636	0.0381
16	Lack of a digital vision and strategy	0.0500	1.0500	0.4415	0.0362
17	Lack of information about potentialities of newer digital technologies	0.1000	1.1000	0.4014	0.0329
18	Threat to intellectual property	0.1800	1.1800	0.3402	0.0279
19	Uncertainty about customers' needs and wants	0.0200	1.0200	0.3335	0.0274
20	Lack of industry specific guidelines, regulations and standardisation	0.0200	1.0200	0.3269	0.0268
21	Lack of legal and ethical policies	0.0200	1.0200	0.3205	0.0263

Source: Author's own compilation

SWARA result of Expert 2 can be seen in the Table 26. Based on the the analysis, the top five digitalization barriers are “complex network systems and lack of system integration”, “lack of communication, coordination and collaboration across different units or departments”, “lack of effective cybersecurity mechanisms”, “data privacy concerns” and “insufficient R&D”. The weight of the first five barriers are 8.21%, 7.46%, 7.11%, 6.18% and 6.06% respectively. Moreover, when evaluating the comparative importance of the barriers, there is not huge differences between barriers. For example, the first barrier (complex network systems and lack of system integration) is 10% more important than the second barrier (lack of communication, coordination and collaboration across different units or departments) and second barrier (lack of communication, coordination and collaboration across different units or departments) is 5% more important than the third barrier (lack of effective cybersecurity mechanisms).

Table 27: SWARA Result of Expert 3

Rank	Barriers	S_{j3}	k_{j3}	q_{j3}	w_{j3}
1	Lack of financial resources		1.0000	1.0000	0.0869
2	Lack of necessary skillset and qualified labor force for adopting new technologies	0.0000	1.0000	1.0000	0.0869
3	High investment/implementation costs	0.0500	1.0500	0.9524	0.0828
4	Lack of a leader with appropriate skills, competencies and experience	0.2000	1.2000	0.7937	0.0690
5	Lack of industry specific guidelines, regulations and standardisation	0.0500	1.0500	0.7559	0.0657
6	Lack of supply chain integration between partners	0.0500	1.0500	0.7199	0.0626
7	Lack of information about potentialities of newer digital technologies	0.0500	1.0500	0.6856	0.0596
8	Lack of a digital vision and strategy	0.0500	1.0500	0.6529	0.0568
9	Complex network systems and lack of system integration	0.0500	1.0500	0.6218	0.0541
10	Lack of legal and ethical policies	0.1000	1.1000	0.5653	0.0491
11	Data complexity	0.0500	1.0500	0.5384	0.0468
12	Lack of effective cybersecurity mechanisms	0.2000	1.2000	0.4487	0.0390
13	Data privacy concerns	0.2000	1.2000	0.3739	0.0325
14	Threat to intellectual property	0.0200	1.0200	0.3666	0.0319

15	Inadequate organizational structure	0.0500	1.0500	0.3491	0.0303
16	Lack of training and training facilities	0.0200	1.0200	0.3423	0.0297
17	Lack of communication, coordination and collaboration across different units or departments	0.0500	1.0500	0.3260	0.0283
18	Resistance to change- employees	0.0000	1.0000	0.3260	0.0283
19	Lack of trust and support among stakeholders	0.2000	1.2000	0.2716	0.0236
20	Uncertainty about customers' needs and wants	0.2000	1.2000	0.2264	0.0197
21	Insufficient R&D	0.2000	1.2000	0.1886	0.0164

Source: Author's own compilation

As can be seen from the Table 27, the first five digitalization barriers include “lack of financial resources (weight: 8.69%)”, “lack of necessary skillset and qualified labor force for adopting new technologies (weight: 8.69%)”, “high investment/ implementation costs (weight: 8.28%)”, “lack of a leader with appropriate skills, competencies and experience (weight: 6.90%)”, and “lack of industry specific guidelines, regulations and standardization (weight: 6.57%)”. According to Expert 3, the “lack of financial resources” and “lack of necessary skillset and qualified labor force for adopting new technologies” are the most important digitalization barriers to logistic important and their importance level are the same.

Table 28: SWARA Result of Expert 4

Rank	Barriers	S_{j4}	k_{j4}	q_{j4}	w_{j4}
1	Lack of financial resources		1.0000	1.0000	0.1484
2	High investment/ implementation costs	0.1500	1.1500	0.8696	0.1290
3	Lack of communication, coordination and collaboration across different units or departments	0.1000	1.1000	0.7905	0.1173
4	Lack of training and training facilities	0.0500	1.0500	0.7529	0.1117
5	Resistance to change- employees	0.1500	1.1500	0.6547	0.0971
6	Lack of information about potentialities of newer digital technologies	0.4000	1.4000	0.4676	0.0694
7	Lack of a leader with appropriate skills, competencies and experience	0.2500	1.2500	0.3741	0.0555
8	Threat to intellectual property	0.3500	1.3500	0.2771	0.0411
9	Data privacy concerns	0.2000	1.2000	0.2309	0.0343
10	Inadequate organizational structure	0.0500	1.0500	0.2199	0.0326
11	Complex network systems and lack of system integration	0.2000	1.2000	0.1833	0.0272
12	Uncertainty about customers' needs and wants	0.1500	1.1500	0.1594	0.0236
13	Data complexity	0.2500	1.2500	0.1275	0.0189
14	Lack of supply chain integration between partners	0.1000	1.1000	0.1159	0.0172

15	Lack of trust and support among stakeholders	0.0500	1.0500	0.1104	0.0164
16	Lack of necessary skillset and qualified labor force for adopting new technologies	0.1500	1.1500	0.0960	0.0142
17	Lack of effective cybersecurity mechanisms	0.1000	1.1000	0.0873	0.0129
18	Insufficient R&R	0.3000	1.3000	0.0671	0.0100
19	Lack of a digital vision and strategy	0.1500	1.1500	0.0584	0.0087
20	Lack of industry specific guidelines, regulations and standardisation	0.0500	1.0500	0.0556	0.0082
21	Lack of legal and ethical policies	0.3000	1.3000	0.0428	0.0063

Source: Author's own compilation

SWARA result of Expert 4 can be seen in the Table 28. Based on the the analysis, the top five digitalization barriers are “lack of financial resources”, “high investment/ implementation costs”, “lack of communication, coordination and collaboration across different units or departments”, “lack of training and training facilities” and “resistance to change- employees”. The weight of the first five barriers are 14.84%, 12.90%, 11.73%, 9.71% and 6.94% respectively. Furthermore, when evaluating the comparative importance of the first and second barriers, the first barrier (lack of financial resources) is 15% more important than the second barrier (high investment/ implementation costs), and the second barrier (high investment/ implementation costs) is 10% more important than the third barrier (lack of communication, coordination and collaboration across different units or departments).

Table 29: SWARA Result of Expert 5

Rank	Barriers	s_{js}	k_{js}	q_{js}	w_{js}
1	Uncertainty about customers' needs and wants		1.0000	1.0000	0.4896
2	Inadequate organizational structure	0.9800	1.9800	0.5051	0.2473
3	Lack of a digital vision and strategy	0.9500	1.9500	0.2590	0.1268
4	Lack of a leader with appropriate skills, competencies and experience	0.9900	1.9900	0.1302	0.0637
5	Resistance to change- employees	0.9500	1.9500	0.0667	0.0327
6	Lack of communication, coordination and collaboration across different units or departments	0.8500	1.8500	0.0361	0.0177
7	Data privacy concerns	0.8000	1.8000	0.0200	0.0098
8	Lack of necessary skillset and qualified labor force for adopting new technologies	0.8500	1.8500	0.0108	0.0053
9	Lack of financial resources	0.7000	1.7000	0.0064	0.0031
10	High investment/ implementation costs	0.8500	1.8500	0.0034	0.0017
11	Insufficient R&D	0.7000	1.7000	0.0020	0.0010
12	Data complexity	0.7500	1.7500	0.0012	0.0006
13	Lack of supply chain integration between partners	0.8000	1.8000	0.0006	0.0003
14	Lack of trust and support among stakeholders	0.8500	1.8500	0.0003	0.0002
15	Complex network systems and lack of system integration	0.6500	1.6500	0.0002	0.0001

16	Lack of effective cybersecurity mechanisms	0.6500	1.6500	0.0001	0.0001
17	Threat to intellectual property	0.7500	1.7500	0.0001	0.0000
18	Lack of industry specific guidelines, regulations and standardisation	0.8000	1.8000	0.0000	0.0000
19	Lack of information about potentialities of newer digital technologies	0.9000	1.9000	0.0000	0.0000
20	Lack of training and training facilities	0.8800	1.8800	0.0000	0.0000
21	Lack of legal and ethical policies	0.9000	1.9000	0.0000	0.0000

Source: Author's own compilation

As can be seen from the Table 29, the first five digitalization barriers include “uncertainty about customers’ needs and wants (weight: 48.96%)”, “inadequate organizational structure (weight: 24.73%)”, “lack of a digital vision and strategy (weight: 12.68%)”, “lack of a leader with appropriate skills, competencies and experience (weight: 6.37%)” and “resistance to change- employees (weight: 3.27%)”. When to evaluate the weight of the barriers, the weight of the first barrier is 48.96%. So, according to Expert 5, “uncertainty about customers’ needs and wants” barrier is the main digitalization obstacle for logistic sector and if the sector finds a solution, nearly 50% of the logistic sector digitalization problem will be solved.

Table 30: SWARA Result of Expert 6

Rank	Barriers	S_{j6}	k_{j6}	q_{j6}	w_{j6}
1	Lack of a digital vision and strategy		1.0000	1.0000	0.4859
2	Lack of a leader with appropriate skills, competencies and experience	0.9500	1.9500	0.5128	0.2492
3	Lack of industry specific guidelines, regulations and standardisation	0.9500	1.9500	0.2630	0.1278
4	Uncertainty about customers' needs and wants	0.9500	1.9500	0.1349	0.0655
5	High investment/ implementation costs	0.9900	1.9900	0.0678	0.0329
6	Complex network systems and lack of system integration	0.8500	1.8500	0.0366	0.0178
7	Insufficient R&D	0.8500	1.8500	0.0198	0.0096
8	Inadequate organizational structure	0.8000	1.8000	0.0110	0.0053
9	Data complexity	0.9500	1.9500	0.0056	0.0027
10	Resistance to change- employees	0.9000	1.9000	0.0030	0.0014
11	Lack of financial resources	0.9800	1.9800	0.0015	0.0007
12	Lack of necessary skillset and qualified labor force for adopting new technologies	0.7500	1.7500	0.0009	0.0004
13	Data privacy concerns	0.9000	1.9000	0.0005	0.0002
14	Threat to intellectual property	0.7000	1.7000	0.0003	0.0001
15	Lack of supply chain integration between partners	0.8000	1.8000	0.0001	0.0001

16	Lack of effective cybersecurity mechanisms	0.8000	1.8000	0.0001	0.0000
17	Lack of trust and support among stakeholders	0.8000	1.8000	0.0000	0.0000
18	Lack of communication, coordination and collaboration across different units or departments	0.8500	1.8500	0.0000	0.0000
19	Lack of training and training facilities	0.8500	1.8500	0.0000	0.0000
20	Lack of information about potentialities of newer digital technologies	0.9500	1.9500	0.0000	0.0000
21	Lack of legal and ethical policies	0.9000	1.9000	0.0000	0.0000

Source: Author's own compilation

SWARA result of Expert 6 can be seen in the Table 30. The analysis revealed that the top three digitalization barriers are “lack of a digital vision and strategy”, “lack of a leader with appropriate skills, competencies and experience” and “lack of industry specific guidelines, regulations and standardisation”. The weight of the first three barriers are 48.59%, 24.92% and 12.78% respectively. Thus, the sum of the weights of the first three barriers are 86.29%. Therefore, according to Expert 6, “lack of a digital vision and strategy”, “lack of a leader with appropriate skills, competencies and experience” and “lack of industry specific guidelines, regulations and standardisation” are the main digitalization obstacle for the logistic sector and if the sector comes up with a solution, more than 80% of the logistic sector digitalization problem will be solved.

Table 31: SWARA Result of Expert 7

Rank	Barriers	s_{j7}	k_{j7}	q_{j7}	w_{j7}
1	Uncertainty about customers' needs and wants		1.0000	1.0000	0.4908
2	Lack of a leader with appropriate skills, competencies and experience	0.9900	1.9900	0.5025	0.2466
3	Lack of a digital vision and strategy	0.9500	1.9500	0.2577	0.1265
4	Inadequate organizational structure	0.9500	1.9500	0.1322	0.0649
5	Lack of communication, coordination and collaboration across different units or departments	0.9000	1.9000	0.0696	0.0341
6	Resistance to change- employees	0.9500	1.9500	0.0357	0.0175
7	Lack of necessary skillset and qualified labor force for adopting new technologies	0.9000	1.9000	0.0188	0.0092
8	Lack of supply chain integration between partners	0.9000	1.9000	0.0099	0.0048
9	Lack of industry specific guidelines, regulations and standardisation	0.9500	1.9500	0.0051	0.0025
10	Lack of information about potentialities of newer digital technologies	0.8500	1.8500	0.0027	0.0013
11	Lack of trust and support among stakeholders	0.8000	1.8000	0.0015	0.0007
12	Lack of training and training facilities	0.7500	1.7500	0.0009	0.0004
13	Data complexity	0.9000	1.9000	0.0005	0.0002

14	High investment/implementation costs	0.7500	1.7500	0.0003	0.0001
15	Complex network systems and lack of system integration	0.8500	1.8500	0.0001	0.0001
16	Data privacy concerns	0.7000	1.7000	0.0001	0.0000
17	Lack of effective cybersecurity mechanisms	0.9000	1.9000	0.0000	0.0000
18	Threat to intellectual property	0.7000	1.7000	0.0000	0.0000
19	Lack of financial resources	0.9000	1.9000	0.0000	0.0000
20	Lack of legal and ethical policies	0.6500	1.6500	0.0000	0.0000
21	Insufficient R&D	0.5500	1.5500	0.0000	0.0000

Source: Author's own compilation

It can be concluded from Table 31, the first three digitalization barriers include “uncertainty about customers’ needs and wants”, “lack of a leader with appropriate skills, competencies and experience” and “lack of a digital vision and strategy”. The weight of the first three barriers are 49.08%, 24.66% and 12.65% respectively. Thus, the sum of the weights of the first three barriers are 86.39%. Therefore, according to Expert 7, “uncertainty about customers’ needs and wants”, “lack of a leader with appropriate skills, competencies and experience” and “lack of a digital vision and strategy” are the main digitalization obstacle for the logistic sector and if the sector comes up with a solution, nearly 90% of the logistic sector digitalization problem will be solved.

Table 32: SWARA Result of Expert 8

Rank	Barriers	S_{j8}	k_{j8}	q_{j8}	w_{j8}
1	Lack of a digital vision and strategy		1.0000	1.0000	0.0920
2	Resistance to change- employees	0.1500	1.1500	0.8696	0.0800
3	Lack of industry specific guidelines, regulations and standardisation	0.1500	1.1500	0.7561	0.0696
4	High investment/ implementation costs	0.1000	1.1000	0.6874	0.0632
5	Lack of legal and ethical policies	0.1000	1.1000	0.6249	0.0575
6	Data privacy concerns	0.0500	1.0500	0.5952	0.0548
7	Lack of effective cybersecurity mechanisms	0.0500	1.0500	0.5668	0.0522
8	Lack of a leader with appropriate skills, competencies and experience	0.0500	1.0500	0.5398	0.0497
9	Lack of financial resources	0.0500	1.0500	0.5141	0.0473
10	Complex network systems and lack of system integration	0.0500	1.0500	0.4896	0.0451
11	Lack of training and training facilities	0.0500	1.0500	0.4663	0.0429
12	Inadequate organizational structure	0.0500	1.0500	0.4441	0.0409
13	Lack of necessary skillset and qualified labor force for adopting new technologies	0.0500	1.0500	0.4230	0.0389
14	Lack of communication, coordination and collaboration across different units or departments	0.0500	1.0500	0.4028	0.0371

15	Lack of information about potentialities of newer digital technologies	0.0500	1.0500	0.3836	0.0353
16	Data complexity	0.0500	1.0500	0.3654	0.0336
17	Lack of supply chain integration between partners	0.0500	1.0500	0.3480	0.0320
18	Lack of trust and support among stakeholders	0.0000	1.0000	0.3480	0.0320
19	Uncertainty about customers' needs and wants	0.0000	1.0000	0.3480	0.0320
20	Insufficient R&D	0.0000	1.0000	0.3480	0.0320
21	Threat to intellectual property	0.0000	1.0000	0.3480	0.0320

Source: Author's own compilation

SWARA result of Expert 8 can be seen in the Table 32. Based on the the analysis, the top five digitalization barriers are “lack of a digital vision and strategy”, “resistance to change- employees”, “lack of industry specific guidelines, regulations and standardization”, “high investment/ implementation costs” and “lack of legal and ethical policies”. The weight of the first five barriers are 9.20%, 8%, 6.96%, 6.32% and 5.75% respectively. Besides, when evaluating the comparative importance of the first and second barriers, the first barrier (lack of a digital vision and strategy) is 15% more important than the second barrier (resistance to change- employees), and the second barrier (resistance to change- employees) is 15% more important than the third barrier (lack of industry specific guidelines, regulations and standardization).

Table 33: SWARA Result of Expert 9

Rank	Barriers	S_{j9}	k_{j9}	q_{j9}	w_{j9}
1	Complex network systems and lack of system integration		1.0000	1.0000	0.1062
2	Data complexity	0.0000	1.0000	1.0000	0.1062
3	Lack of supply chain integration between partners	0.2000	1.2000	0.8333	0.0885
4	Uncertainty about customers' needs and wants	0.1000	1.1000	0.7576	0.0805
5	Lack of industry specific guidelines, regulations and standardisation	0.2000	1.2000	0.6313	0.0671
6	Lack of legal and ethical policies	0.0000	1.0000	0.6313	0.0671
7	Inadequate organizational structure	0.1000	1.1000	0.5739	0.0610
8	Resistance to change- employees	0.1000	1.1000	0.5217	0.0554
9	Lack of a leader with appropriate skills, competencies and experience	0.2500	1.2500	0.4174	0.0443
10	High investment/ implementation costs	0.2000	1.2000	0.3478	0.0370
11	Lack of a digital vision and strategy	0.2500	1.2500	0.2783	0.0296
12	Lack of information about potentialities of newer digital technologies	0.1500	1.1500	0.2420	0.0257
13	Lack of effective cybersecurity mechanisms	0.0000	1.0000	0.2420	0.0257
14	Data privacy concerns	0.0000	1.0000	0.2420	0.0257
15	Threat to intellectual property	0.0000	1.0000	0.2420	0.0257

16	Insufficient R&D	0.0000	1.0000	0.2420	0.0257
17	Lack of training and training facilities	0.0000	1.0000	0.2420	0.0257
18	Lack of communication, coordination and collaboration across different units or departments	0.0000	1.0000	0.2420	0.0257
19	Lack of necessary skillset and qualified labor force for adopting new technologies	0.0000	1.0000	0.2420	0.0257
20	Lack of trust and support among stakeholders	0.0000	1.0000	0.2420	0.0257
21	Lack of financial resources	0.0000	1.0000	0.2420	0.0257

Source: Author's own compilation

As can be seen from the Table 33, the first five digitalization barriers include “complex network systems and lack of system integration (weight: 10.62%)”, “data complexity (weight: 10.62%)”, “lack of supply chain integration between partners (weight: 8.85%)”, “uncertainty about customers’ needs and wants (weight: 8.05%)”, “lack of industry specific guidelines, regulations and standardization (weight: 6.71%)” and “lack of legal and ethical policies (weight: 6.71%)” respectively. According to Expert 9, “the complex network systems and lack of system integration” and “data complexity” are the most important digitalization barriers to logistic important and their importance level are the same.

After that, expert opinions were integrated using equation 4 as the last step of the SWARA method. This integration and the final weights of the barriers are shown in Table 34. “E” means the expert; for example, “E1” means “expert 1”, “E2” means “expert 2”, so on. In conclusion, the overall ranks and weights of the digitalization barriers were determined. The final calculations, ranks and weights of the digitalization barriers and main themes are shown in Table 35 and Table 36.

Table 34: Expert Opinions Integration and Final Weights of Digitalization Barriers

	E1	E2	E3	E4	E5	E6	E7	E8	E9		
BARRIERS	Wj1	Wj2	Wj3	Wj4	Wj5	Wj6	Wj7	Wj8	Wj9	Average	Rank
Complex network systems and Lack of System Integration	0.0093	0.0821	0.0541	0.0272	0.0001	0.0178	0.0001	0.0451	0.1062	0.0380	11
Data Complexity	0.0555	0.0448	0.0468	0.0189	0.0006	0.0027	0.0002	0.0336	0.1062	0.0344	14
Insufficient R&D	0.0444	0.0606	0.0164	0.0100	0.0010	0.0096	0.0000	0.0320	0.0257	0.0222	20
Lack of information about potentialities of newer digital technologies	0.0110	0.0329	0.0596	0.0694	0.0000	0.0000	0.0013	0.0353	0.0257	0.0261	19
Lack of effective cybersecurity mechanisms	0.1247	0.0711	0.0390	0.0129	0.0001	0.0000	0.0000	0.0522	0.0257	0.0362	13
Data Privacy Concerns	0.1534	0.0618	0.0325	0.0343	0.0098	0.0002	0.0000	0.0548	0.0257	0.0414	9
Threat to intellectual property	0.0881	0.0279	0.0319	0.0411	0.0000	0.0001	0.0000	0.0320	0.0257	0.0274	16
High investment/ implementation costs	0.1022	0.0392	0.0828	0.1290	0.0017	0.0329	0.0001	0.0632	0.0370	0.0542	5
Lack of financial resources	0.0228	0.0381	0.0869	0.1484	0.0031	0.0007	0.0000	0.0473	0.0257	0.0414	8
Lack of a Digital Vision and Strategy	0.0703	0.0362	0.0568	0.0087	0.1268	0.4859	0.1265	0.0920	0.0296	0.1147	2
Inadequate organizational structure	0.0289	0.0485	0.0303	0.0326	0.2473	0.0053	0.0649	0.0409	0.0610	0.0622	4
Lack of training and training facilities	0.0808	0.0462	0.0297	0.1117	0.0000	0.0000	0.0004	0.0429	0.0257	0.0375	12



Lack of communication, coordination and collaboration across different units or departments	0.0617	0.0746	0.0283	0.1173	0.0177	0.0000	0.0341	0.0371	0.0257	0.0441	6
Resistance to change- employees	0.0128	0.0408	0.0283	0.0971	0.0327	0.0014	0.0175	0.0800	0.0554	0.0407	10
Lack of necessary skillset and qualified labor force for adopting new technologies	0.0147	0.0490	0.0869	0.0142	0.0053	0.0004	0.0092	0.0389	0.0257	0.0272	17
Lack of a leader with appropriate skills, competencies and experience	0.0159	0.0514	0.0690	0.0555	0.0637	0.2492	0.2466	0.0497	0.0443	0.0939	3
Lack of supply chain integration between partners	0.0177	0.0566	0.0626	0.0172	0.0003	0.0001	0.0048	0.0320	0.0885	0.0311	15
Lack of trust and support among stakeholders (or paydaşlar)	0.0168	0.0577	0.0236	0.0164	0.0002	0.0000	0.0007	0.0320	0.0257	0.0192	21
Uncertainty about customers' needs and wants	0.0162	0.0274	0.0197	0.0236	0.4896	0.0655	0.4908	0.0320	0.0805	0.1384	1
Lack of industry specific guidelines, regulations and standardisation	0.0159	0.0268	0.0657	0.0082	0.0000	0.1278	0.0025	0.0696	0.0671	0.0426	7
Lack of legal and ethical policies	0.0370	0.0263	0.0491	0.0063	0.0000	0.0000	0.0000	0.0575	0.0671	0.0270	18

Source: Author's own compilation

The weights of the digitalization barriers were calculated based on the average value of experts' scores. The rank and final weights of the digitalization barriers to the logistic operation are shown in Table 35.

It can be concluded from Table 32 that the first six digitalization barriers are (1) "uncertainty about customers' needs and wants", (2) "lack of a digital vision and strategy", (3) "lack of a leader with appropriate skills, competencies and experience", (4) "inadequate organizational structure", (5) "high investment/ implementation costs" and (6) "lack of communication, coordination and collaboration across different units or departments."

"Uncertainty about customers' needs and wants" with a weight value of 13.84% has come out to be the most important digitalization barrier to logistic operations in Türkiye. "Lack of a digital vision and strategy" with a weight value of 11.47% is the second most important digitalization barrier, whereas, "lack of a leader with appropriate skills, competencies and experience" has third with significance value 9.39%. "Inadequate organizational structure has fourth with weight value 6.22%. "High investment/ implementation costs" with significance value 5.42% has come out to be fifth and "lack of communication, coordination and collaboration across different units or departments." with significance value 4.41% become the sixth most important digitalization barrier to logistic operation in Türkiye.

Table 35: Ranking of Digitalization Barriers from Most to Least Important

Rank	Barriers	Average Wj	Cumulative
1	Uncertainty about customers' needs and wants	0.1384	0.1384
2	Lack of a Digital Vision and Strategy	0.1147	0.2531
3	Lack of a leader with appropriate skills, competencies and experience	0.0939	0.3470
4	Inadequate organizational structure	0.0622	0.4092
5	High investment/ implementation costs	0.0542	0.4635
6	Lack of communication, coordination and collaboration across different units or departments	0.0441	0.5075
7	Lack of industry specific guidelines, regulations and standardization	0.0426	0.5501
8	Lack of financial resources	0.0414	0.5916
9	Data Privacy Concerns	0.0414	0.6330
10	Resistance to change-employees	0.0407	0.6736
11	Complex network systems and Lack of System Integration	0.0380	0.7116

12	Lack of training and training facilities	0.0375	0.7491
13	Lack of effective cybersecurity mechanisms	0.0362	0.7853
14	Data Complexity	0.0344	0.8197
15	Lack of supply chain integration between partners	0.0311	0.8508
16	Threat to intellectual property	0.0274	0.8782
17	Lack of necessary skillset and qualified labor force for adopting new technologies	0.0272	0.9054
18	Lack of legal and ethical policies	0.0270	0.9324
19	Lack of information about potentialities of newer digital technologies	0.0261	0.9586
20	Insufficient R&D	0.0222	0.9808
21	Lack of trust and support among stakeholders	0.0192	1.0000

Source: Author's own compilation

The total weights of the first six barriers are 50.75%. Therefore, logistic firms that want to digitalize should use all their tools and analyze the market conditions to forecast very well the needs and wants of the consumers and, later, to design their vision and strategy for digital transformation. Moreover, they should give training to leaders to equip them with the necessary digitalization skills and try to find a way to adapt the organizational structure to digital changes. In addition, the logistic sectors should collaborate and receive funds from the government to deal with the high investment/implementation cost of digitalization. Lastly, the logistic firms should find a way to create effective communication, coordination, and collaboration mechanism inside the organization.

Thus, these six barriers are the main digitalization obstacle for Türkiye logistic sector. If the sector focuses on these barriers and takes a step to find solutions, more than half of the logistic sector digitalization problem will be solved.

Furthermore, the weights of the main themes of the digitalization barriers were calculated, and they were ranked from most to least important. The rank and weights of the themes can be seen in Table 36. Based on the analysis, the rank of the main themes are; (1) organizational barriers, (2) extrinsic barriers, (3) technological barriers, (4) data security barriers, (5) financial barriers, and (6) legal and industry barriers.

Table 36: Ranking of Main Themes from Most to Least Important

Themes Rank	Main Themes	Barrier Code	Barrier Rank	Average Wi
1	Organizational Barriers	Lack of a Digital Vision and Strategy	2	0,1147
		Inadequate organizational structure	4	0,0622
		Lack of training and training facilities	12	0,0375
		Lack of communication, coordination and collaboration across different units or departments	6	0,0441
		Resistance to change- employees	10	0,0407
		Lack of necessary skillset and qualified labor force for adopting new technologies	17	0,0272
		Lack of a leader with appropriate skills, competencies and experience	3	0,0939
	Total			0,4202
2	Extrinsic Barriers	Lack of supply chain integration between partners	15	0,0311

		Lack of trust and support among stakeholders	21	0,0192
		Uncertainty about customers' needs and wants	1	0,1384
	Total			0,1887
3	Technological Barriers	Complex network systems and Lack of System Integration	11	0,0380
		Data Complexity	14	0,0344
		Insufficient R&D	20	0,0222
		Lack of information about potentialities of newer digital technologies	19	0,0261
	Total			0,1207
4	Data Security Barriers	Lack of effective cybersecurity mechanisms	13	0,0362
		Data Privacy Concerns	9	0,0414
		Threat to intellectual property	16	0,0274
	Total			0,1050
5	Financial Barriers	High investment/ implementation costs	5	0,0542
		Lack of financial resources	8	0,0414
	Total			0,0957
6	Legal and Industry Barriers	Lack of industry specific guidelines, regulations and standardisation	7	0,0426
		Lack of legal and ethical policies	18	0,0270
	Total			0,0697

Source: Author's own compilation

“Organizational barriers” with a weight value of 42.02% has come out to be the most important digitalization barrier theme to logistic operations in Türkiye. It was followed by “extrinsic barriers” with a weight value of 11.47%. “Technological barriers” was ranked the third item with the significance value of 9.39%.

There are seven digitalization barriers under the organizational barriers theme and the weight value of this theme is 42.02%. Thus, logistic firms should design their vision and strategy for digital transformation, later educate to leaders to equipped with them necessary digitalization skills and and try to find a way to adapt organizational structure to digital changes.



CONCLUSION

Technology has been changing paradigms since the dawn of industrialization, leading to "Industrial Revolutions." In the 21st century, industrial production is at the threshold of a new industrial revolution known as Industrial Revolution 4.0. Rapid and disruptive changes are occurring in the production fields due to Industry 4.0 technology.

This new revolution also triggered logistics changes, and Logistics 4.0 was first introduced in 2011. The logistics field responds to Industry 4.0's requirements by introducing Logistics 4.0. Logistics has undergone four phases, from Logistics 1.0 to Logistics 4.0, in parallel with the industrial revolutions. The last phase of the evaluation of the logistic process is called "Logistic 4.0".

As the digital revolution penetrates many sectors of our society and industries, it is a rapidly growing trend. Digitalization mainly focuses on automating business processes, operations, and information processing.

Digital transformation (DT) refers to transforming an organization by infusing digital technologies into existing processes and relationships to redefine existing capabilities, processes, and relationships to meet future needs better. To sum up, the DT can be defined as reshaping procedure business processes and operations by using new digital technologies. Also, it improves customer experiences, innovates business models, and creates value for customers and all stakeholders. In contrast, many companies perceive digital transformation as "advanced digitization" rather than a continuous process involving changes, adaptations, and improvements.

However, digital transformation has some challenges. The implementation of digitalization is one of the main challenges that companies currently have since they do not have the skilled workers with the competencies needed to take advantage of this. Retraining employees can also be challenging because this can take a long time, as well as can increase the costs associated with the training process

Moreover, it is possible for employees to be worried about losing their jobs as the digital world continues to grow and to be fearful that they may lack the skills needed to handle new technologies. Furthermore, over time, middle managers will also

have to undergo a complete transformation in the scope of their activities, as well as their roles will change and include new tasks that will require more expertise.

On the other hand, through digital investments, companies can improve their competitive advantage and gain a decisive edge over their competitors. By using new digital technologies, businesses can improve their customer experiences, streamline their processes, and innovate their business models in a strategic, tactical, and operational manner.

Several initiatives have been engaged by companies across a wide range of industries in recent years to use digital technologies to their advantage. Digital transformation often transforms key business operations, as well as organizational structures and management methods, as well as products, services, and processes. Utilizing and implementing digital technology causes radical changes in traditional business practices. DT provides more than just changes to business processes; it creates new types of organizations. In addition, DT results in changes in an organization's culture and relationships, as well as in the ability to create value for customers and reach out to them. Business models are changing; organizations are redefining how they create, deliver, and capture value.

Digitalization also reduces manufacturing and logistics services costs by 17.6% and 34.2%, respectively, due to the transformation. As the industry continues to undergo digital transformation, new opportunities for innovative business models are also being created. Digital transformation has proved beneficial for most manufacturing companies (79.9%) and logistics firms (85.5%) (Lehmacher et al., 2017: 5).

Furthermore, some firms and researchers conduct a study to help companies identify where they are in their digitalization journey, analyze their digital capabilities, assess businesses' responses to the digital transformation process, or evaluate the future of trade. For example, in 2016, the firm Accenture developed an Accenture Digitization Index to aid companies in identifying where they are in their digitalization journey, analyze their digital capabilities and create a "digital maturity" profile. The study result showed that the average Accenture Digitization Index score of 106 companies in Turkey is 61%. The total score of 61 percent indicates that Turkey still has a long way to go in digitalization. According to the results of this research, the

sectors with the highest digitization scores were financial services, service activities, retail trade, and the trade and repair of motor vehicles, respectively. However, the transportation and warehousing sector grade is 60; thus, the logistics industry has additional steps to take to digitalize its processes. Moreover, the Digitalisierungsindex Mittelstand 2021/2022 "(Digitalization Index for SMEs) identified the logistic sector as a leading pioneer with a score of 65%, well above the index average of 59% (Deutsche Telekom, 2022).

Besides, the Fujitsu Group surveyed 15 countries in 2017 to assess businesses' responses to the digital transformation process. Based on the results of this study, nearly 90% of businesses are working on multiple digital transformation projects in different stages: some are planning, some are testing, and some are implementing phases. Furthermore, some of these digital initiatives are already yielding positive results. Firms' revenues increased by 46%, and customer relationships improved by 44% due to their digital transformation projects. Following these outcomes were strengthened product competitiveness, improved efficiency, cost reductions, and transformations of business models or processes (Fujitsu, 2017: 3)."

Furthermore, in 2021, Fujitsu conducted another survey to examine how organizations respond to the pandemic and what kind of digital features are crucial to an effective response to the changes that the pandemic caused. The results showed that the revenues of half of the organizations that provide products and services completely offline or partially online decreased. On the other hand, the firms that provide products and services purely online increased their revenues. Moreover, results show that agility, digitalization, and employee well-being played a significant role in the organizations' ability to respond to the pandemic. According to a survey, 82% of organizations have accelerated digital transformation due to the pandemic.

Additionally, DMCC (2021) published a report to evaluate the future of trade, focusing on trade growth, the digitalization of trade, and trade finance and infrastructure. This report recommends companies increase investment in digital technologies to deal with the post-pandemic impacts.

Consequently, the digital transformation and pandemic affect not only one sector but all. The logistics industry is one of them. Digitalization of logistics operations gives essential benefits to companies like allocating resources more

accurately and cost-effectively, increasing effective communication between supply chain members, and providing flexibility to systems to deal with unexpected circumstances like pandemics. However, to initiate the digital transformation process, organizations should determine what should be included and what should be avoided.

It is evident that a lot of logistic companies are looking for guidance on how to prepare themselves and organize themselves for implementing the principles of Industry 4.0. They do not yet know how to take advantage of the opportunities presented by digital transformation and the changes it brings. Although there have been numerous publications in the field, there is still a need to clarify the digitalization barriers facing logistic companies and how they can navigate their digital transformation journey through the correct channels.

Therefore, this thesis is essential to fill this research gap and provide a better understanding of digitalization barriers in the logistics sector. One contribution of this thesis is identifying digitalization barriers in the logistics sector by conducting a comprehensive literature review. Therefore, firms can be aware of logistics' digitalization barriers and evaluate them. The second contribution of this thesis is identifying digitalization barriers to Türkiye logistic operation. Hence, in this thesis, the Delphi method eliminates unrelated items and determines real and important barriers for Türkiye. Thus, the logistic companies operating in Türkiye can have more detailed knowledge about how they will adopt digital technologies successfully. The final contribution of this thesis is to rank each digitalization barrier and theme to Türkiye logistic operation and determine their weight values of them. Hence, the companies know which barriers are essential for them and learn they must focus on which themes. Therefore, they can move forward with solutions and strategies to overcome them.

Firstly, this study followed an established research procedure for systematic literature review in order to analyze the extant knowledge on barriers logistic firms face in adopting digitalization in their operation process in depth and to generate comprehensive barrier classifications based on a theme. PSALSAR method was selected as the research protocol to review specific and reproducible search method to identify, appraise, synthesize, and analyze all research related to the topic. The PSALSAR method was designed based on Mengist et al. (2020) approach. All data of

this study was collected on 25 May 2022 from the Web of Science database (WoS) and Scopus databases. “Barrier, challenge, obstacle, operation, operation process, digitalization, logistic” terms were determined as keywords to search articles. After that, the “Social Sciences Citation Index, Science Citation Index Expanded, and Emerging Sources Citation Index” were selected as the Web of Science index in the WoS database; there was no index in the Scopus database, so there was not any constraint. Moreover, peer-reviewed journal articles, reviews, and early accesses were selected as document types, and English was chosen as the language. The final sample size of this research was 3503.

After that, the appraisal technique was applied to determine the most relevant articles for the study. Firstly, duplicated (12 papers) and non-English (39 papers) studies were eliminated from the sample. Later, the relevant papers' titles, abstracts, and full text were examined. Finally, 23 articles were selected as a final set. These papers were directly related to the digitalization barrier and contained valuable information for the research.

Later, the coding process was started and two different coders followed a code protocol and extracted information from the selected papers. End of the coding process, Cohen's Kappa was calculated ($K = 0.711$) to learn inter-rater agreement. The results showed that this analyzes were reliable.

End of the coding process, 27 various digitalization barriers to the logistic operation were defined. These barriers are; lack of technological infrastructure, complex network systems and lack of system integration, data complexity, insufficient R&D, lack of information about potentialities of newer digital technologies, lack of effective cybersecurity mechanisms, data privacy concerns, threat to intellectual property, high investment/ implementation costs, return on investment (ROI) concerns, lack of financial resources, lack of digital culture, lack of a digital vision and strategy, inadequate organizational structure, lack of training and training facilities, lack of communication, coordination and collaboration across different units or departments, resistance to change- employees, lack of necessary skillset and qualified labor force for adopting new technologies, resistance to change- managers, lack of a leader with appropriate skills, competencies and experience, lack of supply chain integration between partners, lack of trust and support among stakeholders, uncertainty

about customers' needs and wants, high energy consumption, lack of proper waste management (electronic waste and emission risk), lack of industry specific guidelines, regulations and standardization, lack of legal and ethical policies.

In the main theme categorization phases, two coders categorized the 27 barriers based on Verma et al. (2022) articles and received feedback from 3 academicians and two logistic managers. Finally, all feedback was collected and evaluated, and the final version of the main themes was determined. These 27 barriers were categorized under the seven themes as follows; technological barrier, data security barrier, financial barrier, organizational barrier, extrinsic barrier, environmental barrier, legal & industry barrier.

Twenty-seven different digitalization barriers and seven main themes were identified through the structured literature review methodology. However, these barriers covered all topics without considering cultural, economic, political, etc. differences. Therefore, the Delphi method was applied as a second methodology to determine digitalization barriers to logistic operation in Türkiye.

Data were collected from experts who live in Türkiye, and the main language of these experts is Turkish. As the identified barriers had to be translated from English to Turkish, several rules had to be followed to ensure the study's validity. Thus, the guideline of WHO and the study of Hung et al. (2008: 192) were selected to ensure the face and content validity of the study. Based on these guidelines, four steps were applied to evaluate the validity of this thesis. Firstly, forward translation was performed by two academicians familiar with the terminology of digitalization. The mother languages of the two academicians are English and Turkish, so they were bilingual. Secondly, back-translation was performed, and these two academicians converted the digitalization barriers back to English after giving two weeks a break. The next step was an expert panel and pre-testing. Five academicians and two logistic managers read and evaluated the translation and original scale and gave feedback. Survey questions were modified based on this feedback, and the survey was prepared for the first round Delphi study. Lastly, the researcher received feedback from participants at the end of each round and again modified the survey.

Experts' selection was crucial for a successful application in the Delphi study. Moreover, Skulmoski et al. (2007: 9) suggest purposive sampling combined with

snowballing for expert recruitment. Therefore, purposeful expert and snowball sampling were selected as sample methods. In this thesis, participants were selected among managers and academicians who have experience in the logistics field. At the end of the sample selection process, 14 experts were selected as samples. They all have a minimum of 3 years of work experience in logistics, a willingness to participate, and sufficient time for this study.

Following this, the items were arranged and turned into questionnaires for First and Second Round Delphi studies. This study selects a five-point Likert scale as the item type. The selected experts evaluated the questionnaire and whether they are important digitalization barriers to logistic operation. Besides, two consensus criteria were determined. If the median of the item is equal to or more than four and the IQR of the item is equal to or less than 1.2, there is a consensus among panelists. However, if the IRQ of the item is higher than 1.2, the median of the item must be equal or more than 4, and the item must have equal or more than 70% positive ratings to determine whether consensus is met.

Six digitalization barriers to the logistic operation were eliminated in the first Delphi round. Under the technological theme, “lack of technological infrastructure,” under the financial theme, “return on investment (ROI) concerns”; under the organizational theme, “lack of digital culture” and “resistance to change- managers” items were eliminated due to percentage of 4-5 less than 70%. Moreover, under the environmental theme, “high energy consumption” and “lack of proper waste management (electronic waste and emission risk)” were eliminated due to median values below 4. Therefore, these six items were removed from the second survey.

The second Delphi round had 21 items in the second survey. End of the second Delphi round, the panelists reached a consensus about these 21 digitalization barriers, and all the items were accepted as digitalization barriers to logistic operations in Türkiye.

The final list of the digitalization barriers were; complex network systems and lack of system integration, data complexity, lack of information about potentialities of newer digital technologies, lack of effective cybersecurity mechanisms, data privacy concerns, threat to intellectual property, high investment/ implementation costs, lack of financial resources, lack of a digital vision and strategy, lack of training and training

facilities, resistance to change- employees, lack of necessary skillset and qualified labor force for adopting new technologies, lack of a leader with appropriate skills, competencies and experience, lack of supply chain integration between partners, lack of trust and support among stakeholders, uncertainty about customers' needs and wants, lack of industry specific guidelines, regulations and standardization, lack of legal and ethical policies, insufficient R&D, inadequate organizational structure, lack of communication, coordination and collaboration across different units or departments.

Twenty-one barriers and six themes were determined through the Delphi study. The last objective of this thesis was to rank each digitalization barrier to logistic operation and determine their weight values. Therefore, SWARA was selected as this thesis's third and last methodology. This method was applied to determine weights and prioritize the digitalization barriers for Türkiye logistic sector. In this study, nine experts answered the survey. Rank, comparative (relative) importance, coefficient, recalculated weight, and final weights of each barrier's importance were calculated based on SWARA steps.

It can be concluded from the SWARA study that the first six digitalization barriers were (1) “uncertainty about customers' needs and wants”, (2) “lack of a digital vision and strategy”, (3) “lack of a leader with appropriate skills, competencies and experience”, (4) “inadequate organizational structure”, (5) “high investment/ implementation costs” and (6) “lack of communication, coordination and collaboration across different units or departments.”

"Uncertainty about customers' needs and wants" with a weight value of 13.84%, has come out to be the most important digitalization barrier to logistic operations in Türkiye. "Lack of a digital vision and strategy," with a weight value of 11.47%, is the second most important digitalization barrier, whereas "lack of a leader with appropriate skills, competencies, and experience" has a third, with a significant value of 9.39%. "Inadequate organizational structure has fourth, with a weight value of 6.22%. "High investment/ implementation costs," with a significance value of 5.42%, has come out to be fifth, and "lack of communication, coordination, and collaboration across different units or departments." with a significance value of 4.41%, become a sixth most important digitalization barrier to logistic operation in

Türkiye. The sum of the total weights for the first six barriers are 50.75%. Thus, these six barriers are the main digitalization obstacle for Türkiye logistic sector, and if the sector focus on these barriers and take a step to find solutions, more than half of the logistic sector digitalization problem will be solved.

Furthermore, the weights of the main themes of the digitalization barriers were calculated, and they were ranked from most to least important. Based on the analysis, “Organizational barriers,” with a weight value of 42.02%, has come out to be the most important digitalization barrier theme to logistic operation in Türkiye. It was followed by “extrinsic barriers,” with a weight value of 11.47%. “Technological barriers” was ranked the third item with a significance value of 9.39%.

In conclusion, logistics companies should use all their tools and analyze the market conditions to forecast the needs and wants of consumers very well. Moreover, they should revise their vision and strategy based on the digital transformation requirements. Besides, companies should prepare a training program for leaders to equip them with the necessary digitalization skills and try to find a way to adapt the organizational structure to digital changes. Furthermore, the logistic firms should make collaboration and receive funds from the government to deal with the high investment/implementation cost of digitalization. Lastly, they should find a way to create effective communication, coordination, and collaboration mechanisms inside the organization.

This thesis has a few limitations that provide opportunities for future research. The database selection is a limitation of this study. Two types of most relevant databases (Scopus and Web of Science) have been selected for this study. In addition to these two databases, the researchers may be able to include other types of databases (ex: Science Direct and Google Scholar) within the scope of this study for future study.

Furthermore, the research poses twenty-seven digitalization barriers; future studies could involve other issues about digitalization or digital transformation. Moreover, logistic organizations were studied in this study, but other sectors might present different challenges. Therefore, future research can include different sectors. Further research can also investigate the relationship between the various factors and how they affect logistic firms' digitalization performances. Also, one single country

(Türkiye) was selected for adaptation and prioritization of digitalization barriers. Researchers can include firms from other countries as well.

The key digitalization obstacles were ranked using experts' views. A total of nine experts' opinions were taken into account in this thesis. Future results may be improved by increasing the number of experts. Lastly, SWARA was selected as multi criteria decision method (MCDM). In further research, researchers can select a different MCDM method or combine multiple MCDM methods to rank barriers and determine their weights.



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APPENDIX

Appendix 1: Delphi- First Test Survey

Lojistik Sektöründeki Operasyon Sürecinin Dijitalleşmesi Önündeki Bariyerler

Bu çalışmanın amacı, Lojistik sektöründe operasyon süreçlerinin dijitalleşme faaliyetlerinin uygulanmasının önündeki engellerini belirleyebilmektir. Bu çalışmadan elde edilecek tüm veriler kesinlikle gizli kalacaktır ve 3. kişilerle asla paylaşılmayacaktır. Elde edilen tüm veriler yalnızca toplu halde anonim olarak değerlendirilecektir ve bilimsel yayınlarda kullanılacaktır. Bireysel yanıtlar tek başına değerlendirilmeyecektir. İstenildiği takdirde araştırma sonuçları sizinle paylaşılacaktır.

Saygılarımızla,

Araş.Gör. Kevser Yılmaz ve Doç Dr. Aşkın Özdağoğlu

İşletme Fakültesi, İşletme Bölümü, Üretim Yönetimi ve Pazarlama Anabilim Dalı, Dokuz Eylül Üniversitesi

Dijitalleşme ve Dijital Dönüşüm Tanımları:

Dijitalleşme, ulaşılabilir bilgilerin herhangi bir bilgisayar, akıllı telefon, tablet vb. teknolojik araçlar tarafından okunabilecek, o ortamlarda düzenlenebilecek ve iş akışlarına dahil edilecek şekilde dijital ortama aktarılması sürecine verilen ad olarak tanımlanabilir.

Dijitalleştirme örgütlerin, sayısallaştırılmış verileri dijital teknolojileri kullanarak iş süreçlerini, iş yapma modellerini, faaliyetlerini icra ederken kullandıkları yol ve yöntemleri etkinleştirmek, iyileştirmek ve dönüştürmek, iş işlevlerini ve modellerini, dijital, otonom, yarı otonom ve manuel operasyonların karışımıyla birlikte akıllı üretim haline dönüştürmek veya pazarlamak demektir. Örgütlerde dijitalleşme hem veri ve veri kaynağının dijitalleşmesi hem de yönetim anlayışının, süreçlerin dijitalleşmesi olarak görülmelidir.

Aşağıda yer alan ifadeleri, Lojistik sektöründe operasyon süreçlerinin dijitalleşmesinin önündeki bir bariyer olup olmadığını düşünülerek cevaplayınız. (Örneğin: sizin için “Veri Karmaşıklığı” bir engel değil ise 1-kesinlikle katılmıyorum’u işaretleyebilirsiniz). İfadelerin yanında yer alan açıklamada, maddenin ne anlama geldiği kısa bir tanım verilerek açıklanmaya çalışılmıştır.

5- Kesinlikle Katılıyorum

4- Katılıyorum

3- Kararsızım

2- Katılmıyorum

1- Kesinlikle Katılmıyorum

5- Kesinlikle Katılıyorum; 4- Katılıyorum; 3- Kararsızım; 2- Katılmıyorum; 1- Kesinlikle Katılmıyorum

A. Teknolojik Bariyerler	5	4	3	2	1	Bariyerin Açıklaması
Teknolojik altyapı eksikliği						Bu madde "mevcut altyapı ve sistemlerin dijitalleşmeye uygun olarak dönüştürülmesindeki zorlukları, dijitalleşme

						için yeterli dijital ve fiziksel altyapının olmadığını, yetersiz internet bağlantısını veya bağlantı hızındaki yavaşlamaların var olduğunu ve gerçek zamanlı veri analizinin zor olduğunu" anlatmaktadır.
Kompleks ağ sistemleri ve sistem entegrasyon eksikliği						Bu madde "heterojen ve bağımsız bilgi sistemlerinin tasarlanması gerekliliğini, sistem tasarımının karmaşıklığını, sistemler arasındaki entegrasyon eksikliğini ve farklı altyapılara sahip ülkeler için farklı sistemlerin tasarlanmak zorunda olmasını" anlatmaktadır.
Veri Karmaşıklığı						Bu madde "verilerin eksik olmadan, tam ve kaliteli olarak toplanmasının, analiz edilmesinin ve saklanması için zor olduğunu, süreç optimizasyonunun zorluğunu ve firmaların verileri depolamak için büyük miktarda depolama kapasitesine ihtiyaç duyduğunu" anlatmaktadır.
Araştırma ve Geliştirme Faaliyetlerinin (AR-GE) yetersiz oluşu						Bu madde "firmaların yeni teknolojiler ve dijitalleşme süreçleri için yeterince araştırma ve geliştirme bütçelerinin olmadığını" anlatmaktadır.
Yeni dijital teknolojilerin potansiyelleri hakkında bilgi eksikliği						Bu madde "firma ve çalışanlar tarafından Endüstri 4.0 ilkelerinin anlaşılmasını; teknolojik bilgi eksikliğini, dijitalleşmeye yönelik farkındalık ve bilgi eksikliğini" anlatmaktadır.
B. Veri Güvenliği ile İlgili Bariyerler	5	4	3	2	1	Bariyerin Açıklaması
Etkili siber güvenlik mekanizmalarının eksikliği						Bu madde "veri güvenliği ile ilgili problemlerin var olmasını ve dijitalleşme ve sistem entegrasyonu ile beraber siber güvenlik seviyelerinin azalmasını" anlatmaktadır.
Veri Gizliliği ile İlgili Endişeler						Bu madde "veri gizliliği ile ilgili problemlerin var olmasını ve mahremiyet kaygısı" anlatmaktadır.
Fikri mülkiyete yönelik tehditler						Bu madde "şirketlerin fikri mülkiyeti üzerinde kontrol eksikliği ile ilgili endişeleri" anlatmaktadır.
C. Finansal Bariyerler	5	4	3	2	1	Bariyerin Açıklaması
Yatırım ve uygulama maliyetlerinin yüksek olması						Bu madde "Endüstri 4.0 uygulamalarının ve dijital teknolojilerin yüksek finansal yatırım gereksinimlerini, yeni dijital sistem kurulmasının yüksek kurulum ücreti+yatırım maliyetleri+yeni sisteme geçiş maliyetleri+zaman maliyeti olarak çeşitli maliyetlere neden olmasını ve dijital sistemler için eğitim maliyetini" anlatmaktadır.

Yatırım getirisi ve karlılığın düşük kalacağı hakkındaki endişeler						Bu madde "dijitalleşme için yatırımların belirsiz mali getiriye ve karlılığa sahip olmasını" anlatmaktadır.
Finansal kaynakların yetersiz olması						Bu madde "dijitalleşmek için firmaların finansal kısıtlamaları ve sınırlı bütçeye sahip olmalarını, firmaların dijitalleşmek için uygun ve yeterli finansman seçeneklerinin olmaması, dijitalleşme için devlet politikalarındaki mali desteklerin yetersiz olmasını" anlatmaktadır.
D. Örgütsel Bariyerler	5	4	3	2	1	Bariyerin Açıklaması
Örgütsel kültürün dijitalleşmeye uygun olmaması						Bu madde "firmanın teknoloji odaklı ve dijitalleşmeye uygun kültür eksikliğini" anlatmaktadır.
Dijitalleşmenin şirketin vizyon ve stratejisinde önceliğe sahip olmaması						Bu madde "firmanın dijital vizyon ve strateji eksikliğini, politika çerçevesi eksikliği" anlatmaktadır.
Şirketin organizasyon yapısının dijitalleşmeye elverişli olmaması						Bu madde "firmanın dijitalleşme için yetersiz organizasyon yapısına sahip olduğunu, firmada dijital dönüşümle ilgili risk yönetim aracının olmaması veya eksik olmasını" anlatmaktadır.
Dijitalleşme ile ilgili eğitim faaliyetlerinin yetersizliği						Bu madde "firmanın dijitalleşmesi için çalışanlara özel eğitim verilmesi gerekliliğini, firma içi dijital eğitim eksikliğini ve dijitalleşme eğitimi için tesislerin eksik veya yetersiz olduğunu" anlatmaktadır.
Farklı birimler veya departmanlar arasında iletişim, koordinasyon ve işbirliği eksikliği						Bu madde "farklı organizasyon birimlerindeki koordinasyon sorunu ve çıkar çatışmalarını, ortak düşünce eksikliğini, organizasyon içinde yalın ve esnek iletişim yapısının olmamasını" anlatmaktadır.
Çalışanların değişime direnç göstermesi						Bu madde "çalışanların değişikliklere isteksizliğini, çalışanların dijital dönüşüm için yeterli kaynak, kapasite ve motivasyona sahip olmamasını" anlatmaktadır.
İşgücünün sahip olduğu beceri ve niteliklerin dijitalleşme için yetersiz olması						Bu madde "işgücünün analitik, disiplinler arası düşünme ve karmaşıklıkla başa çıkma yeteneklerinin eksikliğini, dijital beceri ve nitelikli işgücü eksikliğini" anlatmaktadır.
Yöneticilerin değişime direnç göstermesi						Bu madde "yöneticilerin dijitalleşmeye karşı ilgi ve destek eksikliğini, dijital dönüşüm için etkili ve uygun yönetim sistemlerinin olmamasını" anlatmaktadır.
Yöneticilerin beceri, yetkinlik ve deneyimlerinin						Bu madde "üst yönetimin dijitalleşme için efektif bir liderlik tarzının olmayışını ve organizasyon içinde dijitalleşme ve

dijitalleşme için yetersiz olması						yenilikçiliği destekleyecek etkili liderlik yönetimi eksikliğini" anlatmaktadır.
E. Şirket Dışı Bariyerler	5	4	3	2	1	Bariyerin Açıklaması
Tedarik sürecinde yer alan tüm paydaşlar arasında entegrasyonun eksik olması						Bu madde "dijitalleşme için tedarikçilerin işbirliği yapma isteksizliğini ve tedarikçi yönetim ilişkisinde yaşanan zorlukları" anlatmaktadır.
Tedarik sürecindeki paydaşlar arasında güvenin yetersiz olması						Bu madde "iş ortaklarıyla güven kültürü oluşturma zorluğunu" anlatmaktadır.
Müşterilerin ihtiyaçlarının ve isteklerinin belirsiz olması						Bu madde "müşterilerin dijitalleşme sürecine ve yeni teknolojilere karşı tutum ve isteklerinin belirsiz olmasını" anlatmaktadır.
F. Çevresel Bariyerler	5	4	3	2	1	Bariyerin Açıklaması
Dijitalleşmenin yüksek enerji tüketimi gerektirmesi						Bu madde "dijitalleşme sürecinde yüksek enerji tüketimi ihtiyacını" anlatmaktadır.
Atık Yönetimi Sistemlerinin Yetersiz olması (Elektronik atık ve Emisyon riski)						Bu madde "dijitalleşme sürecinin ve yeni teknolojilerin kullanılmasında atık yönetim sisteminin yetersiz olmasını, firmaların elektronik atıkları yönetirken emisyon azaltıcı faaliyetlere dikkat etmesinin zorluğunu" anlatmaktadır.
G. Yasal ve Endüstriyel Bariyerler	5	4	3	2	1	Bariyerin Açıklaması
Sektördeki dijitalleşme ile ilgili yönergelerin, düzenlemelerin ve/veya standardizasyonun yetersiz olması						Bu madde "dijitalleşmenin firma ve sektöre etkisi hakkında yeterli bilgi olmamasını, dijitalleşme için küresel olarak uygulanabilir tutarlı teknik standartların, normların, ve sertifikaların eksikliğini" anlatmaktadır.
Dijitalleşme ile ilgili yasal politikaların yetersiz olması						Bu madde "dijitalleşme için yeterli düzeyde standart bir yasal altyapının eksik olmasını" anlatmaktadır.

Cinsiyetiniz: () Kadın () Erkek

Yaşınız: () 18-25 () 26-34 () 35-44 () 45-54 () 55 ve üzeri

Eğitim durumunuz: () İlköğretim () Lise () Üniversite () Yüksek Lisans () Doktora

Mesleğiniz ve pozisyonunuz:

İş deneyiminiz (yıl):

Mail adresiniz:

Katılımınız için teşekkür ederiz.

Appendix 2: Delphi- Second Test Survey

Lojistik Sektöründeki Operasyon Sürecinin Dijitalleşmesi Önündeki Bariyerler- 2. Anket

Bu çalışmanın amacı, Lojistik sektöründe operasyon süreçlerinin dijitalleşme faaliyetlerinin uygulanmasının önündeki engellerini belirleyebilmektir. **İlk ankette katılımcıların hepsi aşağıdaki bariyerleri önemli bulmuştur. Bu ankette bu belirlenen bariyerleri hala önemli bulup bulmadığınızı son kez sormak istiyoruz.** Bu çalışmadan elde edilecek tüm veriler kesinlikle gizli kalacaktır ve 3. kişilerle asla paylaşılmayacaktır. Elde edilen tüm veriler yalnızca toplu halde anonim olarak değerlendirilecektir ve bilimsel yayınlarda kullanılacaktır. Bireysel yanıtlar tek başına değerlendirilmeyecektir. İstenildiği takdirde araştırma sonuçları sizinle paylaşılacaktır.

Saygılarımızla,
Araş.Gör. Kevser Yılmaz ve Doç Dr. Aşkın Özdağoğlu
İşletme Fakültesi, İşletme Bölümü, Üretim Yönetimi ve Pazarlama Anabilim Dalı, Dokuz Eylül Üniversitesi

Aşağıda yer alan ifadeleri, Lojistik sektöründe operasyon süreçlerinin dijitalleşmesinin önündeki bir bariyer olup olmadığını düşünülerek cevaplayınız. (Örneğin: sizin için “Veri Karmaşıklığı” bir engel değil ise 1-kesinlikle katılmıyorum’u işaretleyebilirsiniz). İfadelerin yanında yer alan açıklamada, maddenin ne anlama geldiği kısa bir tanım verilerek açıklanmaya çalışılmıştır.

- 5- Kesinlikle Katılıyorum;
- 4- Katılıyorum;
- 3- Kararsızım;
- 2- Katılmıyorum;
- 1- Kesinlikle Katılmıyorum

A. Teknolojik Bariyerler	5	4	3	2	1	Bariyerin Açıklaması
Kompleks ağ sistemleri ve sistem entegrasyon eksikliği						Bu madde "heterojen ve bağımsız bilgi sistemlerinin tasarlanması gerekliliğini, sistem tasarımının karmaşıklığını, sistemler arasındaki entegrasyon eksikliğini ve farklı altyapılara sahip ülkeler için farklı sistemlerin tasarlanmak zorunda olmasını" anlatmaktadır.
Veri Karmaşıklığı						Bu madde "verilerin eksik olmadan, tam ve kaliteli olarak toplanmasının, analiz edilmesinin ve saklanması için firmalar için zor olduğunu, süreç optimizasyonunun zorluğunu ve firmaların verileri depolamak için büyük miktarda depolama kapasitesine ihtiyaç duyduğunu" anlatmaktadır.
Araştırma ve Geliştirme Faaliyetlerinin (AR-GE) yetersiz oluşu						Bu madde "firmaların yeni teknolojiler ve dijitalleşme süreçleri için yeterince araştırma ve geliştirme bütçelerinin olmadığını" anlatmaktadır.
Yeni dijital teknolojilerin						Bu madde "firma ve çalışanlar tarafından Endüstri 4.0 ilkelerinin anlaşılmasını; teknolojik bilgi

potansiyelleri hakkında bilgi eksikliği						eksikliğini, dijitalleşmeye yönelik farkındalık ve bilgi eksikliğini" anlatmaktadır.
B. Veri Güvenliği ile İlgili Bariyerleri	5	4	3	2	1	Bariyerin Açıklaması
Etkili siber güvenlik mekanizmalarının eksikliği						Bu madde "veri güvenliği ile ilgili problemlerin var olmasını ve dijitalleşme ve sistem entegrasyonu ile siber güvenlik seviyelerinin azalmasını" anlatmaktadır.
Veri Gizliliği ile İlgili Endişeler						Bu madde "veri gizliliği ile ilgili problemlerin var olmasını ve mahremiyet kaygısı" anlatmaktadır.
Fikri mülkiyete yönelik tehditler						Bu madde "şirketlerin fikri mülkiyeti üzerinde kontrol eksikliği ile ilgili endişeleri" anlatmaktadır.
C. Finansal Bariyerler	5	4	3	2	1	Bariyerin Açıklaması
Yatırım ve uygulama maliyetlerinin yüksek olması						Bu madde "Endüstri 4.0 uygulamalarının ve dijital teknolojilerin yüksek finansal yatırım gereksinimlerini, yeni dijital sistem kurulmasının yüksek kurulum ücreti+yatırım maliyetleri+yeni sisteme geçiş maliyetleri+zaman maliyeti olarak çeşitli maliyetlere neden olmasını ve dijital sistemler için eğitim maliyetini" anlatmaktadır.
Finansal kaynakların yetersiz olması						Bu madde "dijitalleşmek için firmaların finansal kısıtlamaları ve sınırlı bütçeye sahip olmalarını, firmaların dijitalleşmek için uygun ve yeterli finansman seçeneklerinin olmaması, dijitalleşme için devlet politikalarındaki mali desteklerin yetersiz olmasını" anlatmaktadır.
D. Örgütsel Bariyerler	5	4	3	2	1	Bariyerin Açıklaması
Dijitalleşmenin şirketin vizyon ve stratejisinde önceliğe sahip olmaması						Bu madde "firmanın dijital vizyon ve strateji eksikliğini, politika çerçevesi eksikliği" anlatmaktadır.
Şirketin organizasyon yapısının dijitalleşmeye elverişli olmaması						Bu madde "firmanın dijitalleşme için yetersiz organizasyon yapısına sahip olduğunu, firmada dijital dönüşümle ilgili risk yönetim aracının olmaması veya eksik olmasını" anlatmaktadır.
Dijitalleşme ile ilgili eğitim faaliyetlerinin yetersizliği						Bu madde "firmanın dijitalleşmesi için çalışanlara özel eğitim verilmesi gerekliliğini, firma içi dijital eğitim eksikliğini ve dijitalleşme eğitimi için tesislerin eksik veya yetersiz olduğunu" anlatmaktadır.
Farklı birimler veya departmanlar arasında iletişim, koordinasyon ve işbirliği eksikliği						Bu madde "farklı organizasyon birimlerindeki koordinasyon sorunu ve çıkar çatışmalarını, ortak düşünce eksikliğini, organizasyon içinde yalın ve esnek iletişim yapısının olmamasını" anlatmaktadır.

Çalışanların değişime direnç göstermesi						Bu madde "çalışanların değişikliklere isteksizliğini, çalışanların dijital dönüşüm için yeterli kaynak, kapasite ve motivasyona sahip olmamasını" anlatmaktadır.
İşgücünün sahip olduğu beceri ve niteliklerin dijitalleşme için yetersiz olması						Bu madde "işgücünün analitik, disiplinler arası düşünme ve karmaşıklıkla başa çıkma yeteneklerinin eksikliğini, dijital beceri ve nitelikli işgücü eksikliğini" anlatmaktadır.
Yöneticilerin beceri, yetkinlik ve deneyimlerinin dijitalleşme için yetersiz olması						Bu madde "üst yönetimin dijitalleşme için efektif bir liderlik tarzının olmayışını ve organizasyon içinde dijitalleşme ve yenilikçiliği destekleyecek etkili liderlik yönetimi eksikliğini" anlatmaktadır.
E. Şirket Dışı Bariyerler	5	4	3	2	1	Bariyerin Açıklaması
Tedarik sürecinde yer alan tüm paydaşlar arasında entegrasyonun eksik olması						Bu madde "dijitalleşme için tedarikçilerin işbirliği yapma isteksizliğini ve tedarikçi yönetim ilişkisinde yaşanan zorlukları" anlatmaktadır.
Tedarik sürecindeki paydaşlar arasında güvenin yetersiz olması						Bu madde "iş ortaklarıyla güven kültürü oluşturma zorluğunu" anlatmaktadır.
Müşterilerin ihtiyaçlarının ve isteklerinin belirsiz olması						Bu madde "müşterilerin dijitalleşme sürecine ve yeni teknolojilere karşı tutum ve isteklerinin belirsiz olmasını" anlatmaktadır.
G. Yasal ve Endüstriyel Bariyerler	5	4	3	2	1	Bariyerin Açıklaması
Sektördeki dijitalleşme ile ilgili yönergelerin, düzenlemelerin ve/veya standardizasyonun yetersiz olması						Bu madde "dijitalleşmenin firma ve sektöre etkisi hakkında yeterli bilgi olmamasını, dijitalleşme için küresel olarak uygulanabilir tutarlı teknik standartların, normların, ve sertifikaların eksikliğini" anlatmaktadır.
Dijitalleşme ile ilgili yasal politikaların yetersiz olması						Bu madde "dijitalleşme için yeterli düzeyde standart bir yasal altyapının eksik olmasını" anlatmaktadır.

Appendix 3: SWARA Survey

LOJİSTİK SEKTÖRÜNDEKİ OPERASYON SÜRECİNİN DİJİTALLEŞMESİ ÖNÜNDEKİ BARIYERLER

Bu çalışmanın amacı, Lojistik sektöründe operasyon süreçlerinin dijitalleşmesinin önündeki bariyerleri önem sırasına göre sıralayabilmektir. Forumda öncelikle belirlenen bariyerleri en önemliden en önemsiz doğru numara vererek sıralamanız istenmektedir (1: en önemli, 21: en önemsiz). Daha sonra ise sizden en önemli kriter, kendinden bir sonraki en önemli kritere göre % kaç daha önemli olduğunu **karşılaştırmalı önem sütununa** yazmanızı rica ediyoruz. Karşılaştırmalı oran 0'dan 100'e kadar herhangi bir sayı olabilir (ör: 5, 33, 58, 70 gibi.). Satırların toplamı 100 olmayacaktır. Bu nedenle 1. Satıra 89, 2. Satıra 90 verebilirsiniz. Eğer her iki bariyerde sizin için aynı öneme sahip ise 0 verebilirsiniz. 21. Satırın karşılaştırmalı önem (%) satırı doldurulmasına gerek yoktur.

Aşağıda örnek bir form doldurma şablonu yer almaktadır. Bu örneği baz alarak lütfen “Dijitalleşme Önündeki Bariyerlerin Sıralanması Formu”nu doldurmanızı rica ederiz.

Örnek:

Kriter	En Önemliden En Önemsiz Doğru Sıralama	Karşılaştırmalı Önem (%)
A.Teknolojik altyapı eksikliği	1. sırada: B	5 (1. Sıradaki B maddesi 2. Sırada alan D maddesine göre % kaç daha önemliydi ki 1. Sırada olmayı hak etti?)
B.Yatırım getirisi hakkındaki endişeler	2. sırada: D	8 (2. Sıradaki D maddesi 3. Sırada alan A maddesine göre % kaç daha önemliydi ki 2. Sırada olmayı hak etti?)
C.Örgütsel kültürün uygunsuzluğu	3. sırada: A	15 (3. Sıradaki A maddesi 4. Sırada alan C maddesine göre % kaç daha önemliydi ki 3. Sırada olmayı hak etti?)
D.Atık Yönetiminin Yetersiz olması	4. sırada: C	X

Yukarıdaki örneği açıklama gerekirse, seçim probleminde etkili olan 4 bariyer bulunmaktadır. Sıralamaya göre en önemli bariyer 2 numaralı bariyer (Yatırım getirisi hakkındaki endişeler), ikinci en önemli bariyer 4 numaralı bariyer, üçüncü en önemli bariyer 1 numaralı bariyer ve en önemsiz bariyer ise 3 numaralı bariyerdur. Son sütundaki değerlere göre, en önemli bariyer olan 2, kendinden bir sonraki en önemli bariyer olan 4'e göre %5 daha önemlidir. İkinci en önemli bariyer olan 4, kendinden bir sonraki en önemli bariyer olan 1'e göre %8 daha önemlidir. Üçüncü en önemli bariyer olan 1, en önemsiz bariyer olan 3'e göre %15 daha önemlidir. (Not: Aynı seviyede öneme sahip kriterler mevcut ise karşılaştırmalı önem kısmında 0 değeri kullanılabilir.)

“Dijitalleşme Önündeki Bariyerlerin Sıralanması Formu”

Bariyerler	En Önemliden En Önemsiz Doğru Sıralama	Karşılaştır malı Önem (%)
A.Kompleks ağ sistemleri ve sistem entegrasyon eksikliği	1. sırada:	
B.Verit Karmaşıklık	2. sırada:	
C.Araştırma ve Geliştirme Faaliyetlerinin (AR-GE) yetersiz oluşu	3. sırada:	
D.Yeni dijital teknolojilerin potansiyelleri hakkında bilgi eksikliği	4. sırada:	
E.Etkili siber güvenlik mekanizmalarının eksikliği	5. sırada:	
F.Verit Gizliliği ile İlgili Endişeler	6. sırada:	
G.Fikri mülkiyete yönelik tehditler	7. sırada:	
H.Yatırım ve uygulama maliyetlerinin yüksek olması	8. sırada:	
I.Finansal kaynakların yetersiz olması	9. sırada:	
J.Dijitalleşmenin şirketin vizyon ve stratejisinde önceliğe sahip olmaması	10. sırada:	
K.Şirketin organizasyon yapısının dijitalleşmeye elverişli olmaması	11. sırada:	
L.Dijitalleşme ile İlgili eğitim faaliyetlerinin yetersizliği	12. sırada:	
M.Farklı birimler veya departmanlar arasında iletişim, koordinasyon ve işbirliği eksikliği	13. sırada:	
O.Çalışanların değişime direnç göstermesi	14. sırada:	
P.İşgücünün sahip olduğu beceri ve niteliklerin dijitalleşme için yetersiz olması	15. sırada:	
R.Yöneticilerin beceri, yetkinlik ve deneyimlerinin dijitalleşme için yetersiz olması	16. sırada:	
S.Tedarik sürecinde yer alan tüm paydaşlar arasında entegrasyonun eksik olması	17. sırada:	
T.Tedarik sürecindeki paydaşlar arasında güvenin yetersiz olması	18. sırada:	
U.Müşterilerin ihtiyaçlarının ve isteklerinin belirsiz olması	19. sırada:	
V. Sektördeki dijitalleşme ile ilgili yönergelerin, düzenlemelerin ve/veya standardizasyonun yetersiz olması	20. sırada:	
Y. Dijitalleşme ile ilgili yasal politikaların yetersiz olması	21. sırada:	X