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Barriers to Digital Supply Chain Management: A Qualitative Research

Dijital Tedarik Zinciri Yönetimindeki Engeller: Nitel Bir Araştırma

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ABSTRACT

Digital supply chain management generates competitive advantage by enabling companies to become more efficient and transparent in compliance with technological developments at every stage of the supply chain by meeting customer needs better. However, enterprises may encounter various barriers in the digitalization of the supply chain. The aim of the study is to identify the barriers encountered in the digital transformation of the supply chain and to discuss solutions or solving these barriers. Themes were obtained by content analysis from the data collected through in-depth interviews with industry professionals. Barriers to the digital transformation of the supply chain were grouped into five sub-themes: (1) financial barriers, (2) organizational barriers, (3) barriers related to employees, (4) technological barriers and (5) barriers related to data management. In the study, solutions for overcoming the barriers to the digital transformation of the supply chain including employees and the process are presented. The results of the study are expected to guide companies in implementing the digital supply chain.

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ÖZ

Dijital tedarik zinciri yönetimi, şirketlerin müşteri ihtiyaçlarını daha iyi karşılayarak, tedarik zincirinin her aşamasında teknolojik gelişmelere uyumlu, daha verimli ve şeffaf hale gelmesini sağlayarak rekabet avantajı oluşturmaktadır. Ancak, tedarik zincirinin dijitalleşmesinde işletmeler çeşitli sorunlarla karşılaşabilmektedir. Bu çalışmanın amacı, tedarik zincirinin dijital dönüşümünde karşılaşılan engelleri belirlemek ve bu sorunları çözmeye yönelik çözümleri ele almaktır. Sektör profesyonellerinden derinlemesine görüşme yöntemi ile toplanan verilerden, içerik analizi ile temalar elde edilmiştir. Tedarik zincirindeki dijital dönüşümün önündeki en-

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geller beş alt tema altında gruplandırılmıştır: (1) finansal engeller, (2) örgütsel engeller, (3) çalışanlarla ilgili engeller, (4) teknolojik engeller ve (5) veri yönetimi ile ilgili engeller. Çalışmada, tedarik zincirinin dijital dönüşümündeki engellere yönelik, çalışanları ve süreci içeren çözüm önerileri sunulmuştur. Çalışma sonuçlarının şirketlerin dijital tedarik zincirini uygulamalarına rehberlik etmesi beklenmektedir.

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1. INTRODUCTION

The rapidly changing business environment has difficult to effectively manage their supply chains (Shrivastava, 2023). Digital transformation involves fundamental changes in business processes. These are collecting large amounts of data (Frank et al., 2019), exchanging information based on digitally, and creating a stronger network between business processes and an efficient customer interface (Matt et al., 2015) using digital technologies.

Digitalization in the supply chain enables greater information availability and vastly superior interaction, communication and collaboration (Büyüközkan & Göçer, 2018). In this way, an intelligent, value-oriented network creates great opportunities to increase trust, agility and productivity and improve logistics between organizations. It also provides the ability to access and control information on time, allowing transparent and clear information to be obtained throughout the supply chain (Rahamneh et al., 2023).

Digital transformation is costly and time-consuming for businesses (O`Reilly &Verdin, 2021). Therefore, it is necessary to investigate the barriers faced for businesses in digitalization. Several studies address the critical success factors, opportunities, drivers, and barriers of digital supply chain (Kache&Seuring, 2015; Linh et al., 2020; Subramaniyam et al., 2021; Annosi et al., 2021; Vass et al., 2021; Rad et al., 2022; Samper et al., 2022). However, there are limited studies to investigate the barriers and challenges of the digital supply chain (Xu, 2014; Luthra & Kumar Mangla, 2018; Bienhaus&Haddud, 2018; Özkanlısoy & Akkartal, 2021; Martins et al. 2020; Yuan et al., 2023; Dixi et al., 2024). The dynamic structure of the supply chain means that there will be a constant need for additional research on developing technologies and business models (Shrivastava, 2023). Hence, there is a need to further clarify the barriers to digital transformation in the supply chain.

The research questions are:

- RQ1: What are the barriersto digital transformation in the supply chain?
- RQ2: How can the companies overcome these barriers?

To answer these research questions, semi-structured interviews were conducted with 10 managers responsible for the supply chain. In this way, the results of the study will contribute to the literature and practice in identifying the barriers encountered in digital transformation in the supply chain and offering solution suggestions.

After the introduction, the literature review identified the digital supply chain and the barriers of the digital supply chain. The third section involves methods and the fourth section demonstrates results. The last section presents the conclusion.

2. LITERATURE REVIEW

Nowadays, technological innovations such as Industry 4.0 are one of the significant factors affecting supply chain development (Linh et al., 2019). Therefore, digitalization in the business world has become a challenge, not a choice. In this context, the traditional supply chain needs to gain competitive advantage by providing real-time information among supply chain partners simultaneously and digitalize for customer satisfaction (Nowicka, 2018). Big data (BD), Internet of Things (IoT), machine learning (ML), Robotic Systems (R), Sensor Technology (ST), Blockchain, Augmented Reality (AR), Virtual Reality (VR), unique identification and imaging innovation, Nanotechnology (N), Omni-Channel (OC), Cloud Computing (CC) technology, Artificial Intelligence (AI), Unmanned Aerial Vehicle (UAV), 3D printing, etc. technologies are developments that facilitate digital transformation (Agrawal et al. 2018; Verhoef et al., 2021; Bigliardi et al., 2023).

"Supply chain management covers the planning, design, implementation, and control of a business' logistics activities, including supply, storage, inventory control, production, distribution, and order fulfillment" (Attaran, 2020). Digital transformation in supply chain is planning and execution, ensuring interaction and integration between members of the supply chain by using innovative technologies in globally distributed supply chain processes (Hoberg et al., 2015; Bhargava et al., 2013).

Integrating new technologies into the supply chain provides a smart, value-oriented network with better insight, processing large amounts of information, broader collaboration and shorter response times (Castorena et al., 2014; Kinnet, 2015; Agrawal et al., 2018; Chase, 2019). In this way, facilitating communication within the supply chain will increase trust, agility and productivity between the parties (Linh et al., 2019; Queiroz et al., 2019). It will create competitive advantage for businesses by efficiently addressing changing customer needs (Khajavi et al., 2015). Through digitalization, not only the flow of products and

services, but also information, technology and finance will be ensured (Weichhart et al., 2016; Zhu et al., 2015; Nasiri et al., 2020).

Digital supply chains directly affect the way industrial businesses manage inventory (Büyüközkan & Göçer, 2017). The digital supply chainhas been associated with many benefits such as standardization of products and processes, speed, flexibility, real-time inventory management, transparent, smart, innovative, scalable, and environmentally friendly (Al-khawaldahet al., 2022; Aityassine et al., 2021). Digital supply chain provides the ability to access and control information on time, enabling integration of information, product innovation, efficient inventory management, and operation and maintenance efficiency (Kache&Seuring, 2017). With a digital supply chain, inefficiencies and risks are reduced, costs are optimized and business growth is supported (Rauniyar et al., 2022).

The benefits of digital transformation in all processes of the supply chain must be achieved through smart technologies (Büyüközkan & Göçer, 2018; Nasiri et al., 2020). However, there are barriersto the transition from the traditional supply chain to the digital supply chain (Xue et al., 2013; Dixit et al., 2024; Frank et al., 2019).Barriers that have affected the digitalization of the supply chain include senior management's reluctance to adopt the digitalization (Agrawal & Narain, 2020; Sharma et al., 2023); lack of industry-specific standards, lack of digital skills and expertise, and expensive installation and operating costs (Agrawal et al. 2019). Developing digital transformation is considered a complex process and costly due to the uncertainty of the return on investment in digital tools (Nauwelaerts & Chakri, 2016). Additionally, there is a lack of consensus on reducing waste such as labor and inventory in its implementation throughout the supply chain (Song et al., 2018; Rahamneh et al., 2023). The main barriers to the implementation of IoT in the supply chain are high investment cost, lack of management vision, employee resistance to change and general personnel problems such as fear of new technologies. Additionally, lack of standardization, interoperability between software systems, and reluctance to share data with supply chain partners are other barriers (Vass et al., 2021). Büyüközkan and Göçer (2018) have mentioned that lack of overall planning is the main barrier to implement digital supply chain. The lack of collaboration with external actors and process, lack of information sharing among partners have hindered the adoption of digitization.

Subramaniyam et al. (2021) have identified high investment costs, lack of skills, and lack of inspiration as the main barriers in the digital supply chain. Operational, managerial, technological, and formal barriers are digital transformation in the supply chain. Technological barriers can also affect operational performance and management-level decision-making. Managerial barriers have been identified as lack of management support, lack of standards and existing infrastructure, desire not to be exposed to risk, inadequacy of supply chain partners' information disclosure policies, communication and coordination difficulties in the supply chain, financial constraints and lack of trust (Ghadge et al., 2020). Operational barriers are high cost, lack of skilled employees and knowledge, waste of time, and complex technologies (Sheel & Nath, 2019). Technological barriers are data confidentiality, latency problems, cyber-attacks, technical problems and low-qualityof data (Cabrera & González 2019). The government's lack of a legal structure to regulate and govern digital supply chain technologies and applications has also been identified as a barrier (Martinsuo & Luomaranta, 2018; Ghadge et al., 2020).

Luthra and Mangla (2018) have investigated barriers to Industry 4.0 technologies in the supply chain. These barriers areorganizational, legal, and ethical issues, strategic, and technological. Organizational barriers include financial constraints, low management support and commitment, weak digital operations vision and mission, lack of workforce expertise, and reluctance to adopt/implement new business models. The technological barriers are the lack of global standards, the lack of infrastructure, the lack of integration of technology platforms, and the low quality of available data. Xu (2014) has found the following barriersduringdigitalization in supply chain management. Companies' reluctance to share information, lack of cooperation with external partners, lack of demand planning information, lack of instructions, demand forecasting error, lack of sufficient participation of senior management, variability and lack of skills in the chain are the barriers tothe digitalization process. Additionally, complexity of supply chain networks, excessive dependence on the supply chain, and difficulty in establishing sustainable relationships with supply chain members are the other barriers (Niemeyer 2014; Kirkland 2014; Hinze et al. 2011). Meanwhile, there are cultural differences, geographical distance and time differences, quality control problems, government regulations, intellectual property concerns, and difficulties in recruiting talented employees due to the global supply chain (Xu, 2014).

Dixit et al. (2024) have examined digital supply chain barriers in five parts: strategic, institutional, technological, and financial and leadership. As a result of the study, it was determined that the lack of urgency in digitalization, lack of appropriate innovation strategies and inadequate leadership are the biggest barriers in the supply chain. In addition, the inadequacy of the strategic road map, the lack of committed senior management, the lack of planning and coordination for the implementation of digital technologies, and the lack of adoption of the governance mechanism are at the forefront (Philip, 2021).

Technical, environmental and legal, financial, sociocultural,technological barriers have also been identified in the digital supply chain. As technical barriers, time is needed to develop Industry 4.0 technologies (Martins et al., 2020). Lack of clarity on what kind of data will be shared between supply chain members, data structures and formats may

also create problems in the use and analysis of data (Pearsall, 2016). There is also a lack of experts (Arya et al. 2017; Bienhaus & Haddud, 2018) and a lack of knowledge and skills in the use of data, digitalization and analysis of information in a quality way (Queiroz & Telles, 2018; Martins et al., 2020).The financial barriers are that the implementation of the technology requires high investment (Haddud et al., 2017; Queiroz & Telles, 2018). However, these technological investments will not always provide financial returns (Martins et al., 2020). The legal barriers are to ensure security and privacy between humans and robots (Weber, 2010), and international legislation is needed to share information between parties (Alotaibi & Mehmood, 2017). Additionally, there is vulnerability, reliability, and complexity associated with technological systems (Martins et al., 2020). There are also barriersto the lack of global standards in the use of Industry 4.0 technologies between the parties and the lack of legislation in data collection (Martins et al., 2020). Integrating electronic equipment into the supply chain will lead to environmental problems by increasing energy consumption (Miao & Zhang, 2014). The socio-cultural barriers are that there are various communication structures between companies (Wang et al., 2016); the problem of collecting data (Kache & Seuring, 2017; Pishdar et al., 2018); a synchronization problem of data (Haddud et al., 2017). There is also resistance among employees to accept technology, ethical and security issues, and fear of the workforce being replaced by technologies (Büyüközkan & Göçer, 2018; Khanna & Sharma, 2017).

Digitalization inthe supply chain is still in its early stages. In implementing a digitalization, certain capabilities need to be developed. During the digital transformation process, employees may resist the mental transformation. Insufficiency of budget and qualified workforce and lack of education isotherbarriers (Büyüközkan & Göçer, 2018; Raj et al., 2020; Özkanlısoy & Akkartal, 2021; Ruel et al., 2023). In particular, employees must have appropriate resources, capacities, and abilities for digital transformation (Bienhaus & Haddud, 2018). Therefore, during the digitalization process, businesses need to provide training and recruiting employees with the necessary skills in the supply chain (Bienhaus & Haddud, 2018).

3. METHODS

3.1. Data Collection

This study is exploratory research that involves semi-structured in-depth interviews.The study utilized a purposive sampling method to select a sample consisting of 10 respondents. The purposive sampling design is employed to guarantee that the chosen respondents possess insight into the phenomenon being studied as well as comprehensive knowledge about the industry (Collis & Hussey, 2013). Interviews were conducted with 10 professional experts of Supply Chain and Digital Transformation in various industrial sectors.In order to cover all necessary topics comprehensively, an interview protocol was devised, comprising a series of open-ended questions serving as a roadmap during the interviewing phase. When the interviewer notices that the same information is repeated in the interviews, he decides that the interviews have reached theoretical saturation (Rowlands, Waddell & McKenna, 2015; Saunders et al., 2018). Since theoretical saturation was reached in the in-depth interview with the tenth participant in the study, no further interviews were conducted.

Table 1 shows the profile of the participants that were interviewed and their companies. It can be seen that

Table 1. Profile of the Participants and Their Companies

Participants /Company	Sector	Sales	Number of Employees	Global/Local	Position	Experience in the company
P1	White Goods	$ 1,8 billion	21.000	Local & Global	Senior System and Process Development Specialist	15 years
P2	Chemistry	$ 65 million	220	Local & Global	Assistant General Manager	27 years
P3	Automotive	$ 1,3 billion	7.000	Local & Global	Planning Manager	20 years
P4	Medical	$ 45-50 million	750	Local & Global	Production and Factory Director	25 years
P5	Steel	$ 64 million	1.450	Local & Global	Purchasing Officer	18 years
P6	Cement	-	600	Local & Global	General Manager	23 years
P7	Packaging	$ 533 million	2.200	Global	General Manager	34 years
P8	Energy	$ 107 million	300	Local & Global	Production Manager	8 years
P9	Cement	$ 77 million	214	Local	Production Manager	15 years
P10	Petrochemical	$ 155 million	+ 5.000	Local & Global	Logistics & Customs Services Manager	15 years

Table 2. Digital Technologies Used in the Company

P1	Big Data Analytics, Industrial Internet of Things (IIOT), SAP Systems, MRP Systems, 3D Printing, Cloud Computing, Robotic Systems
P2	Big Data Analytics (Scada, MRP ERP), Artificial Intelligence, Cloud Computing,
P3	Robotic Process Automation (RPA), Big Data Analytics (SAP Systems, MRP Systems, Power BA Reports), Artificial Intelligence, Industrial Internet of Things (IIOT)
P4	Big Data Analytics (ERP, MES, BI), Cloud Computing, Robotic Systems, Industrial Internet of Things (IIOT)
P5	Big Data Analytics (ERP), Robotic Process Automation (RPA), Industrial Internet of Things (IIOT), Cloud Computing
P6	Big Data Analytics, Robotic Systems, Artificial Intelligence, Industrial Internet of Things (IIOT),
P7	Big Data Analytics, SAP Systems, Robotic Systems, Industrial Internet of Things (IIOT), Cloud Computing (ERP)
P8	Big Data Analytics, SAP Systems, Robotic Systems, Artificial Intelligence,
P9	Big Data Analytics, SAP Systems, Robotic Systems, Artificial Intelligence, Industrial Internet of Things (IIOT), Cloud Computing (ERP)
P10	Big Data Analytics, SAP Systems, Robotic Systems, Artificial Intelligence, Cloud Computing

participants work in different industries such as white goods, chemistry, automotive, medical, steel, cement, packaging, energy and petrochemicals in various roles. Their experience in the company ranges from 8 to 34 years. Number of employees working in their companies is in the range of 214 and 21.000. According to Table 2 can be seen that many important digital technologies are used by companies where the participants work.

3.2. Data Analysis

When analyzing the data obtained through interviews, as suggested by Lacey & Luff (2001), first the data was listened to carefully, and thentape-recorded material was transcribed. Later, data were organized identify and retrieved correctly. Organized data was coded and themes were determined. Themes were obtained based on the interview data. The themes were then refined to finalize the categorization. The names of the categories were formed in consonance with the literature. Codeswere presented together with quotes from interviews.

Content analysis, which is commonly used qualitative method, was utilized to analyze the data collected from participants who work at various industries. Content analysis is defined as a research method for forming reproducible and valid deductions from texts or other sources about how they are used (Krippendorff, 2013). Content analysis is a useful technique for revealing general tendencies (Metin & Ünal, 2022), identifying attitudes, views, and interests (Drisko & Maschi, 2016) as well as discovering concepts in data by coding them (Yıldırım & Şimşek, 2018). Content analysis is highly adaptable since it can be guided by either empirical or theoretical principles (Stemler, 2015). A qualitative analysis program, Maxqda was utilized to analyze and code the transcripts. After describing the crucial study results, the interviews were reread to evaluate the correctness and extensiveness as recommended by (De Casterlé et al., 2012).

Analysis results emphasize that there are two main themes: namely the barriers to digital supply chain transformation and solutions to barriers in supply chain digital transformation. The sub-themes belonging to barriers to supply chain digital transformation are identified as financial, organizational, and technological barriers together with barriers related to employees and data management. The sub-themes in solutions to barriers in supply chain digital transformation were revealed as solutions related to employees and process.

4. RESULTS

4.1. Barriers to Supply Chain Digital Transformation

Although digitalization has many advantages for companies, it is not always easy to transform the companies digitally. There can be several barriers to digital transformation. Participants indicated that their companied experienced financial, organizational, technological barriers together with barriers related to employees and data management when their companies transforming their companies digitally.

Financial constraints are a significant challenge for companies in the digitalization process (He et al., 2024) since digital transformation itself represents investing in digital technologies to take advantage of business opportunities (Hartl & Hess, 2017). Results of the study have shown that financial barriers include high cost of investment and budget insufficiency. Participants stated that since technological investments require foreign currency most of the time, the initial investment is too high, and these technologies also costly because they require investment in infrastructure.Ambiguous economic advantages of investments also strengthen the perception of financial barrier as also supported by literature (Kiel et al., 2017; Özkanlısoy & Akkartal, 2021).

Table 3. Financial Barriers

Code	Statement
Budget Insufficiency	*The biggest barrier might be budget. In a country like Türkiye, where the dollar exchange rate constantly fluctuates, it is very demanding to make a budget and it is also crucial to get a budget. All software companies and all digital companies work with foreign currency. They pay their staff, software developers, etc. in dollars and euros. When outsourcing is used, the price increases already incredibly, even if you do a small project, the cost is very high. There are very few companies in Turkey that can spare money for this. They need this information so much and they need to see the financial benefit to spending money on digitalization." (P1)*
High cost	"*As you constantly collect digital data, you have to develop, grow and invest in your infrastructure. This also creates a cost. You need to constantly support your server structure. But these investments need to be made in order to achieve digital transformation." (P2)* *"While the digital transformation is being carried out, some existing investments may be reinvested, which is a challenge for us. Of course, if digital technologies enter our lives, there must be communication; with machines and systems; Therefore, it is necessary to redesign this infrastructure. This requires a new investment budget." (P8).*

Table 4. Organizational Barriers

Code	Statement
Lack of management support	*"It is difficult for those who have classically spent years to keep up with the current rapid change. It's fast even for us, every day I see different things are being talked about; different things are coming to the fore in the World. If you do not make the necessary investments during the economic crisis, you do not provide the necessary infrastructure; you will not be able to keep up with changes. However, when there is an economic crisis, it can be said to cut investment." (P1)*
Lack of readiness	*"For example, it was done in Europe, in a factory in Europe, and you will localize this application and apply it in here too. There is a process of acceptance for this." (P6)*

Although digital transformation is innovative and beneficial to companies, some companies neglect to provide digital strategy and vision (Erol et al., 2016); however, it is crucial to prepare and support the organization for digital transformation. Organizational barriers include a lack of management support and a lack of readiness. Inadequate leadership (Dixit et al., 2024) and lack of management support (Ghadge et al., 2020) are found as thebiggest barriersto supply chain digitalization. Participants stated that when digital transformation is not supported by top management that becomes a barrier for their company to transform. They also clarified that when people are not ready, the digital transformation becomes difficult. Lack of management support and readiness was also found as inhibiting factors in another study (Özkanlısoy & Akkartal, 2021; Subramaniyametal., 2021).

There are barriers associated with employees in the company. Barriers related to employees consist of lack of skilled employees, resistance to change, and fear of job loss. Lack of skilled employees is also considered as an important barrier in the literature (Sheel & Nath, 2019; Subramaniyam et al. 2021). The scarcity of digital transformation experts and also employees who are knowledgeable about those technologies in the sector was emphasized as one of the main barriers. Participants stated that some of the employees have hard time getting used to the new technologies and digitalization of processes. Furthermore, the fact that companies can significantly reduce labor cost with digital technologies (Bruemmer, 2016) may cause employees to fear losing their jobs.

There are many difficulties in the creation, application, and spread of new digitalized processes (Hirsch-Kreinsen, 2016). Consequently, technological barriers are also evident in digital transformation. According to participants, technological barriers are related to lack of integration, infrastructure and inflexibility. The focus company needs to modify its digital supply chain system to meet the unique requirements of specific partners (Mukhopadhyay & Kekre, 2002) because otherwise there are problems in practicing digital problems as stated by participants. Companies especially have difficulties when their digital maturity levels do not match with their partner companies. Furthermore, the complication of making digital processes flexible is mentioned by participants.

Data management is one of the issues of strategic importance for companies today. Companies use many

Table 5. Barriers Related to Employees

Code	Statement
Lack of Skilled Employees	*"We want everyone and their business units to make their own reports, working like an IT Professional; because we don't have that many people working in IT. We want them to be able to use a large infrastructure whenever they want and create the reports and data science studies, they want using this data. We will prepare infrastructure for them and we will be accelerating this structure called artificial intelligence in the supply chain in the coming years." (P3).*
	"We are having problems finding a workforce, especially software developers. It is already very difficult to find a software developer. You worked with an employee for 10 years, and when he suddenly leaves, there is no longer a man who knows the system. You try again until he learns the job. One of the biggest problems." (P1)
	"The most important thing here is lack of talent. We are applying new generation technologies and not every company has experts such as artificial intelligence or Blockchain experts in this field; especially in the supply chain it's nearly impossible." (P10)
	"Especially in the assignment part, that is, if you are going to assign a report or a job to someone, you will get approval from someone. When that person changes, you should always have a software developer within your organization that is knowledgeable about the subject, to change that old application again in the software or to add a new responsibility if there is a new responsibility." (P2)
Resistance to change	*"The most important problem or the one that catches our eye in the first place, is that these systems are used by people. Because, in fact, we have a little difficulty as we have to change some habits during the implementation phase of each new application, but we can implement it very well after we get used to and adopt the new system." (P4)*
	"It wasn't easy after all. While preparing this infrastructure, employee transformation is not easy. Everyone wants to work with the method they are used to. "We had trouble changing habits" (P7)
	"Obviously, there are problems on the personnel side. As people get used to the systems, there may sometimes be constructs that can be overlooked when planning and constructing the systems. "It may take time to fix them later." (P2)
	"People want to continue their work conservatively because they have been doing the same job for 5 years. He feels threatened. I understand this psychologically. This is seen as one of the biggest obstacles in the digital transformation, that is, issues such as the staff not being ready for me or the staff feeling threatened or not contributing enough." (P1)
Fear of Job Loss	*"When we brought digital solutions, when we brought software robots, people feared that they would lose their jobs." (P7)*
	"Five people work in the department, with digitalization it will decrease to three and employees are afraid that they would lose their job." (P1)

analytical tools to manage the large amounts of data collected (Cambaz et al., 2022). It is difficult to develop a software platform that can collect data within the supply chain from many different sources and use it to ensure the accuracy of data, and manage and execute it (Xu et al., 2013). Therefore, common processes are needed to ensure transparent information, goods and cash flows (Jacobs & Chase, 2014). Managing huge amounts of data in digital transformation is challenging. Additionally, data quality is important for smooth digital transformation (Cabrera & González 2019) and when the formats are different among partners, this may cause problems (Pearsall, 2016). Barriers connected with data management include problems about data access, doubt in data accuracy, low data quality, and manual data entry. Participants expressed those difficulties in accessing the data and not being sure about the data are serious drawbacks. Incorrect and manual data entry also disputes digitalization.

4.2. Solutions to Barriers in Supply Chain Digital Transformation

Even thoughthe digitalization of supply chain digital transformation is challenging, some solutions can be offered against these barriers. Participants explained that their companies already took some steps to prevent errors or overcome some barriers that can be encountered in the process of digitalization. Those solutions are grouped into two main sub-themes; namely, solutions related to employees and solutions related to the process.

When a company is experiencing a digital transformation, it's vital to focus on education and skill training on an individual level and improving digital change management for acceptance on the organizational level. It is important

Table 6. Technological Barriers

Code	Statement
Lack of Integration	"*There are generally integration problems. Problems such as not being able to see what is going on with the supplier, the products in the warehouse, the production and cost plan, imported products and imports, where the material is on the road" (P5*)
	"If we are not at the same digital level as the partners we work with, we may have difficulties receiving the data we need from them. We think that when people in our ecosystem achieve a similar digitalization rate, we will progress more smoothly there." (P7)
Infrastructure	*"There are difficulties in implementation. There were especially periods when the internet infrastructure was cut off" (P2)*
	"Maybe there were some problems within the scope of systemic (hardware and software) infrastructure and network infrastructure, but this created a stimulating effect for us to strengthen that infrastructure side." (P4)
Inflexibility	*"It is very difficult to make the digital process flexible. What we can do in real life is not the same as what we can do in the digital environment; It cannot be possible. For example, in Excel, you can immediately change a cell manually, but in digital, you cannot allow it to be changed manually." (P1)*

Table 7. Barriers Related to Data Management

Code	Statement
Data Access	*"There may be difficulties in accessing various data. Accessing the data or getting the data in the format you want can be very costly." (P3)*
Doubt in Data Accuracy	*"There is always a question mark about the accuracy of the data." (P2)*
	"Generally, the first thing that comes to my mind is data problems. There are many systems, and these systems must interact with each other. There may be problems in data transfer. You need to verify the data and then run the digitalization systems." (P3)
Low Data Quality	*"You need to give the correct data and you need to teach these systems how to make the right decision so that reliable decisions can be made. There may be major problems in tracking systems or problems may arise due to data not being entered or transferred correctly." (P2)*
	"If your data is not accurate, it becomes the biggest obstacle to digitalization." (P3)
Manual Data Entry	*"The difficulties we encountered in managing the supply chain were, in fact, that data was being entered into the system by personnel. There may be delays depending on people." (P9)*

to have a specific and detailed and to integrate the role into the company in a way that aligns with its responsibilities. This could help to lessen the risk that changes may bring (Vogelsang et al., 2019). The social and employment effects of the technical modification of the production system may expedite the processes of digitalization and automation on the labor market for logistics (Bottalico, 2021). Human resourcesare crucial in the digitalization process; therefore, participants stated that carried out many activities to increase the acceptance and ease the process for the employees. Especiallydigital leadership to guide digital transformationis an important factor that facilitates supply chain digital transformation. Having a digital leader that helps to integrate employee to the process is vital. Furthermore, employee transformation is also presented as a solution because it complements the leadership. Participants highlight that working together for a smooth transformation is the key to achieve desired goals in terms of digital transformation.

Participants also mentioned solutions related to the process. These include gradual digitalization, making cost-benefit analysis, back-up and automatization, utilizing user feedback and continuous improvement. Participants stated that it is more beneficial to do this gradually rather than switching to digitalization suddenly and completely. Benefit cost analysis is important to see how much return the investment will provide; literature also underline that the lack of a clearly defined return on investments tends to be one of the major challenges to technologies' implementation in the supply chain (Kiel et al., 2017). Digital transformation is an ongoing process of change (Cichosz, 2018), hence improving is part of the process. Participants emphasized the importance of continuous improvement by consulting users' opinions in this process, as digitalization is an ongoing process.

Table 8. Solutions Related to Employees

Code	Statement
Digital Leadership	*"At the forefront of these tasks, there must be a digital transformation leader. This leader should not be involved in anything else, but solely responsible for digital transformation. If things proceed in the same coordination, there will be a counterpart on the supplier side as well. This way, things will go much smoother." (P5)*
	"*We overcame the problems by meeting with the employees, explaining the process to them, and advancing the processes. They now see digitalization as a tool that will help their work. In this sense, we invest seriously in the transformation of our employees through training and try to explain digital solutions and digitalization to them. We have accelerated the education process, especially with the acceleration of Generative AI (Artificial Intelligence) work." (P7)*
	"In this process, consultancy and training processes on SAP started from the very beginning. SAP is a universal system, but each factory required its own unique structuring and some changes depending on the infrastructure and interfaces of the modules it uses. We carried out the processes of this digital transformation here together with the leaders and employees in the IT department." (P9)
	"We have a digital transformation office that coordinates the digital transformation activities in the entire company. We also have a partner who is responsible for the supply chain. They support us in everything, we brainstorm how new-generation technology can be implemented here. There is a department manager who is completely focused on this work. We also have a partner who is knowledgeable enough about our business to follow the opportunities in our processes." (P10)
Employee Transformation	*"When undergoing digital transformation in Turkey, it's necessary to carry out personnel transformation alongside it." (P1)*
	"In digital transformation, having a team is essential. Competent individuals are needed here. This team really needs to have the capacity to carry out this transformation, and the teams in the factories also need to have the competence to keep up with it. There is a need for guidance from a competent team in terms of digitalization." (P6).
	"Our digital transformation department carries out some activities. For example, we have a program in which profiles are determined and trained on subjects such as new generation Technologies for 9 months. Then they work at different departments of the company and also tell what they have learned to their co-workers. There is another program where the digital transformation team forms small teams from different departments in the company." (P10)

5. CONCLUSION

Nowadays, digitalization is important for almost all industries, and digital technologies are applied in various departments in companies. Digitalization provides many advantages for companies. However, companies also encounter some barriers in the process. The aim of this study is to understand the barriers that companies deal with the digital transformation process in the supply chain and to present some solutions that can be developed against these barriers. This comprehensive review could help form digitally enabled and resilient supply chains that are compatible with future necessities.

In the study, in-depth interviews with companies were asked not only about the barriers encountered in the digital transformation of the supply chain but also about solutions to these barriers. In this regard, the study evaluates the issue in two aspects.The study has revealed that the main barriers in supply chain digital transformation are financial barriers, organizational barriersand technological barriers as well as barriers related to data management. According to findings, financial barriers are budget insufficiency and high cost; which are both related to the requirement of high investment for the digital technologies and also people who will work on those technologies. This finding is in parallel with Haddud et al., 2017; Queiroz & Telles, 2018; Büyüközkan&Göçer, 2018; Raj et al., 2020; Özkanlısoy & Akkartal, 2021; Ruel, et al. 2023 studies. Luthra and Mangla (2018) revealed that the financial barrier is the highest relatively important barrier than others. It is difficult especially forsmall and medium-sized companies to obtain new technologies, advanced equipment, facilities, machines and develop process innovations due to their insufficient financial resources (Lee et al., 2017).

Organizational barriers consist of a lack of management support and a lack of readiness. Support of management and making the company organizationally ready for digital transformation is necessary for proper transformation. Determined management support is needed for digital transformation to occur in the supply chain and business processes (Luthra & Mangla, 2018). Employees' acceptance is crucial when integrating digital technologies, therefore participants highlighted some difficulties when trying to convince and motivate employees. Ruel

Table 9. Solutions Related to the Process

Code	Statement
Gradual Digitalization	*"There should be controlled digitalization, not uncontrolled digitalization." (P3)*
	"We have a process called phasing. We divide the project into phases. We use phasing in two aspects. Firstly, we slowly implement the project, not all at once. We say let's implement part of it now and the rest later. Here, we're doing something like a new phase design; you can think of it as the makeover of the project." (P1).
	"It was already there in its initial establishment, but since the restructuring was for a new factory, it continued to evolve over the years by adding and improving upon it, and this transformation is still ongoing." (P9).
	"We think pilot projects are very important, because at the end of the day, we set out to reveal the new generation technologies and what benefits digitalization activity can bring to us with pilot projects." (P10).
Benefit Cost Analysis	*"We also look at the cost-benefit analysis. That is, how long it will take to pay for itself, whether it's worth it or not, and so on. If, in that sense, a project, even though it seems very nice and appealing, turns out not to be feasible, we can postpone it." (P3).*
	"The cost of investment is too high, and the main issue is what would be the benefit of this investment. However you need to be able to present the benefit accurately with the right methodology. When you can't achieve this, no one wants to go into the unknown and pay a high amount of Money." (P10).
Back Up and Automatization	*"Backups need to be taken very seriously. Data lost due to backups can cause a lot of trouble in the future." (P2)*
	"The difficulties were overcome with the automatic entry of data. Initially, we couldn't fully utilize it. For example, the energy data we use is automatically reported to the system." (P9)
Utilizing User Feedback	*"Users start giving us feedback during the time they use it. Feedback such as 'There's a problem here,' or 'Can we add this feature?' or 'We liked this feature in the past, but it would be better if it was like this.' These kinds of feedback keep coming." (P1)*
	"There used to be a bottleneck in the approval process, which could block the entire system and orders, leading to delayed deliveries and production losses. Both the approval mechanism and reminders in case approvals were not given on time were automated in the system to overcome these challenges. By incorporating and developing some digital advancement, we were able to progress." (P9)
Continuous Improvement	*"If there are particularly old machines here, it's important to modernize them. By modernizing, I mean not throwing them away and buying new ones but digitizing while preserving the existing investment. It involves making them digital with additional hardware and sensors." (P7)*
	"A material is requested from supplier firms. Differences in the requested quantity may occur between the supplier firm and the company scale. Unfortunately, manual intervention was necessary because the system did not recognize it. To assist with this, additional features were defined in the system to address digital challenges, such as defining tolerances, so that within certain tolerances, even if it's not exact, a solution acceptable to the system can be found." (P9)
	"When things get stuck, discussions with new integrator companies or different firms are held to reevaluate situations like developing new programs or redesigning the conceptual designs of digitalization processes. Additional investments or updates are then attempted to minimize problems in those areas." (P8)

et al. (2023) has emphasized that lack of human competency is the significant barrier to implement these technologies. Barriers related to employees which are lack of skilled employees, resistance to change, and fear of job loss remains as other barrier. This codehas also indicated as employee anxiety brought on by a decreased reliance on the employee (Özkanlısoy & Akkartal, 2021). At the same time, in terms of resources and capabilities, the employees have the appropriate skills for digital transformation (Bienhaus&Haddud, 2018). As stated in this study, Ruel et al. (2022) also highlight resistance to change and lack of expertise by employees.

Data management is crucial for digital technology transformation (Cambazet al., 2022). The findings of the study point out that data access, doubt in data accuracy, low data quality, and manual data entry are barriers related to

data management. Trust between supply chain parties in data management is an important element in sharing data (Annosi et al., 2021). Data quality is important for collecting, analyzing, and interpreting high-quality, up-to-date data in the digital supply chain (Helo et al., 2020; Ghadge et al., 2020). Problems in data integration and obtaining quality data also need to be taken into account (Pishdar et al., 2018; Martins et al., 2020). Additionally, there is a lack of competent specialists in properly entering and using data into the system (Kache & Seuring, 2017).

Lack of integration, lack of infrastructure and flexibility are technological barriers. Having digital and non-digital supply chain members in supply chain management causes a lack of integration between members and data (Xu, 2014; Büyüközkan & Göçer, 2018; Brown et al., 2018; Dixit et al., 2024). Additionally, as stated in the study, the fact that the data are in various formats and structures generates problems in data analysis and use (Annosi et al., 2021).

Despite the many opportunities that digitalization in the supply chain provides to several industries, to adopt these technologies, it is necessary to address the solutions applied by companies, in addition to the barriers generated. The categories in solutions to barriers in supply chain digital transformation were revealed as solutions related to employees and process.The findings of the study point out that solutions related to employees can be digital leadership and employee transformation. Having a digital leader that focuses solely on this task and coordinates employees is helpful for smooth transformation. Digital leader is important to develop a vision and strategy for the digital transformation. The digital leader can help to create digital culture which is useful for achieving digital maturity and gaining expertise in digital technologies (Modgil et al., 2022; Dixit et al., 2024). Training programs are also crucial to mitigate digital technology adoptionby employees (Ruel et al., 2023). Literature also underlines that most of the barriers; management needs to prioritize digital transformation, develop digital skills through appropriate training, and pursue digitalization with a sense of urgency (Agrawal et al., 2019; Agostini & Nosella, 2019). Additionally, businesses depend on using their digital skills and capabilities to remain competitive and implement effective innovation strategies.

In addition, solutions related to the process are presented in the study. Those solutions consist of gradual digitalization, making cost-benefit analyses, back-up and automatization, utilizing user feedback, and continuous improvement. Gradual digitalization is essential to ease the adaptation of digital tools and it is also useful to detect any flaws in the system before fully utilizing it. The study results underline the crucial role of proving that digital technologies have high returns, despite their high investment costs, for the adaptation of digital technologies in the supply chain. Cost-benefit analysis is a good way to explain the financial return of digital technologies, since the investment cost is too high (Haddud et al., 2017; Queiroz & Telles, 2018) and needs to be clarified.User comments and feedbacks also provide beneficial guideline for any implementation in the process and help to achieve continuous improvement. It is important to realize that digitalization is an on-going process and therefore companies should always enhance the digital technologies' usability and effectiveness by continuously monitoring and improving the system.Sharma et al. (2020) stated that creating a culture of cooperation across supply chain, which will overcome the data sharing barrier in supply chain.

This study offers fruitful insights for industries that want to utilize digital tools in their supply chain. The findings of the study which encompassed both barriers and solutions are expected to aid companies in adaptation and usage of supply chain digital technologies. However, the study focused on the barriers and solution suggestions for digital transformation in the supply chain. In the future, a more comprehensive study can be conducted by including the driver factors in the digital supply chain. Meanwhile, the nature of the qualitative results, this study does not intend to generalize findings. Future research can focus on one industry and explore that industry's specific needs and solutions by conducting survey-based research.

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