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The Analysis of The Impact of Companies' Logistics 4.0 Awareness on Digital Transformation and Logistics Capabilities*

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ABSTRACT

The study aims to determine the awareness of Logistics 4.0 and examine its impact on businesses' digital transformation and logistics capabilities. A survey was distributed to businesses in the Istanbul Chamber of Commerce's transportation and logistics services committee using a sampling method, and 401 responses were received. It was found that Logistics 4.0 awareness has a significant impact on digital transformation. The sub-dimensions of Logistics 4.0 awareness—business model products and services, process management, information systems infrastructure, and evaluation variables—were found to have significant effects on digital transformation. However, the marketing and customer outreach variables did not have a significant effect on digital transformation. It was also concluded that Logistics 4.0 awareness has a significant effect on logistics capabilities. When examining the impact of the sub-dimensions of Logistics 4.0 awareness on logistics service differentiation and logistics innovation, it was found that marketing and customer outreach, and process management had no significant effect on logistics service differentiation, but did affect logistics innovation. On the other hand, business model products and services, information systems infrastructure, and evaluation variables were found to have a significant effect on logistics service differentiation but no effect on logistics innovation. The study highlights that businesses' awareness of Logistics 4.0 plays a critical role in both accelerating digital transformation processes and developing logistics capabilities. The research contributes theoretically and methodologically by emphasizing that digitalization is not only a technological innovation but also a strategic tool for businesses to enhance their logistics capabilities and gain a competitive advantage.

Keywords : Logistics 4.0, Digital Transformation, Logistics Capabilities, Logistics Service Differences, Logistics Innovation

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İşletmelerin Lojistik 4.0 Farkındalığının Dijital Dönüşüm ve Lojistik Yeteneklere Etkisinin Analizi

ÖZ

Çalışmada Lojistik 4.0 farkındalığının belirlenebilmesi ve bu farkındalığın işletmelerin dijital dönüşümü ile lojistik yeteneklerine olan etkisinin incelenmesi amaçlanmıştır. İstanbul Ticaret Odası taşımacılık ve lojistik hizmetleri komitesinde yer alan işletmelere amaca yönelik örnekleme yöntemi ile anket formu ulaştırılmış 401 kişiden geri dönüş alınmıştır. Lojistik 4.0 farkındalığının dijital dönüşüm üzerinde anlamlı bir etkisi olduğu bulunmuştur. Lojistik 4.0 farkındalığının alt boyutları olan iş modeli ürün ve hizmetler, süreç yönetimi, bilgi sistemleri altyapısı ve değerlendirme değişkenlerinin dijital dönüşüm üzerinde anlamlı etkileri olduğu ancak pazarlama müşteriye ulaşma değişkeninin dijital dönüşüm üzerinde anlamlı bir etkisi olmadığı belirlenmiştir. Lojistik 4.0 farkındalığının aynı zamanda lojistik yetenekler üzerinde de anlamlı bir etkisi olduğu sonucuna varılmıştır. Lojistik 4.0 farkındalığının alt boyutlarının lojistik hizmet farklılıklarına ve lojistik inovasyona etkisi incelendiğinde, pazarlama müşteriye ulaşma ve süreç yönetiminin lojistik hizmet farklılıklarına anlamlı bir etkisi olmadığı ancak lojistik inovasyona etkisi olduğu görülmüştür. Diğer yandan, iş modeli ürün ve hizmetler, bilgi sistemleri altyapısı ve değerlendirme değişkenlerinin lojistik hizmet farklılıklarına anlamlı bir etkisi olduğu ancak lojistik inovasyona etkisi olmadığı sonucuna varılmıştır. Çalışma, işletmelerin lojistik 4.0 farkındalığının hem dijital dönüşüm süreçlerini hızlandırmada hem de lojistik yeteneklerin geliştirilmesinde kritik bir rol oynadığını ortaya koymaktadır. Araştırma, dijitalleşmenin yalnızca teknolojik bir yenilik değil, aynı zamanda işletmelerin lojistik yeteneklerini geliştirip rekabet avantajı elde etmede stratejik bir araç olduğuna vurgu yaparak teorik ve metodolojik bir katkı sunmaktadır.

Anahtar Kelimeler : Lojistik 4.0, Dijital Dönüşüm, Lojistik Yetenekler, Lojistik Hizmet Farklılıkları, Lojistik İnovasyon

INTRODUCTION

Developments and transformation processes in various industrial fields have deeply impacted logistics sector activities, just as they have in other sectors. The logistics sector and industrial revolutions mutually shape and influence each other. In particular, the concept of Logistics 4.0, which involves the integration of digital transformation technologies into the logistics sector under the influence of Industry 4.0, has emerged as a significant development. The ongoing industrial revolution brings numerous innovations and advancements, forcing businesses to adapt to these inevitable changes. Digitalization is not only advancing in the manufacturing sector but also gradually progressing across other sectors, including logistics, becoming a key force shaping the future of business. It is evident that businesses that fail to adapt to these changes will fall behind in competition. Therefore, it is crucial for businesses in Turkey's logistics sector to evaluate their awareness of Logistics 4.0. Companies that effectively manage their resources and adapt to digital transformation trends will be better positioned to gain a competitive advantage on both local and global scales. On the other hand, businesses that fail to comply with or effectively integrate into the digital transformation

process will find it increasingly difficult to maintain their competitive strength and contribute to economic development.

Given that the logistics sector is heavily technology-driven, it is essential to assess it within a technological context. Managing the digital transformation process and adapting to it is not merely a necessity, but rather a goal to achieve success by combining creativity and innovation to present the technologies of the future. Digital transformation can be realized as labor-intensive processes are replaced by technology-based, mechanical processes. When considering the reasons for implementing digital transformation, the process's functioning, the challenges encountered, and potential solutions, the changes in procurement processes, the rapid adaptation of competitive and agile businesses, the fragmentation of market shares, the expansion of competitive areas, and customers' increasing expectations for personalized services make digital transformation a necessity. In this context, adapting to the process is crucial for gaining a competitive advantage with the aim of catching up with the future vision. As competition increases, the role of dynamic capabilities in the digital transformation technologies used by logistics businesses becomes increasingly important.

This study aims to examine the relationship between businesses' awareness of Logistics 4.0 and their digital transformation processes, with a particular focus on its impact on logistics capabilities. The study emphasizes the critical role of Logistics 4.0 awareness in promoting digital transformation and logistics capabilities. The primary research question of this study is: How does awareness of Logistics 4.0 influence the development of digital transformation and logistics capabilities in businesses? This research highlights that understanding and integrating the principles of Logistics 4.0 is a crucial strategic tool for innovation, growth, and long-term sustainability within the logistics sector. The study makes a theoretical and methodological contribution by investigating the impact of Logistics 4.0 awareness on digital transformation and logistics capabilities.

Although there has been much discussion regarding the digitalization of logistics and technological advancements, there is limited research directly examining the relationship between Logistics 4.0 awareness and digital transformation and logistics capabilities. By investigating this relationship, this study contributes both theoretically and practically to the logistics sector and academia. Ultimately, this research provides valuable insights into how logistics companies can manage their digital transformation process and its impact on logistics capabilities. Moreover, the study offers recommendations for logistics companies to effectively engage in the digitalization process, shedding light on future trends in the sector.

1. LITERATURE REVİEW

1.1.Logistics 4.0

Industrial revolutions, beginning in the 18th century, represent a series of significant transformations that continuously evolve. These revolutions have brought about radical

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changes in production processes and led to profound shifts in the economic, social, and cultural structures of societies. The latest stage of these industrial revolutions is the period we are currently experiencing, known as Industry 4.0 (Kagermann et al., 2011, p. 2). This period has led to the emergence of production methods by enabling the transformation and renewal of business models to increase efficiency in industrial production, ensure flexibility and enhance competitiveness.

The business world requires adapting to new demands in a dynamic and customer-oriented manner and developing innovative strategies to achieve logistical goals. Real-time visibility in logistics has become critically important in order to respond quickly and flexibly to instant demands and changes (Kache & Seuring, 2017, p. 11). The ability to adapt to changing demands based on customer needs and requirements serves as a cornerstone and sustainable driving force in forecasting the evolution of logistics.

The concept of Logistics 4.0 was introduced in 2011 to respond to changing customer needs and develop sustainable logistics solutions (Winkelhaus and Grosse, 2020, p. 18). This new paradigm aims to make the logistics flow more efficient, flexible, and agile through the combination of technologies used in the digitalization process. In this context, the framework of ideas for Logistics 4.0 is detailed in the figure.

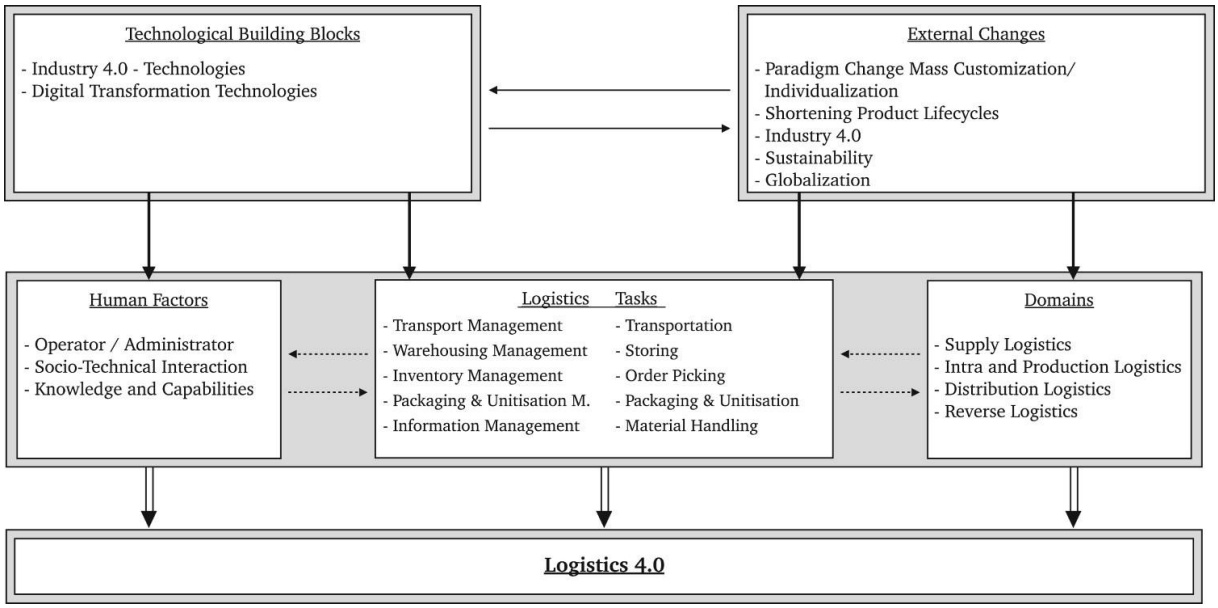

Figure 1: Conceptual Framework of Logistics 4.0 (Winkelhaus and Grosse, 2020, p. 20).

Logistics 4.0 provides certain levels of integration and coordination. It ensures that the information technologies used in different departments within the enterprise are accessible and coordinated at the same time. It also provides an important benefit in terms of cooperation between different businesses. Finally, it is an important management mechanism in

integrating stakeholders, devices and products around the enterprise in a holistic structure (Strandhagen et al., 2017, p. 344).

Other digital transformation technologies utilized through Logistics 4.0, especially blockchain technology, focus on the customer throughout the chain, making the product traceable at every stage and transparently accessible. Thus, the customer can easily access information about where and at what stage the product is, which allows for an increase in the trust relationship along the chain (Thoben et al., 2017, p. 4)

Businesses that see customer satisfaction as a prerequisite are those that have grasped the importance of the concept of logistics 4.0 and have included the customer in decision-making processes by giving the necessary value to customer services in this context. Businesses that aim for effective, efficient, sustainable management with a holistic approach throughout the chain that sees every feedback from the customer as an improvement can control the competitive factor more (Ejsmont et al., 2020, p. 5).

The logistics sector is continually seeking new digital solutions to enhance traceability and predictability. Parallel to technological advancements, the widespread use of mobile sensors has made it possible to track the status and location of loads in real time within logistics processes. This has greatly facilitated the monitoring of trucks and ships, improving operational efficiency. Furthermore, the opportunities provided by cloud technology have made innovative business models like virtual transport feasible. This enables logistics processes to be managed more flexibly and scalable. 3D printers have the potential to bring revolutionary changes to the logistics sector. These printers allow the rapid production of various products and spare parts and their immediate distribution. Thus, delays in the supply chain can be reduced, and changes in demand can be responded to more quickly. Autonomous vehicles also contribute significantly to the digital transformation in logistics. These vehicles increase reliability and minimize human errors by being used in both land and sea transportation processes. The integration of these technologies makes it possible to offer faster, safer, and more cost-effective services in the logistics sector (Gökırmak, 2019, p. 76).

1.2. Digital Transformation

Digital transformation reshapes existing operations and ways of doing business, offering a more efficient, innovative, and customer-centric approach (Verina & Titko, 2019, p. 10). With digital transformation, the concept of "smart" has increased the importance of technology-based solutions. Smart logistics positively impacts the logistics supply chain by offering specialized and value-added services in this context. Smart logistics systems provide fast and effective solutions to the changing demands of customers, preventing the stagnation of the process along the supply chain and making it adaptable (Erdal, 2024, p. 63).

Businesses implement the transformation process by utilizing various applications in the digitalization process. Suppliers, investors, business employees, and managers are among

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the individuals using information systems in this process. Each of them supports business processes by using information systems in different ways and levels. Businesses strive to integrate their digitalization strategies in areas such as business processes, social and mobile applications, big data, cloud technologies, and enterprise applications. This integration strengthens not only the internal processes of businesses but also their interactions with external stakeholders and markets. Thus, businesses succeed in expanding their boundaries and effectively participating in a broader ecosystem (Schwertner, 2017, p. 388).

To detail the digital transformation technologies integrated with Logistics 4.0 technologies, they are briefly mentioned below:

The Internet of Things (IoT) provides businesses with the ability to continuously track and manage their products throughout logistics processes. This technology constantly monitors the flow of goods, collecting and analyzing data produced at each stage. Through the data obtained, businesses can optimize the logistics flow and provide real-time information to all stakeholders in the process. As a result, transparency in logistics operations increases, and the efficiency of processes is improved (Demir et al., 2020, p. 16). *Artificial Intelligence (AI)* is a technology that has the ability to imitate human intelligence and learn according to given commands. As intelligent machines develop, AI can analyze data, make predictions, and make decisions based on these analyses. This process involves processing data using statistical models and algorithms to obtain meaningful results. AI, combined with big data and cloud computing infrastructure with high computing power, represents a technology that allows machines to direct critical information. The integration provided achieves more accurate and effective results (Bouanba et al., 2022, p. 445). *Big Data* refers to data that has emerged with the development of information and technological infrastructure, characterized by large volumes, rapid changes, and various types of data. This data is generated by sensors and systems and is processed through operations such as collection, storage, cleaning, visualization, analysis, and interpretation. As a result, data obtained from different sources is analyzed, enabling the use of this information for strategic decision-making (Akdoğan & Akdoğan, 2018, p. 4). *Autonomous vehicles* are a technology integrated with different sensors that enable them to recognize situational changes in their environment. They analyze the surrounding data to make decisions and move independently without human intervention. These vehicles aim to increase safety, improve operational efficiency, and optimize traffic flow through these technologies (Park & Han, 2023, p. 2). *Autonomous robots* can perceive their environment and move without being directly controlled by an operator or restricted to fixed, predetermined paths. These robots, using AI applications, have advanced computing hardware and software. Due to these features, they can make independent decisions in production processes, act on these decisions, communicate with other robots, and exchange data. These capabilities enable more flexible and efficient production processes

(Banger, 2018, p. 46). *Augmented Reality (AR)* is a technology that can be used in many processes, such as logistics and production. AR systems integrate data created in a digital environment with the real world, providing support to employees. For example, the AR-based order-picking method known as pick-by-vision is an innovative application of this technology. This method makes order picking faster and more effective while shortening working time. Thus, AR increases efficiency in logistics processes and optimizes workflows (Demir et al., 2020, p. 16). *Cloud computing* is a vital technology for autonomous control applications in logistics. This technology supports autonomous logistics solutions using intelligent software tools and is based on scalable IT infrastructure provided by cloud service providers. This approach eliminates the need for companies to make significant investments in IT infrastructure, leaving infrastructure management to cloud service providers. Thus, businesses can perform more efficient and cost-effective logistics operations (Demir et al., 2020, p. 16). *Blockchain technology* has a decentralized management structure, supporting real-time and synchronized operations while ensuring the immutability, anonymity (multi-stakeholder structures), and transparency of data. Blockchain is a distributed network accessible to different parties, where transactions such as contract management, shipment tracking, payment processing, and data transfer are conducted. Activities can be monitored at every step, and transparency is maximized through continuous data distribution among parties. This structure enhances security and guarantees the accuracy of transactions (Partala, 2018, p. 2). *Cybersecurity* encompasses measures to protect against unauthorized access and attacks conducted via computers and the internet. Given the high value and volume of data in digital environments, establishing an effective cybersecurity infrastructure is critically necessary. This infrastructure protects data confidentiality, integrity, and accessibility while providing proactive defense against cyber-attacks. For institutions, governments, and individuals, cybersecurity minimizes the impacts of potential threats and creates a secure digital environment by protecting digital assets. Therefore, comprehensive and continuously updated cybersecurity strategies are of great importance (Kökhan, 2021, p. 97).

In conclusion, digital transformation is an inevitable development process for both individuals and businesses. Organizations that fail to adapt to this transformation process are often unable to sustain their existence successfully. The rapidly changing nature of digital technologies compels organizations to keep up with these innovations; otherwise, they risk losing their competitive advantage and being left out of the market. Therefore, for businesses, effectively managing and adapting to the digital transformation process is an important determinant of survival.

1.3. Logistics Capabilities

Logistics capabilities are considered fundamental elements that enable businesses to effectively manage and optimize their logistics processes. A detailed analysis of logistics capabilities provides critical insights into achieving competitive advantage and operational

efficiency. Therefore, research on logistics capabilities holds significant importance in both academic and applied fields.

Numerous studies have been conducted to measure logistics capabilities, resulting in the development of various definitions and different scales. Comprehensive studies and reviews on logistics capabilities have led to the creation of scales that relate these capabilities to competitive advantage and firm performance (Defee & Fugate, 2010, p. 191). As innovative understanding and developments continue to advance, it becomes inevitable for companies to enhance their capabilities and differentiate in logistics service delivery. This requirement is accepted as a goal that must be continuously maintained for companies to remain competitive and adapt to market demands. To succeed in this dynamic environment, companies must continuously innovate and differentiate their services.

In the global trade system, the supply chains of companies are interconnected and span across the globe. Therefore, effective management of the supply chain is a highly valuable area for each company. Logistics companies aim to generate information, share this information with other stakeholders within the organization, and shape their future strategies. Businesses that embrace differentiation to add value to the process and implement it sustainably have greater power.

Businesses that stand out with their logistics capabilities use these skills to build stronger relationships with the end customer and enhance customer loyalty. They also reduce product costs, thereby increasing their profit margins. These advantages help companies gain a competitive edge. Having high logistics capability offers a significant strategic advantage in terms of enhancing customer satisfaction and optimizing costs (Bakan & Şekkeli, 2015, p. 398).

The variability in global competition and economic differences require businesses to make the most extensive use of their existing logistics capabilities in order to remain competitive. (Karagöz & Akgün, 2015, p. 23). Companies can facilitate the enhancement of their logistics capabilities to a higher level by broadening their perspectives and adopting innovation as a benchmark.

Logistics capability consists of two sub-dimensions. After explaining the concept of logistics capability, its sub-dimensions, namely logistics innovation and logistics service differentiation, will be elaborated on.

1.3.1. Logistics Service Differentiation

The impact of globalization, the diversification of economic partnerships and relationships, the spread of trade between countries, and the increased interdependence among nations have made logistics service differences a prominent concept both nationally and globally. Companies can achieve sustainable competitive advantage only by conducting a proper capability analysis and identifying service differentiations that adapt to logistics

processes. This adaptation and differentiation process makes it possible to manage logistics processes effectively. Additionally, comparing the results of logistics activities with competitive factors is also considered within the scope of logistics service differentiation (Langley et al., 1992, p. 2).

Since the logistics sector has a dynamic, developing, and complex structure, businesses are expected to be different from their competitors in the sector and to provide a service that provides added value. In this direction, businesses that want to gain competitive advantage should read their capabilities correctly, be open to discovery, and be based on sustainable innovation. Only if they take these elements into account, they should be aware that they can add value by offering logistics service differences to the customer. In a changing demand environment, the more open to change and the wider the service possibilities, the more it is expected to be ready to offer differences (Kozan, 2019, p. 20).

Services provided at the time, place, and conditions determined based on customer demands and needs show a direct correlation with customer satisfaction. In line with the "seven rights" of logistics, effectively responding to customer demands, managing processes with quality, and ensuring complete and damage-free deliveries lead to variations in how service quality is demonstrated, depending on how the service is presented. E-commerce, the improvement of logistics services, and the offering of personalized solutions increase the perceived value for customers and highlight the quality brought by service differentiation. These differentiated logistics services are considered a key pillar of customer satisfaction and provide businesses with a competitive advantage.

1.3.2. Logistics Innovation

Among the logistics capabilities, the ability to innovate in logistics refers to the skills shaped by innovative ideas, inventions, and thoughts related to logistics activities within the enterprise. These innovations can be implemented in various ways, such as developing a new product, differentiating existing products, or making products and services more beneficial. Such innovations offer a structure open to improvement, not only increasing efficiency but also addressing unresolved issues and better responding to customer needs. The ability to innovate in logistics creates unique and hard-to-imitate capabilities, enhancing the likelihood of achieving sustainable competitive advantage. Therefore, businesses are encouraged to develop this skill area and conduct research within this scope (Kallio et al., 2012; Yang et al., 2009).

The ability to innovate in logistics is the ability of firms to make changes in their logistics services to gain competitive advantage, increase efficiency, and raise profitability. This capability includes the skills to bring innovations in areas such as planning, strategy development, program creation, method determination, selection of transportation modes, cost management, inventory control, and information technologies (Bakan & Şekkeli, 2015, p. 402). Innovation is critically important for the success of many enterprises, including logistics companies, as these processes enable firms to remain competitive and respond effectively to market demands.

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Logistics innovation is a function that promotes performance-enhancing operational processes aimed at the market, benefiting both service providers and consumers while creating value with a sustainable efficiency understanding. This innovation aims to reduce costs while also serving as a differentiating factor for customers in today's highly competitive environment (Demirdöğen et al., 2018, p. 145).

Innovation is considered by businesses as a valuable capability and when combined with logistics activities, it makes it more difficult to deal with similar practices or imitations by competitors (Yang et al., 2009, p. 4-5). Therefore, when logistics innovation is correctly perceived and implemented, it emerges as a unique factor that provides added value and competitive advantage to businesses.

2. METHODOLOGY

2.1.Hypotheses Development and Research Model

The two main hypotheses analyzed in the current study, along with eighteen sub-hypotheses and their justifications, are as follows:

H1: Awareness of Logistics 4.0 has a significant impact on digital transformation.

There are numerous studies in the literature regarding the impact of Logistics 4.0 awareness on digital transformation. Öztemel and Gürsev (2018) emphasize the importance of digital transformation technologies while stating that the structure of the enterprise should be considered when selecting appropriate technologies. In this context, awareness of Logistics 4.0 enables businesses to improve their processes by influencing which digital transformation strategies they adopt. Additionally, researchers such as Witkowski (2017) highlight that data and IoT elements enhance the innovation potential in the logistics sector, demonstrating that Logistics 4.0 awareness is a supporting factor for digital transformation. Şekkeli and Bakan (2018) reveal the potential of Logistics 4.0, underline its critical importance, and discuss the benefits of its proper implementation. Büyüközkan and Güler (2019) define the existing technologies within the scope of Logistics 4.0, list the expectations related to digital transformation technologies, and present a method for analyzing these technologies. Lagorio et al. (2020) conducted a literature review aimed at identifying gaps to understand how technological trends and developments are progressing in the logistics sector. Studies conducted within this scope indicate that businesses' perspectives on Logistics 4.0, their recommendations regarding their current situations, and the digital technologies they initially consider investing in are subjects of ongoing research.

H1a: Logistics 4.0 has a significant impact on digital transformation.

H1b: Business models, products, and services have a significant impact on digital transformation.

H1c: Marketing and customer outreach have a significant impact on digital transformation.

H1d: Process management has a significant impact on digital transformation.

H1e: Information systems infrastructure has a significant impact on digital transformation.

H1f: Evaluation has a significant impact on digital transformation.

H1a, b, c, d, e, f: A literature review on the effects of the sub-hypotheses of Logistics 4.0 awareness on digital transformation reveals the study by Taş and Alagöz (2021), which aimed to determine the Industry 4.0 awareness levels of logistics firms. Their study found that firms, regardless of whether they actively use Logistics 4.0 technologies, possess a certain level of awareness but are not at the desired level in terms of implementation. Based on this, they provided recommendations for improvement. Similarly, in his study, Çiçekli S. (2020) assessed the awareness and implementation levels of Logistics 4.0 at the Ankara Logistics Base, identified deficiencies, and offered suggestions to enhance the level of implementation. Atlı (2022) conducted an exploratory case study in logistics companies to examine the perception of Logistics 4.0, its current stage, awareness levels, and key considerations regarding the topic. His findings indicated that logistics companies have begun to increase their awareness, are engaging in technological transformation efforts, are establishing R&D centers, and have recognized the significance of technological adaptation training.

H2: Awareness of Logistics 4.0 has a significant impact on logistics capabilities.

The effect of Logistics 4.0 awareness on logistics capabilities, in relation to the H2 hypothesis, is supported by studies such as those by Çetinkaya (2021) and Sarıhan (2021). Çetinkaya's findings show that Industry 4.0 awareness increases innovation. Sarıhan (2021) has determined that supply chain performance is most affected by logistics capabilities and buyer-supplier relationships. This indicates that Logistics 4.0 awareness enhances logistics capabilities, thereby strengthening the competitiveness of businesses. In his study, Kozan (2019) focused on the concept of logistics capabilities and concluded that its impact on performance from a logistics perspective is significant. Based on these studies, it has been determined that the relationship between logistics capabilities and various variables, especially technological advancements, has been investigated. However, no study measuring the effect of Logistics 4.0 awareness on logistics capabilities has been found.

H2a: Logistics 4.0 has a significant impact on logistics service differentiation.

H2b: Business model, products, and services have a significant impact on logistics service differentiation.

H2c: Marketing and customer outreach have a significant impact on logistics service differentiation.

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H2d: Process management has a significant impact on logistics service differentiation.

H2e: Information systems infrastructure has a significant impact on logistics service differentiation.

H2f: Evaluation has a significant impact on logistics service differentiation.

H2a,b,c,d,e,f: The subdimensions of Logistics 4.0 awareness have a significant impact on logistics service differentiation. In the research examining the effect of Logistics 4.0 awareness on logistics service differentiation, studies such as Karadeniz and Başaran (2014) emphasize the impact of information systems on service perception. This highlights the role of information systems infrastructure in determining logistics service differentiation. Additionally, Yılmaz (2020) addressed the importance of the business model in the perception of products and services, which aligns with the current findings.

H2g: Logistics 4.0 has a significant impact on logistics innovation.

H2h: Business model, products, and services have a significant impact on logistics innovation.

H2ı: Marketing and customer outreach have a significant impact on logistics innovation.

H2i: Process management has a significant impact on logistics innovation.

H2j: Information systems infrastructure has a significant impact on logistics innovation.

H2k: Evaluation has a significant impact on logistics innovation.

H2g,h,ı,i,j,k: The subdimensions of Logistics 4.0 awareness have a significant impact on logistics innovation. The effect of Logistics 4.0 awareness on logistics innovation is supported by the study of Çetinkaya (2021). This study shows that some subdimensions of innovation are effective, while the current research demonstrates that process management and information systems infrastructure contribute to logistics innovation.

In the current research, a causal research model has been used to investigate the effects between variables based on the hypotheses developed from the literature.

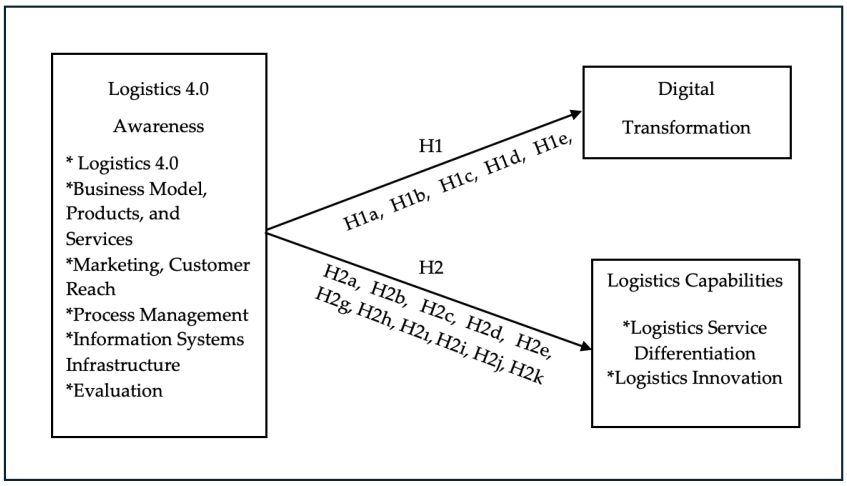

Figure 2: Research Model

The theoretical explanations regarding the impact of Logistics 4.0 awareness on digital transformation and logistics capabilities are provided in the following section. A model has been established to examine the relationship between Logistics 4.0 awareness, which has emerged from Industry 4.0, and its effect on digital transformation and logistics capabilities. The study includes not only theoretical analyses but also the development of a model that will allow for the testing of the proposed hypotheses. In this way, the strategic importance of Logistics 4.0 awareness is emphasized, and the effective role of digital transformation technologies in logistics processes is addressed within a holistic framework of logistics capabilities. The research model designed to carry out these analyses is shown in Figure 2.

2.2.Sampling and Data Collection Method of the Research

Within the scope of the study, a specially prepared survey form was created by conducting a literature review to collect data. The survey form contains pre-determined questions that meet the needs of the research and cover the scales of Logistics 4.0, digital transformation, and logistics capabilities. The prepared questionnaire was directed to participants working in different positions at businesses in the Logistics Services Committee of the Istanbul Chamber of Commerce. To evaluate factors such as the comprehensibility of the questionnaire, the order of the questions, response time, and reliability, a pre-test was first applied to 20 logistics businesses. As a result of the pre-test, minor adjustments were made to the questionnaire, and it was finalized. Based on the population of the conducted study, the large number of logistics businesses operating in Turkey meant that only businesses that are members of the Istanbul Chamber of Commerce Logistics Committee were selected, which defines the scope and limitations of the research. The fact that not all members provided feedback on the survey and the deficiencies in some members' contact information are among the constraints.

The population of the study consists of logistics enterprises that are members of the transportation and logistics services committee of the Istanbul Chamber of Commerce.

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According to the information on the website of the Istanbul Chamber of Commerce, 10,982 enterprises are members of this committee. In accordance with the purpose of the research, sampling was made among these enterprises, and logistics enterprises operating in the international market with high market volume were selected. Purposeful sampling refers to selecting information-rich situations for in-depth research in line with the aim of the study. It is preferred in specific cases that possess certain characteristics and criteria (Büyüköztürk et al., 2016, p. 92). A questionnaire was used as the data collection method. The questionnaires were sent to the selected enterprises via e-mail and they were asked to fill them in online. In the research, the minimum sample size to represent the universe was calculated as 385, but this number was increased to 418. Due to missing data in the questionnaires, 17 forms were considered invalid, and the remaining 401 forms were found to be suitable for analysis. It can be said that this number is sufficient for making generalizations about the population.

Table 1: Sample Size

Population Size	**Sample Size** (95% confidence level)	**Percentage of Population in the Sample**	**Population Size**	**Sample Size** (99% confidence level)	**Percentage of Population in the Sample**
50	44	88,0	200	171	85,5
100	80	80,0	500	352	70,4
500	222	44,4	1.000	543	54,3
1.000	286	28,6	2.000	745	37,2
5.000	370	7,4	5.000	960	19,2
10.000	385	3,9	10.000	1061	10,6
100.000	398	0,4	20.000	1121	5,6
1.000.000	400	0,04	50.000	1160	2,3
10.000.000	400	0,004	100.000	1173	1,2

Source: Prepared using Statistics Canada, 2010, p. 155; Neuman, 2010, p. 351.

As seen in the table, the minimum sample size required to represent the population within a 95% confidence interval has been calculated as 385. The purposive sampling technique was used in the study, and employees working in logistics businesses were selected as survey participants.

As a result of the literature review, it was determined that different scales have been used to measure Logistics 4.0 awareness. In this study, the Industry 4.0 Awareness Survey developed by Veysi İşler (2017) for measuring Industry 4.0 awareness in the manufacturing sector was used as the basis. The dimensions in the scale were adapted to the logistics sector and adjusted to fit the purpose of the research. The questionnaire consists of a total of 33 questions and includes 6 subdimensions: • Logistics 4.0: 5 questions • Business model, products, and services: 4 questions • Marketing and customer outreach: 4 questions • Process management: 6 questions • Information systems infrastructure: 7 questions • Evaluation: 7 questions. The statements in the scale were adapted to the logistics sector context for the

purpose of analyzing Logistics 4.0 awareness. The questions asked to the participants were evaluated using a 5-point Likert scale (1: Strongly Disagree – 5: Strongly Agree).

The Turkish adaptation of the Digital Transformation Scale, created with 12 expressions and a 5-point Likert scale based on various studies (Gudergan & Mugge, 2017; Jafarzadeh et al., 2015; Kane et al., 2016; Lansiti & Lakhani, 2014; Svahn et al., 2017) by Nadeem et al., (2018) and conducted by Sağlam (2021), was used in the study. The questions were prepared with a 5-point Likert scale.

To measure logistics capability, the Logistics Innovation Scale -5 question- (Anderson & West, 1998) and the Logistics Service Differentiation Scale -4 question- (Song & Parry, 1997; Adaptation Lynch et al., 2000) were used. The questions were prepared with a 5-point Likert scale.

3. FINDINGS

3.1.Descriptive Statistics Regarding Participant Businesses

In determining the research sample, demographic information regarding the participants' position in the business, work experience, education level, and gender has been provided. Additionally, information about the business's duration of operation, the digital transformation technologies used in the business, and the areas of activity where these technologies are effective has also been included. The distribution of variables in this regard is shown in the tables.

Table 2: Distribution of Participants According to Demographic Variables

Demographic Variables		Frequency	Percentage (%)
POSITION	Company Owner	45	11,2
	General Manager	68	17,0
	Logistics Employee	184	45,9
	Import/Export	44	11,0
	R&D	14	3,5
	Manager	15	3,7
	Other	31	7,7
Total		**401**	**100,0**
WORK EXPERIENCE	1-5 years	258	64,3
	6-10 years	65	16,2
	11-15 years	39	9,7
	Over 15 years	39	9,7
Total		**401**	**100,0**
EDUCATION	High School	18	4,5
	Associate Degree	54	13,5
	Bachelor's Degree	225	56,1
	Postgraduate	104	25,9
Total		**401**	**100,0**
GENDER	Female	92	22,9
	Male	309	77,1
Total		**401**	**100,0**

In the research, when examining the participants' positions within the company, it was found that a large portion, 45.9%, are logistics employees. The second-highest percentage, 17.0%, is made up of general managers. Following them, 11.2% are business owners, and slightly behind them, 11.0% work in export/import positions. The percentage of participants in managerial positions is 3.7%. It was found that 3.5% of the participants work in R&D roles. Finally, employees working in various positions in logistics companies in the 'other' category make up 7.7% of the total.

When considering the work experience of the participants in logistics businesses, the majority, 64.3%, have been employed for 1-5 years. 16.2% have worked for 6-10 years, while 9.7% have worked for 11-15 years and over 15 years. Based on this, it can be concluded that the majority of employees in logistics companies have worked between 1 and 5 years.

Regarding the education levels of employees in logistics businesses, 4.5% have a high school education, 13.5% have an associate degree, 56.1% have a bachelor's degree, and 25.9% have a graduate degree. This shows that the majority of employees in logistics companies (95.5%) have university-level education. The number of employees with graduate degrees is also significant.

When examining the gender distribution of employees in logistics businesses, 77.1% are male, while 22.9% are female. Based on this distribution, it can be concluded that logistics businesses employ more male employees than female employees.

Table 3: Distribution of Businesses According to Their Duration of Operation

Operational Duration	Frequincy	Percentage
1-5 years	69	17,2
6-10 years	45	11,2
11-15 years	48	12,0
More than 15 years	239	59,6
Total	**401**	**100,0**

When participants were asked how many years their businesses have been operational, it was found that 17.2% of them have been in operation for 1-5 years, 11.2% for 6-10 years, 12.0% for 11-15 years, and 59.6% for more than 15 years. Based on this data, it can be seen that a large proportion of logistics businesses have been operational for more than 15 years. While the majority of employees work for 1-5 years, the businesses themselves have been operational for more than 15 years.

Table 4: Distribution of Businesses According to the Digital Transformation Technologies They Use

Digital Transformation Technologies	Value	Frequency	Percentage
Internet of Things (IoT)	Yes	188	46,9
	No	213	53,1
Big Data	Yes	173	43,1
	No	228	56,9

Cloud Computing	Yes	244	60,8
	No	157	39,2
Blockchain	Yes	83	20,7
	No	318	79,3
Cybersecurity	Yes	219	54,6
	No	182	45,4
Other	Yes	27	6,7
	No	374	93,3

When logistics business employees were asked about the digital transformation technologies used in their companies, 244 people indicated cloud computing, 219 people indicated cybersecurity, 188 people indicated the Internet of Things, 173 people indicated big data, 83 people indicated blockchain, and 27 people selected the 'other' option, referring to traditional methods. Based on this, it can be concluded that cloud computing is the most widely used digital transformation technology in businesses. Some employees selected multiple options, indicating that they use more than one technology.

Table 5: Distribution of Business Activities Affected by the Technologies Used

Affected Activity Area	Value	Frequency	Percentage
Storage	Yes	265	66,1
	No	136	33,9
Stock Management	Yes	236	58,9
	No	165	41,1
Transportation	Yes	303	75,6
	No	98	24,4
Packaging	Yes	143	35,7
	No	258	64,3
Customer Service	Yes	242	60,3
	No	159	39,7
Other	Yes	13	3,2
	No	388	96,8

When participants were asked in which logistics activity areas the technologies used in their businesses were effective, it was emphasized that they were most effective in transportation, with 303 people responding in this regard. Following that, 265 people indicated storage, 242 people indicated customer services, 236 people indicated inventory management, 143 people indicated packaging, and 13 people stated that technologies were effective in other areas. Based on the distribution of the responses, it can be inferred that the technologies used are effective in multiple activity areas.

Data Analysis In testing the developed hypotheses, regression analysis was performed using the SPSS program (Muñoz et al., 2017, p. 79). According to Hair et al. (2014), regression analysis is used to determine the degree to which independent variables explain the dependent variable. In this context, analyses were conducted for the hypotheses identified in the research (p. 204).

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To analyze the data used in the research, the SPSS 23.0 program was utilized. Factor analysis and Cronbach's alpha analysis were performed for the reliability and validity of the scales of logistics 4.0 awareness, digital transformation, and logistics capabilities.

3.2.Reliability Analysis

To conduct the research, a survey form was prepared using three different scales and applied to employees in the logistics sector.

Table 6. Reliability Analysis of Scales

Scales	Cronbach's Alpha	Number of Items (N)
Logistics 4.0 Awareness Scale	**,954**	**33**
Digital Transformation Scale	**,971**	**12**
Logistics Capabilities Scale	**,957**	**9**

The scales used in the study are measurement tools that have been previously tested and validated for validity and reliability in the literature (İşler, 2017; Sağlam, 2021; Anderson & West, 1998; Song & Parry, 1997; Adaptation: Lynch et al., 2000). In the study, Exploratory Factor Analysis (EFA) was applied to assess the factor structure of the scales, and the results were consistent with previous studies in the relevant literature. However, since the factor structure and subdimensions of the scales were thoroughly validated in previous research, an additional Confirmatory Factor Analysis (CFA) was not performed.

Additionally, Cronbach's Alpha coefficients were calculated to determine the internal consistency of the measurement instrument. According to the reliability analysis results presented in Table 6, the Cronbach's Alpha values were calculated as 0.954 for the logistics 4.0 awareness scale, 0.971 for the digital transformation scale, and 0.957 for the logistics capabilities scale. A Cronbach's Alpha coefficient of 0.70 and above indicates that the scale is reliable (Durmuş et al., 2022, p. 89). In this regard, it was determined that all the scales used in the study were highly reliable.

3.3.Normality Analysis

An analysis was conducted to assess whether the logistics 4.0, digital transformation, and logistics capabilities scales used in the research show a normal distribution.

Table 7: Normality Analyses of Scales

Scales	Skewness	Kurtosis
Logistics 4.0 Awareness Scale	-0,186	-0,453
Digital Transformation Scale	-0,582	-0,188
Logistics Capabilities Scale	-0,476	-0,157

When the skewness and kurtosis values of the variables in the study were analyzed, it was concluded that the data were normally distributed for three scales (Tabachnick and Fidell, 2013).

3.4.Analysis of Research Hypotheses

H1: Logistics 4.0 awareness has a significant effect on digital transformation."

Table 8: Regression Analysis Results for H1 Hypothesis

Model 1	R^2	Adjusted R^2	F	Std. Error	Beta	T	P
Logistics 4.0 Awareness	,467	,466	349,659	,709	,683	18,699	0,000

Dependent Variable: Digital Transformation, (*p<0.05)

The regression analysis model conducted to measure the impact of logistics 4.0 awareness on digital transformation is found to be significant. Logistics 4.0 awareness has a significant (p<0.05) and positive effect (R^2: 46%) on digital transformation. The H1 hypothesis is accepted. The explanatory power of the created model is 0.466, indicating that 46% of the digital transformation variable can be explained by the logistics 4.0 variable, and this effect is found to be at a moderate level.

In the continuation of the study, the effect of logistics 4.0, business model products and services marketing customer access, process management, information systems infrastructure, evaluation variables, which are the sub-dimensions of logistics 4.0 awareness, which is the independent variable in the sub-hypotheses of hypothesis H1, on the digital transformation dependent variable was evaluated separately. Multiple linear regression analysis was used to evaluate this effect (Kayaalp, et al., 2015, p. 1).

During the testing of sub-hypotheses, the ANOVA table was evaluated in the first stage. As a result of the evaluation, the model was found to be significant (p:0.000), and multiple regression analysis was conducted.

Table 9: Multiple Regression Analysis Results for H1a, b, c, d, e, f Hypotheses

Model 1	R^2	Adjusted R^2	F	Std. Error	Beta	T	P	VIF	Tolerance
Logistics 4.0				,052	,172	3,207	,001	2,137	,468
Business Model, Products and Services				,072	,152	2,659	,008	2,425	,412
Marketing and Customer Reach				,065	,034	,591	,555	2,487	,402
	,471	,463	58,459						

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Process Management	,075	,172	2,419	,016	3,769	,265
Information Systems Infrastructure	,082	,183	2,606	,010	3,663	,273
Evaluation	,063	,104	2,241	,026	1,612	,621

Dependent Variable: Digital Transformation, (*p<0.05)
Durbin-Watson: 1.940

In an undesirable situation where there is a deviation from the assumption in the regression analysis performed, there is a linear relationship between two or more independent variables in the multicollinearity problem. In this case, the regression model may give contradictory results in some cases. A method used to detect multicollinearity is the variance inflation factor (VIF). VIF measures the degree of correlation among independent variables. If the VIF value of an independent variable is 10 or greater, it is considered that there is a multicollinearity problem. In such cases, independent variables are linear, and the reliability of the regression model is questioned (Salkin and Rasmussen, 2007).

Since VIF and tolerance values indicate whether there is a multicollinearity problem, they also show the suitability of the model for testing the hypotheses. In the model, it is seen that the VIF values of the hypotheses are less than 10 and the tolerance values are greater than 0.2. Therefore, it has been found that there is no multicollinearity problem.

Another important point to consider in regression analysis is the assumption that there should be no relationship among the error terms. If this relationship exists, autocorrelation arises. The reasons for autocorrelation include incorrect model selection, accepting non-linear relationships as linear, excluding important independent variables from the model, and strong relationships among independent variables. As seen in the model, the Durbin-Watson test was conducted to detect the presence of autocorrelation. According to the test, if the DW value is between 1.5-2.5, it is concluded that there is no autocorrelation. According to the analysis, this value (1.940) is close to 2, indicating no autocorrelation (İmir, 1986). In this context, the hypotheses in the model are considered suitable for testing.

In Table 4, the effect of the logistics 4.0 variable on the digital transformation variable, which is the H1a hypothesis, was analyzed. According to the analysis results, it was found to be statistically significant (p<0.05, Beta: 0.172). In the H1b hypothesis, when the impact of the business model, products, and services variable on the digital transformation variable was analyzed, it was found to be statistically significant (p<0.05, Beta: 0.152). In the H1c hypothesis, the effect of marketing and customer reach on digital transformation (p: 0.555) was analyzed, and the findings indicate that it is not statistically significant (p>0.05). In the H1d hypothesis,

it is stated that process management (p<0.05, Beta: 0.172) has an impact on digital transformation. In the H1e hypothesis, the impact of the information systems infrastructure variable on the digital transformation variable was suggested, and according to the analysis results (p<0.05, Beta: 0.183), its effect was accepted. In the H1f hypothesis, it was found that evaluation (p<0.05, Beta: 0.104) has an impact on digital transformation.

As a result of the regression analysis, it was determined that the sub-dimensions of the logistics 4.0 awareness variable, namely logistics 4.0, business model products and services, process management, information systems infrastructure, and evaluation, statistically significantly affect digital transformation, and the H1a, H1b, H1d, H1e, H1f hypotheses were accepted. Based on the analyses, it was concluded that the marketing and customer reach variable does not statistically significantly affect digital transformation, and the H1c hypothesis was rejected.

The explanatory power of the accepted hypotheses of the created model is 0.46, indicating that 46% of the digital transformation variable can be explained by the logistics 4.0, business model products and services, process management, information systems infrastructure, and evaluation variables. This level of effect is moderate.

"**H2:** Logistics 4.0 awareness has a significant impact on logistics capabilities."

Table 10: Regression Analysis Results for H2 Hypothesis

Model 1	R^2	Adjusted R^2	F	Std. Error	Beta	T	P
Logistics 4.0 Awareness	,375	,373	238,990	,760	,612	15,459	0,000

Dependent Variable: Logistic Capabilities (*p<0.05)

Logistics 4.0 awareness was found to have a significant (p<0.05) and positive effect (R^2: 37%) on logistics capabilities. The H2 hypothesis was accepted. The explanatory power of the created model is 0.373, indicating that 37% of the logistics capabilities variable can be explained by the logistics 4.0 variable. This effect was found to be at a low level.

In the continuation of the study, the sub-hypotheses of H2 were evaluated separately for the impact of the sub-dimensions of the independent variable logistics 4.0 awareness, including logistics 4.0, business model products and services, marketing and customer reach, process management, information systems infrastructure, and evaluation, on the sub-dimensions of the dependent variable logistic capabilities, which are logistic innovation and logistic service differentiation. Multiple linear regression analysis was used to evaluate this effect. As part of the research, analyses were conducted for two sub-hypotheses related to the sub-dimensions of logistics capabilities and six sub-hypotheses related to the sub-dimensions of logistics 4.0 awareness.

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Table 11: Multiple Regression Analysis Results for H2a,b,c,d,e,f Hypotheses

Model 1	R^2	Adjusted R^2	F	Std. Error	Beta	T	P	VIF	Tolerance
Logistics 4.0				,060	,179	3,074	,002	2,134	,468
Business Model, Products and Services				,084	,154	2,484	,013	2,425	,412
Marketing, Customer Reach				,075	,048	,757	,449	2,487	,402
	,375	,365	39,368						
Process Management				,087	,060	,772	,440	3,769	,265
Information Systems Infrastructure				,095	,189	2,475	,014	3,663	,273
Evaluation				,073	,105	2,074	,039	1,612	,621

Dependent Variable: Logistic Service Differentiation (*p<0.05)
Durbin-Watson: 1.848

To understand if there is a multicollinearity problem among the variables used in the model, the VIF and tolerance values were examined. The VIF values of the H2a, H2b, H2c, H2d, H2e, and H2f hypotheses were found to be less than 10, and the tolerance values were greater than 0.2, indicating no multicollinearity problem.

The Durbin-Watson test result (1.848) suggests that there is no autocorrelation between the error terms. Therefore, the hypotheses in the model were deemed suitable for testing.

The regression analysis results indicate that the H2a hypothesis, suggesting the impact of the logistics 4.0 variable on the logistic service differentiation variable, is significant (p: 0.002, Beta: 0.179) and was accepted. Similarly, the H2b, H2e, and H2f hypotheses, suggest that business model products and services (p: 0.013, Beta: 0.154), information systems infrastructure (p: 0.014, Beta: 0.189), and evaluation (p: 0.039, Beta: 0.105) have a significant impact on logistic service differentiation, were accepted. However, the H2c and H2d hypotheses, suggesting that marketing and customer reach (p: 0.449, Beta: 0.048) and process management (p: 0.440, Beta: 0.060) impact logistic service differentiation, were rejected.

The regression analysis concluded that the sub-dimensions of logistics 4.0 awareness, including logistics 4.0, business model products and services, information systems infrastructure, and evaluation, significantly affect logistic service differentiation, accepting the

H2a, H2b, H2e, and H2f hypotheses. Meanwhile, the marketing and customer reach and process management dimensions were found to have no significant effect on logistic service differentiation, leading to the rejection of the H2c and H2d hypotheses.

The explanatory power of the accepted hypotheses in the model is 0.365, indicating that 36% of the logistic service differentiation variable can be explained by the variables logistics 4.0, business model products and services, information systems infrastructure, and evaluation. This effect level is considered low.

The next part of the research involves analyzing the impact of the sub-dimensions of logistics 4.0 awareness on another sub-dimension of logistic capabilities, logistic innovation, with six sub-hypotheses.

Table 12: Multiple Regression Analysis Results for H2g,h,ı, i, j, k Hypotheses

Model 1	R^2	Adjusted R^2	F	Std. Error	Beta	T	P	VIF	Tolerance
Logistics 4.0				,060	,097	1,593	,112	2,137	,468
Business Model, Products and Services				,084	,081	1,244	,214	2,425	,412
Marketing, Customer Reach				,076	,151	2,296	,022	2,487	,402
	,313	,303	29,943						
Process Management				,088	,190	2,339	,020	3,769	,265
Information Systems Infrastructure				,096	,075	,944	,346	3,663	,273
Evaluation				,074	,070	1,311	,191	1,612	,621

Dependent Variable: Logistic Innovation (*p<0.05)
Durbin-Watson: 1.702

To understand if there is a multicollinearity problem among the variables used in the model, the VIF and tolerance values were examined. The VIF values of the H2g, H2h, H2ı, H2i, H2j, and H2k hypotheses were found to be less than 10, and the tolerance values were greater than 0.2, indicating no multicollinearity problem (Field, 2013). After confirming that the dataset meets the necessary assumptions for analysis, the measurement model was tested.

The Durbin-Watson test result (1.702) suggests that there is no autocorrelation between the error terms. Therefore, the hypotheses in the model were deemed suitable for testing.

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The regression analysis results indicate that the logistics 4.0 sub-dimension ($p>0.05$, Beta: 0.097) and the business model, products, and services sub-dimension ($p>0.05$, Beta: 0.081) do not significantly affect logistic innovation. However, the marketing and customer reach sub-dimension ($p<0.05$, Beta: 0.151) and the process management sub-dimension ($p<0.05$, Beta: 0.190) significantly affect logistic innovation. Additionally, the information systems infrastructure ($p>0.05$, Beta: 0.075) and evaluation ($p>0.05$, Beta: 0.070) do not significantly affect logistic innovation. As a result, the H2g, H2h, H2j, and H2k hypotheses were rejected, while the H2ı and H2i hypotheses were accepted.

The explanatory power of the accepted hypotheses in the model is 0.303, indicating that 30% of the logistic innovation variable can be explained by the marketing customer reach, and process management variables. This effect level is considered low.

CONCLUSION

For businesses aiming to increase growth and market share in the logistics sector, integrating technology into business processes is an inevitable necessity. To achieve this integration, businesses must be innovative and open to change while carrying out their logistics activities. It is observed that businesses that are open to change can implement technological transformation more easily, achieving strategic efficiency by developing coordinated progress with their stakeholders. In this regard, it is important for businesses that adopt technology and take a digital-focused approach to analyze their position on digital transformation technologies. Businesses need to assess their current status and create a roadmap within this framework. In this context, evaluating logistics 4.0 awareness, analyzing their current position, and developing strategies for the future are of critical importance.

In this study, research was conducted to examine the relationships between logistics 4.0 awareness, digital transformation, and logistics capabilities. Following a brief introduction, a comprehensive literature review was conducted on the concepts of logistics 4.0, digital transformation, logistics capabilities, logistics service differentiation, and logistics innovation. The research method, limitations, sample, model, hypotheses, analyses, and findings were detailed. In the findings section, descriptive statistics of the participant businesses were presented, and data was analyzed based on demographic variables. The results show that a large portion of the participants are logistics sector workers, with the majority having work experience of 1-5 years. In terms of education level, it was found that bachelor's degree graduates form the highest proportion. When examining the business operational durations, it was determined that businesses that have been in operation for more than 15 years are dominant.

When evaluating the data on the use of digital transformation technologies, it was determined that businesses integrate multiple technologies, with cloud computing being the

most commonly used technology. The reliability of the scales used in the research was analyzed, and it was found that the logistics 4.0 awareness, digital transformation, and logistics capabilities scales were highly reliable. The factor analysis results revealed that the scales' factor structures were appropriate and that the distributions were consistent with the original scale items. The logistics 4.0 awareness scale consists of six factors, parallel to the industry 4.0 awareness scale, while the digital transformation scale has a single-factor structure. The logistics capabilities scale was considered in two sub-dimensions: logistics service differentiation and logistics innovation.

When testing the hypotheses of the research, simple linear regression and multiple linear regression analyses were performed to examine the relationships between variables, using the SPSS 23.0 program. A literature review was conducted based on the two main hypotheses and eighteen sub-hypotheses established in the study. It was determined that the hypothesis suggesting logistics 4.0 awareness affects digital transformation was supported and accepted. However, it was found that the impact of the marketing and customer outreach dimension on digital transformation was not significant. This situation may indicate that marketing strategies are not effectively implemented in businesses, or that digital transformation processes are unable to fully integrate these dimensions.

The hypothesis that logistics 4.0 awareness affects logistics capabilities has been supported and accepted. When examining the effects of the sub-dimensions of logistics 4.0 awareness on logistics capabilities, it was found that marketing and customer outreach, as well as process management, do not have a significant effect on logistics service differentiation; however, they do have an impact on logistics innovation. It was also found that the variables of logistics 4.0, business model products and services, information systems infrastructure, and evaluation affect logistics service differentiation, but do not have a significant effect on logistics innovation. These findings indicate that the variables affecting logistics service differentiation do not directly affect logistics innovation, and likewise, the variables affecting logistics innovation are not determinative for logistics service differentiation.

In conclusion, the relationships between logistics 4.0 awareness, digital transformation, and logistics capabilities have been identified consistently with the literature. The findings of the study highlight the importance of strategic planning for the digital transformation process in logistics businesses and show that they need to take necessary steps to gain a competitive advantage. It has been observed that the adaptation of logistics 4.0 facilitates businesses' processes in terms of efficiency, effectiveness, and productivity, while also enabling them to develop customer-focused logistics capabilities with a cost-effective structure.

The main limitation of the study is that it was conducted solely on logistics businesses that are members of the Istanbul Chamber of Commerce. Future studies could increase the generalizability of the results by using broader samples from different geographical regions

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and industries. Furthermore, qualitative research could be conducted to explore the effects of marketing and customer outreach on digital transformation and logistics capabilities in greater depth. In this context, case studies or cross-sector comparisons could provide valuable contributions to the literature. Considering the dynamic nature of the digital transformation process, long-term studies could be conducted to understand how these effects change over time. This study, while contributing to the evaluation of the current position of businesses in the logistics sector regarding technological developments, may also serve as a fundamental source for future research.

Suggestions that can be made as a result of the study:

- Businesses should organize training programs to keep employees' knowledge up to date and seek support from expert consultants.
- To manage digital transformation processes effectively, businesses should develop short-, medium-, and long-term strategies and plan resource investments by managing employee skills properly during this process.
- Before making high-cost technological investments, a cost-benefit analysis should be conducted, and technologies that are most suitable for the business's core activities should be chosen.
- Businesses should conduct feasibility studies to measure the financial impacts of technology investments and carry out market research based on customer demands.
- Businesses should increase their operational flexibility by using digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), automation, cloud computing, and blockchain, and quickly adapt to changing market conditions.
- Businesses should take advantage of big data management by analyzing customer behaviors and market trends and develop marketing and sales strategies through social media and digital platforms.
- Bureaucratic processes should be reduced, paper-based processes should be transferred to online platforms, and traceable, transparent, customer-oriented systems should be created.
- Logistics businesses should develop joint projects with software companies to ensure that all stakeholders involved in the supply chain process can manage financial and operational processes more efficiently.
- Logistics 4.0 and digital transformation models applied in developed countries should be examined, and similar strategies should be adapted for local businesses.

- Before making technology investments, elements such as software, hardware, human resources, and project leadership should be clarified, and budgeting errors should be avoided. The business's overall mission and vision should be aligned with digital transformation goals to ensure coordination among departments.
- Digital transformation processes should be embraced by all employees, and the benefits that the transformation will bring to the business should be explained with concrete examples.
- Businesses should train their current staff to support digital transformation processes and hire external specialist personnel if necessary.
- Businesses should set key performance indicators (KPIs) to measure employee performance and use methods like Balance Score Card and PDCA (Plan-Do-Check-Act) cycles for process improvement.

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İSTANBUL TİCARET ÜNİVERSİTESİ

T.C.
İSTANBUL TİCARET ÜNİVERSİTESİ REKTÖRLÜĞÜ

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İlgi yazınız ile "İşletmelerin Lojistik 4.0 Farkındalıklarının Dijital Dönüşüm ve Lojistik Yeteneklere Etkisinde Yenilik Odaklılığın Rolü" isimli çalışmanın anket sorularına Etik Kurul onayı talep edilmektedir.

Adı geçen ve ekte yer alan anket soruları, Üniversitemiz Etik Kurulunca incelenerek etik tanım, değer ve ilkelere aykırı bir düzenleme tespit edilmediği, önerilen anket sorularının etik kurallara uygun olduğu ve etik onayının verildiği ifade edilmiştir.

Konuya ilişkin bilgilerinizi rica ederim.

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