CHAPTER 15

Digital Transformation in Logistics: Lights-Out Logistics

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1. INTRODUCTION

From the past to the present, people's activities and behaviors have changed with social, economic, environmental, and technological developments. Changes in the environment, economy, and technology have also affected production and distribution activities and pushed them to innovation. As a result of innovation efforts in production and distribution, autonomous communication technologies and tools have started to be used

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(Maslarić et al., 2016). With digital technologies, radical changes have occurred in processes, operations, and all business models. These changes have been effective in many areas. One of the sectors experiencing digital change is the logistics sector (Wei et al., 2019).

Developments in many different areas, including production, supply, and logistics, have contributed to the progress of robotic science, along with the idea of digitalization. Even though the concept of intelligence is accepted as one of the most important differences between humans and machines, today, thanks to the developments in robotic science, the difference between humans and machines is gradually closing. In addition to many disciplines such as psychology, engineering, and computer science, many technological factors such as artificial intelligence, machine learning, and big data have contributed to robotics science (Hacioğlu, 2020). The development of robotics has also affected the logistics industry because the need for industrial robots is very high. In logistics activities, robots should allow the differentiation of products, distinguish various parts from an infinite number of possible combinations, act by perceiving the environment, and interact with the environment (Mikušová et al., 2017). Smart logistics is a topic of discussion due to the increasing prevalence of robots in the logistics industry. Logistics operations can be made more efficient with the help of the Internet of Things, information and communication technologies, and artificial intelligence, among other applications. Increased study in logistics and the emergence of new "smart" logistics applications are both results of these advancements (Feng and Ye, 2021).

Recent technological advancements have resulted in extensive changes within the logistics industry, and in response, the term Logistics 4.0 has emerged. The Logistics 4.0 paradigm in Industry 4.0 shares many characteristics with its constituent parts. This idea is a byproduct of the evolution of logistics into intelligent logistics, which entails a shift from a focus on hardware to one

on software. Autonomous systems and their subsystems are what constitute smart logistics and are required for its realization. Faster information dissemination and stakeholder coordination are two benefits of autonomous systems. Therefore, systems can pick the best optimization automatically in a crisis.

For this reason, Logistics 4.0., smart logistics, and the concept of Lights-Out logistics, a related concept, is a revolution for technology-oriented logistics applications (Timm and Lorig, 2015). Lights-Out logistics is a new concept brought to the literature with the technologies in question. This concept is essentially derived from the "Lights-Out factory" approach. The Lights-Out factory is a production facility where production activities are carried out utterly unmanned without the need for workforce, light, and windows, thanks to robotic technologies, artificial intelligence, and internet technologies (Erdoğan, 2019). Therefore, Lights-Out logistics can be expressed as the carrying out of logistics tasks without the presence of a human being.

Today, the logistics industry has started to automate its activities by using various business robots while doing its activities manually with digitalization. The logistics sector has started to carry out logistics activities with minimum or zero human intervention with technology. These developments have revealed the concept of Lights-Out logistics. However, when the literature is examined, there are very few studies on this concept. Therefore, this research has attempted to clarify the meaning of "Lights-Out logistics" by examining its connections to "Logistics 4.0" and "autonomous logistics."

2. DIGITALIZATION IN THE LOGISTICS SECTOR

Logistics has been an important issue since the earliest times of history. Today, logistics is a process carried out to meet the high level of customer service by responding to competitive price, quality, and market demands more quickly. In this process,

businesses should be able to provide a competitive advantage against their competitors (Slats et al., 1995).

Logistics aims to satisfy customer demands and wishes by controlling the flow of services and goods from the point of origin to the final destination. Handling, production, packaging, transportation, inventory management, and storage are all part of logistics. Delivering the right product or service at the right price, to the right store, in the correct quantity, and to the right customer at the right time is crucial to the success of the logistics industry (Soysal and Bloemhof-Ruwaard, 2017). There is a direct correlation between logistics and business success in the supply chain (Qaiser et al., 2017). Digitalization is crucial for the logistics industry to succeed.

The rapid growth of technology from antiquity to the present day is mainly responsible for the emergence of the digital age. The creation of long-lasting value is sped up by technological advances enabled by digitalization. The advent of digital technologies has resulted in profound shifts in every facet of the business. Overall, the effects of these adjustments have been positive. The logistics industry is undergoing digital transformation (Wei et al., 2019). The dramatic changes in society and industry brought on by the advent and proliferation of digital technologies have resulted in the concept of digital transformation becoming used and discussed in the academic community. In the wake of the Fourth Industrial Revolution, a digital transformation has begun in the logistics and supply chain, with sensors, networks, and complete automation across all industries (Kern, 2021). For businesses to ensure continuity, logistics activities must act in an integrated manner with digitalization. Companies have prioritized and heavily invested in digitalization across the board, including the logistics sector, to take advantage of the many benefits it brings to business generally. Optimizing production and transportation services through digitalization has also elevated the prominence of production and distribution technologies (Bardakç, 2020).

Changes in the logistics sector are divided into various periods, and there are four stages in the historical process, just like in the industry. These stages range from logistics 1.0 to logistics 4.0. With this change, the logistics sector's technological, social, demographic structure, and market conditions have also changed (Radivojević and Milosavljević, 2019).

3. LOGISTICS 4.0

Regarding production technologies, there are four fundamental revolutions in human history. In these revolutions, the steam locomotive was used in freight and passenger transportation, converting steam power to kinetic energy. Steam power is not limited to this but is also used in production processes (Kaya and Özcan, 2020). The second revolution is the discovery and use of electricity. This discovery has gained a quality that changes not only the production processes but also the whole way of life of human beings. The products produced with mass production have been delivered to people in a cheaper, faster, and more efficient way. In the 1970s, import-substituting production policies encouraged value-added production, and scientific innovations and automation technologies were developed (Gunay, 2002). Today, "Industry 4.0", which can communicate with each other through networks and focuses on production based on continuous learning with artificial intelligence technologies, has entered our lives. The term "Industry 4.0", accepted as the beginning of the transformation phase of smart factories from idea to reality, was first announced by the German Federal Government in 2011 as one of the main initiatives of high technology strategy (Hermann et al., 2015).

Logistics has also experienced a constant change from past to present. The logistics sector has developed and renewed this change by following all the changes made in the social, industrial, and technological fields and keeping up with the innovations. Logistics 4.0 has developed in line with technological developments as a

result of developments in the 21st century and continues to develop (Radivojević and Milosavljević, 2019).

There have been four significant changes in logistics since the 1980s. The introduction of water and steam-powered machines in the late 19th and early 20th centuries marked the beginning of the first wave of technological advancements in logistics, often referred to as "Logistics 1.0." Transportation of large quantities of containers and cargo over great distances has historically relied on steam-powered ships and trains rather than on human or animal labor. The heavily used highway has been replaced by the railway and seaway, and the carrying capacity has been significantly increased. The second innovation, Logistics 2.0, emerged in the 1960s as the automation of the transport system, thanks to electric power and mass production. Machines powered by electric motors can now perform the bulk of logistical work thanks to the widespread adoption of technologies like automated storage and retrieval systems and loading and unloading mechanisms. The port's use of container ships has increased, and the reliance on manually operated machinery in warehouses has given way to the employment of electrical workers. The third innovation, Logistics 3.0, came to the fore in the 1980s with the development of computer and information technologies and was called the systematization of logistics management. Logistics information technology systems, such as Warehouse Management and Transport Management, have greatly improved the automation and efficiency of logistics management, inventory, and shipments. Logistics 4.0, the fourth industrial revolution, is still evolving and expanding today, particularly in areas related to the Internet of Things and the digitalization of logistics procedures (Wang, 2016). Logistics 4.0 is seen as one of the spillover effects of Industry 4.0 (Oleśków-Szłapka et al., 2019). The first emergence of the concept of Logistics 4.0 was in 2011. This concept is a concept that emerged to support industry 4.0. Today, concepts such as supply chain, marketing, distribution, inventory, and

order management are also in their fourth stage—logistics 4.0. The concept develops concerning the industrial revolution and technological developments (Radivojević & Milosavljević, 2019). Logistics 4.0 is an idea that seeks to eliminate the need for human labor in the logistics sector altogether (Poli et al., 2018). The concept of Logistics 4.0 is a concept that develops technologies and applications for the improvement of logistics stages. Logistics 4.0 integrates previously separate logistics processes, such as storage and shipping, to address issues with a more streamlined flow of both physical and digital data (Pawlak et al., 2020). Logistics 4.0 can boast of other vital functions: data mining, auxiliary decision-making systems, networking and integration, decentralization and cohesion, self-organization, and autonomy (Prinz et al., 2016).

According to Hofman and Rüsch (2017), two dimensions explain how logistics is affected by Industry 4.0. The first is the physical aspect of the supply chain, which may involve autonomous logistics subsystems like autonomous picking robots or order processing via smart contracts in blockchain technology. The second dimension is the digital supply chain, which includes the Internet of Things (IoT) and other technologies. The second model is called the digital data value chain, which incorporates information gathered with the help of object-assisted technologies.

Logistics 4.0 (Oleśków-Szłapka and Stachowiak, 2018; Tang and Veelenturf, 2019):

- Harmonizes the real and virtual worlds
- Improves supply chain processes
- Reduces the design cost of the products
- Enables the products and services produced to meet consumer needs to reach the consumer more quickly.
- Reduces the risk of errors in the operation of processes
- Provides advanced technology for unlimited data analysis

- Allows all system users to make decisions autonomously
- Makes the supply chain visible and flexible
- Delivery services run by drones or delivery robots speed up delivery
- Provides high reliability in warehouse processes with the use of robot warehousing
- Provides efficiency increase in container loading and transportation with blockchain technology
- Saves labor as autonomous machines and robots do the work.

4. AUTONOMOUS LOGISTICS

Today, where automation and technologies are so important, businesses need to be able to use automation and technologies well in order to exist in a competitive environment both inside and outside. Automation and technological innovations contribute to the automation of enterprises by directing them to innovations in how companies do business (Hacioğlu, 2020). Companies gain the ability to remotely control machines by eliminating complexity with automation. Therefore, with proper planning, the machines can be operated for a long time without supervision. This way, the company can continue its activities by minimizing or completely zeroing its workforce (Noël et al., 2007).

Autonomous logistics includes activities related to the automation, placement, and inventory of all physical assets (Fink et al., 2017). In autonomous logistics, algorithms that define the decision-making behavior of each object and autonomous control methods are essential factors that ensure success in the independent implementation of control in logistics systems (Windt et al., 2010).

According to Roser (2016), the use of robots in production processes was rarely encountered in the middle of industrial

evolution. During this period, the use of robots was more concentrated in dangerous or labor-intensive jobs. However, in the 1980s, the American automotive industry, which entered into a transformation with the pressures of the political environment, implemented a strategy based on completely robotizing its production processes against the Japanese production philosophy based on lean production. This transformation process, led by the American automotive manufacturer General Motors, was owned by the company's top manager, Roger Smith. Smith thus aimed to minimize the human factor and gain a competitive advantage over the superior productivity of its Japanese competitors. The definition of a lights-out factory was first encountered in this period. However, despite the investment of 45 billion dollars, the desired efficiency could not be achieved, and even General Motor was ridiculed at that time by saying that robots painted themselves instead of cars and closed doors designed to be opened with welding (Business Strategy Review, 2003; Null & Caulfield, 2003). As can be understood from the example, technological maturity in production systems must be sufficiently advanced for a disruptive innovation such as the lights-out factory. At the point we have reached today, with the developing technologies in production systems, many sectors have been highly automated, even if they are not entirely lights-out factories, and the share of labor in production factors has gradually decreased. Robots are widely used to boost business output and progress. Today, robots are one of the most critical applications used in the industry. By producing a wide variety of robots, many jobs done by humans have begun to be done by robots. As technology has advanced, robots have found widespread application in fields as diverse as agriculture, the automotive industry, supply chain management, and logistics. Economic productivity has increased with the use of robots and automation. These positive developments have also increased the competitiveness of enterprises. The increase in robotic applications is an essential economic indicator in the development and progress of the country (Tyurina et al., 2019).

The use of robots in modern logistics applications is a crucial factor in determining the success or failure of businesses today (Wang and Du, 2016). Today, robots are essential in closing workforce gaps and increasing efficiency, productivity, and product quality. The development of the logistics industry requires a lot of robot technology. The vast majority of the logistics industry uses artificial distribution routes. As the logistics industry has grown, so have labor costs and the prevalence of mistakes made during the distribution phase. In addition, as the economy has evolved, logistics jobs have become increasingly crucial. The logistics industry, realizing the need to invest in technology to sustain its growth, has begun to do so, primarily by deploying computers and robotics (Wang and Du, 2016).

Robotic transport systems have become an application being used more and more in logistics activities. Robotic handling systems have some benefits. These benefits are (Azadeh et al., 2019; Østergaard , 2018):

- Since they have a flexible structure in meeting changing demands, they are more advantageous than other applications.
- They have the opportunity to work 24/7.
- They are very convenient and valuable for e-commerce transactions.
- They facilitate the integration of subsystems and bring them to a more advantageous position.
- Develop new solutions to operational challenges.
- Robots meet demands for higher quality products at lower costs. It also improves the product's quality and the production line's flow rate.
- Robots reduce costs and help to reconsider activities such as production and logistics.

- They save employees from repetitive tasks and tedious and dangerous tasks.

Robots analyze shipments of different sizes and help optimize operations such as loading and unloading. Today, with the creation and development of new generation technologies, faster computer technologies and more extensive and accurate data analysis have enabled acceleration and development in logistics. The increased use and number of new technologies in many sectors have improved robots' use and application capabilities (Mikušová et al., 2017).

Until recently, robots were machines without much mobility and intelligence. These robots only could simply repeat the task. This feature of robots was seen as sufficient for businesses in production processes, but these features of robots are not sufficient for logistics activities (Landi et al., 2018). The use of robots in logistics activities has become a vital necessity. The automation that emerged with the use of robots has allowed businesses to become more flexible, reduce costs and facilitate many logistics activities. Although most logistics activities are done manually, this situation has become the opposite with increasing technology and automation today (Mikušová et al., 2017).

5. LIGHTS-OUT LOGISTICS

Lights-out logistics is a new concept in the literature. Therefore, an adequate flow of information about the components of lights-out logistics is not yet available in academic applications. Despite this, a future perspective has emerged on some issues, such as autonomous delivery (Figliozzi and Jennings, 2020) and warehouse management, which are some logistics components. The autonomous warehouse market will be predicted to double by 2025 (Material Handling Systems, 2020).

Today, some important new concepts and technological innovations are partially used in the Planning, Transport,

Processing, Storage, and Distribution processes (Lambert et al., 1998), which are among the logistics activity processes. These innovations are the pieces that will complete the puzzle in the lights-out logistics transformation process. Artificial intelligence and Radio Frequency Recognition Technology (RFID) are the most important new concepts and technologies frequently used in the logistics process in recent years. Artificial intelligence is a continuously learning, software-based organism that can perform human-specific cognitive functions such as perception, reasoning, learning, and problem-solving (Iyer, 2021). Artificial intelligence (AI) and machine learning (ML) are two areas that have seen significant progress in recent years. Artificial intelligence and machine learning are two examples of cutting-edge technologies that have helped us begin to find solutions to long-standing problems in different industries. These technologies have many applications and have benefited many fields already, including the medical, automotive, financial, and logistics fields. Companies of all sizes and sectors of the economy need to implement cutting-edge technological strategies to compete in today's global market (Haciolu, 2020).

RFID is an automatic identification technology that provides contactless access to the desired data by using the signals created by radio frequencies. RFID enables object identification to be done accurately and quickly in various challenging environments without requiring manual intervention (Sun, 2012). RFID is one of the crucial technologies in logistics, the use of which is becoming more and more common day by day. Many solutions, such as product identification, tracking of product movements, and real-time data sharing, can be produced using RFID in the entire supply chain. RFID can be used in various ways, but all require two main components: an antenna and a tag with a microchip. The serial number and other information specific to a given object are kept in the tag.

On the other hand, the antenna allows the information embedded in the tag to be transmitted to a reader, which converts the information on the RFID tag into a format that computers can understand (Casella et al., 2022). As an Internet of Things (IoT) component, RFID is one of the leading technologies that will contribute to transparency in logistics. Iot refers to a network of physical objects connected to the Internet that can interact automatically and promptly (Wu et al., 2022). With its emphasis on standardized and interoperable communication protocols, IoT is an integral part of the future Internet. In this framework, real-world and digital "objects" are endowed with unique identities, characteristics, and personalities, capable of configuring themselves and interacting with one another through intelligent interfaces and sharing data in real time. It could be thought of as the framework for a network (Sundmaeker et al., 2010). The Internet of Things (IoT) is a driving force behind Industry 4.0 because it will allow for sophisticated automation, data collection, analytics, and optimizing workflows and processes. Likewise, the Internet of Things will aid producers in comprehending real-time information from the supply chain (Shrouf et al., 2014).

Digitalization applications are used in order to automate logistics activities fully. Digitalization in logistics reveals intelligent logistics applications, namely lights-out logistics (Windt et al., 2010).

Smart logistics is identical to lights-out logistics in terms of definition and characteristics. By leveraging the Internet of Things (IoT) and other forms of intelligent information technology, smart logistics work to make all processes fully autonomous and facilitate the widespread integration and application of the logistics value chain. According to the sophistication of the underlying technologies and the predominant logistics management strategies, the idea of smart logistics can be broken down into four distinct phases (Feng and Ye, 2021). In the first phase of smart logistics, all logistics-related intelligence is concentrated

on a single task. At this point, real-time data-based forecasting, intelligent algorithm-based facility planning, and optimizing transport routes and storage facilities have become the norm. The second phase of smart logistics is where all that logistical operation intelligence comes together. The third phase of smart logistics plans to optimize the entire logistics procedure from a supply chain viewpoint. Intelligent technologies allow supply chain partners to work together more effectively and efficiently. Realizing logistics integration of a cross-supply chain through smart technologies and novel forms of cooperation is smart logistics' fourth and final phase. The most critical logistics management task at this point is optimizing resource allocation between parallel homogeneous and heterogeneous supply chains (Feng and Ye, 2021).

As a result of the concepts and literature review to explain lights-out logistics, it is seen that lights-out logistics are smart logistics activities. Lights-out logistics can be defined as logistics activities in which all logistics activities are carried out automatically without the need for physical effort. Lights-out logistics can also be expressed as the complete automation of the logistics process and the provision of technologies that will not require a workforce.

6. SUSTAINABLE LOGISTICS

Digitalization, automation, and robotic technology will contribute significantly to sustainable logistics activities. In recent years, besides the economic effects of logistics, its social and environmental effects also have an important place. As the effects of logistics activities on the environment have gained importance, logistics and environmental factors have gained importance to researchers, and the concepts of "green logistics, sustainable logistics" have emerged (Qaiser et al., 2017).

Logistics and transportation activities are the centers of global trade and an essential point in global competition. Logistics, as a term, has evolved. Sustainable logistics practices have replaced

conventional ones. Developing environmentally responsible modes of transportation is a critical social issue. Sustainability in logistics encompasses environmental, economic, and social goals. Advanced logistics and supply chain practices significantly contribute to establishing a sustainable transportation system by affecting all sectors, making them more efficient, cost-effective, reliable, measurable, and able to provide a competitive advantage (Lu and De Bock, 2016).

The most crucial aim of the sustainable logistics system is to minimize the environmental effects by increasing profitability and providing long-term performance. Before purchasing products or services, consumers need to have information about product quality, green product production, and businesses' environmental and social responsibilities. For this reason, it is necessary to implement a logistics system that considers long-term improvement for the sustainability of the enterprises. A sustainable logistics system creates a distribution and management system that integrates a logistics system while improving business performance in the long term, ensuring sustainable development (Wichaisri and Sopadang, 2013).

Sustainable logistics help identify sustainable logistics initiatives that are effective in strategic decision-making. Businesses do not have much information about the problems and problems they will experience. For this reason, businesses can make the right decision by using sustainable logistics practices when making decisions or developing strategies (Björklund and Forslund, 2019).

The warnings made by scientists in the past years and considered utopian are experienced with all their reality today. This situation also caused pressure on countries to make environmentalist decisions and brought about radical policy changes. With the Paris Agreement signed in 2015, the most significant reflection of this change occurred in the European Union, and the Green Deal was one of the main policy commitments in the 2019 elections. To

combat climate change, the European Union (EU) has mandated a drastic reduction of greenhouse gas emissions by at least 55 percent by 2030. (European Commission, 2019). Soon, it is expected that various sanctions and obstacles will be imposed on international trade under the name of carbon pricing by countries to consume investments in cleaner and more sustainable ways (World Bank, 2020).

7. CONCLUSION

The most essential and fundamental factor in logistics processes is digitalization. For the business to survive, it must be integrated with digitalization. The significant contribution of digitalization to business pushes businesses to invest more in this area. In the globalizing world, the most critical factor for businesses to survive and gain a competitive advantage is to invest in digitalization and implement it (Bardakçı, 2020). Digitalization activities help to provide a long-term competitive advantage in logistics activities by providing advantages such as improving logistics performance and reducing logistics costs (Woschank et al., 2021). According to research by Dudukalov et al. (2021), businesses that invest in and utilize emerging technologies gain a competitive edge because of enhancements in information availability, cost savings, quality of products, ability to respond, and teamwork. The use of technology in logistics has a positive effect on business performance, according to research by Aslan et al. (2018). These technological advances also contribute to the issue of trust in the logistics sector. Products can be followed more easily by all parties involved in the supply chain with the help of traceability and visibility tools. Technologies like blockchain will soon put the issue of trust between actors on a firmer ground while guaranteeing transparency in the procurement process. It is predicted that all these developments will increase the service quality and provide a competitive advantage to the companies in terms of customer satisfaction (Yıldız, 2020). Automation, robot, and computer technologies should increase

consumption and make it more flexible. This situation puts significant pressure on the logistics industry because automation and robots are two critical factors in increasing profitability and reducing production costs (Patricio and Mendes, 2020).

Supply chain management is also significantly impacted by Industry 4.0, which helps lower costs, increase productivity, efficiency, and flexibility, and enhance product customization within Industry 4.0. As a result, the supply chain is rapidly adopting digitalization, automation, and flexible management practices. When it comes to the production system as a whole, everything from the infrastructure and organizational structure to the products, services, and business models will be impacted by Industry 4.0. Companies that do not invest in pilot projects and educate themselves about these new technologies will lose their competitive advantage and the chance to take the lead in the transformation currently spanning the manufacturing sector. Throughout history, the field of logistics has developed and constantly adapted to the needs of the population, current technological trends, and challenges. The concept of logistics 4.0 imposes requirements on companies, such as significant financial investments, implementation risks, stringent infrastructure requirements, new levels of training, and qualified personnel. Meeting these requirements and meet potential challenges will be possible through the entire company's commitment to change, improving technology and processes, and developing its intellectual resources to support the changes.

From a review of the relevant literature, it is clear that digitalization has resulted in technological advancements in various fields. Logistics is one industry that is undergoing technological changes. As a result of the rise of digitalization, the logistics sector has begun to manually automate its processes by deploying a wide range of business robots. The logistics sector has started to carry out logistics activities with minimum or zero human intervention with technology. These developments have revealed the concept

of lights-out logistics. From the explanation of lights-out logistics provided by the concepts and literature review, it can be deduced that lights-out logistics is an example of smart logistics. Lights-out logistics can be defined as logistics activities in which all logistics activities are carried out automatically without the need for physical effort. Lights-out logistics is the complete automation of the logistics process and the provision of technologies that will not require human hands. The concept of lights-out logistics will become a phenomenon that we will frequently hear about with the technological advances we will experience in the hardware and software sectors in the coming period. For this reason, it has become more critical than ever to facilitate companies' integration into processes and improve the quality of technology, communication, and human resources. States, on the other hand, need to prepare the necessary infrastructure, raise awareness to realize the necessary legal transformations and take social policy measures by considering the positive and negative externalities that may be experienced in the labor markets.

With the development of lights-out logistics, it is expected that many factors, such as shortening processing times, energy efficiency, and more effective resource planning, will contribute to sustainability in the logistics sector. Technological advances are undoubtedly possible by equipping human resources with advanced competencies. It can be predicted that the lights-out logistics applications will bring about the replacement of blue-collar employees employed in the logistics sector with employees with more qualified digital competencies.

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