Chapter 9

Reflection of Industry 4.0 on Logistics Activities: Logistics 4.0

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Abstract

The idea of "Industry 4.0" was developed as a result of the industrial industry's transition to digital manufacturing. The term refers to a new industrial era characterized by the combination of automation of production processes, data exchange, artificial intelligence and the internet. The key goals of Industry 4.0 are to make production processes more efficient, to offer flexibility, and to develop a smarter manufacturing environment. The advancements brought about by Industry 4.0 have had an impact on the logistics sector, along with many other industries, highlighting the transition to Logistics 4.0. Logistics 4.0 refers to the digital transformation in supply chain management. This concept aims to make the processes from production to consumer more efficient, flexible and connected. Logistics 4.0 encompasses a number of developments involving the use of technological innovations and digital platforms. In this study, the historical development of Industry 4.0 and Industry 4.0 are discussed and the components of Industry 4.0 are examined in detail. In addition, in the study, information about Logistics 4.0, which has developed with the effect of Industry 4.0, is given. In the study, sample applications made in logistics activities within the scope of Logistics 4.0 are presented.

1. Introduction

In order to compete with other firms, boost efficiency and profitability, and cut costs, organizations are attempting to provide better service by enhancing their business processes with emerging technology. Technological developments in the field of industry have been effective in experiencing 4 industrial revolutions until today. The utilization of steam power in machines brought to the first Industrial Revolution, and the availability of cheap raw materials and the use of electricity and oil in manufacturing led to the second. The third industrial revolution has taken place as a result of advancements in

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communication and technology as well as machine automation. The fourth industrial revolution, also referred to as "Industry 4.0," has already occurred.

Industry 4.0 refers to human-oriented technologies that integrate with developing technologies where knowledge is at the forefront. At the German Hannover Industry Fair, the phrase "Industry 4.0" was first used. Industry 4.0 can be defined as technologies that enable the integration of physical and digital processes, and the production of products in smart factories with smart processes and their distribution with smart logistics. With the technologies brought by Industry 4.0, production will be realized in a safer and faster way, since information in the processes can be accessed simultaneously, an immediate intervention can be made in case of any error during the processes, faulty production will be reduced with the use of robots and machines, and all processes will be more agile and flexible. With Industry 4.0, new technologies such as the internet of things, big data analysis, cloud computing technology, smart factories, 3D printers have begun to enter our lives.

The logistics sector, along with many other sectors, has been impacted by the innovations brought about by Industry 4.0, which has highlighted the metamorphosis of Logistics 4.0. Logistics 4.0 transformation includes the use of sensors, 3D printers and advanced robots in logistics activities, and the use of software based on information technologies in the entire supply chain. Communication, cooperation and coordination between the stakeholders in the supply chain can be achieved with the digitalization and process automation brought by Logistics 4.0. Today, companies using Logistics 4.0 technologies have an advantage over rival companies. In the coming years, the technologies brought by Industry 4.0 will be used more widely in logistics activities. This will reduce costs and increase efficiency in logistics processes.

Logistics 4.0 enables companies to create new networks, automate the supply chain and be faster in transport activities. This network created by companies includes containers, warehouse management systems, smart pallets, ERP software, driverless transportation systems. Logistics 4.0 consists of the internet of things (IoT), cloud computing technologies, cyber-physical systems (CPS), big data analysis, autonomous robots, 3D printers, smart factories, augmented reality, wearable technologies, etc. In this study, the historical development of Industry 4.0 and the innovations brought by Industry 4.0 are mentioned. In the next stage of the study, the definition of Logistics 4.0 and its historical development are discussed. The

Logistics 4.0 components are covered in the study's last section, which also includes examples of Logistics 4.0 applications in the logistics industry.

2. Industry 4.0

Two important changes that changed the economic history and ensured economic development are the agricultural and industrial revolutions. The change in science and technology over time has greatly affected the industry and industrial revolutions have occurred. With the industrial revolution that emerged in England after 1750, machines began to be used in production instead of hand and body power. Between 1760 and 1840, the introduction of steam power increased industrial productivity in the iron and textile industries. The first industrial revolution, known as Industry 1.0, is defined as the use of steam-powered machinery in manufacturing. After the industrial revolution that emerged in England, it spread to the USA and all over Europe, and the welfare level of the countries began to rise with the increasing production [1].

The technology revolution, also known as Industry 2.0, was the second industrial revolution, beginning in the second part of the 19th century and lasting until the middle of the 20th. The expansion of railway networks and eased access to raw materials were key factors in the 2nd Industrial Revolution's birth. Additionally, the second industrial revolution was made possible by the advancement of technology and the utilization of new energy sources in industry. In the 2nd Industrial Revolution, steel began to be used instead of iron, and it was also among the raw materials used in the production of chemicals. Additionally, the use of oil and electricity as energy sources in place of steam and coal has begun. These technological developments have triggered the emergence of mass production. Henry Ford started using assembly lines around this time to produce the T model car, which provided the groundwork for mass production [2]. As a result of these industrial advancements, urbanization and the establishment of economically robust states both increased. The 2nd Industrial Revolution first started in America and then spread all over the world, especially in Germany and Japan.

After the 1970s, the use of automation in production started to become widespread with the developments in technology. With the end of the cold war, the whole world has become a common market in the globalization process. With the effect of this situation, there has been a great change in traditional production, marketing and sales techniques. With the developments in communication and technology and the use of automation in production,

Industry 3.0, which is the 3rd Industrial Revolution, has emerged. In the 3rd Industrial Revolution, significant developments were experienced especially in the synthetic products, nuclear energy, telecommunications, agriculture, informatics, electronics and fiberoptic sectors [3].

In recent years, the phrase "Industry 4.0," which alludes to the fourth industrial revolution, has gained popularity. At the Hannover Industry Fair in 2011, the idea of "Industry 4.0" was applied for the first time to advance the German economy [4]. Industry 4.0 is a technology-based production method that aims to meet the needs of the sectors in a fast, innovative and reliable way with the developing technology. Industry 4.0 is an industrial revolution that integrates the real and virtual worlds, smart production methods, and the replacement of embedded systems with cyber-physical systems [5]. Industry 4.0 is based on the production process in which smart systems, smart factories and other applications emerging with the development of technology are taken into account. It is thought that efficiency and production capacity will increase with the implementation of Industry 4.0.

New technologies have started to emerge as a result of Industry 4.0. Industry 4.0 consists of internet of things, cloud computing, big data, 3D printers, smart factories, autonomous robots, augmented reality, simulation, and cyber security components.

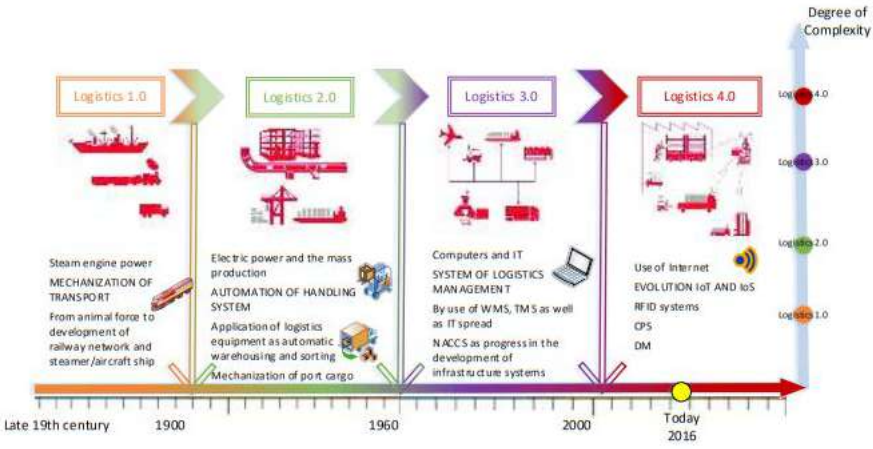
3. Logistics 4.0

In the globalizing world, companies have to develop new strategies to increase their sales and enter new markets. Today, logistics practices for quickly identifying and meeting customer needs are among the most critical activities for companies. Unlike earlier times when the name "logistics" exclusively applied to transportation-related operations, today's definition of logistics includes all actions taken during the manufacturing and delivery of goods to clients. Logistics covers the activities of allocating, planning and controlling the necessary resources for the realization of production, distribution and supply activities. As can be seen, logistics encompasses all operations from the creation of the product through its delivery to the client. It is not just concerned with distribution activities. On the other hand, logistics management offers the management and control of all required actions, from the creation of the items through the delivery to the consumer [6].

In the logistics sector, it should be fast, flexible and in a structure that will increase efficiency in order to meet customer expectations. It is only

possible for businesses to meet these expectations with the successful use of technology. This transformation, which occurs by using new technologies in the logistics sector, is called "Logistics 4.0" or "Smart Logistics". Advanced information technologies are used in the supply chain, along with cutting-edge robots and sensors, as part of Logistics 4.0 [7]. It is seen that companies that have implemented the Logistics 4.0 transformation in their logistics activities in recent years have gained a great advantage over their competitors. Therefore, companies attach importance to the Logistics 4.0 transformation.

Figure 1: Evolution of Logistics 4.0 [8]



Transformations in logistics and supply chain have also been made possible by changes in information and communication technologies. All systems are affected by industrial revolutions, technological developments and changing concepts. As industrial revolutions have progressed over time, so have the processes utilized in logistics [9]. Logistics 4.0 is a result of the innovations brought on by Industry 4.0. Industry 4.0 and Logistics 4.0 have similarities as well as differences.

As with the development of the industry, there were four phases in the development of logistics. The transformation known as Logistics 1.0 started at the end of the 18th century with the adoption of water and steam power in production and transportation vehicles as well as the modernisation of systems. The carrying capacities have risen and transportation mechanization has begun thanks to the use of water and steam power on ships and trains as well as the construction of railway networks [10]. With the use of steam power in transportation vehicles, rail and sea transportation started to be

carried out besides the highway [3]. During this period, finished products are stored in warehouses and the placement of these products is handled manually. Wheelbarrows are used to transport products to vehicles [11].

As a result of the employment of electricity and oil in transportation and communication equipment, logistics 2.0, the second logistics revolution, was born. During this time, the chemical industry saw significant advancements as well as the beginning of the use of materials like steel, aluminum, and copper in the manufacturing of machines. In addition to road transport, important developments were also experienced in steam ship transport and railway transport in this period. One of the most significant inventions of this era is the use of steam container ships for shipping. In this process, logistics equipment working with electrical energy has also been developed. Forklifts operating with electrical energy have started to be used for placing the products on the shelves and transporting them inside the warehouse [12]. With the advancement of freight handling automation, tools for automatic sorting and warehouses came into use.

Automated production technologies are the foundation of the third industrial revolution. The most significant technology advancements in this industrial revolution are industrial robots and numerically controlled machines (Milling, Turning CNC, etc.) that enable flexible output. With the development of software like the Warehouse Management System (WMS) and Transport Management System (TMS) their usage in logistics operations, the idea of Logistics 3.0 has evolved. These softwares used in logistics management ensure that the orders of the suppliers can be supplied in a short time. In addition, with the help of these software, the planning, routing and scheduling of fleet vehicles can be done beforehand. In the Logistics 3.0 period, automatic machines and industrial robots started to be used in logistics activities [13]. In in-production transportation, the use of automatic moving bands, forklifts and automatic robots with predetermined routes have become widespread.

Industry 4.0, often known as the fourth industrial revolution, is a result of the logistics industry's acceptance of new applications offered by cyber-physical systems. In technology-based logistics processes, the use of software-based applications with Industry 4.0 has facilitated the calculation and communication processes and brought the opportunity to reach all stakeholders quickly [9]. Logistics 4.0, which makes use of advanced internet usage and integrates smart products and smart services, is also known as "smart logistics". Logistics 4.0 can be defined as a structure that provides digital management between logistics processes and targets, customers and

stakeholders in the supply chain [14]. With the transformation brought about by Logistics 4.0, traditional tools and devices with fixed functions have started to be replaced by software-based machines that will adapt to the needs of the user, have a flexible structure and can easily add new functions. In hardware-based devices, the technology is used until the device wears out without being renewed, while in software-based machines, the machine is developed by integrating the developing technology with the software, increasing the performance and life of the machine.

It is feasible to improve customer happiness, lower production costs, optimize production, and boost storage and transportation process efficiency by utilizing the transition brought about by Logistics 4.0. In Logistics 4.0, hardware-oriented logistics systems have started to be replaced by software-oriented smart logistics systems [9].

The innovations and technologies used by Logistics 4.0 and Industry 4.0 are similar. Logistics 4.0, as in Industry 4.0 transformation, consists of IoT, digital transformation, autonomous robots, big data analytics, CPS, cloud computing systems, augmented reality, smart factories, 3D printers, wearable technologies, etc.

4. Technologies Affecting Logistics 4.0

With the effect of developing technology, the logistics industry is also in a great change. Innovation and technology have significantly affected the future of logistics. Innovations such as the internet of things, big data analytics, cyber-physical systems, autonomous robots, 3D printers, and wearable technologies that Industry 4.0 has added to our lives have also contributed to the development of logistics activities by being adapted to the logistics industry. The applications of various technologies that have an impact on the logistics sector are covered in this section.

4.1. Internet of Things (IoT)

The Internet of Things is one of the brightest technologies that has entered our lives with Industry 4.0 and can be applied in many areas with the developing technology. It is a technology that makes it possible for network-connected things to communicate with one another and be controlled remotely. Internet of Things technology is briefly shown as "The IoT". Technically speaking, the IoT is a grouping of physical objects that link with the software of mechanical, electronic, computer, and communication systems to enable data transfer over the internet. This technology, which provides machine-to-machine communication, is being applied in many

areas today and continues to develop. It is thought that the following advantages will be achieved with the more widespread and active use of IoT technology in production and logistics:

- Managers at every stage of production will be able to intervene immediately in case of any problem by using smart communication tools.
- It will be possible to follow the supply chain with the labels or sensors placed on the products or objects.
- With the increase in the use of machines and robots, there will be less need for human resources in production.
- When smart devices are used in the internet of things, there will be a decrease in infrastructure and energy costs.
- The income and profits of the companies will be increased.

The IoT technology ensures that not only objects, but also people, data and processes are in continuous communication without interruption [15]. With the RFID tags, barcodes and sensors placed on the products, all transportation and distribution activities from the starting point of the products until they reach the customer can be monitored IoT-based distribution systems make the supply chain more productive and efficient while also empowering managers to make decisions more quickly and accurately. [16].

With the development of international trade, the logistics sector has become more complex and new technologies have been needed in the logistics sector. Utilizing IoT technology in the logistics industry allows for more effective and efficient management of tasks including inventory and warehouse management, resource management, fleet management, and order management [16]. In addition, the IoT can be used in the logistics sector in the tracking and control of vehicles, communication and information management in subjects such as fleet management, road condition, smart parking and road safety. Activities like storage, transportation, and stock management will be transformed throughout the process from the stage of production to the delivery of the product to the client with the application of IoT in the logistics industry. It will be ensured that all activities in these processes can be monitored and controlled [17].

4.2. Big Data Analytics

Today, it is possible to access a lot of data over the internet. However, among these data obtained, there are data that create information pollution and it is thought that it is difficult to extract the desired information from these data. Big data is a term used for databases that are growing and becoming difficult to manage. The difficulty of managing this data is due to the variety, volume and speed of the data [12]. Since the data that can be accessed over the Internet is very diverse and abundant, various software and applications are used to obtain the desired data. Big data is defined as data that can be collected, stored, analyzed, and managed beyond the capability of database management systems and software tools. Big data records every single action that each user makes on the internet. Big data analytics continuously evaluates organizational strategies and activities carried out in production, and examines technologies, skills and practices that will be effective in creating business planning [18].

Big data is applications that reach and combine many different data and make it possible to make decisions with this data. Big data brings together many different data and is effective in decision making, as well as providing advantages in reducing costs and improving product and service flows. It is intended to boost efficiency, lower mistake rates, and increase flexibility through the analysis of big data [19]. Big data applications in the logistics sector have gained great importance in recent years. RFID readers, sensors, logistics software, transportation management systems, etc. generate large amounts of data. In addition, social media data has also affected logistics activities in recent years. Big data is used in determining the routes of the vehicles, in shift planning, in the selection of warehouses, etc., in address verification. In addition, customer preferences are positively affected by creating personalized opportunities with the analysis of customer habits with big data analysis [20].

4.3. Cloud Computing

Cloud computing systems are the provision of data related to information systems from third parties. Cloud computing services refer to the computer model that provides access to the desired data over the internet at any time by using storage devices, cloud centers and applications shared over the cloud [21]. With cloud computing systems, applications in the cloud can be run over the internet with a remote drive or the user's data can be accessed from a remote drive at any time. Cloud computing systems provide the

opportunity to access the data previously stored on the cloud at the desired place and time.

Today, many companies serving on a global basis store their data in cloud computing systems that allow access from different places. Thus, it is possible to quickly access the desired data at many different points. Cloud computing systems can be thought of as a transformation rather than an innovation.

Cloud computing applications are also used in the logistics sector. There are numerous supply chain participants in the logistics sector. Cloud computing platforms make it possible for supply chain participants to collaborate for the least amount of money. With cloud computing systems, it enables them to create logistics collaborations without incurring any cost to software, hardware and data warehouses with information technology resources. With cloud computing systems, any problem experienced in activities such as logistics, transportation and storage can be solved quickly [16]. With the application of cloud computing systems in the logistics sector, previously manual operations have become possible with automation systems, and with the use of automation systems, costs have decreased and productivity has increased [22].

It is feasible to receive, store, and safeguard logistical data using cloud computing technologies. In order to support logistics operations, it also offers the processing and analysis of logistics data. Thus, cloud computing benefits from logistics software exchange for planning logistics operations, determining the routes of vehicles [21].

4.4. Cyber-Physical Systems (CPS)

Cyber physical systems (CPS) are one of the indispensable elements of smart systems. CPS are all the devices and systems that enable communication and cooperation between the virtual and physical worlds. CPS provides bidirectional flow between decision and production systems in production engineering [9]. CPS are systems that enable the interaction of both people and objects by integrating new methods and software and physical capabilities. CPS also provides the opportunity to carry out activities to make calculations, monitor and control transactions by connecting with the physical world and adapting to developing technologies. CPS uses sensors and actuators to link the real world to the digital one. [3]. CPS consists of five key stages:

1. To ensure the integration of the virtual world and the physical world.
2. Creating a system of easily adaptable systems in a dynamic structure.

3. To create systems that can easily adapt to change.
4. Working together with distributed control systems.
5. Establish comprehensive human-system cooperation.

CPS consists of two components, a network consisting of an object or systems connected to each other over the internet, and a virtual environment with computer-generated simulation of behaviors. The most important feature of CPS systems is that they can be activated in a short time by using technology for events that can hardly be noticed with human skills. Since CPSs are connected to the internet, they can access the data very quickly and process and use this data quickly. CPS forms the basis of Industry 4.0 with IoT technology.

CPS ensures that the value chain, production and logistics activities are carried out simultaneously, ensuring the coordination between them, increasing the performance and quickly finding solutions to variable dynamic situations. CPS is widely used in enterprise resource planning [23].

4.5. Autonomous Robots

The internet of things, smart sensors, technological developments in integrated systems have been influential in the development of autonomous robots that are completely computer-controlled. Autonomous robots can perform their functions automatically without the need for human intervention by using technologies such as sensors, remote sensing, and the internet of things. For a device to be considered a robot, it must first be autonomously controlled. Today, robots can perform their movements by sensing physical quantities such as sensors, light, heat, current, magnetism, speed, which can operate under different conditions.

Autonomous robots provide flexibility in production and support the transition to smart manufacturing. With the increase in the use of robots in the industry, it is expected that the robots will adapt to flexible working, the use and calibration of robots will become easier, the development of robots that will adapt to production activities, the prices of robots will decrease [10]. Autonomous robots select, package, test, manufacture and install faster and more efficiently than human power. With the increase in the use of robots in production, automation will increase and there will be a decrease in human error rates.

Autonomous robots are frequently used in logistics activities such as transportation, storage, labeling, packaging and handling. In logistics

processes, autonomous robots are mostly used in warehousing activities. In addition, with the use of automatic racking, RFID and sensor technologies in warehouses, the use of autonomous robots in warehousing activities has become widespread [14].

4.6. 3D Printings

3D printers are devices that can take computer-generated data and turn it into manipulable, three-dimensional things. 3D printers are a technology that creates 3D objects with a layer-by-layer material arrangement designed by using computer aided drawing software. In this method, various materials are printed in sequential layers on top of one another. After any tool, object is designed, the concrete version of this design can be made in three dimensions with the help of 3D printers. The prototype of the product designed with 3D printers can be produced quickly. Thus, it is ensured that the products are brought to the market more quickly [24].

3D printers play an active role in logistics and supply chain. 3D printers can be decisive in choosing a production center or warehouse location. 3D printers allow production centers to be located close to strategic markets, reducing overall costs and transportation costs [25]. In addition, 3D printers are also used in the production of spare parts. By producing the spare part with 3D printers when needed, it provides savings in both storage and investment costs. With the development of e-commerce, companies have started to switch to the same time delivery approach instead of same day delivery. With 3D printers, the product requested by the customer will be produced and delivered quickly. Thus, superiority will be achieved over rival companies and there will be a decrease in transportation and storage costs [10].

4.7. Smart Factories

New production innovations have been used to launch each industrial revolution. Industry 4.0, on the other hand, has been realized with the widespread use of machines with automation in production. In smart factories where production is carried out using automated machines, sensors and robots, there is a decrease in the workforce needed. In addition, less faulty production is made in the production carried out with machines with automation. In order for smart factories to work effectively, it is possible to use the internet of things technology and sensors without any errors. Smart factories increase efficiency and adapt to flexible production.

In Logistics 4.0, logistics activities will be carried out using autonomous vehicles. Ordering the needed product with autonomous robots will increase efficiency in warehousing and logistics activities. Future production will utilize smart factories, which will result in smart logistics applications [14].

4.8. Wearable Technologies

All types of clothing and accessories with built-in computers and cutting-edge technology are considered wearable technologies. Wearable technologies provide control of machines/devices by taking dynamic, instant interaction with employees and operators. This technology provides the interaction between the virtual world and the real world. Smart watches, RFID readers, sensor gloves, glasses, headphones, belts, pens, shoes are used as wearable technologies. These objects are not only light and easy to use, but also do not hinder the movements of the operator [26]. Wearable technologies do not hinder the ability of the staff to use both hands, allowing them to work efficiently.

Wearable technologies, which are especially used in packaging, storage and transportation activities in the logistics sector, are integrated into business processes, increasing efficiency and being effective in reducing costs. For example, the staff working in the warehouse can access all information from the barcode on the product, pallet or equipment with the barcode reader glasses they wear, or the inventory can be processed by determining the location of the product while the vehicle is being loaded. As you can see, wearable technologies increase productivity by speeding up work.

4.9. Augmented Reality

Augmented reality is the images projected from computers in detail with image, sound, graphics, video and GPS data to our environment. This technology enables the simultaneous merging of the physical world and the digital world by using virtual images, graphics, wearable technologies, cameras on computers and smartphones. Augmented reality applications are encountered in many sectors today.

Augmented reality technology is frequently used in the logistics sector. In the field of logistics, where the shelves will be placed in the warehouse setup, which equipment will be placed where, and the routes of the vehicles can be determined with augmented reality technology. Augmented reality applications ensure that the risks and dangers that the personnel may encounter can be determined in advance, and also prevent occupational

accidents [10]. In addition, the use of this technology provides the reduction of errors, flexibility in production, and an increase in working speed.

5. Conclusions

Nowadays, it is getting harder and harder to compete with the productions made using traditional methods. Therefore, the developing technology in every field should also be effective in the industry. With the use of new applications and automation that emerged with the developing technology in the industry, Industry 4.0, which is the 4th Industrial Revolution, took place. With Industry 4.0, IoT, big data analytics, CPS, cloud computing autonomous robots, augmented reality Technologies, 3D printers have started to be used.

Supply chain management and logistics management have both been impacted by developments in information and communication technology with Industry 4.0. The concept of Logistics 4.0 has evolved as a result of the application of new technologies introduced into our lives with Automation and Industry 4.0 in the logistics industry. Like Industry 4.0, Logistics 4.0 creates integrated solutions that enable the integration of new information technologies with logistics processes. Logistics 4.0, which consists of similar technologies used by Industry 4.0, consists of technological components such as big data analytics, IoT, CPS, RFID technology, cloud computing, autonomous robots, augmented reality, 3D printers.

When Logistics 4.0 is successfully implemented, the logistics process of the product takes place fluently. The success of the companies in the logistics processes provides a more efficient working environment between the customer and the supplier, the manufacturer and the wholesaler. In addition, the use of these technologies reduces costs and is effective in reducing errors in processes. With Logistics 4.0 applications, oil consumption is also reduced, thereby reducing the carbon footprint.

In this study, the industrial revolutions that occur with the reflection of technological developments on the industry are mentioned and Industry 4.0, which is the 4th Industrial Revolution, is discussed in detail. The technologies that came into our lives with Industry 4.0 have had an impact on numerous industries, including the logistics industry, and they have also revealed applications for Logistics 4.0. In this study, the components of Logistics 4.0, which started to be implemented with Logistics 4.0, are explained and information is given about the technological developments in the logistics sector and the new applications that have emerged. However, with the developing technology, new applications, software and technologies

are applied in the logistics sector. In future studies, it is thought that it would be appropriate to develop the literature by considering new applications in the logistics sector in detail.

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