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Green Logistics In The Context Of Industry 4.0

Endüstri 4.0 Bağlamında Yeşil Lojistik

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ABSTRACT

Industry 4.0 and Green Logistics are two concepts whose importance is increasing day by day with the effect of technological developments and globalization. Autonomous processes, thanks to Industry 4.0 applications, provide great benefits to institutions in terms of time and cost. However, it also makes very important contributions to the field of Green Logistics, thanks to the energy savings, error minimization and continuous monitoring provided by smart systems. In this study, Green Logistics has been examined within the scope of Industry 4.0. In the study, the Transition Process to Industry 4.0, the Concepts of Industry 4.0 and Green Logistics, the Importance of Industry 4.0 for Green Logistics and its Contributions to Green Logistics were examined.

Key words: Industry 4.0, Green Logistics, Energy, Smart Systems

ÖZET

Endüstri 4.0 ve Yeşil Lojistik, yaşanan teknolojik gelişmeler ve küreselleşmenin etkisiyle önemi her geçen gün artan iki kavramdır. Endüstri 4.0 Uygulamaları sayesinde otonomlaşan süreçler kurumlara zaman ve maliyet açısından büyük fayda sağlamaktadır. Ancak bunun yanı sıra akıllı sistemlerin sağladığı enerji tasarrufu, hata minimizasyonu ve sürekli gözlemleme imkanı sayesinde Yeşil Lojistik alanında da çok önemli katkıları bulunmaktadır. Bu çalışmada Endüstri 4.0 kapsamında Yeşil Lojistik incelenmiştir. Çalışma içerisinde Endüstri 4.0'a Geçiş Süreci, Endüstri 4.0 ve Yeşil Lojistik Kavramları, Endüstri 4.0'ın Yeşil Lojistik İçin Önemi ve Yeşil Lojistiğe Katkıları incelenmiştir.

Anahtar Kelimeler: Endüstri 4.0, Yeşil Lojistik, Enerji, Akıllı Sistemler

1. INTRODUCTION

Industrial revolutions are processes with radical changes that are constantly renewed and affect the whole world with the advancement and development of technology.

The Industrial Revolution, which marked a turning point in history, was characterized as the transition from a mode of production based on human and animal power to one based on machine power, and it is considered one of the most significant events in human history (Jensen 1993, De Vries 1994, Ashton 1997).

Some argue that the industrial revolution was the greatest profound change in human life in the world's history (Hobsbawm, 1968:7). In later centuries, the world economy began to form as a unified entity, with advanced areas and colonies linked by economic activity division.

According to Tutar, the industrial revolution was "a profound transformation movement in production technology that developed in England in the middle of the 18th century, the beginning of the transition to mechanization dominated by technology, and expanded quickly throughout Europe (Tutar, 2013: 67), This change-transformation in England, particularly weaving, and all the innovations in the economic field that began in the iron and steel industry and the railway sector and expanded over the world, began in the iron and steel industry and the railway sector (Parlak, 2011:217).

The revolution spread quickly throughout Western Europe and the United States after it began in England (Aksoy 2017). The Industrial Revolution, which brought along many radical changes in terms of history, means going one step further in the history of humanity. Therefore, it is possible to express the Industrial Revolution as the structuring of a new civilization (Adıgüzel and Yüksel 2011).

The stages of the industrial revolution, along with the technological development and change process, have passed into the literature in the form of four stages from the past to the present.

2. INDUSTRIAL REVOLUTIONS AND INDUSTRY 4.0

During 1700's, the impact of industry 1.0, the starting point of industrial revolutions, became visible. Thomas Newcomen invented the Steam Engine in 1712. With the use of water and steam technology in production and the construction of railways, the mechanical production process started, and the production of a human-centered workshop was shifted to machine-oriented factory production. In other words, physical labor has given way to mechanical power in manufacturing. Steam power has added capability to the machines, which have increased in use both numerically and functionally (Aegean Region Chamber of Industry-EBSO, 2015: 4).

Between 1870 and 1914, steel started to be used in the industry alongside iron, and a new transformation was experienced with the inclusion of electricity instead of steam energy in the production process and Industry 2.0 emerged. The mass production process was started with the electrical systems installed in Ford Motor factories. The superiority of the Second Industrial Revolution over the First Industrial Revolution is the emergence of scientific knowledge. Thanks to the invention of electricity, telegraph and telephone used in this period, telecommunication technologies started to become widespread.

Machines' power and speed have risen as a result of electrical energy. During this time, the concept of mass production became popular. States with industrial production power include the United Kingdom, Germany, the United States, and Japan (EBSO, 2015: 5). The tape production method was regarded as the start of the second industrial revolution when electricity became a viable energy source. Production has been relocated to enormous factories as a result of the Second Industrial Revolution, and the concept of electricity has taken precedence over the concept of mechanics.

In the 1950s, there was a noticeable increase in the rate of technological advancement and industrial production. Industry 3.0, unlike previous industrial revolutions, is characterized by the use of renewable energy sources rather than finite energy sources. Programmable machines developed in the 1960s triggered the Industry 3.0 revolution, along with the gradual spread of scientific knowledge and its more active use. With the Third Industrial Revolution, automation was started in production thanks to the use of electronics, information technologies and the internet, and the Post-Fordism period was entered while the Fordism period was ending (Alçın, 2016). With the widespread use of computers and the internet, production has become easier and globalized as a result of the integration in the world economies. The third industrial revolution is a technological revolution, and it is widely assumed that countries who can develop nuclear energy technology will be able to achieve it.

As a result of the widespread and intensive use of the Internet, the concept of Industry 4.0 has emerged, a process in which the strengths of the traditional industry are integrated with information and communication technologies. The term Industry 4.0, which was first used at the Hannover Fair in 2011, was later prepared by the working group of Robert GmbH and Kagermann in 2012 as a proposal for the 4th Industrial Revolution, and was presented as the final report of Industry 4.0 at the Hannover Fair in 2013. The most important contribution of Industry 4.0 to all sectors is the elimination of deficiencies such as brain power, which is not in technology but human, and high efficiency, which is in technology but not human, by means of software programs. Industry 4.0, in a broader sense, is a change that will influence all aspects and levels of life in order to meet individual wants and address global concerns, thereby obtaining the competitive power demanded by the global market (Banger, 2018).

The building blocks of Industry 4.0 are Internet of Things, Cyber-physical Systems and Internet of Services.

Internet of Things; is the transfer of data received from a human, device or smart reader to other systems. In other words, it is the transfer of data received from an object in a system to other systems via a network, and the ability to connect devices to each other (Rouse and Wigmore, 2020). In order to make people's lives easier, we come across the internet of things in many application areas such as e-health, smart environment, smart cities, logistics. In order to benefit from the internet of things efficiently; it is necessary to collect data from sensors, store the collected data, analyze the stored data, and enable necessary updates and improvements (Gökrem and Bozuklu, 2016:49).

Cyber physical systems are defined as the systems that are in charge of communication, production process and cognitive mechanisms by making use of information technology. They are used in many areas such as medical monitoring, autonomous vehicle services and robotic devices (Banger, 2017:46). The basis of Industry 4.0's multidimensional and rapid technological progress is cyber-physical systems. The emergence and rapid spread of autonomous vehicles, advances in robotics, the emergence of smart factories, the development of 3D printers can be listed as the opportunities provided by the cyber-physical system. Cyber-physical systems, which connect the real world and the virtual world via the internet and enable production to be made much more easily, use sensors, software systems and communication technologies to establish this relationship. In the cyber-physical system, the production process is controlled automatically thanks to the sensor systems, and human intervention is minimized or even eliminated. In other words, cyber-physical system technologies can be used to monitor products, ensure the safety of the elements in the chain, provide information about demand, stock and sales, and predict anomalies in production (Frazzon, Silva, & Hurtado, 2015).

The systems that consist of business models and service infrastructures in order to provide services and that allow service vendors to offer their services via the internet are the internet of services (Herman, Pentek and Otto, 2015: 9).

Industry 4.0 is basically built on six principles; interoperability (interaction of humans and smart factories), virtualization (connecting data in sensors with virtual plant models), decentralization (autonomous management - the ability of cyber-physical systems to make decisions by themselves), real-time capability (fast collection of data and analysis), service orientation (providing services over the internet of services), modularity (plug-and-play feature providing a flexible adaptation system to smart facilities) (Fırat and Fırat, 2017:10-23).

The advantages of Industry 4.0 can be expressed as making the supply chain transparent, facilitating the control over the machines, ensuring stock optimization, flexible production and high efficiency.

Recent advances in information and communication technology, coupled with increasing pressures on digitalization and automation in manufacturing, have opened the way for several opportunities to improve logistics activities and supply chains as well (Strandhagen et al., 2017).

3. GREEN LOGISTICS

Green Logistics; measures and minimizes the negative impact on the environment of all operations for the execution of logistics activities in a way that does not harm the environment or cause the least possible damage; in other words, it tries to reduce the energy and environmental footprint in terms of load distribution with supply chain applications. Green logistics, which covers all the actions taken to minimize the ecological effects of logistics activities by measuring, includes the whole process between production and consumption. Therefore, suppliers, manufacturers and customers need to work together. In this context green logistics management consists of four main components: green purchasing, green production and material management, green distribution and marketing, and reverse logistics (Zhu and Sarkis, 2006).

Green purchasing decisions are the activities of purchasing recyclable, reusable or recycled materials in which environmental impacts are taken into account (Min and Galle, 2001; Sarkis, 2003).

Green production is a production process that does not pollute the world or deplete natural resources and can be recycled or preserved (Shamdasani et al., 1993). In other words, it is a production process that is highly efficient and produces little/no waste by using inputs with low environmental impact.

Green distribution and marketing; designs distribution and marketing activities in a way that causes the least harm to the environment (Jain and Kaur, 2004), and creates an environmentally friendly marketing and distribution network.

Reverse logistics; including processes such as recycling, destruction, burning, and recycling of unwanted materials (waste material, cans, bottles, paper, etc.) can be defined as environmentally friendly logistics activities that increase environmental efficiency and are redesigned to manage the flow of products or parts in order to use resources effectively (Carter and Ellram, 1998).

In this context, green logistics is the restructuring of activities in a way that takes into account environmental sensitivity at every step of the logistics network. Transporting products in large groups, using environmentally friendly fuel for production and shipping, using ecological transportation and efficient distribution systems, reducing packaging materials, using recycled materials in packaging, using sustainable pure products, recycling, training employees , raising awareness of customers and encouraging reverse logistics activities can be listed as examples of this configuration.

The collection of products that are not needed by the consumer and that have completed their useful life, to be transformed into new products, delivered to production centers and evaluated constitute an important area of green logistics. In the "Green Logistics 2016 Research Report", the world's first and only Green Logistics Report, it was emphasized that product life cycle and reuse should be given importance to ensure overall sustainability.

There are overlapping activities as well as contrast between reverse logistics and green logistics; there is no clear limit. Waste product and reuse reverse logistics; recycling and disposal are considered an important part of green logistics. However, while reverse logistics is applied to save economically or to transform the loss into profit and to provide competitive advantage, green logistics is not generally seen as an economic concern, but rather arises because of the image of the company or being a part of a conscious decision (Nylund,2012:49).

Reverse logistics; associated with the collection, shredding and processing of the products used; recycling, reuse and reproduction functions are seen as the common intersection areas of reverse logistics facing green logistics and these are called green reverse logistics activities (Ekinci,2018:33-34). Redesigning the packaging to limit the use of materials or reducing the energy used in transportation and the pollution created are important activities, and the classification of these activities is more appropriate for the field of green logistics (Rajagopal, 2015: 43). The use and remanufacturing of reusable transport containers is seen as both reverse logistics and green logistics activities.

4. THE IMPACT OF INDUSTRY 4.0 ON GREEN LOGISTICS

With the development of the concept of Industry 4.0, research on the concept have been conducted in a variety of industries. Logistics is one of Industry 4.0's most essential application areas. In this perspective, it is reasonable to expect considerable changes in logistical activities as a result of Industry 4.0. (Hompel and Kerner, 2015). Companies in the logistics business must evolve as a result of Industry 4.0 practices. The route to logistics 4.0, as part of the Fourth Industrial Revolution, enables new business models. Among the elements of logistics 4.0 that enable new business models are instant information sharing, automated solutions, and real-time big data analysis (Strandhagen, Vallandingham, Strandhagen, Stangeland, Sharma.,2017). Different areas of logistics have improved, such as sustainability, efficiency, customer responsiveness, and traceability. According to Solvay et al. (2017), the two most important factors influencing the future of logistics are digitalization and supply chain automation..

The impact of Industry 4.0 on the supply chain should be considered holistically, as it is critical to establish good cooperation between suppliers, manufacturers, and customers in order to increase transparency throughout the entire process, from the moment an order is placed to the end of the product life cycle (Tjahjono et al., 2017). Developments in the transportation and logistics sector are leading to significant improvements; it contributes positively to all stages of the supply chain and logistics, from production through delivery of the finished product to the client (Kayapnar., 2017).

When viewed through the lens of logistics organizations, the benefits of Industry 4.0 applications appear to be better efficiency and higher service quality (Delfino et al., 2017). Researchers have begun to employ ideas such as "Logistics 4.0" and "Smart Logistics" as a result of the growth of Industry 4.0 and the role of logistics in this process. According to Timm and Lorig (2015), these principles explain the transition from hardware-based to software-based logistics.

Industry 4.0 converts a manufacturing system and supply chain into a smart manufacturing system based on cyber-physical interactions between connected elements. This transformation allows the business processes and activities to become more flexible, cost-effective, and ecologically friendly, resulting in a more flexible, cost-effective, and environmentally friendly manufacturing system. The Industry 4.0-based, sustainability-oriented idea encompasses not only environmental protection and control activities for industrial management, but also process safety programs such as resource efficiency, employee and community welfare, and smarter and more flexible supply chain operations.

The digitalization of the supply chain has also been greatly influenced by the Industry 4.0 revolution (Yıldız, 2018). The traditional supply chain's communication routes have now gone digital. Buyer-supplier relationships are now more reliant on digital communication than on face-to-face interactions. Furthermore, the continual development of new technologies like as service software and social media has digitized supply chains by increasing the effectiveness of communication between firms and their supply chain partners (Obal and Lancioni, 2013). (Abdel-Basset et al., 2018).

Supply chains today necessitate a large number of complicated actions that must all be managed and monitored (Büyüközkan and Göçer, 2018a). Physical warehouses are being replaced by digital data centers, which are replacing physical boxes and vehicles. Production, delivery, and operations are typically carried out individually in the non-digital structure (Büyüközkan and Göçer, 2018b).

Industry 4.0 necessitates a paradigm shift in how goods and services are bought, manufactured, distributed, sold, and consumed throughout the supply chain (Koh et al., 2019: 817-818).

Industry 4.0 is defined as the integration of cyber-physical systems in manufacturing and logistics, as well as the use of the internet of things in manufacturing processes. This encompasses the value chain, business models, services, and workplace environment (Prause and Weigand, 2016: 104). Digitization and integration of value chains, products, and/or services are part of Industry 4.0 / digital operations, which are based on cyber-physical production systems that strive to integrate the physical and digital worlds of production (PWC, 2016).

The fuel consumed during logistics activities, the frequency of shipment, the distance to the customer and the market, the performance of the distribution in terms of weight, material and shape of the packaging, and the green concept of the supply chain (Sarkis, 2003). Making logistics activities environmentally friendly at every step, such as reducing transportation costs and optimizing warehouse locations, is one of the important practices for green supply chain.

The amount of fuel used in logistics activities, the frequency of shipments, the distance between the customer and the market, the distribution performance in terms of weight, material, and packaging shape, and the supply chain's green concept (Sarkis, 2003). One of the fundamental strategies for a green supply chain is to make logistical activities ecologically friendly at every step, such as lowering transportation costs and optimizing warehouse sites.

The supply chain structures in which the digital supply chain is the main point are a new trend growing in the supply chain and logistics industry around the world (Lin and Jones, 2009: 589). Due to technological advancements, logistics activities, which are defined as the process of delivering and storing manufactured goods, services, and all information flow from the point of production to the end customer in an effective and efficient manner, have taken on a new dimension(Özgüner, 2017: 10).

In terms of innovation, added value, and sustainability, Industry 4.0 presents significant prospects for the logistics industry. The production processes of smart factories will be controlled in an integrated manner with suppliers, warehouses, market shelves, or vehicles in the Industry 4.0 strategy, which will make instant interactions the center point along with all supply and logistics activities. Stock levels, supply chain failures, damaged products, and demand variations will all be constantly monitored thanks to smart machines, and all business activities will be coordinated on-site to ensure efficiency (Çetin, 2017).

Vehicles equipped with satellite tracking systems are in communication with other vehicles, traffic and road status information, various sensor data related to vehicle and load, and the widespread use of smart systems, where route and route information is given autonomously on a vehicle basis, thereby improving the efficiency and effectiveness of logistics activities, in addition to Industry 4.0 applications. Increased productivity is possible (Çetin, 2017).

5. CONCLUSION: CONTRIBUTION OF INDUSTRY 4.0 APPLICATIONS TO GREEN LOGISTICS

The developments in Industry 4.0 have seriously affected logistics and led to the birth of logistics 4.0, thus improving different aspects of logistics such as sustainability, efficiency, ability to respond to customers and better traceability, as well as the essential elements of the business have become affected by this. Industry 4.0 technologies standardize all systems and ensure sustainability by reducing carbon emissions. These increase the operational efficiency in logistics and enable logistics enterprises to stand out from the competition. Industry 4.0 has made it easier to implement many innovations in the field of Green Logistics, as in every field of logistics.

The use of Industry 4.0 has serious effects on many issues such as fleet management, vehicle occupancy rate, route planning, vehicle and driver performance, fuel consumption and delivery speed. With the use of Industry 4.0 applications, businesses have provided instant intervention to all processes by effectively planning vehicles, drivers, loads and routes. The integration of simultaneous monitoring systems used in businesses with sensors has enabled the simultaneous control of points such as whether the drivers use safe vehicles (brake speed, fuel consumption rate, etc.), whether they are on the right time and on the right route during the cruise, whether they reach the customer at the appointment time. Route planning has increased the speed of transportation and delivery, service quality and customer satisfaction by minimizing errors. Reducing the distance traveled reduces the carbon footprint by reducing fuel consumption. Reducing carbon emissions not only contributes to businesses, but also increases the sustainability of logistics in terms of economy, environment and society.

Industry 4.0, which at first glance is only seen as a technological development, has great potential to popularize environmentally friendly practices. Thanks to energy-friendly smart vehicles, fuel consumption, which is the biggest expense of the logistics sector, is reduced, while carbon emissions, which are sources of fossil fuel use, are also reduced.

Thanks to IoT, one of the most common applications of Industry 4.0, all monitoring and documentation can be done online. In this way, the human workload, the cost of transporting people and the waste of paper created by environmental pollution and paper waste can be prevented.

Thanks to Industry 4.0, simulation technology, which has entered our lives, can prevent waste caused by planning errors in many areas, including logistics. Thanks to the simulations to be made before taking action in logistics problems with high cost and importance such as production, transportation problem and optimization, the optimum scenario can be implemented without wasting cost, resources and time.

Thanks to drone cameras, the cost of unused stock, which is an important expense in the logistics industry, can be eliminated. In cases where employees are used to monitor stocks and product lifetimes, some products may be overlooked and cause waste. However, if drone cameras are used, any product will be examined without skipping and necessary actions can be taken according to the condition of the products.

In addition to the camera system, Industry 4.0 applications can provide great benefits for warehouse systems, which are a serious branch of the industry. Optimization applications to be used for the placement of the warehouse, in-warehouse movement systems, security systems to be programmed in accordance with the characteristics of the stored product will reduce the waste that will occur in the warehouses. These wastes cause environmental pollution as well as high costs.

With the use of Industry 4.0, error costs, labor costs and fuel costs are reduced. In businesses, Industry 4.0 applications can be used in cost analysis to measure pricing and the place of the business in the market.

Finally, thanks to the recycling systems developed through Industry 4.0, it is possible to get rid of the dangers and costs of waste. In addition to the cost they create, these wastes carry a great danger potential for the health of nature and living things. Thanks to recycling systems, this danger is eliminated and institutions can reduce their costs.

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