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The Importance of Logistics 4.0 within the Scope of Industry 4.0: Evaluation of Logistics 4.0 in an Enterprise in Terms of Sustainability

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Abstract – Industry 4.0 and Logistics 4.0 are highly scientifically significant terms. They are linked to the common trend of digitization, virtualization and networking of data and information. Logistics 4.0 is part of Industry 4.0 and will support the development of Industry 4.0. It is clear that there is no Industry 4.0 without Logistics 4.0. Industry 4.0 has impacted not only the industrial environment but all related sectors, including services and logistics, and the change is expected to continue. The logistics sector has an important role in the entire Supply chain of industrial processes and therefore changing needs in the industrial environment directly affect the logistics sector. This research provides a basis for examining the definitions and content of Industry 4.0 and Logistics 4.0 in detail. Due to the increasing supply and demand in Supply chains today, one of the most important tasks in future supply chain planning will be to provide flexibility while avoiding complexity and uncertainty. One of the most important prerequisites for supply chain flexibility is the development of network-based collaborations and the use of Industry 4.0 applications. Within the scope of this research, a literature review including the concepts of Sustainability, Industry 4.0, Logistics 4.0 and Supply Chain Management was conducted. Sample application studies on this subject were examined. Depending on the characteristics obtained and prepared as a result of the researches carried out depending on the purpose of the study, the development model offered by a company and the development model offered by white goods manufacturers are compared in terms of sustainability. In this context, suggestions are made in terms of Sustainable Logistics 4.0. In this study, the Analytic Hierarchy Process (AHP) method was applied in an integrated manner to the decision-making problem within the scope of sustainable logistics 4.0 through the criteria of Logistics 4.0 service offerings integrated with the dimensions known as sustainable indicators (economic, environmental and social) depending on the development of production, manufacturing, investment, value chain, strategic service, functional service and quality control for a company-enterprise operating in the Marmara region among the white goods manufacturers in Turkey.

Keywords – Analytic Hierarchy Process (AHP), Industry 4.0, Enterprise, Logistics 4.0, Supply Chain Management, Sustainability

I. INTRODUCTION

Industry 4.0 and Logistics 4.0 are highly scientifically significant terms. They are linked to the common trend of digitization, virtualization and networking of data and information. Logistics 4.0 is part of Industry 4.0 and will support the development of Industry 4.0. It is clear that there is no Industry 4.0 without Logistics 4.0. Industry 4.0 has impacted not only the industrial environment but all related sectors, including services and logistics, and the change is expected to continue.Industry 4.0; It is the name given to the new Industrial Revolution that emerged with the use of Internet of Things (IoT), Big Data and Machine-to-Machine Communication technologies, where business processes are managed with data-based scientific methods. With these technologies, in the system architecture where all the equipment in the production area is defined with a unique internet address (Alçın, 2016; Barreto, 2017; Krykavskyy et al., 2019).

The necessity to invest in new technology is one of the greatest issues facing manufacturing companies during the Fourth Industrial Revolution. An international movement in technologically advanced manufacturing nations is attempting to revitalize (and transform) industrial and manufactured fundamental skills via the application of cutting-edge the use of information and communication technologies. Due to the high cost of these technologies, firms might have to incur debt in order to pay for their widespread use. Businesses could also be responsible for educating their staff on how to utilize these new technology. The requirement to modify their business strategies is another difficulty for manufacturing companies. Manufacturing companies used to be able to compete on pricing. Businesses ought to differentiate themselves on quality, innovation, and interpersonal relationships in the Fourth Industrial Revolution, though. This implies that companies may require to spend money on R&D and create fresh methods of communicating with clients. Advanced manufacturing technologies (AMT) accelerated the development of subsidiary-level R&D skills through assisting with particular R&D initiatives and serving as a catalyst of innovative cooperation. AMT built an environment for integrated development, lowering the risks associated with R&D decentralization.Employees in the industrial sector are facing new problems as a result of the Fourth Industrial Revolution. There may be certain job cuts in industry as automation advances. Nevertheless, new positions might also be generated in the fields of computerized system repair, maintenance, and development. The Fourth Industrial Revolution will also require workers to have higher levels of competence. They will require the ability to use new technology, as well as the capacity for critical thought and problem-solving(Zhong et al., 2017; Posada et al., 2015; Szalavetz, 2019; Horváthand Szabó, 2019).

A number of issues, including shorter product lifecycles, greater diversity, and shifting consumer expectations, are posing difficulties for the manufacturing sector. Companies are gradually turning to new technology to aid in their adaptation to these problems in order to stay successful.In the production sector, innovative technologies like the following are being used: AI is being utilized to streamline processes, enhance judgment, and customize goods and services. Patterns are found by analyzing data using machine learning (ML). This might aid companies in enhancing their operations as well as their goods and services.Physical objects are being connected to the internet through the Internet of Things (IoT). Businesses may now gather data and track their processes in real time thanks to technology. Three-dimensional printing is being utilized to produce prototypes and specialized goods. Businesses may cut expenses and increase efficiency thanks to this.These are only a handful of the most recent advances being applied in the industrial sector. We may anticipate seeing even more innovative technology utilized to aid firms in adjusting to the issues they confront as the sector continues to develop (Spath et al.,2013; Adolph et al., 2014; Lasi et al., 2014; Bauer et al., 2015).

In order to preserve managerial advantages over rivals and to motivate them to adapt to the the outside environment's gradual modifications, such as throughout the course of our conclusions, and enhancing customer expectations, in line with the anticipated shifts, the industry has become more and more prepared to get involved in the advancement of emerging technologieschanges (Spath et al.,2013; Adolph et al., 2014; Lasi et al., 2014; Bauer et al., 2015; Horváth and Szabó, 2019).

The goal of this study is to evaluate Industry 4.0's fundamental ideas, benefits, review of literature, and practical application methods. Discovering recently developed industries with huge data about production system and technology could be done by investigating previously published articles.

This research serves as a foundation for evaluating Industry 4.0 and Logistics 4.0 concepts and content in further depth. One of the most crucial issues in future supply chain strategy could include to enable flexibility although preventing complexity and unpredictability due to the growing supply and demand in supply chains currently. The usage of Industry 4.0 applications and the creation of network-based partnerships are two of the most crucial requirements for flexibility in the supply chain.A review of the literature that covered the ideas of sustainability, industry 4.0, logistics 4.0, and supply chain management was done as part of this study. On this topic, sample implementation studies have been looked at. The development approach supplied by a corporation and the development model provided by white goods manufacturers are contrasted in the context of sustainability based on the features that were gathered and compiled as a result of the studies conducted in accordance with the research's goal.

II. Materials and Method

A. *Industry 4.0*

The shift to an innovation-based economy using data, knowledge, and IoT is represented by Industry 4.0. opens. Industry 4.0 enables quicker than ever responses to consumer demands.Robots are at the center of Industry 4.0.When Industry 4.0 becomes fully operational and social, problems will also arise. The first thing that comes to mind in these problems is unemployment. Industry 4.0 is a target and aims to bring together information technologies and all vital mechanisms. Industry 4.0; It is a set of systems consisting of three stages: the Internet of Things, the services of the Internet, and the cyber-physical systems. This structure makes a great contribution to the formation of the vision of smart factories.In some sources, it is referred to as the 4th Industrial Revolution.Human and material that gave the first impetus to the whole industrial process, paving the way for the acceleration of changes.Period corresponds to the transition from manual to mechanized production (Douaioui et al, 2018:129). After the first industrial revolution, the new goal was to shift from the power of electricity, oil and gas utilization and thus the transition to innovations in world production, communication and transportation paved the way for the second industrial revolution (Alçın, 2016; Barreto et al., 2017; Vyas, 2018; Szalavetz, 2019; Logistics 4.0 and smart supply chain management in Industry 4.0, 2023).

Businesses now have a higher level of awareness and influence over their operations because to the capacity to collect and evaluate data from various sources. They are now able to manage resources more effectively and respond to customer inquiries and requirements more swiftly as a result. Everyone can anticipate seeing many more methods for firms to use data to enhance their processes as Industry 4.0 progresses. This will result in a manufacturing sector that is more profitable, productive, and focused on customers. Here are some instances of how Industry 4.0 is being applied to enhance the production process in more detail: Real-time data from detectors and machinery is being used by businesses to track manufacturing and spot possible issues. Before an issue produces a disturbance, this knowledge can be utilized to take preventative action. Data is being used by businesses to improve their supply networks. To do this, data may be used to analyze product circulation, spot possible bottlenecks, and improve inventory level choices. This may be accomplished by employing 3D printing or other types of technology to produce goods that are customized to each consumer's unique needs (Alçın, 2016; Barreto et al, 2017; Vyas, 2018; Gerbert, 2019; Logistics 4.0 and smart supply chain management in Industry 4.0, 2023).

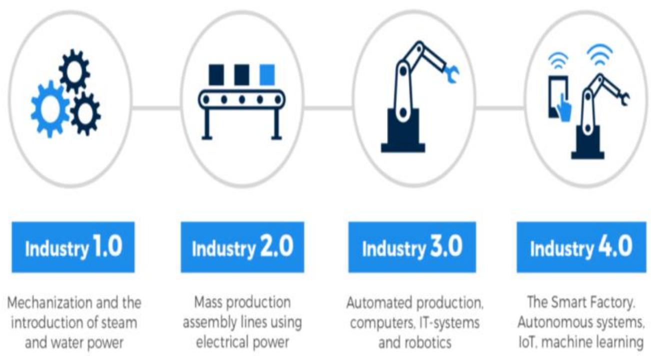

Figure 1. Industrial Revoluation Industry 1.0 to Industry 4.0 (Dima, A., 2021, Access Date: 21.05.2023)

The team manner of living and working has been significantly impacted by each of the four industrial revolutions. Machines and steam power were introduced into the production process during the first industrialization, which got underway in the late 18th century. As a result, production significantly rose and the method commodities were manufactured changed. Electricity and mass manufacturing were introduced during the second industrial revolution, which got underway in the middle of the 19th century. This resulted in new sectors, including the automobile industry, as well as even larger productivity gains. Digital devices and technology for information were first developed during the third industrial revolution, which started in the late 20th century. As a result, bulk production gave way to personalized manufacturing, and new industries—like the software industry—began to emerge. The employment of cutting-edge technology, including artificial intelligence, robots, and the Internet of Things, is a defining feature of the fourth industrial revolution, which is now under progress. Companies may now automate procedures, collect and evaluate data, and tailor goods and services thanks to these technology. The manufacturing industry is significantly being impacted by the fourth industrial revolution. These innovations are being used by businesses to increase flexibility, productivity, and efficiency. These innovations are also being used to develop fresh goods and services that cater to consumer demands. Researchers may anticipate even more changes to the manufacturing sector as the fourth industrial age progresses. Success in the future might be well-positioned for companies that can adapt to these developments. Implementers of Industry 4.0 appear to be more adaptable, smart, and able to adjust, which puts them in a better position to choose bandwidth. These businesses can gather and analyze data in real time, which helps them better understand their clients and business processes. They can automate procedures, which frees up staff members to work on other important projects. These businesses can thus make wiser choices and react to market shifts more swiftly (see Figure 1; Duxbury, 2012; Adolph et al., 2014; Bauer et al., 2015;Harnisch, 2015; Gerbert et al., 2015; Vyas, 2018; Dima, 2021; Dima, 2021).

B. *Logistics 4.0*

Logistics is the process of transporting goods or materials from the center to the destination by using resources such as personnel, vehicles, facilities and equipment. Logistics is an important link in the process from production to consumption. Intelligent systems, the internet of things, artificial intelligence, big data, small data, cyber systems technology, which helped the beginning of the Industry 4.0 process, have developed in connection with the production system. The processes of supplying the raw materials required for production and delivering the goods to the consumer, the management of logistics activities has become increasingly complex and has necessitated the use of these technologies. Digitalization therefore requires careful execution is a necessary process. Additive manufacturing/3D printing, augmented reality, big data analytics, blockchain technology, cloud services, collaborative planning, forecasting and replenishment, unmanned aerial tools, electronic, data exchange, e-procurement, enterprise resource planning, global positioning systems and general packet radio services (GPS and GPRS), pick-to-light and pick-by-voice, radio As logistics is part of this paradigm shift, the new technological environment new tools and knowledge are needed to facilitate adaptation. Technology is not an end in itself, meet current development demands withintergenerational equity and ensure that the logistical operations needed is a tool to improve competitiveness and sustainability (Pfohl et al., 2015; Pfohl et al., 2017; Szymańska et al., 2017; Scherf, 2019; Yılmaz and Duman, 2019; Logistics 4.0 and smart supply chain management in Industry 4.0, 2023).

The conventional supply chain management and logistics hierarchies that consumers are accustomed to seeing are about to undergo disruption. This is because new technologies being developed as a result of the fourth industrial revolution are altering the way consumers conceive about logistics. For instance, companies may now link physical items to the internet thanks to the Internet of Things (IoT). This implies that companies may get information from these gadgets in real time and utilize it to increase production and efficiency. Artificial intelligence (AI) is a different type of technology that is upending the logistics sector. Routing and scheduling duties are two examples of the kind of work that AI is being utilized to automate, freeing up staff to concentrate on more important tasks. A more decentralised and independent supply chain is being created as a result of the advancement of these new technologies. This implies that companies can make better judgments and react to market developments more swiftly. Everyone may anticipate even more modifications to the logistics sector as the fourth industrial revolution progresses. Future success would be ideally situated for companies which could adjust to these developments. Definitely agreed that there could be greater independence across various logistical components in the future. This is as a result of firms seeking for new methods to increase production and efficiency. Corporations may increase their bottom line through implementing automation and using data more effectively. It's crucial to remember that the shift to a more self-sufficient supply chain won't occur quickly. Businesses will face a variety of difficulties, such as the need to invest in new technology and acquire new skills. In general, logistics has an exciting future. A more effective and profitable supply chain is being produced as a result of the development of new technologies. Future success would be strategically located for companies that can adapt to these developments (Alçın, 2016; Barreto et al., 2017; Scherf, 2019; Yılmaz and Duman, 2019; Logistics 4.0 and smart supply chain management in Industry 4.0, 2023).

C. *Sustainablity-Sustainable Growth*

A broad notion, sustainability covers a variety of topics, including population size, schooling, healthcare, reproductive health, and environmental issues.The foundation of sustainability is the notion that current demands must be met without jeopardizing the capacity of future generations to satisfy their own requirements. As a result, we must devise strategies for resource utilization that are both effective and long-lasting.Population expansion is one of the main obstacles to a sustainable way. By 2050, the world's population is projected to be 9.7 billion, placing a pressure on resources including food, water, and energy. Inequalities is another difficulty for sustainable growth. Growing inequality between the affluent and the poor is causing poverty to rise and the natural world to deteriorate.Everyone are able to accomplish a truly sustainable future if they take on these issues. In addition to protecting the natural world, they must discover strategies to foster fair and sustainable growth in the economy. The allocation of resources is an important aspect of sustainable growth in addition to population. They must make sure that funds are allocated in a fair and equal manner. As a result, we must deal with problems like inequalities, poverty, and degradation of the environment.If the developers want to assure an improved future for themselves and for generations to come, they have to confront the complicated problem of sustainable growth. (Hamilton, 1995; Dulupçu, 2000; Dollar, 2001; Redclift, 2005; Hepburn, 2006; Munasinghe, 2009).

The achievement of the framework for sustainability, which takes into account how the economy, society, and environment are all interconnected, depends on a number of other sustainability- sustainabile factors. These functions include social sustainability, ecological sustainability and economic sustainability.

(i)Economic Sustainability: The following refers to the potential of the economic system to meet the requirements of the population at large, the lowering of poverty through the eradication of unfair distribution of income, the eradication of unequal treatment among individuals concurrently with this, and the distribution of useful products and services. Only the smooth operation of such a sound and stable financial system can guarantee the achievement of a sustainable growth model. Only strong economic growth may result in environmental protection and poverty reduction (Dasgupta and Heal, 1974; Hartwick, 1978; Dasgupta and Heal, 1979; Burns and Holden, 1995; Goodland, 1995; Dollar, 2001; Redclift, 2005):

(ii) Ecological Sustainability: The safeguarding of ecological equilibrium provides for ecological sustainability. The fundamental ecological equalizes, life support systems, renewable resource systems, genetic variety, biological productivity, places, and ecosystems have to be adequately safeguarded for the approach to sustainable development to succeed (Munasinghe, 1993; Burns and Holden, 1995; Goodland, 1995; Markandya et al., 2002).

(iii) Social sustainability: Social normsIn a country where the social structure is not well-established, social sustainability cannot be discussed. First and foremost, the social organizations' cultural

organizations should be permitted to operate in a healthy manner in order to preserve social sustainability and a well-established social system. On the other hand, in addition to consistently addressing basic human requirements, social fairness and involvement in decision-making should be guaranteed, and a setting should be created that allows for the maximum amount of engagement. In other words, it is important to promote the involvement of all societal segments in the formulation of sustainable growth strategies. The objective of this is to successfully implement environmental and economic decision-making procedures.(Burns and Holden 1995; Adger, 2000; Markandya et al., 2002; Folke et al., 2005; Yeni, 2014; Blewitt, 2015).

III. Results

The factory has begun to gain from a variety of technological benefits thanks to Industry 4.0. A line of manufacturing which doesn't need human labor, machines that can interact with one another without the assistance of humans, a system that enables production to be started and stopped without entering the manufacturing facility, free of mistakes mass production, product changes made with inadequate software, gathering information in one location, and immediate error correction.

One of Industry 4.0's main advantages is that it may aid in boosting productivity and efficiency in the production process. This is due to the ability of corporations to automate formerly done by people operations using modern technology. For instance, sensors may be used to track the functioning of machinery, and robots can be employed to build items.

The ability to enhance quality control is another advantage of Industry 4.0. This is so that firms may gather and evaluate data on the manufacturing process using modern technology. This information may be utilized to spot possible issues before they become a problem.Ultimately, Industry 4.0 has the potential to increase industrial processes' adaptability.The use of Industry 4.0 technology by a company was assessed in this section of the study in order to assess the manufacturing facilities efficiency and performance of this manufacturing facilities business due to the inputs and results of the features of the production process for the purpose of analysis in regard to management, happiness, and with the organization's expectations.The study that's mentioning assesses how Industry 4.0 technologies affect a company's production efficiency and performance. The research is concentrating on the leadership and satisfaction of the firm, as well as the inputs and outputs of the production system. The goal of this study is to offer recommendations on ways to enhance the company's logistics activities' sustainability. Using Industry 4.0 technology to increase the sustainability of logistics operations is known as "Sustainable Logistics 4.0." The use of sensors to monitor the flow of products, data analytics to plan the best course of action, and the use of energy generated from renewable sources to power logistics processes are a few examples of what this might entail. Recommendations are offered within the perspective of Sustainable Logistics 4.0.

Recommendations are offered in this regard in terms of Sustainable Logistics 4.0. The criteria of Logistics 4.0 service offerings integrated with the dimensions known as sustainable indicators (economic, environmental, and social) based on the evolution of manufacturing, production, expenditures, value chain, strategic service, functioning service, along with quality control for a business were used in this research to apply the Analytic Hierarchy Process method to the issue of decision-making throughout the framework of sustainable logistics 4.0. It appears that the study describes how to use the Analytic Hierarchy Process (AHP) to assess how Industry 4.0 technologies would affect the long-term viability of transport operations for a Turkish manufacturer of white goods. A decision-making technique called the AHP may be used to weigh many choices and reach a conclusion. The process entails dividing the choice into a hierarchy of factors, giving each a weight, and then making the decision. Each choice is given a score based on its weights, and the choice with the greatest score is considered to be the best one. The parameters used in the study you're referring to for assessing the effect of Industry 4.0 innovations on the sustainability of logistical processes are as follows: (i) Economic: The financial effects of the technology, including money saved and money made, (ii) Environmental: The effects of the technology on the natural world, such as the decrease in gases and garbage, (iii) Social: The effects of technology on society, including how it affects employment and local communities.

Indicators have been determined by using various domestic and foreign literature sources, lFacility-activity reports of logistics business, interviews with experts working in the field of sustainable logistics companizes and using the opinions of the authors (Undesa, 2000; Carraro et al., 2009; interviews of the experts, opinions of the authors, reports of business, literatüre about logistics 4.0 and Industry 4.0 etc.). These are presented as Table 1 and Table 2;

Table 1. (a) Criteria of Logistics 4.0 Service Offerings for Sustainable Logistics 4.0 and (b) Social Indicators

(Sustainable Indicators) Criteria of Logistics 4.0 Service Offerings for Sustainable Logistics 4.0	(e)	(s)	(en)
Economic- Value Chain Service Offerings (e)	1	0.2	4
Social-Strategic Service Offerings (s)	3	1	4
Enviromental-Functional Service Offerings (en)	0.4	0.3	1

(a)

SOCIAL INDICATORS (Strategic Service Offerings)
Functional Service Offerings (s1)
Multimodal transportation Full truck load transportation (s2)
Warehousing (s3)
Inventory management (s4)
Customs clearing (s5)
Freight forwarding (s6)
Freight consolidation Reverse logistics (s7)
Packaging/Labeling Import/export management Order processing (s8)

(b)

Table 2. (a) Economic Indicators (b)Environmental Indicators

ECONOMIC INDICATORS (Value Chain Service Offerings)
Help to focus on core competencies (e1)
Reduce logistics costs (e2)
Improve process lead time (e3)
Improve process responsiveness (e4)
Improve process capability and cycle time (e5)
Improve customer service (e6)
Improve conformance quality (e7)
Increase supply chain flexibility (e8)

(a)

ENVIRONMENTAL INDICATORS (Functional Service Offerings)
Reliability (en1)
Cost (en2)
Reputation (en3)
Delivery performance (en4)
Customer relationship (en5)
Flexibility (en6)
Quality of services (en7)
Ability to meet customer needs Strategic commitment to customers (en8)

(b)

The AHP is being used in the study to examine several possibilities for utilizing Industry 4.0 technology in order to improve the sustainability of logistics processes for the manufacturer of white goods. The study's objective is to offer suggestions for how the business might employ such technologies to meet its sustainability objectives.

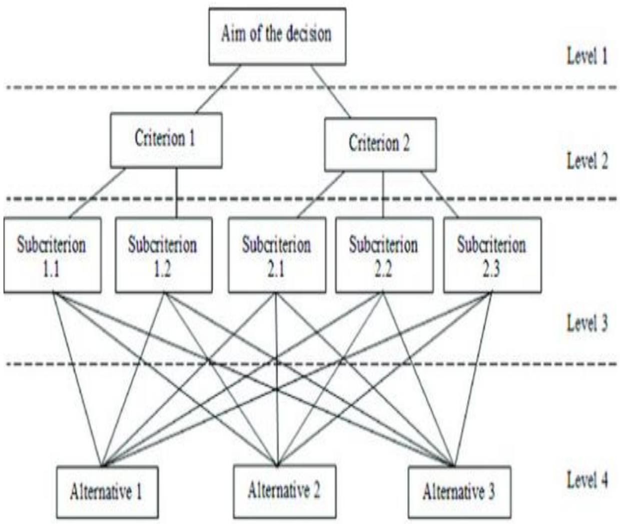

Figure 2. The analytic hierarch process (AHP) approach has a structure that is hierarchical.

An example of a hierarchical structure is illustrated in Figure 2 (Saaty, 1990; Saaty, 2008; Wątróbski et al., 2016). The Analytic Hierarchy Process (AHP) is a pairwise comparison measuring technique that creates priority scales based on the opinions of experts. The approach begins by organizing a decision-making problem as an upside-down tree hierarchy with the primary objective at the top. The second level is reserved for partial aims that support the primary purpose. Each set at each level satisfies the aim of the level to which they are subservient to themselves and each partial goal at the second level can be divided into goals at the third level. In this work, these imperfect aims are regarded as criteria. A lower level compares the options pairwise based on how well they contribute to achieving each goal or criterion from the lower level. Comparisons between pairs are carried out utilizing Saaty's approach (Saaty, 1980; Saaty, 1990; Saaty, 1994; Leal, 2020).

Using a hierarchical framework to reflect the decision issue, the Analytic Hierarchy Process (AHP) is a decision-making technique. Objectives, subgoals, criteria, and choices make up the hierarchy. The decision's overarching aims are its goals. The smaller, more focused objective that must be accomplished in order to complete the goals are known as subgoals. The criteria are the elements that will be taken into account while assessing the decision-making options. The many solutions that might be selected to address the decision problem are known as the choices. The choice problem is made easier to handle by the AHP's hierarchical nature. It also ensures that all pertinent aspects are taken into account while making the decision. The AHP is a somewhat difficult strategy, yet it may be a very useful decision-making tool. It is frequently employed in commerce, engineering, and other industries where complicated judgments must be made (Saaty, 1990; Saaty, 2008; Wątróbski et al., 2016).

AHP, One of the most crucial corporate operations is decision-making. For their choices, managers require projections that are precise and trustworthy. They achieve this by using scientific standards, which would offer superior results. The choice problem may be summed up as the process of choosing the best option from a group of possibilities based on a minimum of one target or criterion. One of the popular techniques for choosing the best option is the Analytical Hierarchy Process (AHP). The approach has drawn a lot of interest and has been applied to the real-world resolution of several decision-making issues. AHP has been applied effectively at a variety of organizations and companies. Despite its universality, the procedure is easy enough to implement in Excel. One of the most significant benefits of AHP is its capacity to be used for group choices, in which every participant can assess pairings and the group outcome is derived as the mathematically optimal agreement. In reality, the method's answers are well accepted since the outcomes are impartial and devoid of political interference. AHP has been used more frequently in recent years in conjunction with other methodologies, and Goal Programming and AHP are typically used to solve decision-making issues. In a setting with several criteria for decision-making and numerous decision-makers, the procedure is used to select among a sizable number of choices in the presence of certainty or ambiguity. This approach is founded on the idea that, when making decisions, information and experiences are just as important as statistics. The following phases make up the decision-making procedure using AHP steps (Saaty, 1980; Markland, 1989; Schniederjans and Wilson, 1991; Saaty, 1994; Yurdakul, 2000): These steps are as below;
(i) Define the choice issue. Which is the critical choice to be made? Whatever are the decision's objectives? (ii) Create a hierarchical framework. Divide the choice issue into criteria, subcriteria, and decision options.Discover the criterion weights. To establish the relative relevance of the criteria, use pairwise comparisons. (iii) Consider the decision options. Pairwise comparisons should be used to analyze the various options based on each criterion. (iv) Compute the decision-alternative ratings. The assessments of the choice possibilities on each factor are multiplied by the weights of the criteria to determine the scores of the decision possibilities. (v) Choose the best option for a choice. The best decision alternative is the one that received the highest score. (vi) Making difficult judgments is possible with the help of the AHP, a potent decision-making technique. It's crucial to keep in mind that the AHP is a sophisticated procedure and might not be appropriate for all selections.

The Saaty's ratio scale, which ranges from ‘1’ to ‘9’ and consists of opposing values, ought to be included when defining the positivity of matrix structures. Whereas ‘1’ denotes equality of the contrasted alternates or the criteria and 9 denotes an important advantage of alternative or criteria throughout all others. Table 3 provides the definitions of each value on the Saaty's ratio scale(Saaty, 1980; Markland, 1989; Saaty, 1994; Bevilacqua and Braglia, 2000;Saaty, 2001; Saaty, 2008).

Table 3. Numerical and verbal values of the scale for the AHP method (Bevilacqua and Braglia, 2000; Saaty, 2001; Saaty, 2008)

Numerical Evaluation	Verbal Evaluation
1	Compared objects (decision alternatives or criteria) are equivalent
2	The decision-maker hesitates between an equivalent and weak advantage of one object compared to over the other
3	A weak advantage of one object over the other
4	The decision-maker hesitates between a weak advantage and a considerable advantage of one object compared to the other
5	A considerable advantage of one object over the other
6	The decision-maker hesitates between a considerable advantage and a significantly bigger advantage of one object compared to the other one
7	A significantly bigger advantage of one object over the other
8	The decision-maker hesitates between a significantly bigger advantage and a huge advantage of one object compared to the the other
9	A huge advantage of one object over the other

AHP is an equation-based method for evaluating qualitative and quantitative factors in decision making which incorporates into consideration the top choices of the group or individual.Human judgements are increasingly being used in decision-making situations. AHP attempts to give the possibility for decision-makers to understand their own decision-making processes through taking into account experiences of decision-makers in various psychological and sociological contexts. The goal of this strategy is for the decision-makers to adopt decisions that are more efficient. .The relative weights of subitems within categories must be calculated through normalization utilizing these significance numbers. Finally, based on the subjective values of the upper levels, determine the weights of the lowest level items (options) in the hierarchy. (When making a decision using AHP, the relative significance of a choice comparative to a higher-level object, the corresponding significance of that top-level item comparative to a higher-level item, and so on) the overall relative benefits of the alternatives may be discovered at the level of terms. A complete exploratory rating is established through ordering the choices from best to worst in terms of their entire relative benefits.(Saaty, 1980; Saaty, 1994; Dağdeviren & Eren, 2001: Bevilacqua and Braglia, 2000;Saaty, 2001; Saaty, 2008).

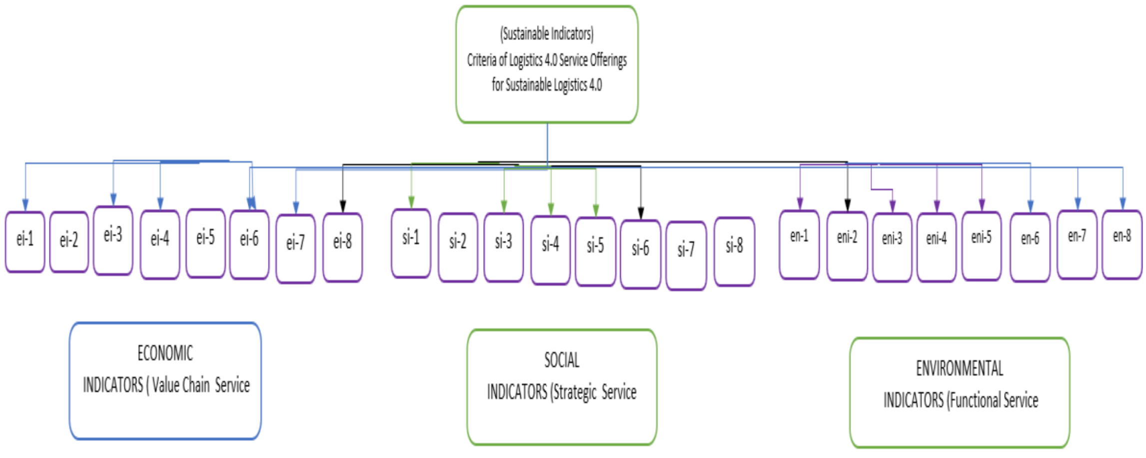

Figure 3. A AHP Model to Solve the Problem by the criteria of Logistics 4.0 service offerings incorporated with the dimensions known as sustainable indicators (modified by author)

In the Analytical Hierarchy model, as in Figure 3, there is a goal at the top of the hierarchy, and below this goal, there are criteria and options, respectively. The criteria of Logistics 4.0 service offerings incorporated with the dimensions known as sustainable indicators (economic, environmental, and social) based on the improvement of the manufacturing process, investing, value chain, strategic service, functioning service, and quality control for a company-enterprise were used to apply the Analytic Hierarchy Process technique in a coordinated way to the decision-making problem throughout the context of sustainable logistics 4.0.

Table 4. Assessment of Sustainable Development Indicators via Integrating AHP method - Criteria of Logistics 4.0 Service Offerings for Sustainable Logistics 4.0

Matrices to Fill | *reduced matrices* | *coefficients* | *Aw(t)* | *CI* | *CI/RI*

(Sustainable Indicators) Criteria of Logistics 4.0 Service Offerings for Sustainable Logistics	(e)	(s)	(en)	reduced matrices			coefficients	Aw(t)		CI	CI/RI
Economic- Value Chain Service Offerings (e)	1	0.2	4	0.762	0.706	0.545	0.671	2.158			
Social-Strategic Service Offerings (s)	3	1	4	0.190	0.176	0.364	0.244	0.753	3.110	0.055	0.095
Enviromental-Functional Service Offerings (en)	0.4	0.3	1	0.048	0.118	0.091	0.085	0.258			

ECONOMIC INDICATORS (Value Chain Service Offerings)	e1	e2	e3	e4	e5	e6	e7	e8	reduced matrices								coefficients	Aw(t)		CI	CI/RI
Help to focus on core competencies (e1)	2	5	0.4	2	3	0.3	0.3	0.4	0.093	0.275	0.077	0.059	0.222	0.081	0.056	0.222	0.033	0.103			
Reduce logistics costs (e2)	0.3	1	0.3	3	0.4	0.3	0.3	0.4	0.053	0.057	0.077	0.059	0.056	0.081	0.333	0.056	0.018	0.092			
Improve process lead time (e3)	4	7	1	1	4	1	1	1	0.356	0.362	0.231	0.354	0.333	0.323	0.028	0.333	0.003	0.127			
Improve process responsiveness (e4)	2	0.5	0.5	2	0.4	0.3	0.5	1	0.093	0.031	0.120	0.354	0.028	0.067	0.333	0.028	0.012	0.103	6.456	0.163	0.126
Improve process capability and cycle time	0.4	4	0.4	4	1	0.5	3	2	0.125	0.143	0.447	0.168	0.333	0.171	0.349	0.333	0.027	0.181			
Improve customer service (e6)	5	5	1	3	3	1	1	0.5	0.353	0.362	0.077	0.3354	0.246	0.326	0.043	0.182	0.042	0.193			
Improve conformance quality (e7)	3	2	0.4	0.4	1	4	4	0.6	0.093	0.031	0.447	0.059	0.093	0.231	0.117	0.091	0.057	0.131			
Increase supply chain flexibility (e8)	4	3	3	1	0.3	1	1	1	0.125	0.143	0.448	0.067	0.143	0.120	0.246	0.273	0.072	0.31			

SOCIAL INDICATORS (Strategic Service Offerings)	s1	s2	s3	s4	s5	s6	s7	s8									coefficients	Aw(t)			
Functional Service Offerings (s1)	1	4	0.3	3	0.5	3	0.4	0.4	0.356	0.093	0.191	0.257	0.192	0.185	0.362	0.168	0.175	0.103			
Multimodal transportation Full truck load transportation (s2)	0.3	1	0.3	2	0.3	1	0.5	1	0.093	0.178	0.183	0.325	0.191	0.067	0.031	0.029	0.052	0.181			
Warehousing (s3)	3	4	3	3	0.3	4	0.6	1	0.125	0.181	0.097	0.087	0.183	0.176	0.143	0.254	0.231	0.031			
Inventory management (s4)	0.5	0.4	0.4	1	0.5	1	1	3	0.089	0.367	0.277	0.173	0.097	0.192	0.183	0.257	0.052	0.128	6.567	0.167	0.135
Customs clearing (s5)	4	4	3	4	1	3	4	3	0.253	0.123	0.097	0.253	0.362	0.261	0.261	0.325	0.020	0.101			
Freight forwarding (s6)	0.6	0.5	0.4	1	0.3	1	5	0.3	0.087	0.132	0.277	0.191	0.031	0.257	0.089	0.087	0.016	0.125			
Freight consolidation Reverse logistics (s7)	0.3	0.4	0.5	0.5	0.5	1	0.6	0.4	0.067	0.370	0.098	0.183	0.143	0.231	0.354	0.192	0.029	1.587			
Packaging/Labeling Import/export management Order processing (s8)	0.5	0.4	0.4	0.4	0.5	0.5	3	0.3	0.171	0.145	0.370	0.097	0.089	0.087	0.254	0.261	0.007	0.456			

ENVIRONMENTAL INDICATORS (Functional Service Offerings)	en1	en2	en3	en4	en5	en6	en7	en8									coefficients	Aw(t)			
Reliability (en1)	1	4	0.3	0.4	0.3	1	0.3	0.4	0.029	0.067	0.077	0.182	0.088	0.097	0.087	0.123	0.007	0.065			
Cost (en2)	0.4	1	0.3	0.4	0.3	0.5	0.3	0.4	0.254	0.176	0.231	0.182	0.093	0.176	0.231	0.132	0.006	0.033			
Reputation (en3)	3	1	2	0.5	0.4	3	1	1	0.257	0.192	0.120	0.364	0.178	0.182	0.240	0.192	0.023	0.127			
Delivery perfomance (en4)	3	0.5	1	0.5	0.3	4	0.5	1	0.243	0.188	0.222	0.333	0.181	0.245	0.063	0.077	0.015	0.103	6.257	0.063	0.084
Customer relationship (en5)	3	2	2	1	1	3	3	2	0.325	0.261	0.447	0.3354	0.367	0.327	0.572	0.231	0.031	0.176			
Flexibility (en6)	1	3	0.5	0.3	0.4	1	0.5	0.3	0.087	0.127	0.188	0.111	0.167	0.087	0.065	0.191	0.128	1.280			
Quality of services (en7)	0.3	1	0.3	0.3	0.3	0.5	2	0.5	0.031	0.067	0.250	0.444	0.333	0.087	0.123	0.183	0.175	0.320			
Ability to meet customer needs Strategic commitment to customers (en8)	3	3	1	2	0.5	3	1	0.5	0.335	0.601	0.125	0.074	0.056	0.231	0.132	0.097	0.050	1.629			

As a result of the application made with the AHP as seen Table 4, it has been seen that the Economic Indicator (economic criteria: 0.193) has a higher priority in ensuring Sustainable Indicators)

Criteria of Logistics 4.0 Service Offerings for Sustainable Logistics 4.0 for a company-enterprise operating in the Marmara region among the white goods manufacturers in Turkey. Improve Customer Service (0.193), which is among the economic indicators, has a higher value than the others. Second priority is the Social Indicator (social criteria: 0.181). The Environmental Indicator (environmental criteria: 0.076) is in the last place.Multimodal Transportation (1.181), which is among the social indicators, has a higher value than the others and has a higher priority in this indicator group.Considering the environmental indicators, Customer Relationship (1.176), which is among these indicators-criteria, has a higher value than the others and has a higher priority in this indicator group.It would be crucial for the advancement of sustainability and sustainable development to give more priority to and work to enhance certain sustainable change criteria-indicators.

To sum up, AHP is a technique that is frequently used in the field of decision theory and includes a measuring technique that considers opposing, quantifiable, or conceptual criterion. By developing multi-level decision frameworks and producing pairwise comparison matrix with AHP, qualitative ratings of criterion and choices are calculated (Saaty, 1980; Vargas, 1990; Saaty, 1994).

Industry 4.0 is essentially a process that has a significant impact on manufacturing. Since manufacturing and logistics cannot be thought of independently. Innovation and Industry 4.0 really interact frequently. Nowadays, it could be exceedingly unlikely for one to continue functioning without the other.

A company developing a machine learning-related product or service may find that there isn't enough demand for it in the market if it doesn't provide a unique answer. Every new product may be created from an inventive standpoint. Many firms were forced to transition away from the physical setting and toward digital. Big data, machine learning, neural networks, and a wide range of digital services have brought this to their attention once again. As a result, individuals may employ industry 4.0 as a technology for effective mass-prevention of the major issues we face today. The need for human labor will decline as a result of many of the improvements brought on by Industry 4.0.

IV. CONCLUSION

Internationalization, rivalry, and the advancement of business technology have prompted industries to evolve in order to manufacture goods. This is one of the most significant logistical issues confronting productive companies. To make a significant difference, fast technology adoption is required. Industry 4.0 is essentially an approach that has a significant impact on manufacturing. Because it is impossible to separate manufacturing and logistics, all of Industry 4.0, which has begun to have an influence throughout the world, has revolutionized the way business is done in the logistics industry.

The latest phase of the Fourth Industrial Revolution, or Industry 4.0, is a time of intense technology advancement that is revolutionizing our way of life and the way we work. Because companies are rapidly utilizing new technology to automate procedures, gather and analyze data, and tailor goods and services, this revolution continues to have a tremendous influence on the logistics sector.

Using Industry 4.0 technology to increase the effectiveness and sustainability of logistics businesses is known as "logistics 4.0." The use of sensors to monitor the flow of products, data analytics to plan the best course of action, and the use of environmentally friendly energy for powering the logistic

Though Industry 4.0's transferring environment is causing supply chain management to change, people are still required to plan and carry out actions since not all tasks can or should be automated. Depending matter how independent everyone want organizations to be, this is true.To satisfy the demands and objectives underlying Industry 4.0, nevertheless, a more computerized, intelligent, and more independent transportation of resources, supplies, substances, , and data between the place of creation and the location of consumption, as well as the numerous sites in between, is essential.

Major expenditures in the acquisition, updating, and maintenance of technological infrastructure pose challenges in complementing and updating the technologies used in logistics processes to enhance efficiency and enable the transition to Logistics 4.0 in order to satisfy the needs of customers and consumers. This method allows logistics systems to react rapidly to clients, boost order traceability and visibility in real time, and promote joint decision-making among different supply chain participants.

The advances connected to Industry 4.0 have had a direct impact on all types of company decision-making processes. While industry 5.0 is now being discussed, all firms have finished the process of adjusting with industry 4.0 and have been required to establish novel company structures that include technology connected to new inventive methods. Through the viewpoint of industry 4.0 and innovation, all these different innovations could include at the core of our lives. They could change vocations, satisfy existing wants, and maybe even generate new ones. Industry 4.0 includes logistics, which will aid in the growth of industry 4.0. It is evident that Industry 4.0 cannot exist without Logistics 4.0.The necessity for a translucent dispersed, adaptable, resilient, dynamic, predictive, and intelligence logistics framework is one of the biggest obstacles to establishing a Logistics 4.0 infrastructure.

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