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Industry 4.0 Journey and Key Resources

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Abstract

Contemporary industry development has continued for hundreds of years, and has undergone three major changes. Today, a new process, which is the fourth industrial revolution, Industry 4.0, has been introduced. Industry 4.0 is a goal and aims to bring information technologies and all vital systems together. Industry 4.0; It is a set of mechanisms consisting of three processes: internet services, internet of things and cyber physical systems. The fourth industrial revolution, which will bring the new world order, all of the production and living areas will have smart equipment and the systems will work in an integrated manner. It is inevitable for firms to apply the fourth industrial revolution to their organizations in order to protect and sustain their existence in the current competitive environment. In this context, in the study, information about the process leading to the fourth industrial revolution, the concept of Industry 4.0 was emphasized and brief information about the cyber physical system, internet of things, data analytics, big data and smart factories, which are used as important sources for the success of this revolution, are included.

Keywords: Intelligent Production, Industry 4.0, Industrial Revolution

Introduction

The concept of industry or industry is a branch of activity that has been constantly changing over the years. The techniques used in production and management in the production process continue to change over time. This change caused not only production processes or industry, but also the demographic structures, economic conditions, cultures of the countries, and even the borders of the countries. The beginning of the change in question is shown in the trend of change that started in England in the mid-18th century. Later, this trend spread across Europe and the world. Throughout history, there are two important changes that have led to economic growth, which has affected the lives of societies. These changes take place in the history of the economy as the agricultural and industrial revolution (Pamuk and Soysal, 2018: 42 ;Özsoylu, 2017: 42).

The agricultural revolution is the transition of societies that continue their lives with hunting and gathering, to the settled life and domestication and farming and livestock. This change has caused radical changes in the social and economic life of societies. As a result, settled life has begun, population growth has increased, leading to the development of architecture, art and culture, private property understanding has emerged, management style and administrative structuring have developed (Özsoylu, 2017: 42).

After this period, the industrial revolution, the second important development, started approximately 10 thousand years later. The industrial revolution that started in England in the late 18th century is the replacement of muscle power to machine power. With the presence of steam machines and ginning machines and entering business life, textile factories started production, production increased and became cheaper. For this reason, the invention of steam machines, the most important elements that started the industrial revolution, is considered as the prevalence of the production and use of textile and iron mine. The industrial revolution that started in England

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spread to other European countries and the USA in a short time, the level of wealth and prosperity has increased continuously. Industrialization has made the majority of the population in the agricultural sector producing in the industrial and service sectors (Ortaş, 2005 :2).

The industrial revolution that began in the late 18th century, the industrial age, has undergone four major revolutions until today with the change and development it has introduced. The first revolution started with the use of steam and water power and machinery in the factories, and the second revolution continued with the use of electricity and the wholesale production. The third revolution started with computers entering our lives. The industrial revolution, which radically changed life in the 1800s, has been transformed for the fourth time in itself, and Industry 4.0, a new revolution, appears before us. Industry 4.0 includes an industry that adds "intelligence" to the production stages with the connectivity and convenience provided by the internet. Businesses and factories are getting smarter with different technologies every day (Öztürk and Koç, 2017: 787).

The Industry 4.0 revolution brings a new standard of living to today's world. Intelligent production systems, the internet of things, the internet of systems, 3-D printers, three-dimensional printers, smart sensors, drones, robotic technologies, wearable technologies, big data, cloud computing, data transfer, artificial intelligence and many more technological concepts have not saturated before us stands as market opportunities. Firms need to be open to change and make good use of these opportunities. In this new revolution, it is predicted that individual entrepreneurs will be more in the foreground than rooted firms. Entrepreneurship will be important topics for companies that want to improve themselves, to master software languages, to focus on innovation, to learn continuously, to manage technology and innovation (Dirsehan, 2017: 1).

Expressed with different concepts such as the Digitized Industry, the Fourth Industrial Revolution and Digital Transformation, Industry 4.0 develops a flow and revolution that will affect all sectors of economies and companies of all sizes. Continuing industrial activities without taking part in this flow seems challenging. Industry 4.0 should be involved in all future policies, investments, plans and projects of institutions (Fırat and Fırat, 2017: 211-212).

In this study, it is aimed to explain the process leading to Industry 4.0, Industry 4.0 and its tools to the readers and to show the innovations and privileges brought by Industry 4.0 in the globalizing world. In the following sections, the definition of Industry 4.0 has been explained in detail and the necessary tools have been introduced and emphasis has been emphasized.

The Process That Leads to the Fourth Industrial Revolution

Before the fourth industrial revolution, producers continued their production with the understanding of production in the second stage of the industry. The main goal here is to make life easy. Machinery and equipment developed in different fields from transportation to household appliances have always been aimed at this purpose. However, with the gaining weight of electronic and information technologies, which started to be commercialized and entered daily life in the early 1970s, automation of production has increased and its move to advanced stages has brought different and new dimensions (Özsoylu, 2017: 44).

Especially the years of 1980-1990 brought very different approaches to production processes. As the market grew, the competition increased at the same rate. With globalization, the economy of scale has been replaced by the economy of scope and the goal of all companies has been to open up to the world or to become a brand. With these developments, industries have turned to specialization and efficiency in production, to higher quality and cheaper production. During this period, developments in two areas were very determinant. The dazzling changes seen in the communication, information and communication sectors heralded the fourth industrial revolution. At the beginning of the 3rd industrial revolution, this sector experienced slow and weak developments, and there was a complete boom in a short time. Computers have developed and become so small that they can be used in pockets, they can be used by everyone and have become widespread. Undoubtedly, the acceleration of this

process has been achieved with the spread of the internet. By entering a new period, the world has shrunk and the concepts of time and space have gained new meanings (Görçün, 2016: 45).

After these new developments and changes, production patterns changed and supply chains gradually expanded. With the development of computers, design activities differed and diversified. Computer-aided production with advanced technology has become widespread and broke ground. In addition to this process, developments in other branches of science were added, interdisciplinary studies increased, mechanical devices were enriched with electronic elements and became smart.

When summarized finally, there have been changes in the structural features and all processes of the industry. The developments in communication, information and communication technologies before Industry 4.0 and the direct use of these developments in the industry point to the end of an era and a new era (Görçün, 2016: 45; Özsoylu, 2017: 45).

Industry 4.0

Industry 4.0 first appeared in 2011 with official documents and became the harbinger of a new industrial revolution. This system, which is tried to be developed in order to meet the basic needs, has become a serious mainstay as a result of the dimensions of the technology. To understand why this change is called Industry 4.0, the studies and developments in Germany should be examined. This trend emerged in Germany and spread over the world over time. First of all, in 2011, the German Ministry of Education and Research created 10 projects that they thought would contribute to the development and development of the future by evaluating the current situation of the country and these projects were published under the name of "Future Projects of 2020 in High Technology Strategy". The main purpose of this project was about the use of new energy sources, sustainability and smart technology. One of the projects published was Industry 4.0 and was first announced at the Hannover Fair (Fang, 2016: 326; Pamuk and Soysal, 2018: 44).

This change, referred to as Industry 4.0, includes a structure that will completely change the relations of production and consumption. On the one hand, it explains the production systems that adapt to the changing needs of the consumer instantly, and on the other hand, it describes automation systems that are in continuous communication and coordination with each other and encourages close cooperation between various disciplines in product development (Sinan, 2016: 22; Herter and Ovtcharova, 2016: 400).

Mrugalska and Wyrwicka (2017) describes the concept of Industry 4.0 “integration of complex physical devices and machines with networked sensors and software used to better predict, control and plan commercial and social outcomes” or “a new value chain organization throughout the lifecycle of products. and the level of management ”. Industry 4.0 has focused on optimization of value chains due to its autonomous control and dynamic production. It covers the design and implementation of competitive products, services, strong and flexible logistics and production systems. Batista et al. (2017) state that Industry 4.0 is an advanced development stage in the organization and management of the entire value chain process in the manufacturing industry, sensor and actuator infrastructures. Can and Kıymaz (2016) say that Industry 4.0 plans to work jointly with each other, directly or indirectly related to production, and envisages digital data, software and information technologies to work in integration with each other. According to Jian et al. (2016), Endütri 4.0 includes various factories, companies, suppliers, logistics, customers, resources, etc. means a complete communication network that will exist between. Here, each section optimizes real-time configurations based on the demand and condition of the relevant sections in the network. In other words, the future business network is being added by each collaboration department that can achieve self-organizing status and deliver real-time responses. Andreas et al. (2016) report that Industry 4.0 is the new technological developments that are the backbone of the internet and support technologies integrating physical objects, human actors, smart machines, production lines and processes across organizational boundaries.

In a globalizing world, the way to economic development and growth is possible with a steady increase in exports. The increase in exports brings with it competition and with the increasing competition, it is possible to use resources effectively (Şimşek and Yiğit, 2019: 175). In this context, Industry 4.0 revolution is seen as an important strategy for survival in the future competitive environment. This includes flexible logistics and production systems, as well as the design and implementation of competitive products and services. Industrial companies are currently focusing on the concept of industry 4.0 to tackle challenges such as increased individualization of products, increasing resource efficiency and shortening time to market (Rennung et al., 2016: 374). Another reason for focusing on Industry 4.0 is the change in consumer demands. Today, individuals have started to need to quickly access new products due to the globalization of the world and the amount and variety of products produced. Therefore, it is vital for companies to launch their new product as quickly as possible. In addition, the need to meet individualized customer demands is considered as one of the factors that trigger the last industrial revolution (Pamuk and Soysal, 2018: 45).

In smart factories emerging with the new revolution, technological devices connected with inretnet control the entire production chain and make their own decisions. New technologies bring the digital, physical and biological worlds together. These worlds, which are integrated with each other, change the ideas about the sectors, economies and markets. In order to adapt to Industry 4.0, it is not enough for companies to change production lines only. In order to be successful, all processes of both production and marketing must be re-planned (Öztürk and Koç, 2017: 788).

The objectives of Industry 4.0 are to provide mass customization of products produced by information technologies, to ensure automatic and flexible adaptation of production chains, to monitor parts and products, to facilitate communication between products, machines and parts, to apply human-machine interaction paradigms, to provide internet-enabled production optimization of objects in smart factories. and to provide new types of services and business models in terms of value. In addition, the importance of Industry 4.0, which transforms the world into a huge information system by connecting individuals, objects and systems on the road to value creation, and the positive effects it brings to production can be listed as follows (Öztürk and Koç, 2017: 788; Mrugalska and Wyrwicka, 2017: 470; Lu, 2017):

- Efficient use of energy resources
- More automation in production with Industry 4.0, more mass production depending on customer preferences, maximum production quality, fast innovation process and less resource usage
- Minimizing the cost of producing personalized products
- Manufacturing processes to allow more flexible and free systems and applications
- Facilitating logistics operations by increasing the data transmission speed and ensuring the production of products closer to the customer thanks to 3D printers.
- Eliminating the problems in the demand chain
- Optimizing decision making thanks to real-time end-to-end visibility
- Providing the highest output from a given resource volume and using the lowest amount of resources possible to achieve a specific output
- Innovative services, new forms of employment, enabling SME’s and new enterprises to develop

Industry 4.0 Tools

Industry 4.0 covers numerous technologies and associated paradigms. Some of these are Radio Frequency Identification, Enterprise Resource Planning, Internet of Things, Industrial Internet of Things, Cyber-Physical Systems, Cloud-Based Manufacturing, Smart Factory, Smart Product, etc. can be listed as. These features are not only highly associated with internet technologies and advanced algorithms, but also point out that Industry 4.0 is a value-added information processing and industrial value-added process. Industry 4.0 needs some important tools in order to achieve its goals. With these tools, the above-mentioned objectives can be achieved by

improving the information network and communication. Here, some of Industry 4.0 tools such as cyber-physical system, internet of things, data analytics, big data and smart factories are briefly summarized.

Cyber-Physical System

All the structures that involve the communication and coordination between the cyber world and the physical world are defined as Cyber-Physical Systems. In addition, Cyber-Physical Systems, which is an important part of the fourth industrial revolution, means controlling the machines with extraordinary intelligent and flexible software Pamuk and Soysal, 2018:46 ;Sinan, 2016: 27). The main role of Cyber-Physical Systems is to fulfill the agile and efficient requirements of production and to increase the efficiency and profitability of the entire industry. The fourth industrial revolution is characterized by an unprecedented connection called the Internet and Cyber-Physical Systems, which can be considered as systems that connect the physical and virtual world. More precisely, Cyber-Physical Systems is the integration of computation with physical processes. It is to provide a completely new degree of inspection, surveillance, transparency and efficiency at this production stage. Cyber-Physical Systems perform the integration of networks using multiple sensors, actuators, control process units and communication devices, as shown in figure 1 below. In Cyber-Physical Systems, previously programmed systems can operate without requiring any intervention by providing M2M† communication thanks to the software and sensors embedded in the built-in production factors. Therefore, with a programming to be made at the beginning of the system in a general framework, the entire process of the system can be performed automatically without any intervention or extra effort (Hofmann and Rüsch, 2017: 29; Oesterreich and Teuteberg, 2016:137; Lu, 2017).

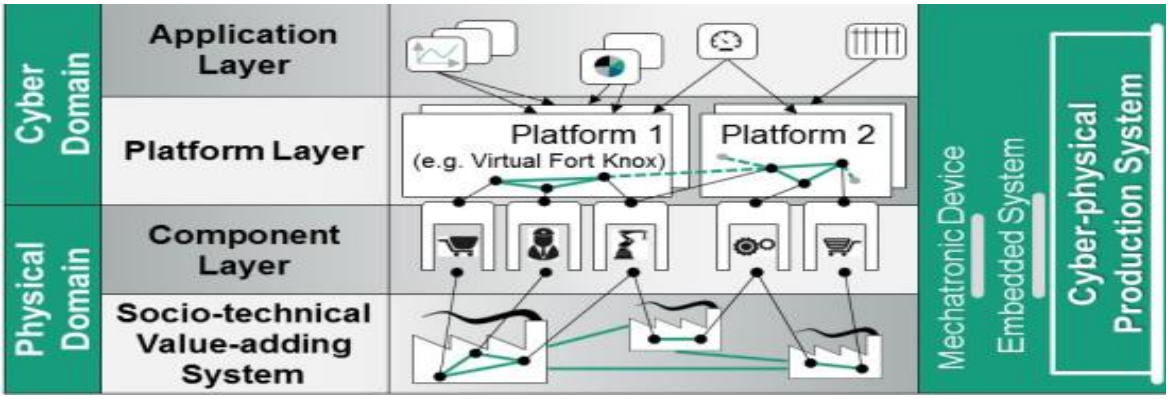

Figure 1: Cyber-Physical Systems (Landherr et al., 2016: 27)

One of the most distinctive features of Cyber-Physical Systems is that very difficult operations can be realized in a very short time with human intelligence and power. Since Cyber-Physical Systems are connected to the internet, they can access the data very quickly and process the obtained data and incorporate it into the production process. It can also adapt to external conditions as it can connect with the outside world (Görçün, 2016:50).

Internet of Things

While the Internet of Things is referred to as "The Lot", it includes the communication of physical devices with network connections and remote control of these objects. This system, which enables the communication of the machines among themselves, continues to develop rapidly (Gubbi et al., 2013: 1650; Roblek et al., 2016: 7). The Internet of Things is expected to open many economic opportunities and is considered one of the most promising technologies with great destructive potential. The expression of the Internet of Things was put

† M2M is the technology that enables companies to communicate wirelessly between information centers and machines.

forward by entrepreneur Kevin Ashton. The idea was formulated in 1999 to describe a system where the physical world communicates with computers and sensors located everywhere. With this formula, a system of everything was created by considering not only the objects but also processes, data, people and even animals or atmospheric phenomena as a variable Hofmann and Rüsch, 2017: 31; Witkowski, 2017: 766). The concept of "Internet of Things" became famous in the early 21st century and was considered as a technology that enables industries to move from Industry 3.0 to Industry 4.0 by adding information to products and processes in the supply chain Hofmann and Rüsch, 2017: 31; Trappey et al., 2017: 220).

Smart Factories

With each industrial revolution, the production stages of the factories have changed and the role of the human factor in production has changed with the introduction of automation. Employment growth and economic growth are among the main objectives of the fourth industrial revolution. With the fourth industrial revolution, new work stages in production are expected and a change in the required workforce profile is expected. It is estimated that the need for low-qualified workforce will decrease with the establishment of smart factories and the high-tech automation systems used with it. The new design aims to further reduce the rate of error in production, speed up the production process and further reduce production costs. The basic tools of creating smart factories are the automation systems we mentioned in our study. Providing M2M communication will ensure that the coordination in the production process is smooth and timely. For this to be created, the internet system of objects must be implemented without any problems, and communication between the machines must be supported by software and sensors. In addition, cyber-physical systems also play a major role at this stage (Pamuk and Soysal, 2018: 47).

The benefits of smart factories include mass customization that allows people to order a custom product, or to make their own design, in the prototyping process or just before the product reaches its final form. Another important factor is flexibility. M2M communication and creating cyber physical systems will add flexibility to the production stages and make it easier to make some changes in the process. In addition, it is crucial that the system inside smart factories acquire the ability to perform and perform big data analysis appropriately. In addition, the benefits of this system are not only within the factory, but will also help the supply chain network to have more information about these situations (Shrouf et al., 2014: 698; Tuominen, 2016: 380).

Data Analytics and Big Data

Large and complex datasets that are too large to be processed by existing information systems are called big data. In other words, the data that is larger than the known database management systems and software tools' ability to collect, store, manage and analyze is called "big data". Big data includes every action an internet user does on the internet. Every website entered during the day and every point clicked has the characteristics of a data. To date, all this information has been characterized as an information dump, as it is not possible to store data in existing databases and use it in reporting systems (Özsoylu, 2017: 51). In today's world, data is produced through devices and machines and stored in cloud infrastructure systems. Business management or consumers in normal life can access this data when needed. It is estimated that the size of the data in the existing networks will be much more in the coming years. So from an industry perspective, big data will play an important role for Industry 4.0. According to the German government, the fuel of the fourth industrial revolution is expected to be big data (Roblek et al., 2016: 9; Yin and Kaynak, 2015: 144).

Big data offers very important opportunities. First of all, there are three important values such as lowering costs, improving decision making, and improving products and services. When big data is analyzed with the right analysis methods, it will provide a basis for businesses to be more accurate in their decisions, manage their risks better, and encourage innovative breakthroughs. Considering that the right plans can be produced only from the right information, the importance of big data for Industry 4.0 is also clear. Companies that use big data correctly and purposefully will take the lead in a competitive environment, increase efficiency, decrease costs,

supply methods will improve, customer relations and marketing approaches will become more dynamic Davenport, 2014: 55; Özsoylu, 2017: 53).

Conclusion

Industry 4.0, which is accepted as the fourth revolution of the industrialization process, is the edible period that will affect all layers of the society with the public and private sectors. The informatics infrastructure that forms the fourth industrial revolution realizes smart production, new production prototypes emerge with smart production, and as a result, structural changes are expected in the processes ranging from daily life to work life, from the structure of products to supply and sales. Until the fourth industrial revolution, every industrial revolution prepared the ground for minor and important changes. With the internalization of communication, internet, informatics, automation, robots and data collection technologies in daily life and production phase, progress will be achieved in the fourth revolution of the industry.

The creation of industrialization value of countries with developed industries takes shape with the revolution called Industry 4.0, which is now the fourth stage of industrialization. This revolution follows the third industrial revolution that began in the 18th century and was based on electronics and information technologies to achieve a high level of automation in production.

The development for the fourth industrial revolution has now had a serious impact on the manufacturing industry and will continue to multiply in the future. For this reason, companies that want to increase their competitiveness in the future should apply the Industry 4.0 revolution to their production organizations and consequently use technologies such as smart robots, cyber-physical systems, and cloud-based manufacturing in their factories.

Finally, in order for countries to catch up with Industry 4.0 and to be among the leading countries, steps should be taken to facilitate the access of all industrial companies to digital technologies and to create digital platforms. In addition, policy makers and academics need to provide appropriate solutions for the widespread use of the smart industry, and all stakeholders need to focus on a common goal.

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