The Effects of Artificial Intelligence on Industry: Industry 4.0

Serkan SAVAS
Cankiri Karatekin University

Introduction

For many, when the industry is mentioned, the first thing that comes to mind is Factories and Production. There is a term that has been heard frequently in the last decade: Industry 4.0. Although this term, which has been used for the last decade, connotes with words such as “factories” and “industry”, when it comes to the subject, a huge scope emerges. Before starting to explain this scope, it is necessary to mention the versions “1.0”, “2.0”, “3.0”.

Wars have been the factors determining the living spaces of nations and the borders of countries for centuries. However, the factors affecting the changes in living conditions and lifestyles and affecting the economies of societies have been agriculture and industry. The biggest factor affecting the transition from nomadic life to a settled life by hunting has been the revolutions and innovations in agriculture (Ozsoylu, 2017). The most important development of the industry was experienced in the 18th century. Although references are made to different dates of the 18th century in different sources, the most important development here has been the “steam engine”. Making different mechanical systems available depending on the power of the steam engine and here is Industry 1.0 (Bagcı, 2018; Pamuk & Soysal, 2018; Soylu, 2018). With this development, serious changes have begun to occur in people’s working life and economy. Thanks to the technological developments brought by the steam machines, the production in the factories have increased. While this increase increases the need for raw materials, on the other hand, it has started to enable countries with this technology to gain superiority over other countries.

The 19th century brought the birth of a second revolution in the field of production in human life. Industry 2.0, which came out with electricity and mass production lines. Railway transportation systems developed thanks to steam engines facilitated the transportation of raw materials from one place to another. Thus, it has also facilitated the delivery of the materials needed in the factories with increasing production speed to the factories. The widespread use of electrical energy and the use of oil as a fuel in the 20th century brought radical changes in human life (Alcin, 2016; Jänicke & Jacob, 2009). The era of mass production, which conformed to a certain standard, was begun, instead of personalized handmade products. Thus, the prices became cheaper and people’s living standards began to change.

The 20th century has been a century in which the rate of development of technology has increased exponentially. The World Wars are undoubtedly the catastrophes faced by humanity as the major factors that accelerate this development. Enemy states, trying to establish superiority over each other, made inventions one after another. The second half of the 20th century heralded the beginning of a new era in production with computers and programmable machines that started to be developed after the Second World War. Information and communication technologies (ICT), electronics, automation, and Industry 3.0. Automation has been achieved in the production sector with programmable microprocessors and robots have taken their place in the factories. In many parts of the factories in developed countries, automatic operations with robots have begun to be performed (Siemens, 2021). The robot industry will develop gradually and will take its place at more key points in the following periods.

In the 21st century, developments in ICT such as artificial intelligence (AI), the internet, and big data gave the production sector a completely different look. Industry 4.0. Digital technologies have become used in all areas of life. Production in the factories has become editable without the human factor. In this section, the relationship between AI and production/consumption, and even from where supply/demand relations bring societies and where they lead them are mentioned.

Industry 4.0

The term Industry 4.0 was first used at the Hannover Fair held in Germany in 2011. In a study prepared by Henning Kagermann, Wolf-Dieter Lukas, and Wolfgang Wahlster, it is stated that the world has entered a new era that can be called Industry 4.0 (Henning et al., 2011). Germany then started to carry out studies on this subject within the framework of a strategic plan, and thus the term Industry 4.0 began to be officially accepted in the world. In different countries of the world, the components specified as Industry 4.0 appear under different names. Although the term Industry 4.0 is widely accepted in Turkey, these components and this process are used in different countries as “Industrial Internet” (Bruner, 2013; Li et al., 2017), “Internet+” (Hong, 2017; Wang et al., 2016), and “Factories of the Future” (Herrmann et al., 2014; Jardim-Goncalves et al., 2017) etc. Since it is widely accepted in the world, the contribution of AI technologies to the production sector has been mentioned, especially by going through the term Industry 4.0. Development of the industrial revolution is shown in Figure 1.

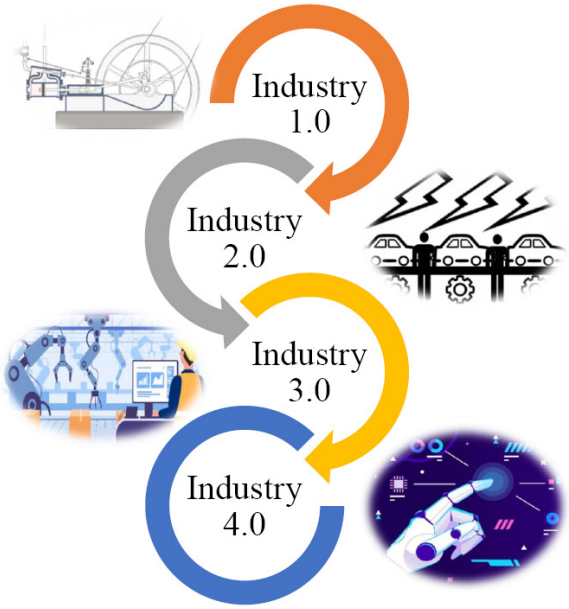


Figure 1. Development of the Industrial Revolution

Although Industry 4.0 has become a necessity rather than a choice for countries, many countries have not even completed the previous processes yet. According to a report prepared by TÜBİTAK for 2016, the digital maturity level of the industry in Turkey is between Industry 2.0 and Industry 3.0. Only 22% of companies have extensive knowledge and 50% have strategies to integrate relevant technologies within 3-5 years. 3 sectors with the highest maturity level; Materials (Rubber and Plastic), Computers, Electronics and Optical Products, Automotive and White Goods Sub-Industry. The 3 technologies that are considered to provide the most added value; Automation and Control Systems, Advanced Robotic Systems, and Additive Manufacturing (TUBITAK, 2016).

Demand is one of the important factors that direct production systems. Speed has become one of the most important factors in production, especially since the speed factor has become very decisive for people. With this new industrial revolution, the machines in automation systems were replaced by systems that enable instant tracking by communicating with data systems at the same time. Thus, the operators who managed the data were immediately informed about the malfunctions and problems on the production line and had the opportunity to solve the problem quickly.

Key Dynamics of Industry 4.0

One of the factors affecting the developments in the industry is the concept of big data. The entire cycle of the parts and products in production, from the production process on the band to the delivery to the customer, can be followed. This is how the production and consumption cycle can be personalized. Processes can be managed dynamically. Even the production data in the factory, product comments on social media and product

complaints on different sites can contribute to decisions about how the product should be made in the next stage. If these data are looked at from within the production facility, for example, the information that a cutting tip will wear from which product can be determined and faulty production can be prevented. New versions of the product can be shaped according to customer comments, taking into account the product follow-up and product comments after the sale.

Big data means storing, accessing, and processing information in a wide variety of high-volume and high-speed data. Processes such as analyzing this data, recognizing patterns, and revealing hidden connections mean big data analysis and are at the top of the agenda of technology companies in today's world, both because of their performance and management difficulties, and to create competitive advantage (Sagıroglu & Sinanc, 2013). The development of sensor technologies, the increase in mobility, the increase in the use of social networks, and the development of communication technologies have also brought about the birth of the concept of big data, increasing the variety, speed, and amount of data produced (Savas & Topaloglu, 2016). It is not possible to manage, process, and extract information with traditional database management systems of high-volume, complex, and high-speed data. Therefore, it requires different algorithms, techniques, and technologies, such as software running in parallel on server clusters (Jacobs, 2009). The solution to this requirement is found in AI. AI is not a new concept, in fact, its foundation dates back to seventy years ago and it is obvious that it will shape our future. With the contribution of sensor technologies, social media data, corporate data, and many more data, the need for AI technologies has increased during the evolution from data mining to big data (Savas, 2020). Big data processes are continuous processes and the example diagram is shown in Figure 2.

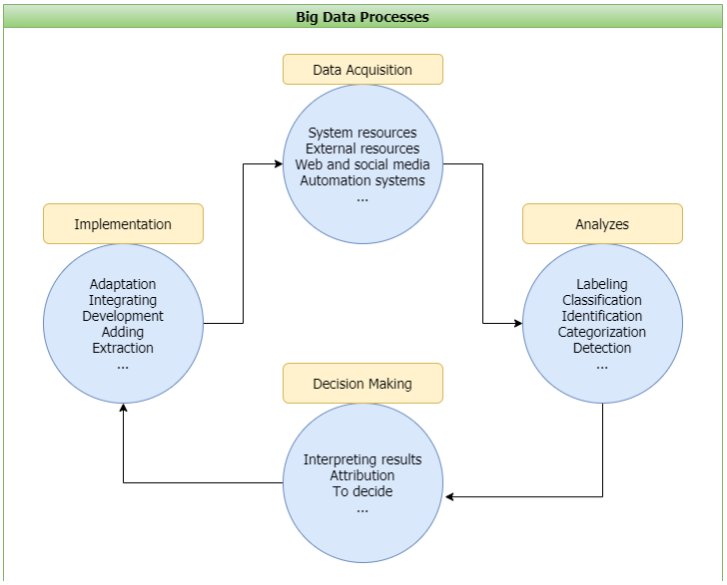


Figure 2. Big Data Processes

Another key dynamic is the Internet of Things (IoT), which makes it possible for machines on the production line to communicate with each other. This concept will probably be mentioned more frequently in the coming years. Because now, devices that use these technologies in daily life are used not only in industrial environments but also in homes. Today, televisions, refrigerators, ovens, heaters, and even smart vacuum cleaners have internet connections. The number of people using these devices will continue to increase. This is how the IoT is spreading. This technology is also used in factories. With AI technologies, this data is processed and improvements are made regarding the production-consumption cycle.

The IoT has been defined as "the ability of objects in our daily use to connect to the Internet and send and receive data" (Commission, 2017). The concept of the IoT has emerged with Radio-frequency identification (RFID) technology. The camera system installed by about 15 academics at Cambridge University in 1991 to see the coffee machine was an eye-opening application when evaluated under the conditions of the day. The system sent the image of the coffee machine to computer screens three times a minute. It took its place in history as the first example of the concept of the "IoT" because it is online and in real-time. In 1999, Kevin Ashton listed the benefits of RFID technology application and suggested its use. The proposed system; was a global system standard based on radio waves and sensors that gave rise to the concept of the "IoT". In today's internet, just as IPv4 network technology is used for human-to-human and human-to-machine communication via machines, IPv6 technology has special importance for IoT-based devices to work together. In IPv4, while a gateway converts between the protocols of different devices, it is aimed to remove this situation with IPv6 and to enable devices to work together without protocol problems (Geng, 2017; Ocal et al., 2021).

The fields of application for IoT technologies are as numerous as they are diverse, as IoT solutions are increasingly extending to virtually all areas of every day. The most prominent areas of application include the smart industry, where the development of intelligent production systems and connected production sites are often discussed under the heading of Industry 4.0. In addition; smart home applications with intelligent thermostats and security systems are receiving a lot of attention, while smart energy applications focus on smart electricity, gas, and water meters; smart transport solutions with vehicle fleet tracking and mobile ticketing; smart health areas with surveillance of patients and management of chronic diseases; and smart city projects with real-time monitoring of parking space availability and intelligent lighting of streets can be mentioned in IoT concept (Wortmann & Fluchter, 2015). The IoT components and processes are shown in Figure 3.

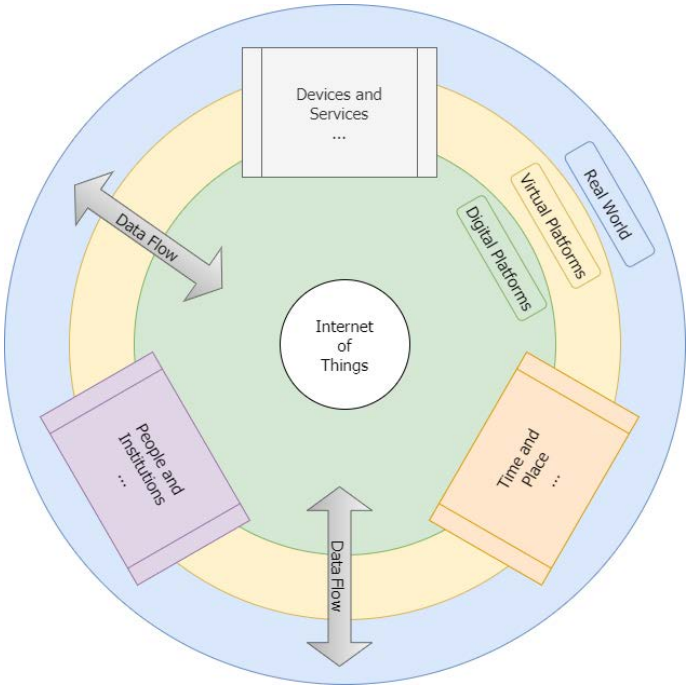


Figure 3. IoT Components and Processes

Another important element for Industry 4.0 is Cloud Computing (CC) technologies. Hardware-independent, flexible, expandable, and fast information infrastructure has been provided with these technologies. Thus, even the data of a factory in different countries were collected in a single-center, resulting in an enormous integration in production automation. This is only a sample for the production part of the business. It is also possible to benefit from CC on the consumption side.

CC can be defined as information services that are easy to manage, scalable according to needs, easily accessible from many different devices, and offered on common resources. CC, which offers the flexible structure of institutions is helping to manage ICT services. The cloud approach, reduce costs, although reducing the risks offers a safer work environment (Ersever et al., 2017).

Adopting and utilizing CC provide several major benefits. Some of these benefits can be mentioned like (Brian et al., 2008):

- Enables economies of scale for both the provider side and user side.
- Allows organizations to focus on their core competencies in a sustainable manner.
- Follows information technologies' evolutionary logic, or the achievement of ever-greater complexity and to continually improve information hiding or "transparency engineering."

CC has specific characteristics and realizations that, compared with other forms of outsourcing, have both advantages and disadvantages. On-demand self-service, Broad network access, resource pooling, rapid elasticity, and measured services can be can be counted among the characteristics of CC (Brian et al., 2008). The components of the CC are shown in Figure 4.

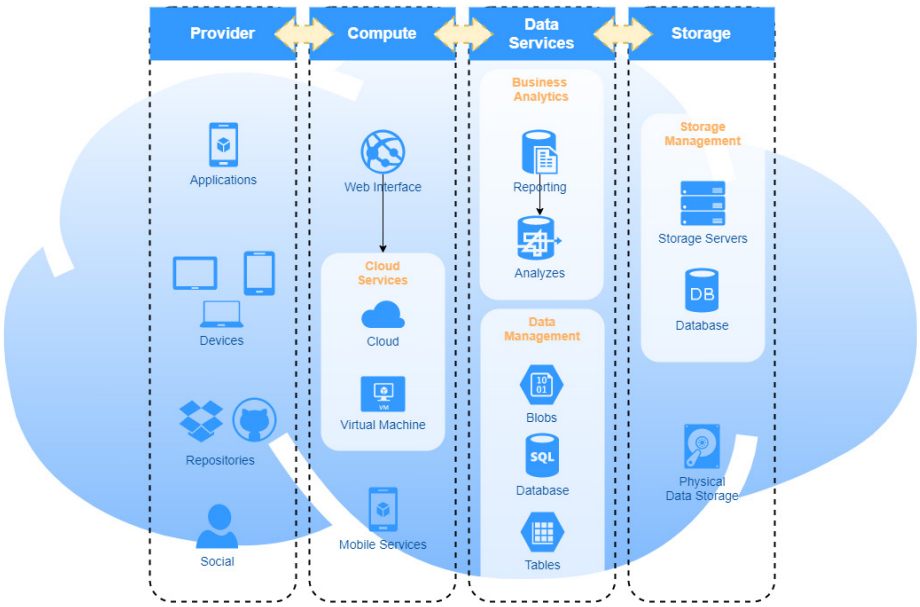


Figure 4. Components of CC

Cyber security (CS) is also one of the major issues of Industry 4.0. If ICT are involved, there are always cyber risks and threats. Especially in environments where there is such a large amount of data, which can be explained with big data, ensuring the security of the data is one of the problems that need to be dealt with.

CS can be defined as "the set of tools, policies, security concepts, security assurances, guidelines, risk management approaches, activities, pieces of training, best practices and technologies used to protect the assets of institutions, organizations, and users in the cyber environment" (Alkan, 2012). In the Industry 4.0 process, with the emergence of cyber-physical systems, these systems have become open to cyber threats. These vulnerabilities have made smart systems and Industry 4.0 systems a favorite of attackers. Although these systems make significant contributions to human life such as efficiency, speed, and operability, if cyber security vulnerabilities are not properly evaluated, the true potential of Industry 4.0 may never be reached (Yilmaz et al., 2021) defined information security elements in Industry 4.0 as "accessibility", "confidentiality", and "integrity" as seen in Figure 5.

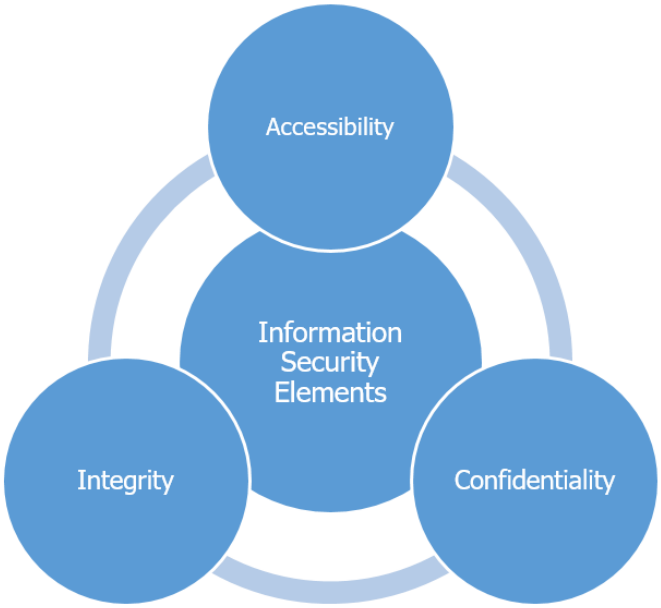


Figure 5. Information Security Elements in Industry 4.0

The developments in the production sector together with AI brought with it new factory applications called “Smart Factories”. In these factories, the production has been completely customized and the communication between the products and the machines as well as the communication between the operators and the machines has been made continuous and traceable. In fact, factories that are called dark factories and completely self-produced began to emerge. With the fourth revolution, robots began to be used both in the field of production and in the field of service. While the robots on the production line can perform tasks that require manpower, the robots on the service line are now able to perform smarter operations with AI technologies.

The main purpose of smart factories is to reduce the error rates in production, accelerate the production processes, and reduce the production costs by providing an automation system. Smart factories provide important benefits such as prototyping, ordering the first version of the product before it is produced, or the opportunity to make your own design. Thus, with the industrial revolutions, factories had to update their production processes and the role of the human factor in these processes changed with the coming of automation. At this point, with the emergence of smart factories and high-tech automation systems, the need for low-skilled labor has decreased considerably (Calp et al., 2018).

Apart from these, there are also different factors that can be counted as key dynamics for Industry 4.0 such as autonomous robots, simulation technologies, augmented reality, blockchain technology, and sensor technologies. The number of these components is increasing with the developing technology.

Discussion and Conclusion

Today, with the developments in ICT, consumers can easily access the product anywhere in the world. While this provides ease of consumption for individuals, it also creates a globally competitive environment for producers, not only on a country basis. It does not seem possible to remain indifferent to Industry 4.0 components in order to strengthen the country's economy, compete with global production power, and maintain the supply-demand balance. For this reason, it is necessary to understand these technologies as a whole and to evaluate their opportunities by creating a country strategy.

This new industrial revolution, which has been on the agenda for the last decade, continues as a process in which major countries carry out locomotive activities. However, especially with the progress of AI studies, the gap between countries will gradually increase and there will be a distinction between producing and consuming countries.

The industry 4.0 concept, which brings innovations listed as global interaction of storage systems and resources and machines, development of unique smart products with location information, implementation of smart factories that adapt to product features and optimize resources, the realization of new business models, new social infrastructure in the workplace for employees, work structure sensitive to individual differences, better work-life balance, responding to individual consumer requests, and instant engineering and smart software developed for instant response to problems, has features that will affect human life at every stage of life (Alcin, 2016; Calp & Dogan, 2018).

In order to realize all these, structures called cyber-physical systems need to be established. All machinery, equipment, and systems need to be integrated into this structure. When this is the case, there are significant differences between countries that have the opportunity to install these technologies and those that do not. For this reason, these technologies need to be put in place as soon as possible if it is desired to survive in the competitive system because the consumption habits will not end.

From all these mentioned, it is obvious that although a revolution focusing on products similar to the previous revolutions in the industry has been realized with AI, the situation will no longer be only in this field. The commitment to digital life, the inclusion of these technologies in daily lives and even being an indispensable part of them will affect all stages from production processes to consumption and marketing. Along with these, the growth of countries, their existence in global competition, business conditions, working styles, education levels and types, investment areas, and many other issues will be affected one after the other like a domino effect.

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About The Authors

Serkan SAVAS is a faculty member at Çankırı Karatekin University, Faculty of Engineering, Department of Computer Engineering. Previously, he worked as a teacher and administrator in schools affiliated with the Ministry of National Education. He worked on Data Mining in his master's education and on Artificial Intelligence, Deep Learning, Cyber Security, and Social Networks in his doctoral education. He has written and conducted many National and International projects such as Artificial Intelligence Applications in Education, Deep Learning Applications in Education, 3D Educational Technologies, Entrepreneurship, Social and Local Purpose Projects in the institutions he worked for. He received training on subjects such as project cycle management, project preparation, process management and developed his experience with project applications. He also teaches Artificial Intelligence, Deep Learning, Cyber Security, Project Preparation, and Generation Z in different institutions. Serkan Savaş, who has published articles and papers about his work in national and international journals and conferences, also has a published book called @Sosyal Medya and an international book chapter called Z Kuşağı Öğrencisini Tanımak.

Email: serkansavas@karatekin.edu.tr, ORCID No: 0000-0003-3440-6271

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