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TÜRKİYE İMALAT SEKTÖRÜNDE ENDÜSTRİ 4.0 ADAPTASYON DÜZEYİ[1]

Öz

Teknolojideki hızlı değişim imalat sanayini de etkilemekte. Firmaların bu teknolojinin ve dijtalleşmenin bu kadar hızlı geliştiği ortama uyum sağlamaları gerektiği açıktır. Dördüncü Sanayi Devrimi'ne kadar hızlı adaptasyon sağlanırsa, şirketler bu devrimsel ortamda rakiplerine göre avantaj elde edecek ve sürdürülebilir kalkınmayı gerçekleştirecektir. Kuşkusuz gelişmiş ülkeler düzeyine çıkmaları veya bu ünvanı korumaları da aynı konuya bağlı olacaktır. Bu çalışmada Türkiye'de üretim sektöründe faaliyet gösteren firmaların Endüstri 4.0 olgunluk düzeyleri incelenmiştir. Verilerin analizinde SPSS v28 programı kullanılarak yapılan korelasyon ve regresyon analizleri sonucunda; Şirketlerde kullanılan dijital uygulamalar; ERP %70,1 yüksek kullanım oranı ile birinci, CRM %64,5 ile ikinci, MRP %31,0 ile üçüncü ve BI %28,9 ile dördüncü sırada yer almaktadır. Yine kullanılan Endüstri 4.0 uygulamaları; Büyük Veri ve Analitik %46,7 ile ilk sırada, Siber Güvenlik %45,7, Bulut Bilişim %44,7, Yapay Zeka %28,9, Derin Öğrenme ve Makine Öğrenimi %25,4, Otonom Robotlar %22,3 olarak tespit edilmiştir. Diğer yandan, sektöre göre Endüstri 4.0 olgunluk seviyeleri; Lojistik/Nakliye: 3,85

[1] Produced from the published doctoral thesis on Leadership in the Fourth Industrial Revolution and a Model Proposal: Leadership 4.0.

ilk sırada, BT/Elektronik/Yazılım: 3,83 ikinci sırada ve Enerji: 3,80 üçüncü sırada yer almaktadır.

Anahtar kelimeler: Endüstri 4.0, Türk Sanayii, Dördüncü Sanayi Devrimi, Olgunluk Seviyesi

INDUSTRY 4.0 ADAPTATION LEVEL IN THE MANUFACTURING SECTOR OF TURKEY

Abstract

The rapid change in technology is also affected to the manufacturing industry. It is clear that companies need to adapt to the environment where this technology and digitalization are developing so rapidly. If rapid adaptation is achieved until the Fourth Industrial Revolution, companies will gain an advantage over their competitors and achieve sustainable development in this revolutionary environment. Undoubtedly, their rise to the level of developed countries or their protection of this title will depend on the same issue. In this study, the Industry 4.0 maturity level of companies in the production sector in Turkey has been examined. As a result of correlation and regression analyzes using SPSS v28 program in the analysis of the data; Digital applications used in companies; ERP ranks first with a high usage rate of 70.1%, CRM is in the second place with 64.5%, MRP is in the third place with 31.0% and BI is in the fourth place with 28.9%. Industry 4.0 applications used again; Big Data and Analytics ranked first with 46.7%, Cyber Security 45.7%, Cloud Computing 44.7%, Artificial Intelligence 28.9%, Deep Learning and Machine Learning 25.4%, Autonomous Robots 22.3% detected. On the other hand, Industry 4.0 maturity levels by sector; Logistics/Transport: 3.85 in first place, IT/Electronics/Software: 3.83 in second place and Energy: 3.80 in third place.

Keywords: Industry 4.0, Turkish Industry, The Fourth Industrial Revolution, Maturity Level

INTRODUCTION

Industry or Industry 4.0 refers to a process we are in today. Therefore, it is not a completed period yet and theories about its future are emphasized. Industry 4.0 in general; robots take over production, production with 3D printers, the development of artificial intelligence, big data studies and many other innovations. It was supported by Germany, Japan and the USA. Kagermann's 2011 article is taken as a basis for the theoretical beginning of Industry 4.0. 4. He states that the industrial revolution includes not only the development in automation, but also intelligent observation and decision-making processes (Alçın, 2016).

Industry 4.0 first came to the fore at the Hannover Fair in 2011. It was explained in the report prepared by the Working Group appointed by the German Government in 2013. The Fourth Industrial Revolution or Industry 4.0 is a concept that describes the rapid change in technology, industries and societal norms and processes in the era we live in due to increased connectivity and smart automation. The concept has been used extensively in the scientific literature and was popularized in 2015 by WEF Founder and Chairman K.Schwab. Schwab argues that the changes seen are more than just improvements in efficiency.

In general, a comprehensive and explanatory definition of Industry 4.0 is made on a related platform as follows: "Industry 4.0 defines the Fourth Industrial Revolution, which is a new level in the organization and management of the entire value chain in the life cycle of products and production systems. This cycle focuses on customer demands that are increasingly individualized and includes services that span the entire chain, starting from the idea stage, from product development and production order, to distribution and recycling of a product to the end user." (Soysal & Pamuk, 2018).

Industry 4.0 was seen as different from other revolutions. Because this revolution progresses exponentially, not linearly. New technology products that are interconnected are developing rapidly by influencing each other (Rogers, 2017). With digitalization, this revolution has accelerated and the diversity of technology has increased. It is expected that it will be able to make progress at the same time in all fields that will affect all kinds of scientific fields, not only from the communication of machines, but also to information processing technologies. Industry 4.0 brings about a major change in the production system. With this process, an automation-based and integrated system emerges. It has become more important how smart technologies are used in production rather than what is produced in the industry. It can be said that a situation in which not only automation development but also decision-making and smart observation processes are included.

Fourth Industrial Revolution

The industries of the leading countries in the industrial breakthrough of today's world are evolving with the fourth phase of the industrial revolutions, which is the last part of the process since the industrial revolution and is called Industry 4.0. In this process, technology-based smart production is aimed with the fourth industrial revolution compared to the previous three industrial revolutions. In this last industrial revolution; In smart factories that make smart productions based on informatics, it is aimed that the machines manage themselves without being dependent on people in the production process. Automation processes in smart factories mean that devices and machines communicate with each other and determine and regulate production processes within themselves. For example, in case of a resource shortage at any stage of production, the necessary resource order is placed automatically, faults can be detected and fixed instantly and on-site, and the system can be operated at full capacity and without any problems (The Boston Consulting Group & TÜSİAD, 2016).

Industrial revolutions can be handled in four groups (Schwab K. , 2017, s. 16);

• Industry 1.0: It is the mechanical production revolution that started with the use of railways and steam engines in the years 1760-1840.

• Industry 2.0: It is the revolution of integrating mass production line and electrical energy in the late 1800s.

• Industry 3.0: It is the revolution in the 1960s when digital technologies replaced electrical and mechanical technologies in production.

• Industry 4.0: Developing digitalization is the name of the era and revolution in which almost every product and service in our lives can be digitized. see Fig. 1.

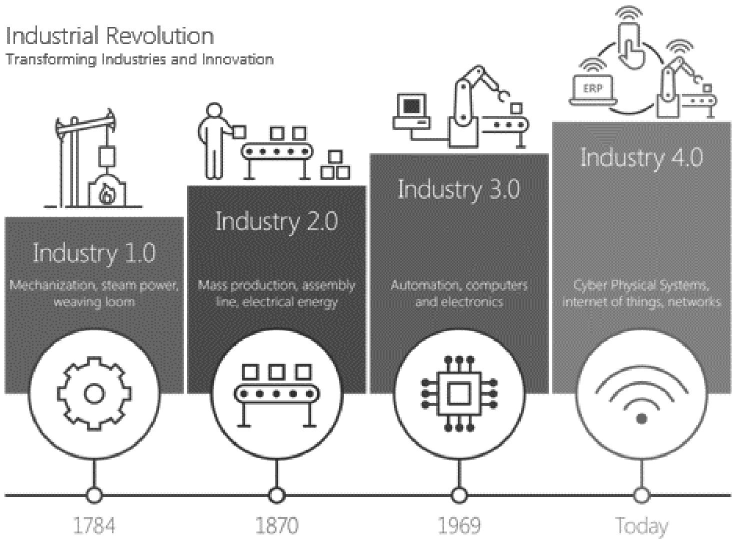

Figure 1 – Industrial Revolutions

Technological advances within the scope of Industry 4.0 can be grouped under the following headings. These;

- Big Data & Analytics
- Cyber Security
- Cloud Computing
- Artificial Intelligence
- Deep Learning & Machine Learning
- Autonomous Robots
- Internet of Things & Internet of Services (IoT-IoS)
- Additive Manufacturing (3D Printers)
- Virtual Reality - Augmented Reality (VR-AR)
- Smart Factory
- Cyber Physical Systems. see Fig. 2.

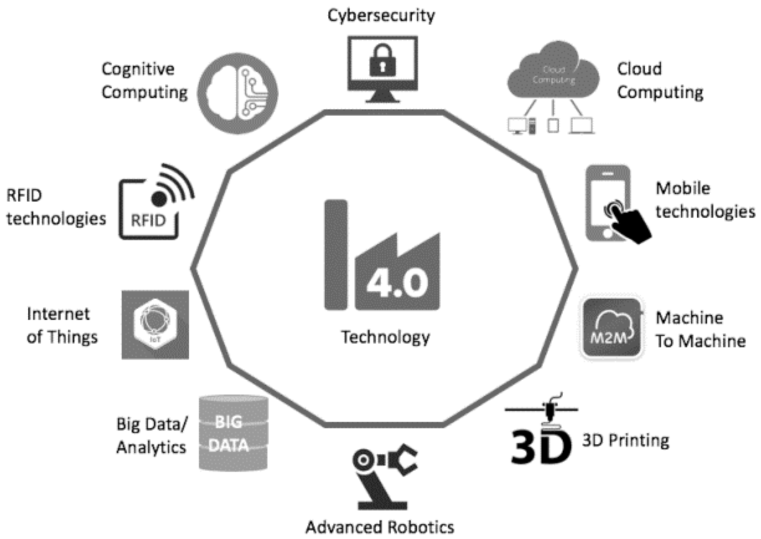

Figure 2 – Industry 4.0 Technological advances

Big Data & Analytics

With the development of technology, the ways of accessing information have also increased. However, the fact that information can be obtained from many places leads to a decrease in the confidence in the information that has been reached, and to the problem of useless and wrong information.

It becomes impossible to report, store and use these data in a beneficial way. Thanks to big data, it has become usual for the collected data to become meaningful and to be able to be processed. Big data; It can be defined as the way of transforming the data obtained from different sources such as social media shares, blogs, photos, blogs, videos, system logs into a data format that can be processed and interpreted. Many sectors and applications also prioritize better management of risks and faster and more accurate decisions.

Big data is an application that enables decision making by using a large number of different data together. Most organizations operating in the Industry 4.0 environment have only their own databases becoming insufficient. In today's business environments, there is a need to analyze data coming from external sources, to reveal new information and to use this information in organizational processes. Since traditional database systems are insufficient to meet today's needs, most large-scale organizations are now making large investments in big data. Thanks to big data, analysis processes do not only reveal past performance; It also ensures that action is taken in accordance with the current situation and makes predictions for the future (Lee, Kao, & Yang, 2014).

Big data analytics is the use of advanced analytical techniques against very large, diverse data sets containing structured, semi-structured and unstructured data from different sources and in different sizes from terabytes to zetabytes. Big data is a term applied to datasets whose size or type is beyond the ability of traditional relational databases to capture, manage and process data with low latency. Big data has one or more of the following features; high volume, high speed or high diversity. Artificial intelligence, mobile, social, and the Internet of Things are increasing data complexity through new data formats and sources. For example, big data comes from sensors, devices, video/audio, networks, log files, computing applications, the web and social media, many of which are generated in real time and at a massive scale. Analysis of big data enables analysts, researchers, and business users to make better and faster decisions using data that was previously inaccessible or unavailable. Businesses can use advanced analytics techniques such as text analytics, machine learning, predictive analytics, data mining, statistics, and natural language processing to gain new insights independently of previously unused data sources or in combination with existing corporate data (Perry, 2017).

Cyber Security

Attacks by professional hackers or hacker groups on computers and the internet to corporate or individual websites, networks or computers with the aim of gaining and harming are called "Cyber Attacks". Cyber Security describes the protection of information technology systems that make up the cyber space from threats, ensuring the confidentiality, integrity and accessibility of the information therein, identifying attacks and cyber situations, taking precautions for these determinations, and then bringing back the problems encountered in the systems before the Cyber Security attack. As information technologies progress, the opportunities to access information increase, and thus it becomes difficult to ensure the security of information. Today, Cyber Security threats have increased with the use of information systems in all areas of life. The fact that major Cyber Security breaches have become ordinary and regular attracts the attention of companies and leaders all over the world. In recent years, many organizations around the world have been drawing attention to such events and trying to understand and manage the cyber risks that arise in an increasingly complex digital society. Therefore, it is a very important component for industry 4.0, which intensively works with virtual environments and whose infrastructure depends on it (Yıldırım, 2018).

Cybersecurity is the practice of protecting computers, servers, mobile devices, electronic systems, networks, and data from malicious attacks. It is also known as information technology security or electronic information security. The term applies in a variety of contexts, from business to mobile computing, and can be divided into several common categories (Kaspersky, 2022);

• Network security: an application to protect computer networks from malware, targeted attackers and intruders.

• Application security: focuses on keeping software and hardware free from threats. A compromised application could gain access to the data it was designed to protect.

• Information security: protects the integrity and confidentiality of data, both in storage and in transit.

• Operational security: includes processes and decisions for processing and protecting data assets. The permissions users have when accessing a network, and the procedures that determine how and where data can be stored or shared, all fall under this umbrella.

• Disaster recovery and business continuity: defines how an organization will respond to a cybersecurity incident or any other event that causes operational or data loss. Disaster recovery policies, taking into account the organization's operations and information, detect and enable restoration to return to the same operating capacity as before the event. Business continuity is the plan and state that the organization returns to while working under certain resource constraints.

• End-user training: addresses the most unpredictable cybersecurity factor: people. Anyone can accidentally infect an otherwise secure system with a virus by not following good security practices. Teaching users how to delete suspicious email attachments, not insert unidentified USB drives, and various other important lessons is vital to the security of any organization.

Cloud Computing

Cloud computing can be defined as a model in which users access various information services such as computing, storage and applications over the internet without knowing where their information is stored, on which servers these applications run and how they are technically configured. Since the cloud is often used as a metaphor to represent the internet, this computing model is called cloud computing (Sultan, 2010).

Cloud computing can be defined as a model where users access various information services such as computing, storage and applications over the internet without knowing where this information is stored, on which servers these applications are running and how they are technically configured. Since the cloud is often used as a metaphor to represent the internet, this computing model is called cloud computing. (Sultan, 2010). Thanks to the cloud computing model, the capacities of computers will be used more effectively by using scalable hardware and software, and companies will be able to implement IT applications faster and at lower costs. Cloud computing significantly changes the existing IT structures of companies and offers them many advantages, especially cost and flexibility (Marston, Li, Bandyopadhyay, & Zhang, 2011).

The term cloud computing also refers to the technology that makes the cloud work. This includes a type of virtualized IT infrastructure (servers, operating system software, networking, and other infrastructure that is abstracted using proprietary software) so that it can be pooled and partitioned regardless of physical hardware boundaries. Whether you use a computer or mobile device at home or work, a cloud app like Google Gmail or Salesforce, streaming media like Netflix, or cloud file storage like Dropbox, they actually use some form of cloud computing almost every day.

Artificial Intelligence

Artificial Intelligence, also referred to by the acronym AI, refers to systems or machines that mimic human intelligence to perform tasks and can gradually improve itself with the information it collects. The definition of "Artificial Intelligence" in the literature changes with the development of technology. Artificial intelligence is the ability of a computer or computer-controlled robot to perform tasks often associated with intelligent beings. The term is often used to develop systems equipped with human intellectual processes such as reasoning, meaning discovery, generalization, or learning from past experiences. In the early 1950s, Alan Turing's "Can Machines Think?" The term “Artificial Intelligence” was used by Computer Scientist and Cognitive Scientist “John McCarthy” in 1956 at the “Dartmouth Conference”, the artificial intelligence conference organized for the first time (Nilsson, 2019).

Artificial intelligence is software engineering and technology, intelligent computer programs or algorithms. The purpose of artificial intelligence systems is to allow machines to mimic human cognitive functions, such as reasoning and problem solving, to perform a job usually done by humans. AI given tasks are accomplished by storing and analyzing big data using these algorithms (Shrikant, Swami, Doiphode, & Singh, 2021).

Today, it finds a wide range of applications in many business lines, from medicine and health to tourism, from defense industry to production, from national security to government applications. Even futurists predict that in the future, even wars will be with armies equipped with artificial intelligence. Working integrated with each other, factory worker robots, unmanned aerial vehicles, autonomous wheeled vehicles (buses, taxis, automobiles, etc.) have gradually begun to take their place in social life. The navigation systems in currently used cars are equipped with pedestrian or live recognition systems, collision avoidance systems, thousands of lines of algorithms and hundreds of chips. Smart cities, traffic light times that change according to traffic density, navigation systems that suggest new routes according to traffic density, smart cleaners that know the house, software that recommends products according to researched topics on social media, mobile applications that recommend meals according to the online food types you choose, and more. hundreds of them become indispensable in our lives.

Deep Learning & Machine Learning

Machine learning is considered a type of artificial intelligence that can unleash results even for which it was not programmed. In 1959, Arthur Samuel defined machine learning as "the ability to learn results for which machines were not specifically programmed". Arthur Samuel made a checkers game that can work in a computer environment, learn from his own mistakes and thus improve himself. Machine learning, like artificial intelligence, has been idle for years. It did not become popular until the 1990s when data mining began to be used. Data mining is the application of algorithms used to uncover similar motifs with similar sequences in the data it holds. Machine learning does the same, but data mining goes one step further and changes the behavior of the program about the information it learns. Deep learning is a field of study that covers artificial neural networks and similar machine learning algorithms with one or more hidden layers. In other words, at least one artificial neural network is used and with many algorithms, the computer obtains new data from the data at hand (Schwab, 2019).

A subset of machine learning, which is basically a neural network with three or more layers, is called deep learning. These neural networks attempt to simulate the behavior of the human brain by allowing it to learn from large amounts of data. In addition, single-layer neural networks can make approximate predictions, while additional hidden layers allow to optimize and improve accuracy. Deep learning drives many AI applications and services that improve automation and perform analytical and physical tasks without human intervention. Deep learning technology lies behind everyday products and services (such as digital assistants, voice TV remote controls, and credit card fraud detection) as well as emerging technologies (such as self-driving cars).

Autonomous Robots

Robots can be defined as electromagnetic devices that can perform their pre-programmed tasks. With the interaction of robots with other devices and machines, the productivity of companies will also be increased. Intelligent robots can work directly under the control of an operator, as well as move through a computer program. The use of robots in the formation of all kinds of goods produced by peeing raw materials dates back to the 1970s. However, thanks to advanced sensor, actuator technologies and artificial intelligence algorithms, adaptive, flexible robots that can work in harmony in any environment have begun to be produced. Whereas in the past production lines were adjusted and arranged according to robots, today robots keep up with existing production systems. Robots can distinguish parts with advanced virtual vision capabilities and act differently for each product. Manufacturers in various industries have long used robots in their operations. Robot technology in the world is now both becoming more autonomous, flexible and collaborative by improving its competencies and reducing the cost of ownership. In the future, robots will increase their interaction with each other, work more safely side by side with humans, and improve their learning abilities (The Boston Consulting Group & TÜSİAD, 2016).

Autonomous robots are devices that have the ability to learn about their environment and operate for long periods without human intervention. Examples of these robots range from autonomous helicopters to robot vacuum cleaners. Robots can move without human assistance throughout the operation and avoid situations that could cause harm to themselves or people and property. Autonomous robots are also likely to adapt to the changing environment. Simpler autonomous robots use infrared or ultrasound sensors to see obstacles, allowing them to navigate around obstacles without human control. More advanced robots use stereo vision to see their environment; cameras give them depth perception and software allows them to find and classify objects in real time. Autonomous robots, for example; It helps in busy environments such as hospitals. Instead of employees leaving their jobs, an autonomous robot can quickly deliver lab results and patient samples. When considered in terms of the production industry, robots are already making their mark in many sectors. Many examples such as assembly and welding robots in automotive, intra-factory logistics vehicles, AGVs (Automatic Guided Vehicles), cobots working in harmony with live operators are used today.

Internet of Things & Internet of Services

The concept of the Internet of Things was first used as the title of a presentation in 1999 by Kevin Ashton, co-founder of the Massachusetts Institute of Technology (MIT) Auto-ID Center. "The internet of things," published by the International Telecommunication Union (ITU) in 2005. The concept of “Internet of Things” was announced with the ITU Internet Reports” report. It is possible to define the concept of the Internet of Things as a system of devices that communicate with each other through various communication protocols and form a smart network by connecting to each other and sharing information. The Internet of Things can also be defined as a network structure where devices and machines communicate data among themselves, collect data and decide with the information it creates, without the need for human touch or data entry (Altınpulluk, 2018).

Researchers predict that with the arrival of 5G technology, new architectures, technologies and hardware will soon pass through the IoT. Zhiguo Ding, one of the researchers at Lancaster University, states that the 4G infrastructure we use today will not be sufficient for the future and mostly IoT-related applications. Today, IoT examples with wireless connection systems such as UWB, RFID, Bluetooth will become much higher data rate and uninterrupted connection (Aydın, 2021).

Even today, smart phones, wearable devices (smart watches, smart bands, etc.) are equipped with many technologies such as biosensors, location sensors, and communicate by providing data to different environments and different applications. With the advancement of IoT technologies and its building block 5G infrastructures, this will evolve into smart cities and smart lives alongside smart homes and smart factories.

Another term is industrial IoT. Industrial IoT (IIoT) refers to the application of IoT technology in industrial environments, especially in relation to the instrumentation and control of sensors and devices using cloud technologies. Recently, industries are using machine-to-machine communication (M2M) to provide wireless automation and control. But with the advent of cloud and connected technologies (such as analytics and machine learning), industries are able to reach a new layer of automation and with it create new revenue and business models. The following are some common uses of IIoT (Oracle, 2022);

- Smart production
- Connected assets and preventive and predictive maintenance
- Smart power grids
- Smart cities
- Connected logistics
- Smart digital supply chains

Additive Manufacturing (3D Printers)

One of the most developing topics in recent years is 3d printers. Many futurists think that 3D printing will start a new era for humanity and will lead to new steps in innovation. This production technique is also called additive production. In 3D printers, the software builds layers by superimposing the molten material, and the product can be produced in one piece. The product created by adding allows us to produce with a very small part of the raw material and provides a great advantage in production. It offers advantages such as the very rapid production of very specific special parts and the production of complex parts that cannot be produced with the molding technique. Its use is rapidly spreading from the automotive industry to the medical industry, from the construction to the retail industries (Schwab, 2017).

Virtual Reality - Augmented Reality (VR-AR)

Computer technology, which started in the 1980s and started to develop after the 1990s, has entered every aspect of our lives today. These developments in science and technology have increased the importance of knowledge and enabled the formation of an information society. Now, human beings have gone to various searches for the processing and presentation of information with computers, and they have revealed different concepts. One of these concepts is the concept of "virtual reality". We can define the concept of virtual reality briefly as “reconstruction of reality”. Virtual Reality- VR” is a set of concepts and tools that try to make us feel as if we are in a virtual universe. Augmented Reality -AR, on the other hand, brings together the real world and the computer-generated virtual world and enables us to interact with the digital (virtual) world without breaking away from the real world. Today, it has started to be used in many sectors and business lines. In particular, the term metaverse has started to gain popularity (Kayabaşı, 2005).

The term virtual reality naturally consists of both the words "virtual" and "reality". The term virtual means intimacy and the term reality is what we experience as humans. So the term “virtual reality” basically means “close to reality”. Man knows and defines the world through his senses and perception systems. In school, everyone learned that there are five senses: taste, touch, smell, sight and hearing. But these are only the most prominent sense organs. The truth is, humans have a lot more senses than that, like a sense of balance. These other sensory inputs, as well as the special processing of sensory information by the brain, provide a rich flow of information from the environment to the mind. Everything known about reality comes through the senses. In other words, the entire experience of reality is simply a combination of sensory information and the brain's mechanisms for making meaning for that information. It is plausible, then, that if information fitted to the senses can be presented, the perception of reality will also change in response. A version of reality is presented that is not actually there, but from the human perspective it is perceived as real, which is exactly what virtual reality is. In summary, virtual reality (VR) offers the senses a computer-generated virtual environment to explore (Virtual Reality Society, 2022).

Smart Factory

Smart factories create a system that can manage complex production processes quickly and smoothly, thus allowing less faulty production, and responding to customer requests more quickly. Depending on the advances in communication and informatics, we have high-speed internet, wireless network, cloud computing and very large storage areas among our possibilities. By making use of these, a smart factory system can be established. The smart factory is a concept used to describe the application of different combinations of modern technologies to create a hyperflexible, self-adapting manufacturing capability. Smart factories are an opportunity to create new forms of efficiency and flexibility by connecting different processes, information streams and stakeholders in a streamlined fashion. Smart factory initiatives might also be referred to as “digital factory” or “intelligent factory.” (Gartner, 2022).

This is what smart factories use; It is a broad manufacturing category that uses smart and integrated computer manufacturing, high adaptability and fast-flexible design changes, digital information technology and technical workforce training. In addition, sometimes rapid changes in demand-driven production levels include benefits such as optimization of the supply chain, efficient production and recyclability. In this concept, the smart factory has interoperable systems, multi-scale dynamic modeling and simulation, smart automation, powerful cybersecurity and networked sensors (Gartner, 2022).

Cyber Physical Systems

Systems in which physical mechanisms are controlled or monitored by computer-based algorithms are basically called cyber-physical systems. Autonomous cyber-physical systems are systems that can make decisions and operate independently. However, at this point, cyber-physical system development is mostly in semi-autonomous systems. The term cyber-physical system was coined in 2006 by then program director of the US National Science Foundation, Dr. Introduced by Helen Gill. But these systems have a much longer history, going back to the beginnings of cybernetics, defined by the mathematician Norbert Wiener as the science of control and communication in machines and humans. R. Sabatini, leader of the Cyber-Physical Systems Research Group, said, “Cyber-physical systems (CPS) combines elements from different scientific theories and engineering disciplines, including cybernetics, embedded systems, distributed control, sensor networks, control theory, and systems engineering. builds on it”. In general, a widely accepted definition of cyber-physical systems refers to systems in which software and hardware components are seamlessly integrated to perform well-defined tasks. As recent research trends support the introduction of artificial intelligence (AI) and machine learning functions, these tasks are increasingly automated and distributed across multiple agents. This helps move towards building reliable autonomy in so-called "intelligent" cyber-physical systems, or iCPS. Communication, control and computing are the three essential elements for cyber-physical systems. It often combines sensor networks with embedded computing to monitor and control the physical environment, and feedback loops that allow this external stimulus to self-activate communication, control or computation (King, 2022).

Although there are still too many organizations using unconnected systems today, connectivity is increasing day by day and has started to take an important place in the industry. Today, it is no longer possible to think of the physical world and the virtual world separately from each other. While the virtual world is built on the real world, the boundaries of physical life are expanded by the virtual world. Cyber-physical systems that provide the connection and information exchange between these two worlds constitute one of the most fundamental forces of Industry 4.0. Today, advanced technology information systems are located at the center of production processes. Machines equipped with cyber physical systems and technologies will have new interfaces. In order to be faster and more flexible in controlling them simultaneously and making the necessary updates, the equipment in the value chain needs to be supported with new innovations and adapted to cyber-physical systems. The basis of Industry 4.0 is to enable production processes and systems to connect with various networks through different interfaces and communicate with various services (TOBB, 2016).

METHODS

The research group consists of companies potentially affected by the Industry 4.0 revolution in Turkey. It consists of a total of 197 company employees between the ages of 21-60, at the graduate, undergraduate, associate degree and high school education levels of the companies in the ISO500 list.

Industry 4.0 Scale: Studies are newly shaped today to measure Industry 4.0 maturity. The strongest of them; It is the 2016 Global Industry 4.0 Survey of PWC (Price Waterhouse Coopers). With this scale, which is currently in effect as self-assessment, the Industry 4.0 maturity level of companies in four sub-headings/dimensions as Business Models-Product and Service Portfolio, Market and Customer Entry, Value Chains and Processes, Organization and Culture is tried to be analyzed. This scale was also used in this study. The 5-point Likert-type scale consists of 21 statements.

IBM SPSS Statistic v28 program was used in the analysis of the data obtained from the research. Descriptive statistical methods were used in the analysis of the data.

FINDINGS

In this section, the findings and comments determined as a result of the research are given.The demographic characteristics of the participants in the study are given in Table 1. As can be seen, approximately 53.8% of the employees participating in the research are female and 46.2% are male. Age distribution; 51-60 (5.6%), 41-50 (14.7%), 31-40 (45.7%), 21-30 (34%) were determined. It is seen that the majority of the employees are white collar and upper middle and lower level managers. Education levels; Postgraduate 48.7%, Undergraduate 45.2%, Associate Degree 4.6%, High School 1.5%.

Table 1. Demographics of the respondents

		Frequency	**Percent (%)**
Gender	Female	106	53.8
	Male	91	46.2
Age	21-30	67	34
	31-40	90	45.7
	41-50	29	14.7
	51-60	11	5.6
Number of Employees	1-10	13	6.6
	11-50	14	7.1
	51-200	34	17.3
	201-500	45	22.8
	501-1000	33	16.8
	1000+	58	29.4
Company Sector	Automotive	45	22.8
	IT/Electronics/Software	29	14.7
	Other	28	14.2
	Logistics	14	7.1
	Construction	11	5.6
	Textile	11	5.6
	Chemistry	10	5.1

	Mining /Metal	10	5.1
	Energy	9	4.6
	Health	6	3
	Education	5	2.5
	Machinery	5	2.5
	Food	4	2
	Defence Industry	4	2
	White Goods	3	1.5
	Agriculture	3	1.5
Education Level	Master's degree	96	48.7
	Bachelor's degree	89	45.2
	Associate degree	9	4.6
	High school degree	3	1.5
		197	100

Table 2. shows the minimum, maximum, mean and standard deviation values of the answers given by the participants to the scales. On 5-point Likert scales, the mean was 1.00-2.33 (low); It is examined at three levels: 2.34-3.66 (medium) and above 3.67 (high) (Karasar, 2016). The average of the answers given by the participants to the Industry 4.0 scale was 3,506 (±0.7415). In other words, it has been determined that there is a moderate level of participant perception.

Sub-components of Industry 4.0 maturity scale; Business Models, Product & Service Portfolio average is 3.605 (±0.7407), Market & Customer Access average is 3.492 (±0.8999), Value Chains & Processes average is 3.570 (±0.9069), Organization & Culture average is 3.299 (±0.9173).

Table 2. Descriptive Analysis

	N	**Min.**	**Max.**	**Mean**	**Standard Deviation**
Industry 4.0 Maturity	197	1.52	5.00	3.506	0.7415
1.Business Models, Product & Service Portfolio	197	1.50	5.00	3.605	0.7407
2.Market & Customer Access	197	1.00	5.00	3.492	0.8999
3.Value Chains & Processes	197	1.00	5.00	3.570	0.9069
4.Organization & Culture	197	1.00	5.00	3.299	0.9173
Valid N (listwise)	*197*				

The analysis of digital applications used in the companies where the participants work is given in Table 3. ERP - Enterprise Resource Planning ranks first with a high utilization rate of 70.1%, CRM - Customer Relationship Management ranks second with 64.5%, MRP - Material Resource Planning ranks third with 31.0%, and BI - Business Intelligence ranks fourth with 28.9%.

Table 3. Digital Applications

	Frequency	**Percent (%)**
ERP - Enterprise Resource Planning	138	70.1%
MRP - Material Requirements Planning	127	64.5%
CRM - Customer Relationship Management	61	31.0%

BI - Business İntelligence	57	28.9%
SCM - Supply Chain Management	50	25.4%
WMS - Warehouse Management System	48	24.4%
EDI - Electronic Data Interchange	44	22.3%
MES - Manufacturing Execution System	41	20.8%
RPA- Robotic Process Automation	30	15.2%
PLM - Product Lifecycle Management	28	14.2%
BPM - Business Process Management	24	12.2%
EAM/CMMS - Enterprise Asset Management	22	11.2%
APM - Application Performance Management	15	7.6%
Other	8	4.1%

The Industry 4.0 applications used in the companies where the participants work in Table 4. Big Data & Analytics ranks first with 46.7%, Cyber Security 45.7%, Cloud Computing 44.7%, Artificial Intelligence (Chatbot, Image processing, Digital twin etc.) 28.9%, Deep Learning and Machine Learning 25.4%, Autonomous Robots 22.3% is seen as.

Table 4. Industry 4.0 Applications

	Frequency	**Percent (%)**
Big Data & Analytics	92	46.7%
Cyber Security	90	45.7%
Cloud Computing	88	44.7%
Artificial Intelligence	57	28.9%
Deep Learning & Machine Learning	50	25.4%
Autonomous Robots	44	22.3%
Internet of Things & Internet of Services (IoT-IoS)	35	17.8%
Additive Manufacturing (3D Printers)	28	14.2%
Virtual Reality - Augmented Reality (VR-AR)	26	13.2%
Smart Factory	19	9.6%
Cyber Physical Systems	15	7.6%
Other	2	1.0%

As can be seen in Table 5. Industry 4.0 maturity levels are seen according to the sector. Logistics/Transportation: 3.85 is in the first place, IT/Electronics/Software: 3.83 is the second, and Energy: 3.80 is the third. Afterwards, respectively; Textile: 3.69, Agriculture: 3.68, Food: 3.60, White Goods: 3.57, Construction/Construction Products: 3.49, Other: 3.43, Automotive: 3.42, Machinery: 3.41, Chemistry/Plastic/Ceramics: 3.38, Defense Industry: 3.35, Education :3.12, Metal/Mining:3.10, Pharmaceutical/Health:2.66 sectors.

Table 5. Industry 4.0 Maturity Scores by Sector

	Mean
Logistics	3.85
IT/Electronics/Software	3.83
Energy	3.80
Textile	3.69
Agriculture	3.68
Food	3.60
White Goods	3.57
Construction	3.49
Other	3.43
Automotive	3.42
Machinery	3.41
Chemistry	3.38
Defence Industry	3.35
Education	3.12
Mining /Metal	3.10
Health	2.66

DISCUSSION & CONCLUSION

Acting appropriately in this unpredictable, uncertain space requires looking at technology from a new angle, one that takes into account the many facets of technological change and seeks to put the knowledge thus obtained into practice at the personal and corporate levels. Technologies will inevitably play a role in finding solutions to many of the problems we face today, but they are also contributing to these problems and creating new ones. Just as none of the stakeholder groups can solve these problems alone, these problems cannot be solved through the use of technologies alone.

ERP and MES etc of production and service. real-time monitoring with integrations, dynamically reacting to changes in demand from the customer, Information Technologies supported planning and logistics processes (in all processes from sales forecasting to production, warehouse planning and logistics), Sophistication of the digitality of production and service equipment (Digital factory , sensors, IoT connectivity; digital monitoring, control, optimization and automation etc.), the degree of digitalization of your horizontal value chain (continuous information flow from customer order to supplier, production and logistics to service) cannot differ much by industry.

The degree to which companies create value from data (e.g. Analytics team, employment of data scientists, reports on Excel, ERP and/or MES, Business intelligence applications, Big data applications etc.), level of Industry 4.0 related capabilities and resources (e.g. Data analytics , Cloud computing, Internet of Things/IoT, Cyber-physical systems/CPS , Human-machine Interface/HMI, production security, digital product lifecycle/PLM etc.), participation and support of top and middle management regarding Industry 4.0 and degree of specialization, degree of corporate cooperation on Industry 4.0 issues with external stakeholders such as academia, industry, suppliers or customers. It is natural that there will be differentiation by sectors in points such as open labs for customers and Smart Factory environments.

Transformation and change is possible for any company, it will affect us in many ways, from our external relations, as well as the relationships of leaders with their teams and the way they motivate, to goal setting and performance measurement methods. It's more of a way of thinking than a matter of technology. Therefore, we cannot wait for our work to be finished by appointing someone to carry out the digitalization and transformation process or to develop our information technologies in line with the new standards. Each of us must be the chief digitalist and transformer of our respective fields of duty. As managers of organizations, areas or units, they must be the driving force of change. Companies must evolve in their strategy to embrace a range of concepts in radical innovation. On the other hand, the execution of processes requires us to act much more agile on the basis of developments in technology. The faster and more agile organizations are, the greater the profit.

Digital transformation is not only about technology, but also about strategy. Although it requires you to update your IT infrastructure, it is more important to update your strategic thinking. Traditionally, the task of IT managers was to focus on the automation and improvement of existing business processes. Today, digitalization involves re-imagining and recreating the business. Adapting to digital transformation and Industry 4.0 and surviving in destructive competition is definitely not a linear process. After this study (even while this study is being done), there will be new studies on it. The leadership model put forward with the aforementioned working group on how Leadership should be in Industry 4.0 will also be open to change and development. How the world will transform after the Industry 4.0 revolution (perhaps it will be called Industry 5.0), what will change in our lives and business life, business models, ways of doing business, how people's needs and expectations will evolve, how artificial intelligence, autonomy, energy types will develop, new discoveries will be made. In this new era, which will be shaped by innovations and initiatives, leadership will undoubtedly be affected by this change and transformation and will have an impact on its shaping in this era (Schwab, 2019, s. 315-318).

In the last century, civilization has become increasingly aware of the transformative relationship between societies and the technologies developed. The first two industrial revolutions and the two world wars showed that technologies are not just a set of machines or systems connected with production and consumption. Technologies are powerful elements that shape societal perspectives and values. Economies, societies and ideologies are built with technology. According to Klaus Schwab, with the increase in the use of technology in production and robotic developments, the economy that shifted to the east for cheap labor will turn to the west again and the rise of the west will begin again. In fact, in the Industry 4.0 revolution we are in, the World is no longer the old World. When an invention is made, it does not remain local. Contract manufacturers of 20 years ago, countries such as India, China, and South Korea are now producing technology, and the amounts allocated from their budgets to R&D are increasing every year. Turkey is also striving to become one of these countries.

While Turkey is among the developing economies, if it catches the fourth industrial revolution, it can make up for what it missed in the previous revolution. With the globalization of the world, inventions, discoveries and technologies are being transferred from country to country faster than before. With the development and acceleration of the Internet, especially with the addition of 5G technologies, this speed will increase even more. While one country develops in the world, it does not seem possible for the other to lag far behind.

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