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Industry 4.0 And Possible Contribution to Turkey's Economy

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Objectives of thesis

The main purpose of this thesis is to determine the positive and negative effects of Industry 4.0 on the Turkish economy. For this purpose, the objectives of the thesis were determined as follows:

- The history of Industry 4.0 and theoretical examination of the elements of Industry 4.0.
- Examining the impact of Industry 4.0 on Turkey's economic indicators.
- Comparative analysis of Turkey's status in terms of Industry 4.0 with a few selected countries.

For the purpose of the thesis, the study is composed of two main sections. The first section is the theoretical part. In this section, Industry 4.0 and the status of Turkey in Industry 4.0 will be discussed theoretically. In this part, theoretical and empirical studies on Industry 4.0 and Turkey's relationship with Industry 4.0 will be included. The second part of the thesis consists of the practical section. In this section, the relationship between Industry 4.0 status and economic indicators of Turkey and selected countries between certain dates will be analyzed empirically.

In the other sections, the findings obtained as a result of the analysis will be compared with other studies in the literature.

Methodology

In order to achieve the aim of the thesis, first of all, the elements of two main arguments should be determined. These parameters are the data required to determine the status of a country in Industry 4.0, and the second one is the economic data indicating that the economy of a country is developing. In the literature review, it was observed that the researchers handled the Industry 4.0 parameters of a country in different ways. These parameters are as follows:

- R&D expenditures, number of scientific and technological articles, patent applications representing new inventions, science and technology exports

- Global Innovation Index, number of people working in R&D departments

- The share of high technology exports in total exports, the share of information and technology products in total product exports, the number of researchers

- Global Innovation Index

• Level of society's digitization (accessibility of Internet technologies), mention of Industry 4.0 in normative and legal documents of the state, volume of financing of scientific research

In terms of economic indicators, which is the second main argument of this study, it is observed that there are more common aspects in the studies in the literature. Basically, the GDP growth rate comes first among the countries' economic development levels.

In this study, Industry 4.0 parameters and economic indicators of Turkey and selected countries will be used as dependent and independent variables, since it is aimed to examine Turkey's Industry 4.0 situation and make a comparative analysis with a few selected countries. Global Innovation Index and High Technology exports, patent applications and R&D expenditures etc. will be taken as indicators of Industry 4.0, and GDP growth rates of countries will be taken as an economic indicator. As a sample, the data of these countries between the years 2005-2019 will be taken. Databanks of international organizations such as OECD and The World Bank etc. will be used to collect data. Quantitave research methods planning to be used in the thesis.

The proposed extent of the thesis

70 – 90 pages

Keywords

Industry 4.0, Artificial Intelligence, Cloud Technology, Turkey, Development level of Industry

Recommended information sources

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Declaration

I declare that I have worked on my master's thesis titled "Industry 4.0 Possible Contribution to Turkey' Economy " by myself and I have used only the sources mentioned at the end of the thesis. As the author of the master's thesis, I declare that the thesis does not break any copyrights.

In Prague on 31 March 2022

Gulnur OZDEMIR

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Industry 4.0 And Possible Contribution to Turkey's Economy

Abstract

Industry 4.0 is the process of coordinating machinery, computers, sensors and all other production processes independent of humans and making them more efficient. The main point of Industry 4.0 is to disable most of the manpower in applications, to run processes autonomously, to increase the efficiency of systems and production systems developed through machine learning. In this new industrial process, information technologies and machines are used together. It is an inevitable result that the emergence of Industry 4.0 will have positive and negative effects on national economies. While the competition between countries will provide competitive advantage to some countries with Industry 4.0, some countries will lag behind in the competition. In this study, the effects of Industry 4.0 on the Turkish economy were examined. As a result of the study, although it is seen that Turkey has been developing in the last 10 years, it is seen that it has not covered enough distance when compared to other countries. In the study, a comparative analysis of Japan, China, Germany, Greece and Turkey was made and an empirical analysis was made with the data of these countries. In the empirical analysis, the Global Innovation Index, which is considered as the indicators of Industry 4.0, the number of patents of countries, the effect of High Technology Exports and R&D Expenditures on GDP growth rates were examined, although a long-term relationship was determined between these indicators, the causality relationship was only with the Global Innovation Index. It has been determined in the number of patents and the number of patents with the GDP Growth rate. It is evaluated that the findings do not yield fruitful results due to the fact that Industry 4.0 is not a very old concept yet and the data are scarce.

Keywords: Industry 4.0,Artficial Intelligence, Cloud Technology , Turkey, Development level of Industry

Průmysl 4.0 a Možný Přínos pro Tureckou Ekonomiku

Abstrakt

Průmysl 4.0 je proces koordinace strojů, počítačů, senzorů a všech dalších výrobních procesů nezávislých na lidech a jejich zefektivnění. Hlavním bodem Průmyslu 4.0 je deaktivovat většinu pracovní síly v aplikacích, provozovat procesy autonomně, zvýšit efektivitu systémů a výrobních systémů vyvíjených pomocí strojového učení. V tomto novém průmyslovém procesu se informační technologie a stroje používají společně. Je nevyhnutelným důsledkem, že nástup Průmyslu 4.0 bude mít pozitivní i negativní dopady na národní ekonomiky. Zatímco konkurence mezi zeměmi poskytne některým zemím s Průmyslem 4.0 konkurenční výhodu, některé země budou v konkurenci zaostávat. V této studii byly zkoumány dopady Průmyslu 4.0 na tureckou ekonomiku. V důsledku studie, ačkoli je vidět, že se Turecko v posledních 10 letech rozvíjí, je vidět, že ve srovnání s jinými zeměmi neurazilo dostatečnou vzdálenost. Ve studii byla provedena srovnávací analýza Japonska, Číny, Německa, Řecka a Turecka a empirická analýza s daty těchto zemí. V empirické analýze byl zkoumán Global Innovation Index, který je považován za ukazatele Průmyslu 4.0, počet patentů zemí, vliv exportu špičkových technologií a výdajů na výzkum a vývoj na tempo růstu HDP, i když dlouhodobý vztah Tyl zjištěno mezi těmito indikátory, vztah příčinné souvislosti byl pouze s indexem Global Innovation Index. Je určen v počtu patentů a počtu patentů s tempem růstu HDP. Hodnotí se, že zjištění nepřinášejí plodné výsledky vzhledem k tomu, že Průmysl 4.0 ještě není příliš starým konceptem a dat je málo

Klíčová slova: Průmysl 4.0, Umělá Inteligence, Cloudová Technologie, Turecko, Průmysl na Urovni Rozvoje

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List of abbreviations

GDP: Gross Domestic Product

HTE: High-Technology Export

R&D: Research & Development

GII: Global Innovation Index

OECD: Organization for Economic Co-operation and Development

TUSIAD: Turkish Industrialists' and Businessmen's Association

1 Introduction

Industry 4.0 is the process of coordinating machinery, computers, sensors and all other production processes independent of humans and making them more efficient. The main point of Industry 4.0 is to disable most of the manpower in applications, to run processes autonomously, to increase the efficiency of systems and production systems developed through machine learning. In this new industrial process, information technologies and machines are used together. Therefore, the effect of human errors and slowdowns will be minimized and the process can be managed through robotic technologies (Mokry, 1999). In this process, heavy industry processes will be made more flexible, together with computer and internet networks, and can be transformed into an efficient and rapidly updated. With Industry 4.0, it is a fact that an enterprise that can adapt to the rapidly developing technologies of our age and can make quick decisions against production speed, diversity and capacity increases can be more competitive (Lucas, 2002). In order for them to grow economically in their countries, they need to be able to adapt to this change process occurring in the industrial world.

With Industry 4.0, it is aimed to make the adaptation of all production processes, which started to be used in the 3rd Industrial Revolution, with computer systems. With this change, there is an increase in productivity and acceleration of production with robotic systems independent of humans. Stages such as the automation and remote monitoring of physical systems, the communication of new generation robots and machineries with each other and with humans, and the fact that robots have learning algorithms with artificial intelligence are within Industry 4.0 (Daemmrich, 2017).

Turkey, which is the subject country of this thesis, has an important place in world trade due to its geographical location and population. It is very important for the Turkish industry, which is at the level of economically developing countries, to adapt to Industry 4.0 technology, as it is for other countries. In this thesis, the positive and negative effects of Industry 4.0 for the Turkish economy will be examined. In this context, a comparison will be made between Turkey and Germany, Japan, Greece, China. In the first part of the study, the objective and methodology to be used in the comparative analysis will be included. A comprehensive literature review will then be made. In the third part, the findings obtained as a result of the analysis will be found. Finally, the thesis will end with the discussion and conclusion part.

2 Objectives and Methodology

2.1 Objectives

The main purpose of this thesis is to determine the positive and negative effects of Industry 4.0 on the Turkish economy. For this purpose, the objectives of the thesis were determined as follows:

• The history of Industry 4.0 and theoretical examination of the elements of Industry 4.0.

• Examining the impact of Industry 4.0 on Turkey's economic indicators.

• Comparative analysis of Turkey's situation in terms of Industry 4.0 with a few selected countries.

As a result of the comparative analysis made in this context, it is planned to answer the following questions:

• Is Turkey sufficiently developed in terms of Industry 4.0?

• How much do High Technology Exports, R&D Expenditures and Global Innovation Index, which are considered as Industry 4.0 indicators, affect economic growth?

• What are the differences between the selected countries and Turkey in terms of Industry 4.0?

For the purpose of the thesis, the study is composed of two parts. The first piece is the theoretical piece. In this part Industry 4.0 will be examined theoretically. In this part, theoretical and empirical studies on Industry 4.0will be included. The second part of the thesis consists of the applied part. In this section, the relationship between Industry 4.0 status and economic indicators of Turkey and selected countries between certain dates will be analyzed empirically.

In the other sections, the findings obtained as a result of the analysis will be compared with other studies in the literature.

2.2 Methodology

In order to achieve the aim of the thesis, first of all, the elements of two basic parameters should be determined. These parameters are the data required to determine the place of a country in Industry 4.0, and the second one is the economic data showing that the economy of a country is developing. In the literature review, it was seen that the researchers handled the Industry 4.0 parameters of a country in different ways. These parameters are as follows:

• R&D Expenditures, Number of Scientific and Technological Articles, patent applications representing new inventions, science and technology exports (Aydemir, 2021)

• Global Innovation Index, number of people working in R&D departments (Erkekoğlu & Uslu, 2021)

• The share of high technology exports in total exports, the share of information and technology products in total product exports, the number of researchers (Yıldırım, Yıldız & Durak, 2020)

• Global Innovation Index (Anuslu & Fırat, 2020)

• Level of society's digitization (accessibility of Internet technologies), Mention of Industry 4.0 in normative and legal documents of the state, volume of financing of scientific research (Bogoviz et al., 2019)

In terms of economic indicators, which is the second main argument of this study, it is seen that there are more common aspects in the studies in the literature. Basically, the GDP growth rate comes first among the countries' economic development levels. In addition, the current account deficit, which shows the difference between import and export amounts, is an important indicator of the development of a country.

In this study, Industry 4.0 parameters and economic indicators of these countries will be used as dependent and independent variables, since it is aimed to examine Turkey's Industry 4.0 situation and make a comparative analysis with a few selected countries. Global Innovation Index and High Technology exports, patent applications and R&D expenditures will be taken as an indicator of Industry 4.0, and GDP growth rates of countries will be taken as an economic indicator. As a sample, the data of these countries between the years 2005-2019 will be used. The purpose of choosing these dates was due to the fact that the data of the selected countries could be obtained exactly. However, it is thought that there is a suitable date range for the evaluation of Industry 4.0 in terms of countries. Data banks of international organizations such as OECD and The World Bank will be used to collect data.

Panel data analysis method will be used in the analysis of the data. Eviews 10 packet analysis program will be used to perform this analysis. The analysis will consist of four stages. First, the descriptive statistics of the variables will be calculated, and the mean values, maximum and minimum values and standard deviations of the variables will be calculated. Then, the stationarity of the data will be measured to prevent the occurrence of false regression in the analysis. For this, Augmented Dickey Fuller (ADF) unit root test will be applied to all variables. In the third stage of the analysis, cointegration tests between the variables will be done with the Pedroni cointegration test. In the last stage, Panel regression analysis will be applied in order to determine the causality relationship between the variables.

Panel data analysis is a method used to analyze the data of more than one element in a certain time period. The regression model of panel data analysis is formed as follows.

$Yit = \alpha i + \beta Xit + uit$

Here t=1, ... denotes the time up to T. i denotes the cross-sections and the mass (i=1, …N) to which the investigated relations to which the variables belong. There are K variables in Xit which does not contain a constant term. αi t is taken as constant over time and i shows the effects of each cross-section (Egeli & Egeli, 2007). In panel data analysis, models are established according to the structure of error terms. These; fixed effects (fixed effects) and random effects (random effects) are in the form of two types. The main difference between fixed and random effects models is that dummy variables take on different roles. If dummy variables are considered as part of the intercept, it is a fixed-effects model. If dummy variables are considered as an error term, a random effect model can be mentioned (Uğurlu, 2015). Another difference between these two models is whether the constant and time effects are related to the explanatory variables. In reality, fixed effect estimator and random effect estimator models cannot be said to be perfect.

We can explain this as follows; The problem is that the random-effect estimator gives biased estimates above the true effect, while the fixed-effects estimator model gives estimates below the true effect (Johnson & Dinardo, 1997).

The regression model created for Turkey in this study will be as follows. Analyzes will be made on the same model for other selected countries after Turkey.

In the equation; It represents GDP growth rate, GII global innovation index, HTE high-tech exports, PA patent applications and R&D variables.

3 Literature Review

Industrial revolutions include transformations that change social life from beginning to end and provide the opportunity for economic development for countries that lead and adapt to change. In countries where industrial revolutions take place, social, cultural, political and economic change and development take place. Among these, the most important transformation and one that needs to be examined is economic life. Countries that remain outside of their globalization within the global world order may lose their competitive advantage. In order to catch industrial revolutions and competitive advantage, it is of great importance to examine and implement the developments leading to the revolutions (Lucas, 2002).

When the industrial revolutions are examined, there is a technological development and innovation on the basis of the revolutions. With the globalization of world economies, the importance of the concept of innovation has increased. With the increase in the standard of living, the countries that carry out innovation have the opportunity to attain a welfare environment in all areas of life and can provide competitive advantage, especially in the economy. Innovation can initiate the transformation process in all areas of society and become the main driving force of economic development. For this reason, it is very important to define the industrial revolutions in the historical process and the areas where innovation took place in the fourth industrial revolution, the content and elements of innovation.

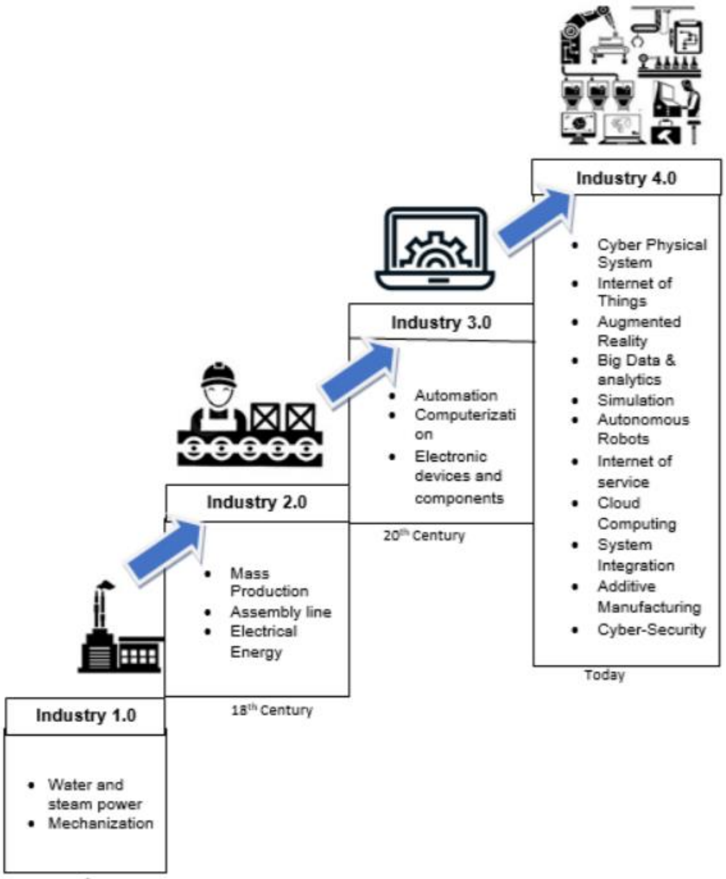
Obtaining and researching information that includes the elements determined for the realization of Industry 4.0 can create unmissable opportunities for every country. The knowledge and inventions that can be obtained during the realization of these elements, besides being the most important element of the process, are also important as a result of creating economic value. There is no doubt that a new product or service that creates economic value will be one of the most important elements of economic prosperity, competitiveness and growth for the coming years.

3.1 History of The Industrial Revolutions

The industrial revolution is the transformation that changes the production structure, creates mechanization, is expressed as technological development and affects the society in every aspect. In order for a technological development to be called a revolution, it must cause a great economic and social change. A real industrial revolution does not only result from technological innovations, but also creates an impact at the level of industrial organization, reduces production costs and ensures that the most appropriate firm scale is achieved (Lucas, 2002).

The cost advantage and optimum economies of scale that occur with technological development can affect the country's economy and provide a growth advantage. What is important for the economic growth created by technological development is that it creates an increase in per capita output and increases human productivity (Palmer, 2012). From the first industrial revolutions to today's revolutions, there has been a change and mechanization of production systems resulting from human needs and the necessities of the period. There are four major industrial revolutions, and in this section, the developments that led to the first three industrial revolutions and the fourth industrial revolution are tried to be explained. The schematic diagram of overview for the industrial revolutions is illustrated in Figure 1.

Figure 1. The History of Industrial Revolution



Source: Tay et all, 2019

3.1.1 The First Industrial Revolution

The first industrial revolution was largely confined to England during the 1760-1830 period. The production process has been transformed into mechanization in production by passing from hand production to machine production. The first industrial revolution occurred when coal-fired machines were adapted to steam-powered engines; Thus, a factory economy emerged. Increasing numbers of these machines were given steam power. The efficiency of water power has also increased (Mokry, 1999).

Although the standard of living was low in this period, with the industrial revolution, technology started to progress, production materials began to diversify, and the quality of life of the people increased significantly (Daemmrich, 2017). The coal and iron reserves owned by England enabled the revolution to start naturally in this country and this was seen in England in the first social effects. At the same time, coal began to replace bio-fuels and wood in this period. The first industrial revolution that started in England and years later it was adapted by Europe and the USA. (Lucas, 2002)

The main driving sector of the first industrial revolution was the textile industry. Especially the new machines used in the textile industry increased the production capacity of a worker approximately forty times, and thus the production speed and amount increased significantly (Özdogan, 2017). This has caused the daily lives of the average population to change. Their incomes and living standards began to grow steadily, although these positive results were slowly emerging (Rafferty, 2018). Determining the impact of such technological developments on the economy is of great importance in terms of country evaluations. The economic consequences of technological development for countries emerge in later periods. Countries that cannot catch up with the technological revolution may move away from the competitive environment, but by following the innovations with determination and adapting them at the country level, competitiveness and growth targets for these countries can be achieved.

One of the technological advances of the first industrial revolution, the steam engine first appeared in 1709, but before 1830 its impact on the economy was not that great. After 1830, the economic importance of the steam engine increased with its widespread application to transportation and manufacturing in areas where water power was not available. One of the most important reasons for this increase is that the steam engine is a pioneer in the development of other engines and plays an important role in the development of thermodynamics (Daemmrich,2017). The combination of steam power and mechanized production has created a step change in output. This dynamic increase in capacity and productivity has led to urbanization, the growth of regional and global market economies, the availability of democratic governments, and a rising middle class in the western hemisphere (Idris, 2019).

At the beginning of the period, England banned the export of machinery, skilled workers and production techniques. Despite this, England was the first country to encounter the social problems of industrialization. The second industrial revolution was driven by both unmanaged development and negligible government intervention, which allowed a large portion of the population to be exploited for profit. However, the monopoly of England did not last for years. Two Englishmen, William and John Cockerill, developed machine shops in Liege and brought the industrial revolution to Belgium in about 1807. Belgium was the first country in Continental Europe to be economically transformed. Like its British ancestors, Belgium also carried out the industrial revolution by concentrating on iron, coal and textiles (Lucas, 2002)

Until the second industrial revolution of 1870, the production methods continued to change, the workers became specialized, the workers were separated according to their specializations and the organization scheme was formed, and these stages gradually spread all over the world over time (Özdogan, 2017). France; It industrialized more slowly and less extensively than England and Belgium. As Britain established industrial leadership, France plunged into the revolution, and the uncertain political situation discouraged large investments in industrial innovation. By 1848, France had become an industrial power, but despite great growth, France, like other European countries, lagged behind England. The French and Belgian bourgeoisie lacked the wealth, power, and opportunity of their British counterparts. Political conditions in other countries also hindered industrial expansion. For example, despite its large coal and iron resources, Germany did not begin its industrial expansion until national unity was achieved in 1870. However, after it started, Germany's industrial production grew very rapidly and became the world leader in the steel and chemical industry. Participated in the industrial revolution in Japan with stunning success (Idris, 2019)

Eastern European countries were left behind at the beginning of the 20th century. The mid-20th century saw the industrial revolution spread to industrialized regions such as China and India. The rise of US industrial power in the 19th and 20th centuries far exceeded European effort. In the 1900s, the United States of America became the world's leading industrialized country (Özdogan, 2017). Despite these positive results slowly emerging, their incomes and living standards began to grow steadily (Rafferty, 2018). The first industrial revolution, which is the first revolution in which the effects of people's living standards and economic life were seen from the moment that technological production began to become widespread, is the first period in which technological products that emerged with innovation were used in production activities.

3.1.2 2th Industrial Revolution

The transition to the second industrial revolution took place between 1870-1914 and the second industrial revolution is also known as the technological revolution. (Rafferty, 2018) Among the features of the period are the efficient use of electrical energy, the commissioning of mass production lines aimed at minimizing manpower and maximizing product and production in a short time (Roblek et al, 2020).

The evolution towards the second industrial revolution occurred not only as a result of the application of scientific knowledge to industry, which was actually the last stage of the first industrial revolution, but also as a result of the use of the inductive method in an industry study. The revolution was formed by the combination of different groups of ideas. The first set of ideas led to the creation of cost calculations by determining the relative profitability of different parts of the factories. The second group of ideas accelerated the work of mechanical engineering with the methods of practice or trial and error, precise calculations and measurements. Finally, the great decline in product prices in the United States between 1865-96 revealed the necessity of reducing costs and the third group of ideas was formed. For these reasons, continuous mass production, which was designed in America and brought to England in the 1960s, was discovered while looking for ways to reduce costs, which became a necessity over time (Idris, 2019).

The second industrial revolution is the next wave of systems change for humanity, united around the modern belief that science and technology are the way forward for a better life and that progress is destiny in many ways. As a necessity of the age, entrepreneurs have reached different production methods by applying science to production and directly benefiting from the opportunities of science and engineering (Philbeck and Davis, 2019). During the second industrial revolution, the USA developed in every sector. All nations of the world benefited from the opportunities of the second industrial revolution. During the second industrial revolution, global humanity experienced developments on the basis of science (Mokry, 1999). The second industrial revolution started not only in the USA, but also in England and Germany. Another important role of this change was assumed by Japan. The revolution in Japan was supported by the government and every level of society was directed in a planned way and emerged strong and rich from this process (Daemmrich, 2017).

The industrial revolution did not change actual working methods, but was brought about by the invention of technologies that accelerated the actual work process that led to mass social change, rather than leading to higher production levels. The second industrial revolution occurred in the first decade of the twentieth century, with the convergence of electrical communication with oil-fired internal combustion engines (Rifkin, 2011) The message sent all over the world was the international importance of early industrialization in England, the importance of the steam engine, and the broad social change that occurred as farmers became factory workers (Palmer, 2012).

The second industrial revolution extended the very limited and localized achievements of the first to a wider range of activities and products. This period was a period in which scientific knowledge in certain fields was applied to technological life. During this period, great groundbreaking inventions in the fields of energy, materials, chemicals and medicine were realized. These inventions were important not because they had a great impact on production itself, but because they increased the efficiency of research and development in micro-creative activities (Mokyr, 1999).

It is clear that every new information contributes to the development of technology and the continuation of the product movements that emerge. Technology emerges as a result of knowledge. In addition to the contribution of useful knowledge to technological progress, technology also has considerable feedback to science. It has become an important issue to be the focal point of scientific thought in the light of new inventions and to record scientific facts and regularities. In addition, reshaping technology that creates better tools and equipment to test hypotheses has been a goal. The first industrial revolution and the technological advances before it had little scientific basis. Until 1850, engineering, medical technology, and agriculture were pragmatic bodies of applied knowledge, but it is rarely understood why they worked. This meant that most of the time people didn't know what things worked and what didn't. In this context, it was seen that the inventions after 1870 were different from the ones before it. The period of 1859-1873 has been described as the most productive and intense of innovations in history (Mokry,1999)

However, the technological innovations of this period brought about a transformation that could mean a historical discontinuity with the previous ones in England at the end of the 18th century, moreover, the process of social transformation. was a process that was not resolved until the second half of the 19th century. (Daemmrich, 2017) The second industrial revolution accelerated the mutual feedbacks between science and technology. The continuity and acceleration of technological progress in the third quarter of the nineteenth century was increasingly driven by useful knowledge. As a result, the second industrial revolution extended the very limited and localized successes of the first to a wider range of activities and products. New technologies have reached the daily lives of the middle class and working class more than ever before, and living standards and the purchasing power of money have increased rapidly (Lucas,2002).

The second industrial revolution is also called the US industrial revolution. Taylor's famous work Principles of Scientific Management, published in 1911, initiates a decisive impetus for the second industrial revolution. Alongside Taylor's ideas, welfare work and industrial burnout research gained widespread acceptance in engineering and other industries (Idris, 2019). Efforts in the industrial field developed on the basis of science are aimed at increasing economic welfare and productivity. For this purpose, in the second industrial revolution, inventions and innovations such as electricity, internal combustion engine, chemical industry, petroleum and other chemicals, paper, electrical communication technologies (telegraph, telephone and radio), indoor plumbing and running water and there have been changes in social spheres compared to the First Industrial Revolution, such as scientific thought, art and culture, architecture, lifestyle, etc. (Mohajan, 2020).

It has been stated before that one of the most important innovations brought by the second industrial revolution is electricity. Electricity has also been an area where completely new knowledge is used to solve economic problems. In this process, the first electrical production line was used (TOBB,2016). Based on the scientific discoveries of scientists such as Dane Hans Orsted and the American Joseph Henry, in 1821 Michael Faraday invented the electric motor in 1821 and the dynamo in 1831. The telegraph, along with the railways, was an early example of a technological system that was a combination of separate inventions that needed to be formatted. In this close collaboration between science and technology, the telegraph was clearly a second-generation technology. The use of electricity expanded rapidly in the 1870s. A miniature electric railway was exhibited at the Berlin exposition in 1879, electric trams worked in Frankfurt and Glasgow in the 1884s. The ability to supply large quantities of goods from one place to another, owing to the capabilities of machinery, along with railways and electric power, enabled the formation of production lines and the use of mass production. One of the best-known examples of mass production has been the Ford Motor Company, which applied Henry Ford's mass production techniques in the late 1910s (Mokyr, 1999).

The results of the second industrial revolution are briefly as follows: The nature of the production organization has changed. In the chemical industry, especially with the use of economies of scale in manufacturing, the cost has decreased, the importance of petro-refined and derivative products has increased, and economies of scale have brought mass production to the agenda. Because of the changing production technologies, the efficiency of industrial systems has increased.

The second industrial revolutions used large economies of scale and growth momentum was achieved in some industries (Idris,2019). Among the most important developments in technology between 1870-1914, the establishment of the iron and steel industry in England, the invention of chemical products in Germany, the invention of rubber and synthetic plastic in the USA in 1869, and the breakthrough in synthetic material by an American in 1907 once again has enabled science and technology to continue to advance in leaps and bounds (Mokyr, 1999). Among the other innovations of the second industrial revolution, there are transportation, development of production engineering, innovations in agriculture and food sector. The positive effect of each innovation in economic life is very important.

The early 1900s saw incomes rise, working hours gradually decreased, some forms of social insurance emerged, nutrition and shelter gradually improved, and living standards clearly rose. Statistical evidence from demographics proves this. In France, the infant mortality rate decreased by about 50% between 1870 and 1914. In France, this rate fell from 201 per thousand in 1870 to 111 in 1914. In Germany, these rates were 298 and 164. Average life expectancy has increased from around 40 to 50 years in the UK (Özdogan, 2017). The decline in death rates and the increase in life expectancy were partly due to higher incomes. With technological advances, as people earn higher incomes, they can buy more and better food, live in less cramped and better-heated housing, have better clothes, and have easier access to running water, sewage, and medical care.

The second industrial revolution differed from the first in that real wages had a direct impact on living standards and technological leadership shifted its geographic focus away from England to a more dispersed region (Mokyr, 1999) As the industrial revolution progressed, countries experienced economic growth. In the 1900s, the largest share in the world economy was in England with 24%, while America with 19%, Germany with 13%, Russia with 9% and France with 7% took place respectively. While Europe was the pioneer of the industrial revolution with 62%, in 1913 America had 1/3 of the world in production (Özdogan, 2017).

3.1.3 3th Industrial Revolution

The third industrial revolution was driven by enhanced awareness of the need to find energy technologies that will enable sustainable development and the achievement of climate goals (Mokr., 1999). In addition to the inventions discovered in the second industrial revolution and the new technological machines that started to be used, the digital revolution took place in the third industrial revolution. Especially after the 1950s, innovations that made leaps in the field of informatics and information science have occurred (Özdogan, 2017). In the 1960s, the welfare society and consumer society created by the increasing industrialization with digitalization reached their peak. However, before this leap, there were some developments that triggered technological innovation. While economic recession and crisis emerged in 1967 in the USA and Western European countries, which are at the forefront of the welfare society, the World Oil Crisis emerged in 1973. In 1972, a team working with the Meadows published a study called Limits to Growth, emphasizing that population and industrial production would increase at a constant rate, and the need for raw materials would increase and eventually run out. The effort to overcome the problems caused by the oil crisis created an opportunity to explore and apply new technologies in the Western Bloc. The resulting social problems and crises have created a suitable environment and opportunity to use new technologies and new organic knowledge (Erkan, 1992).

As a result of this economic crisis and the needs arising, in the late 1960s and early 1970s, in the light of the developments in the field of computer and electronics known as programmable logic control systems, the production was increasingly optimized with increasing efficiency and improvements. and its automation led to the emergence of the third revolution. It has been revealed that the signs of the third industrial revolution are being prepared to create a world of energy independence by utilizing green technologies, and this revolution is far beyond the first and second industrial revolutions. For two centuries, these pioneers remained within the confines of companies and dominated the economic and political landscape from this perspective. Technological developments have been characterized by existing centralized and hierarchical institutional power. The third industrial revolution emerged and spread among the newly structured technological and digital nodes, gaining strength and organized among societies (Daemmrich, 2017).

The third industrial revolution, which paved the way for Industry 4.0, took place with the use of electronics and information technology in production automation, and a widespread digitalization wave took place in the third revolution (Lucas, 1999). In the years of the third industrial revolution, digital logic circuits and technologies such as computers and internet based on these circuits began to be used in factories. This digital revolution has also laid its foundations in the information age. The production processes and complexity that emerged with the digital revolution could be managed with the help of information and communication technology, which is applied in approximately 90 percent of all industrial production processes (Aydemir, 2018).

This wave of digitization has created the appropriate environment for the promotion of smart objects such as industry 4.0 and cyber-physical system-based products and machines (Idris, 2019). Therefore, industry 4.0 and the convergence of digital and physical technologies are based on the third industrial revolution and developments in this industrialization stage (Aydemir, 2018). All these developments show that information technology will play a leading role now and in the future of production. The developments in the information age within the industrial revolution, the production of new technologies and the change in our lifestyle have led to the conclusion that the transformation of this age is very rapid. The main reason for the rapid transformation from industrial society to information society is the speed of development of new technologies and the high flexibility of people to adapt to these technologies. During the third industrial revolution, humanity became more conscious of technological innovations and had wider opportunities compared to the first and second industrial revolutions. In 1970, about half of the workers were called "knowledge workers". These accounted for over 53% of the total workforce income. (Erkan, 1992).

An innovative and creative society underlies the technological change brought about by the third industrial revolution and the information age. Efforts to produce smart computers that try to replace the human brain, innovations in microbiology extending to the structure of the human brain, developments in space, scientific developments such as the search for a universe outside the solar system, new machines produced based on technological innovations, developments in electronic communication, space vehicles, automobiles and medicine. went beyond the innovations of the industrial revolution and created the information age and formed the basis of the fourth industrial revolution (Aydemir, 2018).

Another technological innovation that has increased its popularity today and whose foundations were laid in the third industrial revolution has been artificial intelligence. It also facilitated the processing of artificial intelligence datasets based on deep learning and machine learning, which emerged in the 1960s when computer systems began to develop. With artificial intelligence, complex data is detected and the behavior of large systems is predicted, and the implementation and control of large physical systems that require extreme precision are provided (Öztürk and Ateş, 2021).

With the realization of computers and artificial intelligence, computing and production designs, the emergence of automobiles, airplanes and engineering wonders was formed by the meeting of scientific knowledge with technology. For example, with these technologies, unmanned aerial vehicles can transport orders and small packages, and today, there will be an increase in address delivery applications. The first programmable smart controller (PLC) Modicon 084 was one of the introduced devices produced with computer and artificial intelligence (TOBB,2016). In the 1980s, technological developments in medicine, chemistry, geology and other branches of science with image synthesis, CD-ROM production, microelectronic developments on the basis of communication technologies, robots, biotechnological developments also increased efficiency and productivity in production (Erkan, 1992).

3.2 The Emergence and Importance of Industry 4.0

The foundation of Industry 4.0 was laid in Germany. The term Industry 4.0 is derived from an initiative launched by the German government to maintain the long-term competitiveness of the manufacturing industry. Industry 4.0 is a strategic initiative of the German government, which has traditionally largely supported the development of the industrial sector. In this sense, industry 4.0 can be seen as an action for Germany to maintain its position as one of the most influential countries in machinery and automotive production. It is a fact that the importance of technological development and innovative thinking in the realization of this birth cannot be ignored (Kagermann et al., 2013).

Industry 4.0 is not a development that emerged by itself, but a process whose foundations are based on previous revolutions and whose foundations were laid with inventions in line with human needs. Technological revolutions consist of links connected to each other by a chain, from the first revolution to the steam engine, electricity, mass production with machines, digitalization with the information industry, and cyber-physical systems that emerged at the last stage. At the end of the 18th century, factories working with steam engines were established and production with machines began. With the second industrial revolution, which gained momentum at the end of the 19th century and at the beginning of the 20th century, mass production became possible with the more efficient use of electricity and the machines provided by the assembly line. Thus, with the third industrial revolution, the industry in the 1970s, combined with the computer and digital world, reached a perfect speed and became automated (Özdoğan, 2017).

In the following years, with the third industrial revolution, industrial technological advances, especially information technologies (IT), mobile communication and e-commerce, have gradually increased. The Programmable Intelligent Controller (PLC), which is a feature of the third industrial revolution, will be replaced in the fourth industrial revolution by Programmable Automation Controller (PAC) and Industrial PCs (IPC), which have much more flexible capabilities apart from similar features, that is, it will withstand extreme temperature, dust, humidity, vibration, energy fluctuations. left to computers designed in such a way. (TOBB,2016).

With the fourth industrial revolution, a new wave of technological progress is taking place, which is very different from other revolutions. Industry 4.0 is considered a disruptive technology that will pave the way for new generation industrial production systems, completely different from the existing ones. The fourth industrial revolution has been the industrial revolution that needs to be examined more closely because it is the first industrial revolution that has been announced before, not after the 20th. On the other hand, industry 4.0 can be perceived as a natural transformation of industrial production systems triggered by the digitalization trend (Aydemir, 2018).

The fourth industrial revolution rises on the digital revolution. The character of the revolution is mobile internet, which is much more widely used than the third industrial revolution, smaller but more powerful sensors that are cheaper, and machine learning with artificial intelligence. Industry 4.0 is a set of processes that transform the entire system and country structures with the rapid transformation in technology and digitalization, and are candidates for influencing all areas of society. The importance of Industry 4.0 comes from this rapid transformation. It is expected that the social development of the countries that adapt to this process very quickly, primarily in terms of economy, will increase. This process, which expresses the increasing involvement of the information sector in the production stages, will achieve even more success with the application of increasing R&D-intensive technologies and the increase in smart factories (Idris, 2019).

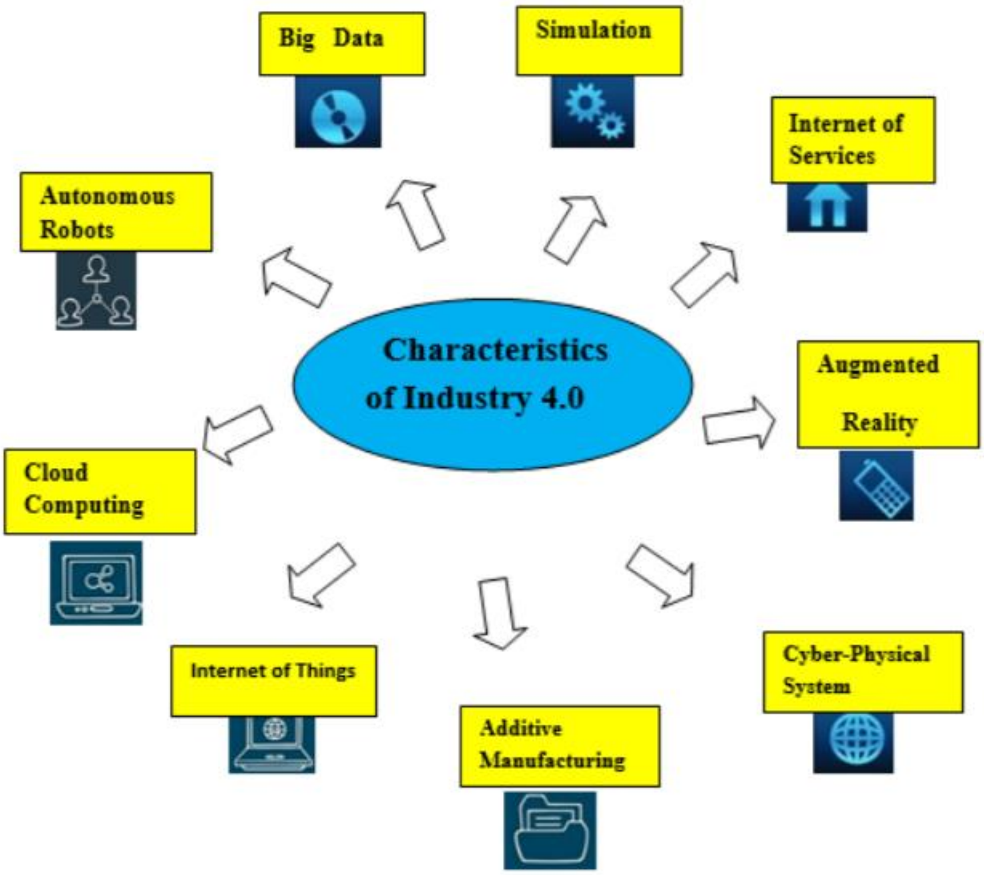
Industry 4.0 was mentioned for the first time at the Hanover Fair in 2011. Since then, the German government has taken the term and turned it into a strategy project for Germany's affairs (Sabo, 2015). In order to catch up with industry 4.0, the foundations of which were laid in the previous revolutions and started to take place long before it was put into words in Germany, some applications need to be realized. In all countries aiming to catch Industry 4.0, both the public sector and the private sector should be sufficiently conscious and sufficient resources should be transferred in this direction. A society that is conscious of this issue and is supported both financially and socially can come to the point of being able to compete with other developed countries in information technology and innovation.

Industry 4.0 represents a series of important changes in the way economic, political and social value is created, modified and distributed. These shifts in societal values are closely linked to the emergence of new technologies that span the digital, physical and biological worlds, and are expected to be even stronger when they combine and reinforce each other (Aydemir, 2018). Global competitiveness can become dangerous if the technological innovations that make up Industry 4.0 are left behind. It is expected to determine the place of the countries in the world economy and the level of technological development, to take a share from the production of products with high added value, to reach the level of industry 4.0, and to make very important contributions to the growth and development of the countries. In this respect, it is of great importance for developing countries to invest in technology production and innovation activities in order to organize all economic, human and social resources, and to follow closely the developments in this direction, in order to realize industry 4.0, taking into account the goal of being among the countries with high competitive power.

3.3 The Main Elements of Industry 4.0

The fourth industrial revolution is shaped by some technological factors. These technological factors are internet of things, internet of services, big data, cyber physical systems, cloud computing system, autonomous robots, simulation, horizontal and vertical integration, cyber and physical systsms, additive manufacturing and augmented reality. Many of these technological advances that underpin Industry 4.0 are already used in manufacturing, but these factors are expected to transform manufacturing with industry 4.0. Combining these factors with a fully integrated, automated and optimized production flow in the flow of activity; It is expected to lead to greater efficiency and a change in traditional production relations between suppliers, manufacturers and customers as well as between man and machine (Aydemir, 2018). The characteristics of Industry 4.0 is shown below at Figure 2.

Figure 2. The Elements of Industry 4.0



Source: Tay et al., 2019

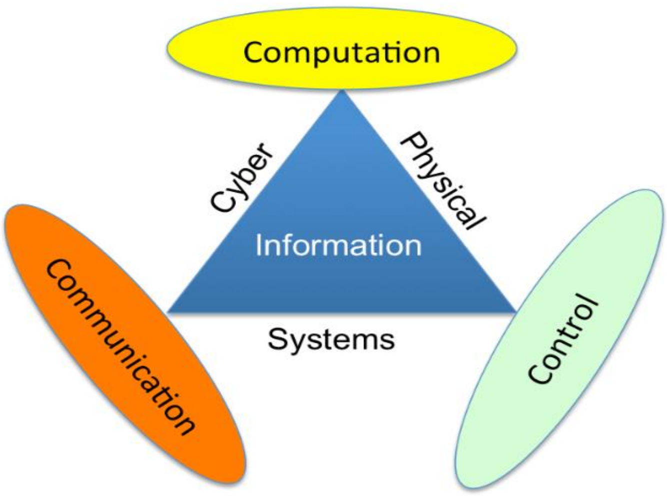
3.3.1 Cyber-Physical Systems

Today, we see that computers, internet and physical systems are interconnected and interactive in many systems. Computing systems that operate embedded in physical systems enable the calculation of information received from the sensors of physical systems and the communication of physical systems with each other with algorithms created by calculations

(Wolf, 2009). In this way, the systems in which physical systems and computer systems work together are called cyber-physical systems (CPS). Systems such as computerized vehicles, aircraft control systems, wireless sensor networks, smart city networks are examples of CPS. Along with these systems, many medical devices such as pacemakers in the health sector are also examples of cyber-physical systems (Bahetti and Gill, 2011).

Industrial control systems, smart Grid systems, medical devices and smart cars can be given as examples of Cyber Physical systems. Industrial control systems are used in different industries for control and monitoring purposes along with production activities. Smart Grid systems, on the other hand, are a different cyber-physical system that can achieve purposes such as electricity distribution to cities. This system is used in renewable energy sources, city grids and many other systems with automatic voltage control. Cyber-physical systems are also used in pacemakers, implants and prostheses. These systems enable the body-worn medical device to transmit information via a wireless connection. Smart cars are also good examples of cyber-physical systems. Systems such as autopilot in these cars allow the cars to be driven outside of human control, and accidents caused by human error can be prevented in this way (Raja, 2021). Cyber-Physical systems generate information through communication, computation and control processes, as seen in Figure 5.

Figure 3. Cyber Physical Systems



Source: Raja, 2021

The most important feature of cyber-physical systems is that they provide the connection between the physical world and the computing world through the sensors and actuators they use. The main elements of cyber physical systems are embedded computers, sensors, software and communication technologies. Cyber-physical systems also interact with each other. The two important elements that make up the cyber-physical systems are the internet network that enables the communication of objects and systems, and the virtual network in which the calculations are made by transforming the behavior of the physical systems into a simulation (Zanero, 2017).

One of the most important cyber-physical systems in the industry is smart factory technologies. All activities that take place during production in these factories are carried out thanks to cyber-physical systems. During this process, which is also called Industry 4.0-based production processes, the machines in the production processes are in communication with other machines through the interfaces they use. As with the smart phones we use, it is ensured that the machines are both in communication with other platforms via the internet and calculations are made through sensors. The most obvious benefit of smart factories is the absence of human-induced errors. Since all orders are made automatically by machines and processes are automated by algorithms, there is no human error in the process. Faults occurring in the system can also be detected and fixed automatically (Wolf, 2009).

3.3.2 Internet of Things

The concept of the Internet of Things, as the name suggests, is a system in which objects can be connected to each other with the help of the Internet, and objects can be adapted to the digital world with embedded computers and Internet networks. This system allows objects to communicate with each other and with central control points, without the need for human intervention, by giving an identity to the objects. Today, we come across Internet of Things applications in many different areas. The main uses of the Internet of Things are to make processes more efficient, to make effective decisions with the support of large data and to increase the value of the work done.

We can see the Internet of Things applications in many applications that facilitate the transactions of consumers in daily life, as well as in industrial processes and corporate activities. The internet of things, which we can see in smart homes and many white goods, is also encountered in factories operating in the automotive sector, telecom and energy distribution sectors.

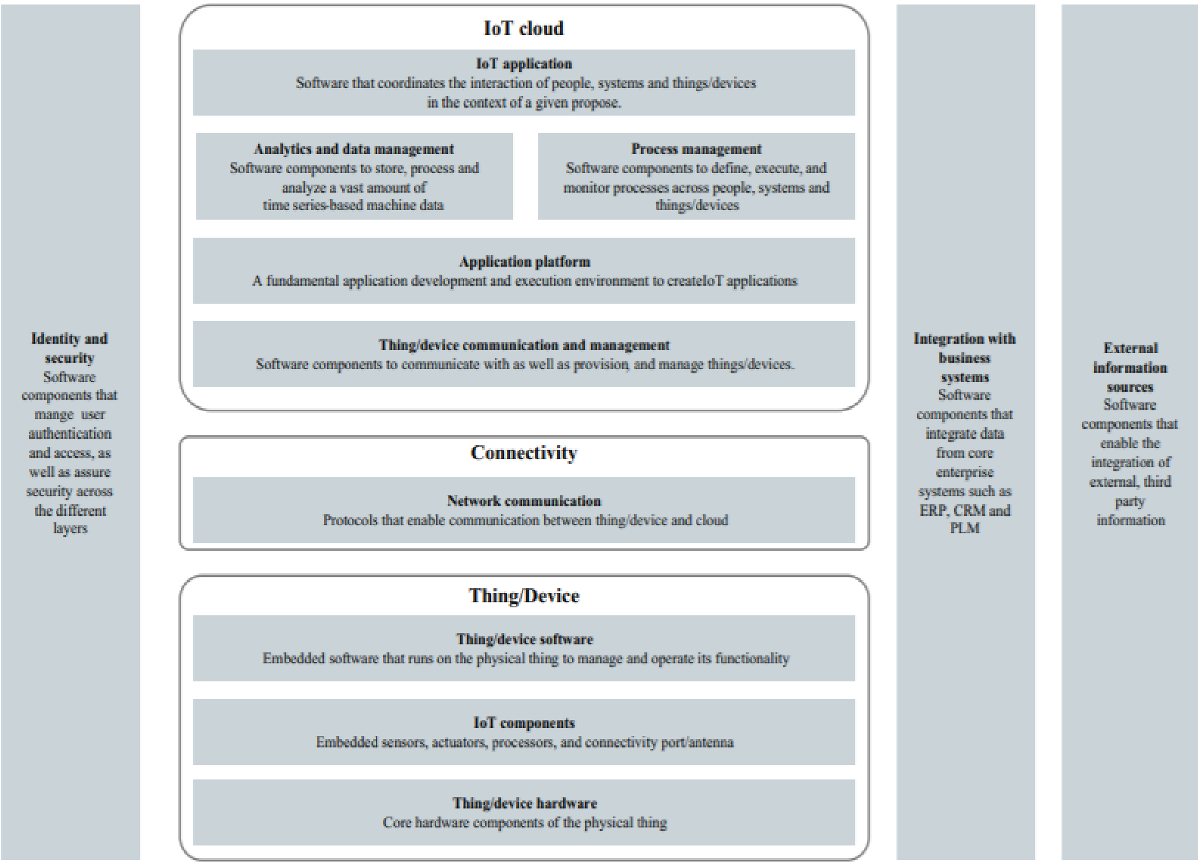
Today, many homes have smart televisions, kombi boiler systems that can be controlled by smart phones, and lighting systems. All of these applications are included in the Internet of Things applications. Along with these applications, there are wearable devices that provide information to doctors by collecting the data of users through sensors placed in the health sector, and devices that enable emergency response teams to arrive at their destination as soon as possible. Again, hospitals and other institutions can also carry out inventory controls through internet of objects applications.

The Internet of Things allows objects to add value to processes other than their primary function. For example, while the primary function of a light bulb is to illuminate the place where it is located, with the Internet of Things, it can detect whether there is a person in the place where it is located, and send a signal to the mobile phone of the host in case of unauthorized entry. The primary function of a warehouse is to be the place where materials are held. However, with the internet of things, the warehouse also adds a great value to the work by turning into an object that follows the inventory without the need for a human being. However, the value added by the objects in the internet of things is not limited to their own functions. They can also add value as a system by interacting with other objects. For example, a tractor enables a systematic efficiency to be obtained by communicating with other objects such as combine harvesters and balers involved in agricultural activities with the Internet of Things. (Wortmann & Flüchter, 2015).

In the internet of things, the system consists of three basic layers. These layers are object/device, connection and cloud layers. Among these layers, there are sensors and actuators added to the device layer according to the requirements of the internet of things together with the device. The link layer provides the communication of the device with the cloud layer. The cloud layer, on the other hand, contains the software needed within the scope of the internet of things. However, interaction with these other devices is also provided from this layer (Porter & Heppelmann 2014).

The layers and processes of the Internet of Things are shown in Figure 4.

Figure 4. Internet of Things Stack



Source: Porter & Heppelmann 2014.

3.3.3 Internet of Services

Since the 2000s, the service sector has grown very rapidly compared to many other sectors. 70% of Germany's total economic added value in 2008 came from the service sector. Information technologies have a very different place in the service sector today. In the 21st century, information technologies have succeeded in getting ahead of all other sectors. The concept of the internet of services is the services of companies in the service sector to their customers by using information technologies and the internet. Since the customers of the companies have reached the global level by exceeding the local borders today, providing services over the internet and benefiting from the internet of services has become a necessity in order to be successful in the competitive environment (Buxmann, Hess & Ruggaber, 2009).

Companies are trying to produce different business models in order to get ahead of their competitors in the globalized competitive environment. Companies that differ from their competitors with these business models can come to the fore in their sectors. The IKEA brand has been able to differentiate itself among its competitors with its furniture concept that people can assemble themselves, and its model based on Ebay auctions. Based on these examples, companies have become aware of the fact that their work can be done in different ways. The biggest innovation that has emerged as a result of the search for different business models in the service sector since the 2000s has been the use of the internet in service delivery. While the internet of services caused a radical change in terms of consumers in discovering and demanding services, it also brought the competition to the internet environment in terms of service providers (Cardoso, Voight & Winkler, 2009).

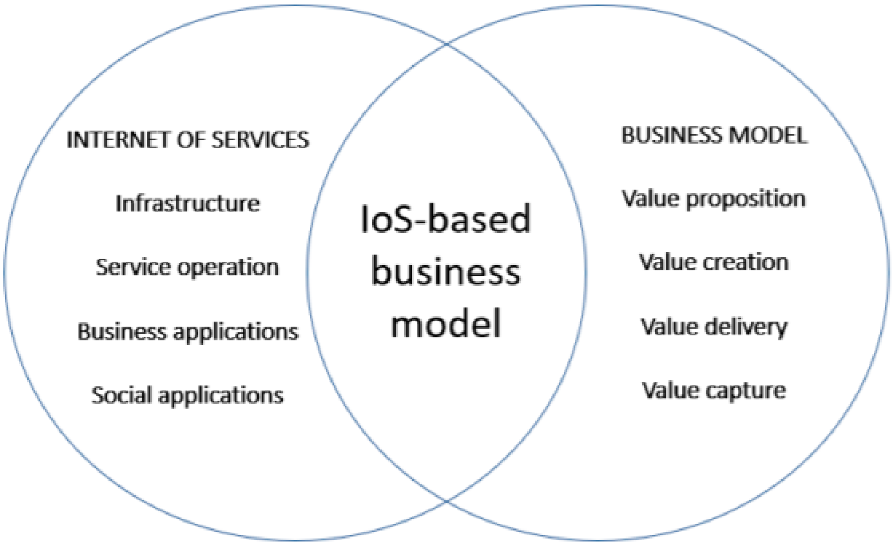
In the internet of services, the service provider company makes all its physical processes virtual. These processes include all fields of activity such as procurement, production, logistics and marketing. The company, which manages a virtual process using the Internet of Things applications, has to take advantage of the opportunities of other Industry 4.0 elements such as big data, cloud and simulation.

There are many services that we use in daily life in terms of internet of services applications. The most prominent of these are financial technologies, internet markets and social applications. Financial services, which we also see as fintech, appear in banking, investment consultancy, trade and asset valuation applications (Reis et al., 2022).

The use of internet of services applications in the financial sector aims to minimize human errors and provide more comfortable service to customers. Thanks to these applications, both banks and users gain many advantages. One of the biggest advantages for bankers is to be able to obtain customer data in a more organized way and to reach more customers. In this way, banks can use the data more efficiently and make a more intuitive decision to increase or decrease their assets. In addition, financial security weakness of internet of things applications can sometimes be encountered. For this reason, security controls of these applications should be made at a higher level compared to traditional applications (Reis et al., 2022).

Marketplace applications are among the most frequently used applications in internet of services applications. In these applications, physical products are exhibited on the internet and a bridge is established between the producer, the intermediary and the consumer. Applications such as Amazon and Ali Baba are the most well-known applications of the Internet of Things Marketplaces. Consumers can only do their shopping over the internet without physically seeing them through marketplace applications, and communication between the consumer and the service provider is provided over the internet. In these applications, manufacturers and service providers carry out all their activities such as inventory tracking, advertising and marketing over the internet. An example of an internet of services-based business model is shown in Figure 5 (Reis et al., 2022).

Figure 5. Internet of Services Based Business Model



Source: Reis et al., 2022

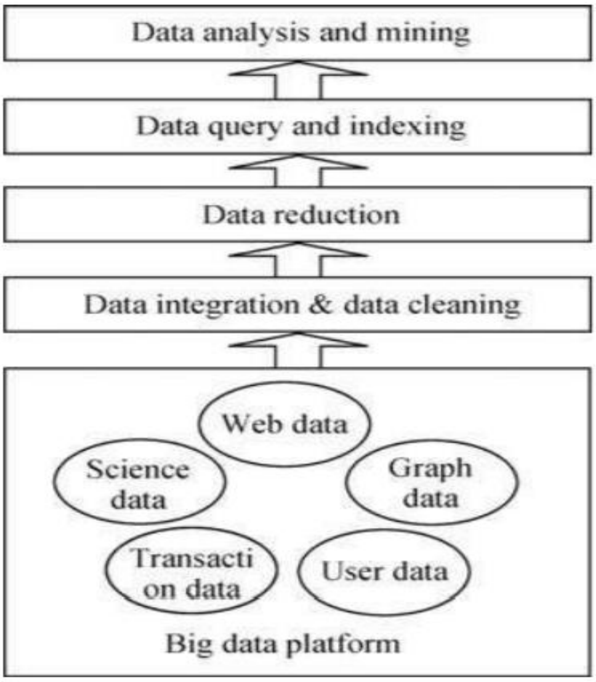
3.3.4 Big Data

Today, more than half of the world's population is an internet user. People use the internet for many different reasons, from shopping to communication. All activities carried out on the Internet, applications such as the Internet of Things, Internet of Services, and all network activities reveal many scientific or non-scientific data. While these data want to be used for many different purposes, it has become very important to collect, analyze and use these data for a specific purpose. The increase in the speed, volume and diversity of data on the Internet has led to the emergence of the concept of "Big Data". In today's global competitive environment, understanding big data and making decisions by analyzing big data means making a difference for companies. For companies, the use of big data offers many opportunities and advantages. At the Davos World Economic Forum held in 2012, the concept of data was mentioned for the first time as an economic value. In 2011, the amount of data held by 15 large companies in the USA was more than the amount of data stored by the library of congress. The number of examples that can be given to the size of the data quantities is quite high. For example, the data owned by the Wall Mart chain of stores consists of more than 1 million customer data transactions every hour. Another example can be given from Facebook. In 2010, the number of content shared by people via Facebook reached 30 billion (Dogan & Arslantekin, 2016).It is not possible to process big data by means of traditional database techniques. This data type is heterogeneous data with different volumes and includes all digital content obtained from different sensors (Aktan, 2018).

Big data provides many advantages to companies as in other Industry 4.0 elements. The most important of these advantages are cost reduction and time saving. In addition to this, it also increases the possibilities of decision making within the company. The main purpose of small data in traditional trade is to facilitate internal decision making mechanisms. What recommendations should be offered to customers? These data provide answers to questions such as which customers will cease to be customers of the company in the near future and how much inventory should be in the warehouses. In big data analysis, answers can be found for much more than these questions. Big data allows both the analysis using small data and the analysis of many ancillary elements. This includes the use of other companies' data other than the companies' own data.

In today's technologies, data does not come from a single source as in traditional data methods. The basis of the concept of big data is the diversity of sources of data and the fact that it can be in different models. Although the variety of data provides many advantages, its processing and analysis can be just as difficult. Data are evaluated in three main categories: structured, semi-structured and unstructured data. Different technological systems are used for each data class. Big data is also expressed as 3V due to the variables of speed, variety and volume. However, some problems in the processing of big data required the addition of different Vs such as virtual data and value data in addition to these Vs (Chen et al., 2013). Chen et al. (2013) classified big data under five main headings. These are web data, graph data, user data, transaction data and science data. Transaction data is data such as web logs, commercial transactions, sensor data in IoT applications. Scientific data are high-energy physics data, health data, and data from data-intensive experiments. Web data is data on billions of pages on the web. There is a large amount of data on the backs of web pages. These data can be scanned and integrated with other data sources. Graph data, on the other hand, is data consisting of a large number of data nodes and the connections between these nodes. The processes on big data are shown in Figure 6.

Figure 6. The Processes of Big Data Analyse



Source: Chen et al, 2013

3.3.5 Autonomous Robots

In today's technologies, data does not come from a single source as in traditional data methods. The basis of the concept of big data is the diversity of sources of data and the fact that it can be in different models. Although the variety of data provides many advantages, its processing and analysis can be just as difficult. Data are evaluated in three main categories: structured, semi-structured and unstructured data. Different technological systems are used for each data class. Big data is also expressed as 3V due to the variables of speed, variety and volume. However, some problems in the processing of big data required the addition of different Vs such as virtual data and value data in addition to these Vs (Chen et al., 2013). Chen et al. (2013) classified big data under five main headings. These are web data, graph data, user data, transaction data and science data. Transaction data is data such as web logs, commercial transactions, sensor data in IoT applications. Scientific data are high-energy physics data, health data, and data from data-intensive experiments. Web data is data on billions of pages on the web. There is a large amount of data on the backs of web pages. These data can be scanned and integrated with other data sources. Graph data, on the other hand, is data consisting of a large number of data nodes and the connections between these nodes. The processes on big data are shown in Figure 6.

In an increasingly competitive environment with the rapid development of technology, the search for methods of making more profit with less cost has also accelerated. One of the most important results of these searches is autonomous systems, which is one of the possibilities brought by technology. Autonomous systems have started to be developed to be used in jobs that people cannot do due to their physical limitations, and over time, the similarities of these autonomous systems with humans have started to increase. Today, autonomous robots that can do almost every job that humans can do are widely used in many branches of the industry. The country where robot technology was first used was Japan. At first, this robot technology was reacted with the concern that it could cause people to be unemployed, but later it was seen that this technology increased job opportunities more (Cengelci & Cimen, 2005).

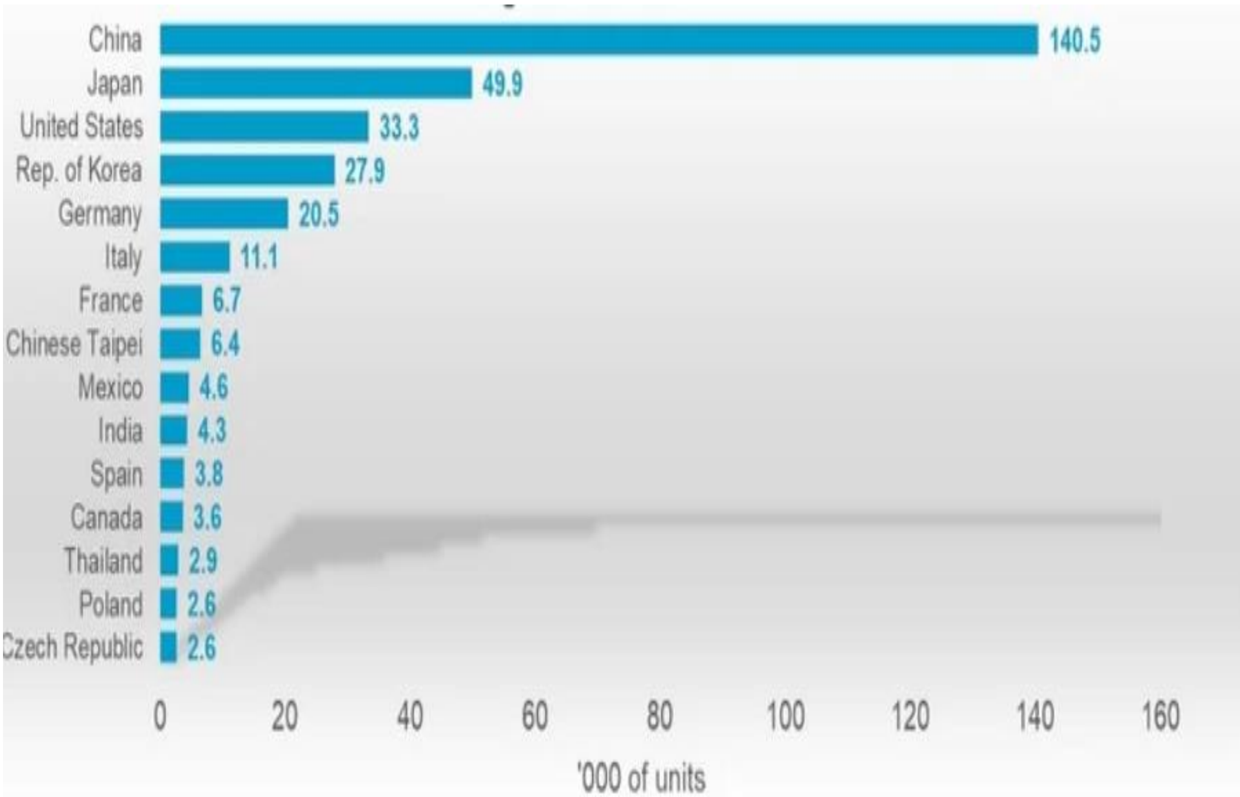
It is the situation where the production processes, understood by the word autonomous in industries, are carried out using robotic technologies in an unmanned way. Thanks to autonomous robots, which are an important part of Industry 4.0, human-induced errors are minimized or eliminated, thereby reducing the costs that will occur due to errors. Today, we see that autonomous robots are used by many different sectors from the automotive sector to the health sector. Autonomous robot technologies provide many advantages to companies with both faster processes and accurate and instant analysis. Autonomous robots are categorized in two separate classes. These are industrial robots and service robots.

It is possible to list the usage purposes of industrial robots as follows (Yılmaz, 2006):

- Reducing labor costs
- Preventing people from working in dangerous jobs
- Increasing efficiency
- Preventing difficulties in finding skilled workers
- Ensuring that extremely heavy and difficult work is done that people cannot do.
- Allowing work to be done without interruption
- Preventing human errors

According to the International Robotics Federation (IFR) 2020 Industrial Robots report, the number of autonomous robots used in factories around the world increased by 12% in 2020 compared to 2019 and reached 2.7 million. The data of industrial robot systems established in the 15 largest economies worldwide in 2019 are shown in Figure 7.

Figure 7. Annual installations of industrial robots Top 15 countries



Source: IFR 2020 Report

As can be seen from the figure, more than 75% of the world robot production market is under the domination of 5 countries. These countries are China, Germany, South Korea, USA and Germany. With the production of 140,000 robots, China has a market dominance well above all other countries. With this production, China produces more robots than all of Europe and the USA.

3.3.6 Cloud Computing

Cloud computing is used to express an infrastructure support used to access computing, storage and applications over the internet without knowing how they are stored or on which servers they are running. Cloud computing is an infrastructure service offered in the field of information technologies. To give an example from daily life, people simply plug in the electrical device or press the button of the lamp to use electricity. They are not concerned with how electricity is produced or distributed. They only pay an infrastructure fee for this electricity service they receive. Similarly, in cloud computing, it can be defined as an infrastructure support in the field of information technologies. Just as people do not need to have an infrastructure knowledge about electricity, you do not need any information on how to provide data service, storage service or application support in cloud computing.

All these processes are done by your service provider and you pay a fee to your service provider for these services (Seyrek, 2011). In cloud technologies, the only responsibility of the service user in terms of cost is in terms of service. The costs and maintenance of the equipment used are covered by the service provider (Akben and Avsar, 2017).

It can be very costly to maintain information technologies and to ensure the sustainability of information storage units for a person or a company. Purchasing the software, making its continuous updates and ensuring their security can be very troublesome in terms of both cost and labor. Outsourcing of information technologies such as cloud computing brings great convenience to companies (Hayes, 2008).

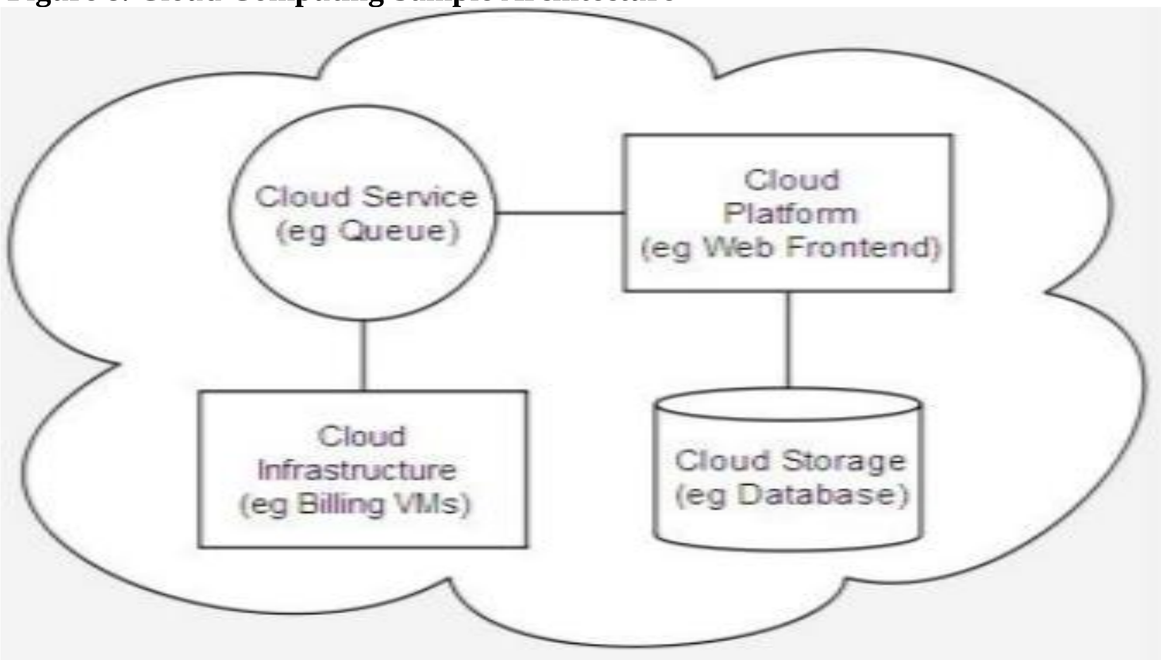
Cloud Computing technology is defined by the National Institute of Standards and Technology (NIST) as an informatics service where users can receive network, server, storage, application and computing services with minimum hassle and minimum interaction with the service provider. The advantages of cloud computing to users can be listed as follows (Brian et al, 2008).

• Provides economic competitive advantage to user companies. Thanks to the advantages of providing users with fast solutions in providing information infrastructure, responding quickly to the problems experienced and sustainability advantages, companies save a great deal from both their workforce and hardware and software costs.

• Thanks to cloud computing, companies focus on their own products, not the computing they use as a tool. This increases their productivity.

An example of cloud computing architecture is shown in Figure 8.

Figure 8. Cloud Computing Sample Architecture

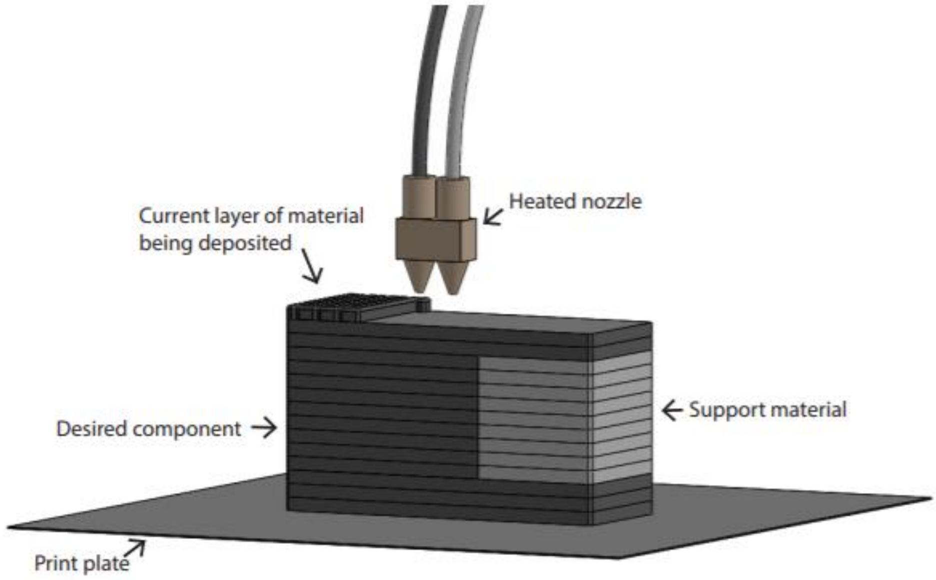


Source: Mirashe and Kalyankar, 2010

3.3.7 3d Printers

It is a technology that enables users of 3d printers to create a physical object, not a software or a virtual entity. Thanks to 3d printers, users can take an object they draw in their hands, not the printout of a text they write. Although there are many different types of 3d printers, they are generally classified into three main categories. These are Fused Dposition Modeling, Stereolithography printers and selective laser sintering. FDM is a type of printer that is applied by a method in which a plastic is melted and cooled. Stereolithography printers are a variety in which ultraviolet rays are used to obtain objects. Selective laser Sintering, on the other hand, is a type of printer in which laser beams are used to create objects, as the name suggests (Moorefield-Lang, 2014). The most widely used and known type of 3d printers are FDMs. An image of an FDM 3d printer is shown in Figure 9.

Figure 9. Cloud Computing Sample Architecture



Source: Grutle, 2015

3d printers represent a layered process. The created objects are created by creating certain sections in layers and bringing these sections together at certain resolutions. For this reason, it is also referred to as additive manufacturing. In the development process of 3d printers, it is seen that entrepreneurs and people who are interested in the subject rather than large corporate companies are the pioneers. Three-dimensional printers have versatile uses, both in terms of individual processes and industrially. For this reason, first of all, it is necessary to decide for what purpose the printers are intended to be used. These purposes are as follows (Şahin and Turan, 2018):

• Creating a prototype and mold before starting the production process of a product

• Conversion of surface shapes into physical data for topographic analysis.

• Implementation of practices called mass customization in order to manufacture products specifically for the person,

• Creating models for applications such as prosthesis and implants in the field of health and for easier diagnosis of a disease,

• Spare Parts production.

The advantages of using a three-dimensional printer can be listed as follows (Şahin and Tıran, 2018):

• Since the design of the objects is digital, it is easy to share, store and transfer to another place,

• Easily making changes and updates during the design process,

• Easy to customize products,

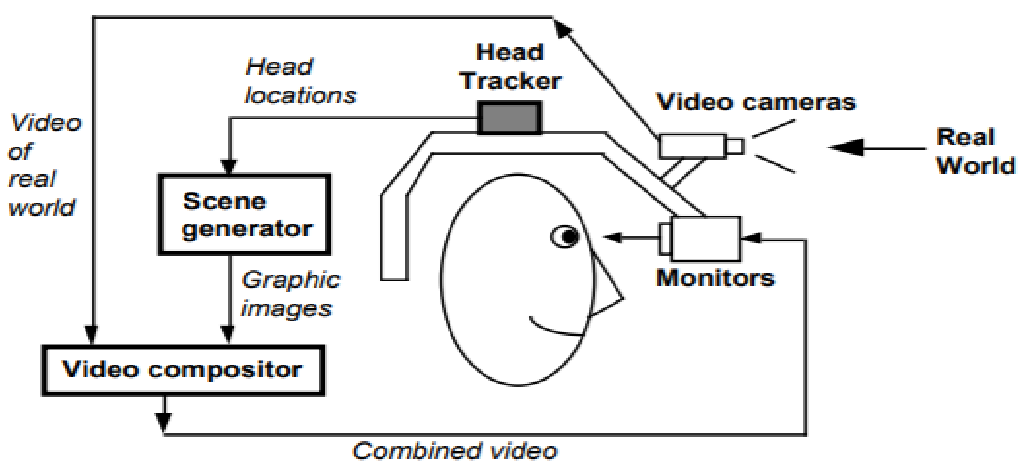
• Being cost effective in both investment and production processes,

• The most effective use of raw materials, the completion of the production period with minimum waste.

3.3.8 Augmented Reality

Today, one of the most remarkable technologies related to Industry 4.0 is Augmented Reality (AR) technology. This technology is one of the technologies that we have recently started to encounter more frequently in our daily lives. There are two different versions of this technology. One of them is virtual reality and the other is augmented reality. While virtual reality mostly refers to a technology in which users disconnect from real life and enter a completely virtual environment in three-dimensional games, in augmented reality, real world and virtual reality are interconnected and data and images can be added to real life itself. Augmented reality technology was first used in military fields. One of its first applications is an application that allows pilots to see both the real image and the data coming from the transparent screen at the same time, thanks to a transparent screen placed on the helmets of fighter pilots. After the military fields, augmented reality applications have started to be used in many different fields today and continue to be used (Icten and Bal, 2017). Figure 10 shows the diagram of the augmented reality application placed on a fighter pilot's helmet.

Figure 10. Augmented Diagram of War Pilot Helmet



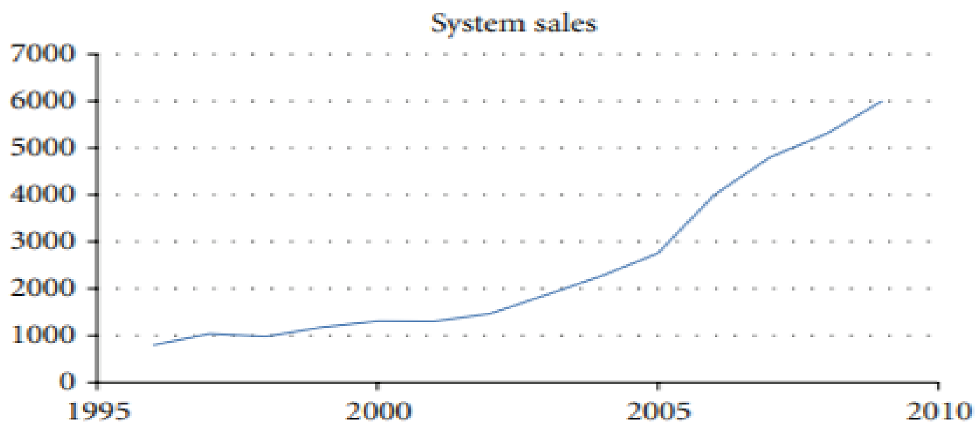
Source: Azuma, 1997

One of the application areas of augmented reality is the medical sector. Augmented reality applications offer a very convenient environment especially for preoperative observation and training of doctors. Thanks to the three-dimensional images created by the patient's ultrasound, MR and tomography images, doctors gain the necessary experience before the surgery. However, in the operating room, doctors have the opportunity to see details that are impossible to see with the naked eye, thanks to Augmented Reality. One of the application areas of augmented reality is the maintenance and repair of complex machines. With augmented reality, the machine can be easily maintained and repaired in 3D step by step. In this way, repair and maintenance applications that would normally take a lot of people's time or cause them to make mistakes can be done in a shorter time and without errors. One of the areas where augmented reality applications are used the most is the fields of architecture and engineering. Augmented reality applications, where all the details of a building, an automobile or a machine can be visualized, provide great convenience for engineers and architects (Azuma, 1997).

3.3.9 Additive Manufacturing

Additive manufacturing technology was first used for prototype production in the 1980s. For this reason, the name rapid prototyping was first used. Over time, the use of this technology has started to increase due to the convenience it provides in the field of industry. Figure 11 shows the increase in system sales from 1995 to 2010. The number of sales, which was less than 1000 in 1995, increased by 6 times and reached 6000 in 2010s. As can be seen from Graph 11, there has been a rapid acceleration especially since 2005.

Figure 11. Growth of rapid prototyping

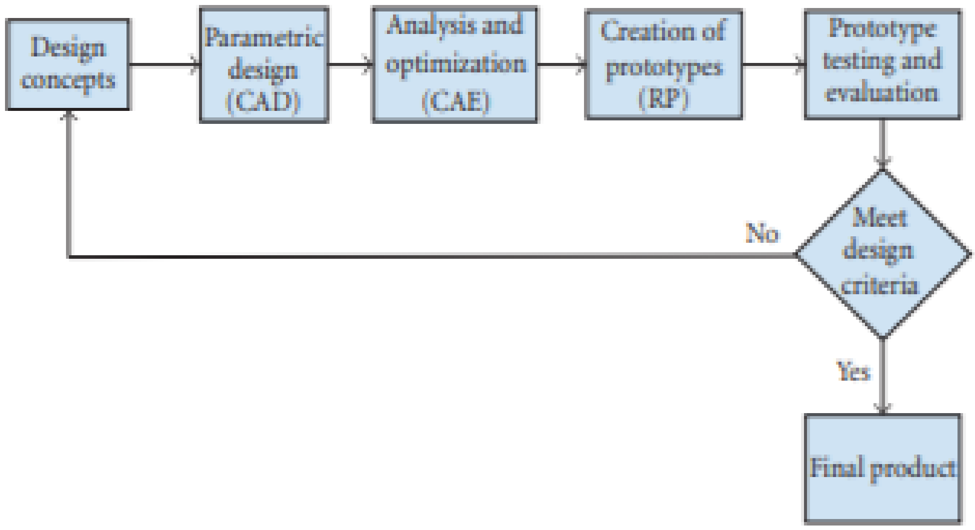


Source: Wong & Hernandez, 2012

Although this technology is based on the same logic, it can be used in many different ways. The most widely used additive manufacturing technologies are stereolithography

(SLA), melt stacking modeling (FDM), three-dimensional printer (3DP), selective laser sintering (SLS), selective laser melting (SLM), electron beam melting (EBM) applications. Today, we encounter applications in many fields such as medicine, dentistry, space industry and jewelry. With this technology, product manufacturing is done by using three-dimensional data, by producing layer-by-layer materials and adding them to each other. Drawings created by using 3D design programs, reverse engineering or computed tomography data can be easily converted into a product by the additive manufacturing method (Ozsoy & Duman, 2017). The stages of additive manufacturing are shown in Figure 12.

Figure 12. Product development cycle



Source: Wong & Hernandez, 2012

Today, additive manufacturing has many uses. One of them is the production of light parts, which are especially needed in aircraft and car production. Since it is very important to produce the lightest part to be safe during the production of cars and airplanes, the production of these parts is usually done by additive manufacturing. The production of these parts without the additive manufacturing method requires both more labor and more cost, and additive manufacturing provides great benefits to this sector both in terms of labor and cost. In addition to these sectors, the additive manufacturing method can be used for architects to create models. In traditional applications, architects create their models by hand, and this method is quite challenging for complex structures, and it is often not possible. However, the additive manufacturing method provides great convenience for architects in this regard. Architects who design their drawings in three-dimensional design programs can then transform these drawings into a physical object with the additive manufacturing method and transform their models into a visual form. Apart from these applications, it can also be used in health applications, implant and prosthesis production, membrane production in the construction sector, furniture production and non-industrial manufacturing for hobby purposes (Wong & Hernandez, 2012).

3.3.10 Simulation

A simulation is a virtual simulation of a real system or process. Simulations are virtual environments created for the realization of impossible or costly experiments. However, it can also be used for the purposes of designing, analyzing and optimizing complex systems. Today, there are many areas where simulations are used. Simulation applications has many different uses such as

• Performing performance trials in production, inventory and transportation processes,

• System evaluations and process improvements in Health Services, airports, banking and logistics operations,

• Deciding on military tactics and strategies,

• Giving education,

• Testing a newly made design before it is put into practice (Coskun, 2020).

Today's production processes and the size of companies have reached gigantic sizes and become complex. The management of these processes, making plans or adding new developments to these processes can be very difficult and costly. For this reason, the simulations created can help decision makers about the results of the plans or new designs in real life. However, simulations can be used effectively in many educational fields. Simulations in fields such as pilot training, ship captain training or medical training cause significant savings. To give an example, while it is very difficult and unsafe for a ship captain to use a ship in stormy seas during training, this situation can be simulated in a simulation environment and stormy sea training can be given. However, natural disaster simulations are very effective on how people should behave in these disasters.

3.4 Practical Part

In this section, the positive and negative effects of Industry 4.0 on the Turkish economy will be analyzed empirically. As explained in the methodology section, the analysis will be done by measuring the effect of some indicators of Industry 4.0 on Turkey's GDP growth rate. In this context, it was thought that including Turkey and different countries in the analysis and making the analysis comparatively would bring better results. In this context, Japan, China, Germany and Greece were also included in the analysis. With the inclusion of these countries in the analysis, it is evaluated that the effect of Industry 4.0 on the Turkish economy will be better understood.

3.4.1 Industry 4.0 and Turkey

The developments in the world industrial history have had great effects on the development of Turkey as well as in the rest of the world. One of the most important reasons why the Ottoman Empire lost its power and economic superiority compared to other countries in history is that it could not catch up with the innovations brought about by the first industrial revolution. With the first industrial revolution, the fact that the products produced in the factories in Europe could not compete with the craft products of the Ottoman Empire, made the Ottoman economy an economy dependent on foreign countries. However, the periods in which the Republic of Turkey, which was established with the collapse of the Ottoman Empire, was the best economically, were the periods in which it kept up with the technological developments in the world (Arkan, 2018).

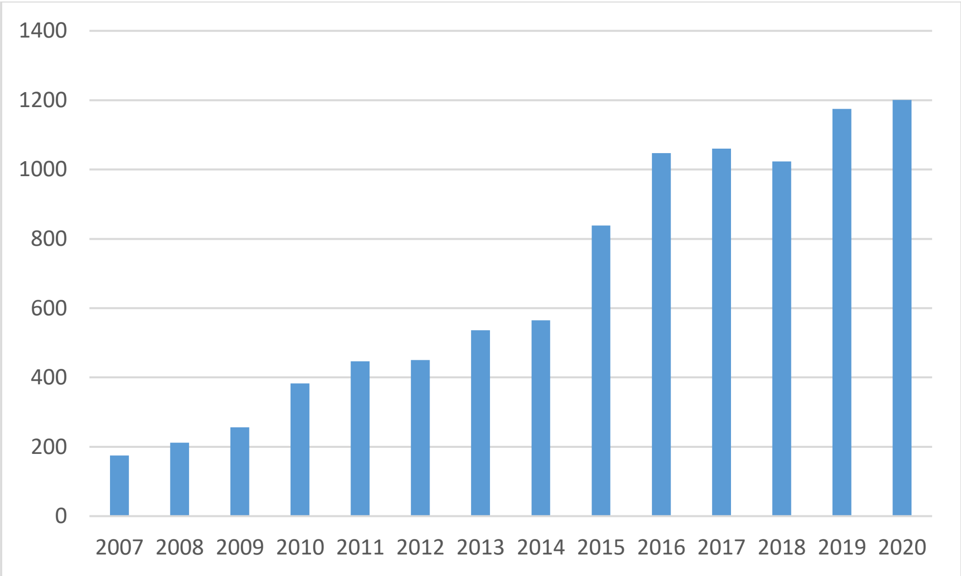
Industry 4.0 has a very important place in terms of Turkey's economic development movement. It is vitally important for the Turkish economy to be able to follow the innovations brought by Industry 4.0 and produce value-added products in order to maintain its competitiveness with the world markets. The most important parameter will be the Industry 4.0 transformation for Turkey, which is currently in the status of developing countries, to reach the status of developed country (TUSIAD, 2016).

The place of patents is very important in measuring the progress of countries in technological innovations. The point that a country has reached in terms of technological productions can be determined by looking at the nationality of the patent owner, and with this information, the contribution of the country to the global patenting activity can be agreed. Napoletano et al. state that the technological performance of countries can be evaluated together with both the number of global patents and the number of national patents.

Considering that new inventions are a part of innovation, it is thought that the number of patents can be a criterion for the progress of countries in Industry 4.0.

In this respect, by looking at the progress in the total number of patents between 2005-2018 in Turkey, it can be seen how progress has been made in Industry 4.0 between these dates. In Figure 13, the change in the total number of technological patents received in Turkey between the years 2005-2020 is given.

Figure 13. Change in the Number of Technology Patents in Turkey Between 2005-2020

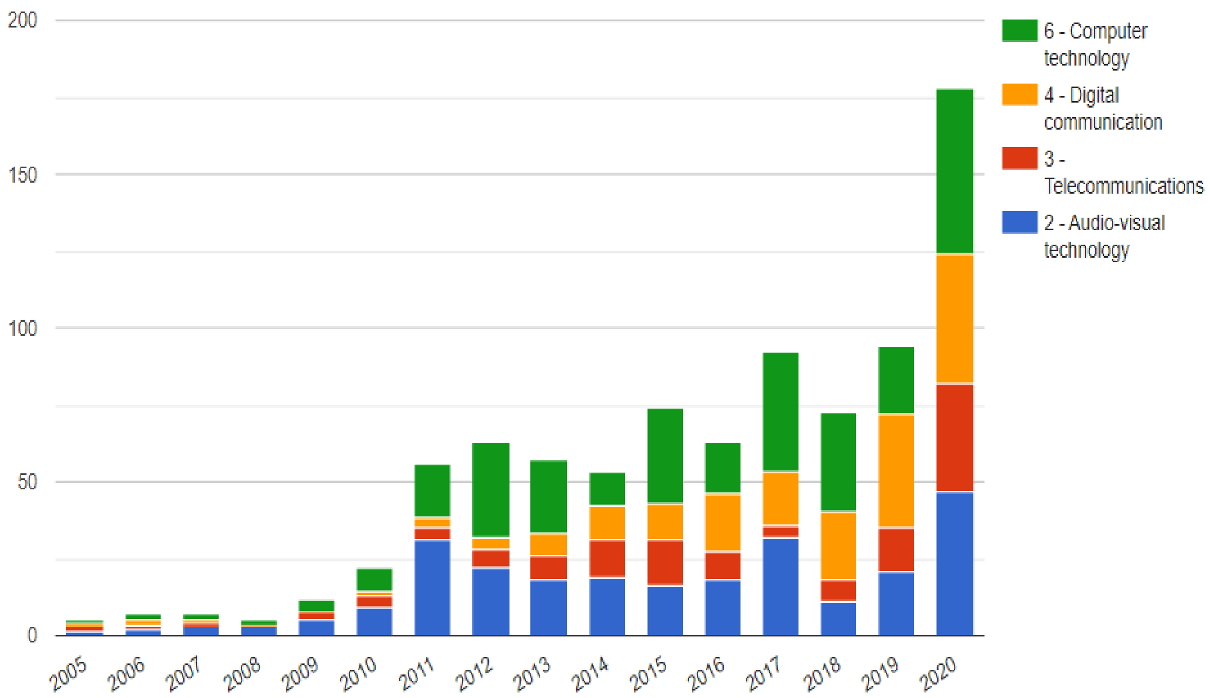


Source: WIPO,2022

As can be seen in Figure 13, there has been a significant increase in the number of technology patents in Turkey since 2005. The number of technology patents, which was 175 in 2007, reached 1200 in 2020.

In addition to the number of technology patents, the number of information and communication technologies patents of countries also plays an important role in understanding the future expectations and development of countries. Within the scope of Industry 4.0, information and communication technologies form an important basis and other technological infrastructures are built on information and communication technologies. In this respect, it is thought that the change in the number of information and communication technologies patents in Turkey will be an important data for the development of Industry 4.0. Figure 14 shows the change in the number of patents in Turkey between 2005 and 2020 in the fields of computer technology, digital communication, telecommunications, and audiovisual technologies. It is seen that there has been a significant increase in the number of patents in this category since 2005. However, it is also seen that the increase has not gained a trend, and although there has been a serious increase since 2011, the increase is not regular in other years, except for 2020.

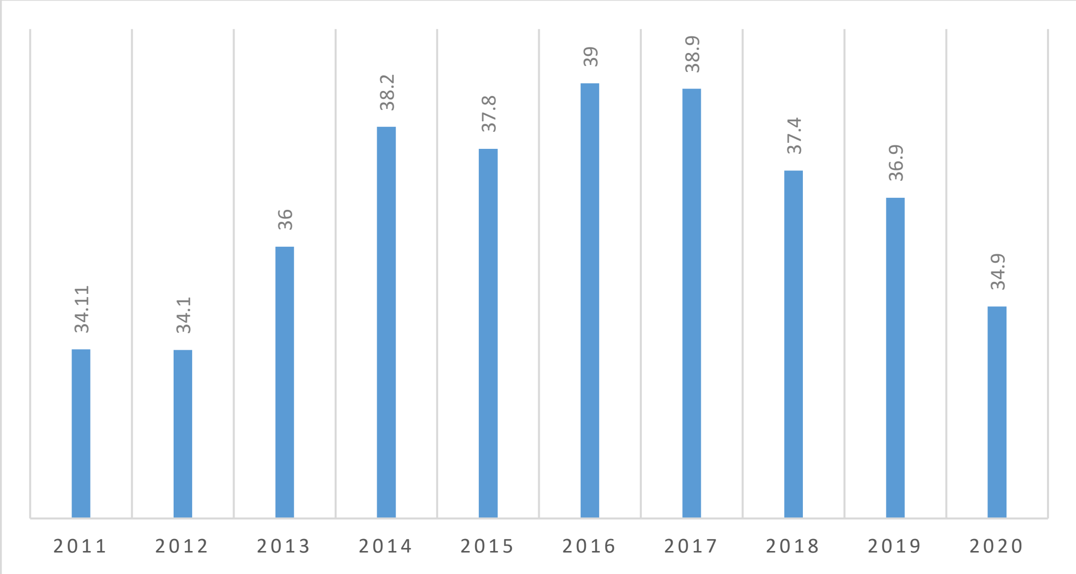
Figure 14. The Change in The Number of Patents in Turkey Between 2005 And 2020 In Selected Fields



Source: WIPO,2022

Innovation has a very important place in order to gain an advantage over their competitors by making the global competitive performance of countries sustainable and to accelerate their national development. In the global competitiveness report published by the World Economic Forum, it is emphasized that countries should harmonize their understanding of innovation with the components of Industry 4.0 and that entrepreneurships should be made within this framework (Ovacı, 2017). Innovation is an important parameter that shows the technological developments of countries in the context of Industry 4.0. The Global Innovation Index, published annually by WIPO, shows the innovation development of countries, and in this index, countries are scored according to certain parameters. The change in Turkey's Global Innovation scores for the years 2011-2020 is shown in Figure 15. Turkey's Global Innovation Index record is not trending regularly, as seen in Figure 15. Although an increase was observed until 2016, it has decreased since then.

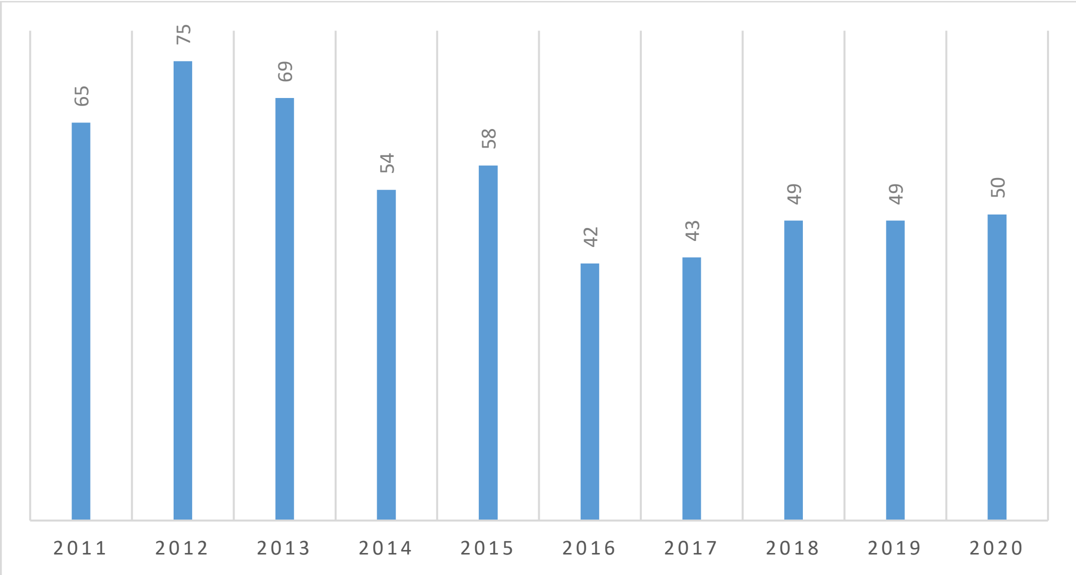
Figure 15. The Change in Turkey's Global Innovation scores for the years 2011 -2020



Source: WIPO, 2022

The change in Turkey's situation in Global Innovation Index ranking between 2011 and 2020 is shown in Figure 16. As seen in Figure 16, there has been an improvement in the Global Innovation Index ranking, which shows Turkey's global situation, in 2016, but since this date, progress has stopped and there has been a regression in the 2018-2020 period, as in the score shown in Figure 15.

Figure 16. The change in Turkey's situation in Global Innovation Index ranking between 2011 and 2020

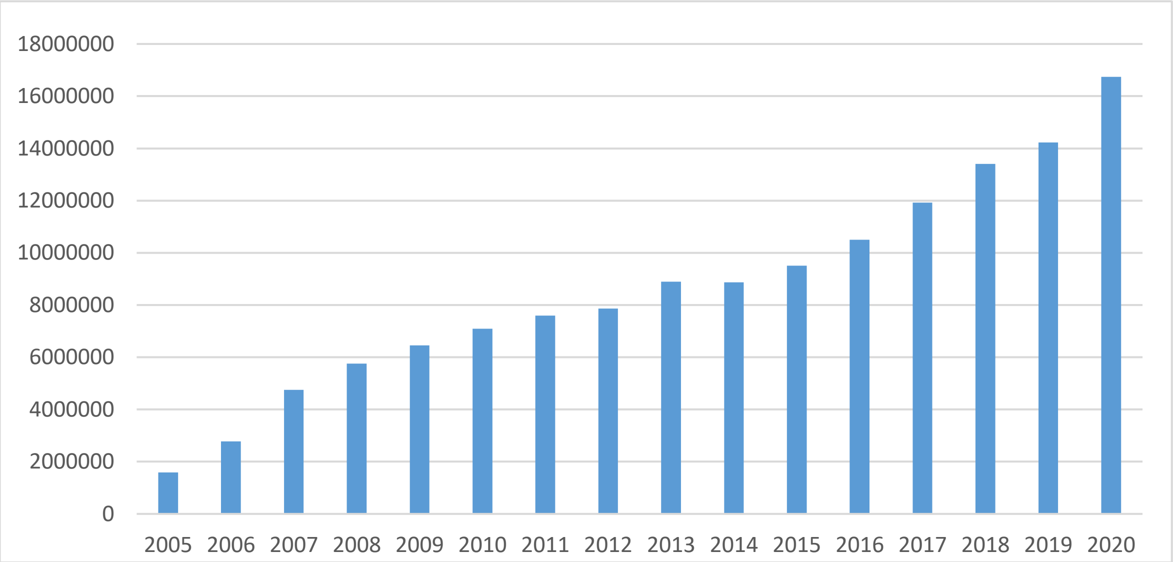


Source: WIPO,2022

As can be seen in Figure 15 and Figure 16, there has been a steady increase in Turkey's Global Innovation score since 2011 and progress in country rankings. However, it can be said that it is still quite behind in terms of ranking in general. Turkey, which was 65th in 2011 and 75th in 2012, rose to 50th place in 2020. However, according to its economic level, these times show that Turkey has not yet advanced enough in terms of innovation.

One of the basic requirements of Industry 4.0 is the internet network. The infrastructure required for the internet access and high speed internet of the end users in the country is called broadband internet. The fact that all components of Industry 4.0 are connected to a network necessitates the internet infrastructure to be faster and in broadband. Internet bandwidth is extremely important in order to benefit from Industry 4.0 technologies (Aydın & Kaya, 2019). Therefore, the broadband internet usage of the end users of the countries will show us the infrastructure status of the country on Industry 4.0. Figure 17 shows the change in broadband internet users in Turkey between the years 2005-2020.

Figure 17. The change in broadband internet users in Turkey between the years 2005-2020

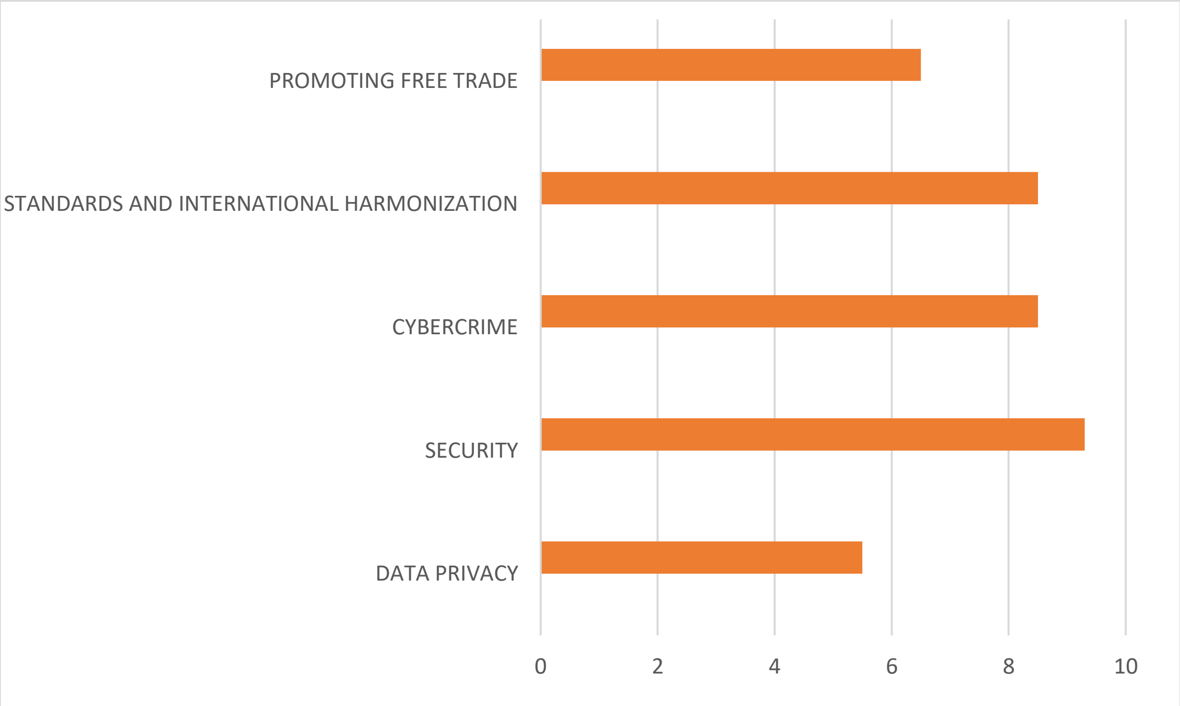


Source: The World Bank Databank

As seen in Figure 17, there has been a significant increase in the number of broadband internet users in Turkey since 2005. Broadband internet users, which were 1.6 million in 2005, increased to 16 million in 2020. The increase appears to be in a regular trend. The number of broadband internet usage by population in Turkey, which was 2.3 per 100 people in 2005, reached 19.8 in 2020.

As mentioned before, one of the important components of Industry 4.0 is cloud computing technology. The cloud computing system is a technology used in the storage and management of data due to the size of the data used in production. A report showing the adaptation and transformation of countries towards cloud computing technologies was published by Business Software Analysis (BSA) in 2018. Figure 18 shows Turkey's scoring according to data privacy, security, cybercrime, supporting compliance with international rules and supporting free trade according to this report, while Figure 19 shows Turkey's ranking among 24 countries.

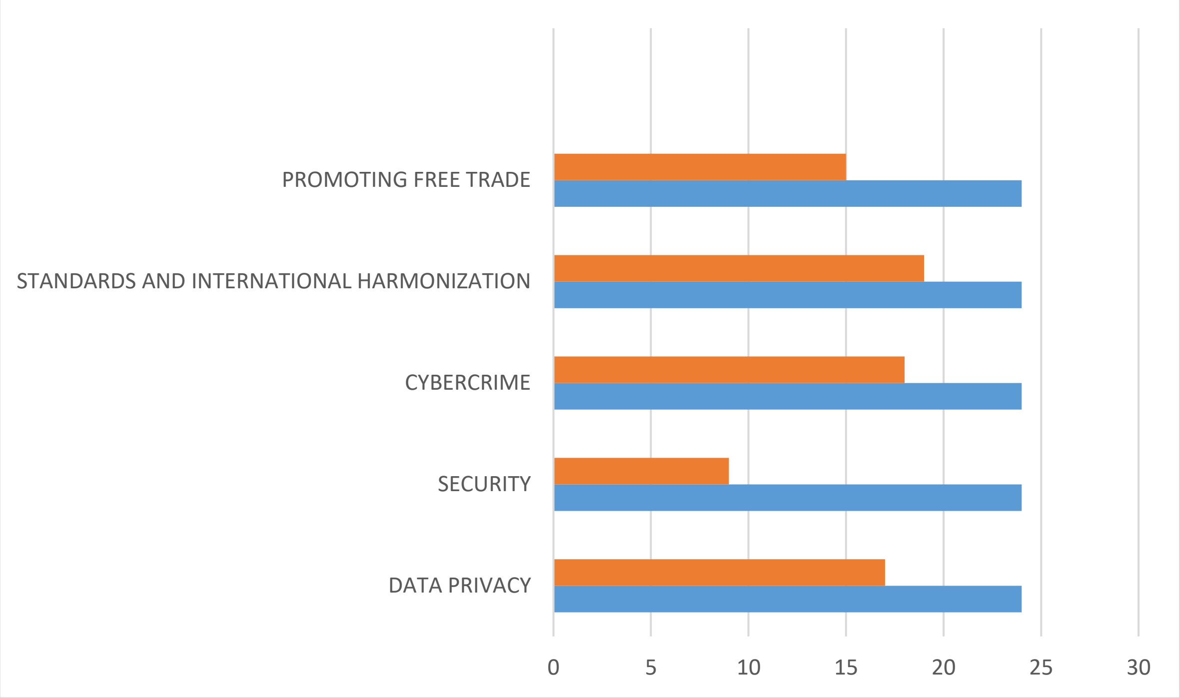
Figure 18. 2018 Global Cloud Computing Score of Turkey (0-12,5)



Source: Business Software Analysis (BSA), 2018

Turkey's Global Cloud Science Score is shown in Figure 18. As can be seen, Turkey's scores remain close to the average out of 12.5, and it is seen that it only has good scores on the security side.

Figure 19. 2018 Global Cloud Computing Ranking of Turkey



Source: Business Software Analysis (BSA), 2018

According to the BSA 2018 report, it is seen that Turkey is far behind in the ranking among 24 countries and there is still a long way to go within the framework of cloud communication technologies. It is seen that Turkey is only among the top 10 countries on the security side among 24 countries.

In its report published in 2016, the Turkish Industry and Business Association (TUSIAD) drew attention to the advantages of Turkey's geographical location and low-cost production and stated that its importance in the global value chain, when combined with Industry 4.0, would give Turkey a great competitive power. In addition, in this report, TUSIAD has listed some structural challenges that Turkey has to deal with and must change as follows (TUSIAD, 2016):

• Dependence on imported raw materials in exports,

• Low share of value-added products in total production,

• The labor force's deficiencies in new technologies,

• Rapid transition of the workforce from industry to the service sector.

Looking at Turkey's R&D investments, the expenditures of the private sector, higher education institutions and the state between the years 2015-2020 and human resources are given in Table 1 according to the data of the Turkish Statistical Institute.

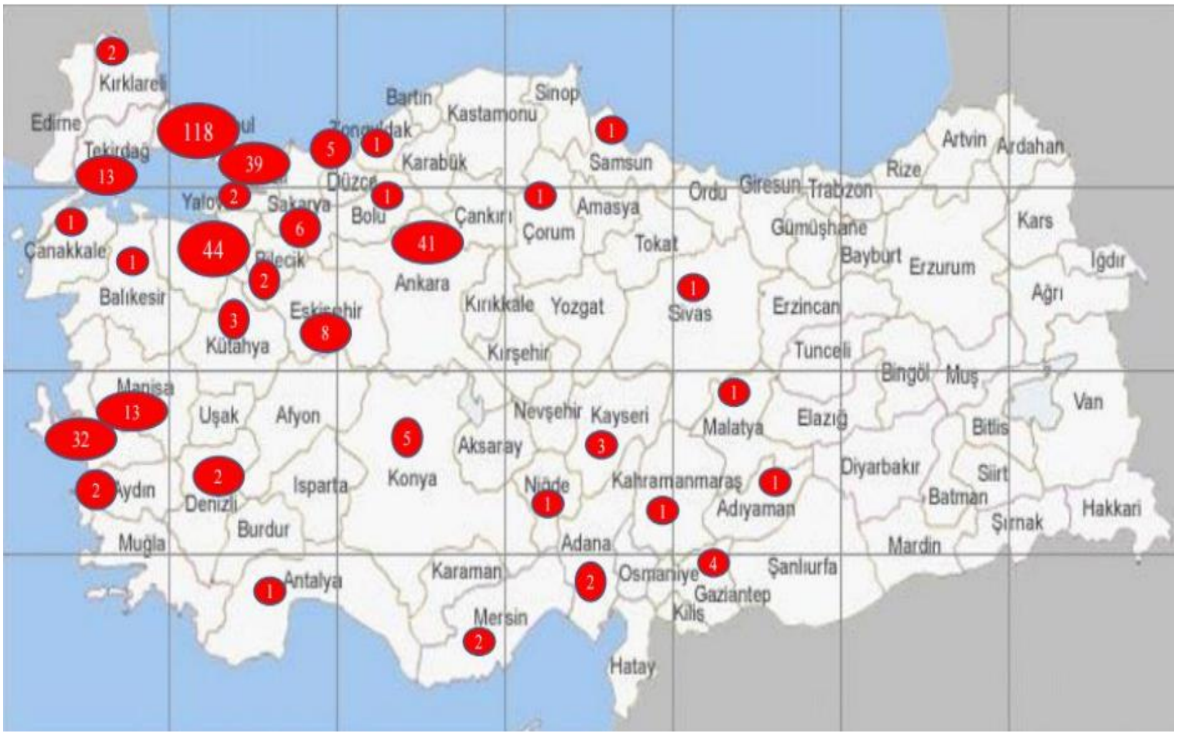
Table 1. Turkey R&D Statistics

		2015	2016	2017	2018	2019	2020
GDP(Gross Domestic Product) (%)		0,88	0,94	0,95	1,03	1,06	1,09
Total R&D Expenditure (TL-TRY)		20.615.247.954	24.641.251.935	29.855 477 805	38.533 672 884	45.953 691 096	54 956 827 217
Financial and Non-Financial Corporations(TL-TRY)		10 308 737 689	13 359 011 600	16 980 836 067	23 289 367 294	29 500 710 718	35 623 334 563
General Government(TL-TRY)		2 130 766 481	2 338 372 843	2 858 435 052	3 559 213 870	3 044 485 454	3 716 726 729
Higher Education Sector(TL-TRY)		8 175 743 784	8 943 867 493	10 016 206 686	11 685 091 720	13 408 494 924	15 616 765 925
R&D personnel (Headcount)		224 284	242 213	266 478	289 791	305 811	321 392
	Financial and non-financial corporations	77 551	83 873	101 404	118 867	129 798	144 674
	General Government (TL-TRY)	14 217	13 372	12 828	12 884	10 472	11 044
	Higher Education Sector(TL-TRY)	132 516	144 968	152 246	158 040	165 541	165 674
R&D personnel (TL-TRY)		122 288	136 953	153 552	172 119	182 847	199 371
	Financial and Non-Financial Corporations(TL-TRY)	66 667	72 579	87 918	104 376	114 931	130 279
	General government (TL-TRY)	12 328	11 799	11 345	11 379	8 886	9 439
	Higher education sector(TL-TRY)	43 293	52 576	54 289	56 364	59 031	59 653
Trendline	It is observed that there is a steady increase in the trend of Turkey's R&D statistics.						

Source: Turkey Statistical Institute,2022

However, it is seen that R&D investments in Turkey do not spread throughout the country, but concentrate especially in the Marmara region. When the country's R&D centers are examined, it is seen that there is a great concentration especially in Istanbul. The map showing the cities where the country's R&D centers are located is shown in Figure 20. In Figure 20, it is seen that although there are 118 R&D centers in Istanbul, there are no R&D centers in many provinces.

Figure 20. R&D centers of Turkey



Source: Bulut &Akcaci, 2017

In February 2016, a number of decisions were taken by the Turkish Science and Technology Supreme Council for the development of Industry 4.0 and information technology in Turkey. The most notable among these decisions is to support R&D studies on subjects such as Cyber physical systems, artificial intelligence, sensors, robot technologies, Internet of Things, Big Data, cyber security and cloud computing in order to increase the Industry 4.0 capabilities of companies in Turkey, and to support the use of these technologies by domestic companies. This decision is an important decision in terms of showing Turkey's awareness of Industry 4.0. Since then, many incentive packages on Industry 4.0 have been announced. Among these incentives, there are many alternatives such as tax reduction, premium support and grant support (Yuksekbilgili & Cevik, 2018).

3.4.2 Comparison of Turkey and selected countries in Industry 4.0

Industry 4.0 first entered our lives with an industry report published in Germany in 2013. The report was written to describe the investments planned to be made in R&D studies to bring Germany to manufacturing within the scope of industrial manufacturing, and the steps to be taken to increase the competitiveness of Germany, especially in the automotive and machinery sectors, are listed. As a result of the progress made step by step much earlier, Industry 4.0 has become one of the main processes of industrial life with this report (Acatech, 2013).

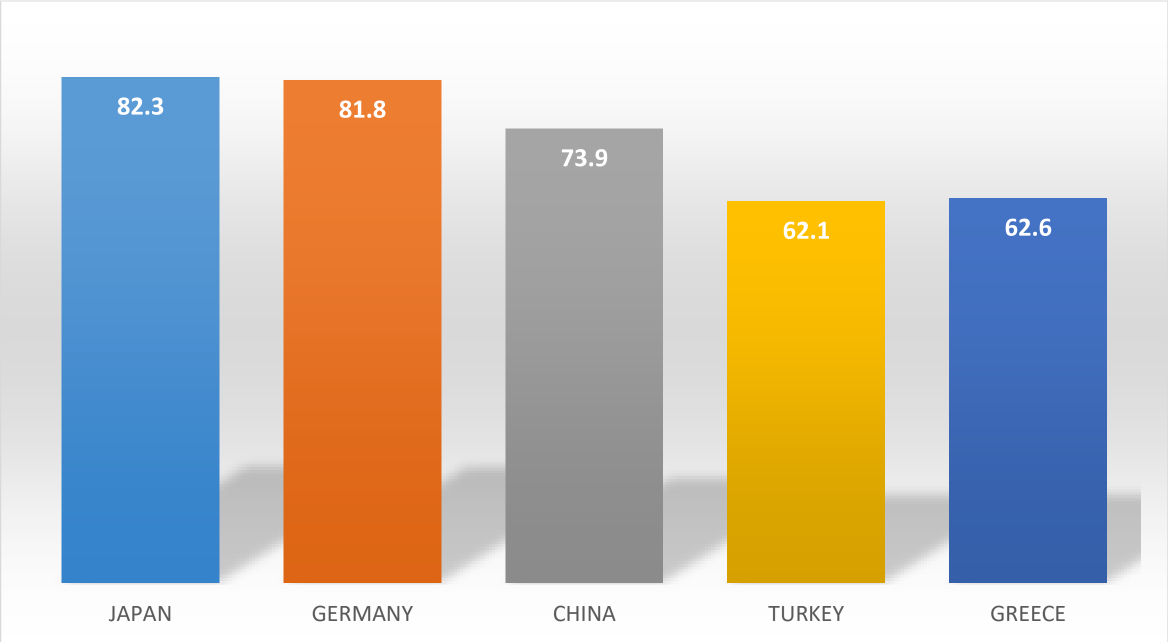
Today, the competition between companies and countries globally is at a much higher level than in the past. In this competition, all manufacturers are constantly in search of responding to consumer demands, while at the same time reducing their costs compared to their competitors and increasing their efficiency at the same time by making more mass production. Industry 4.0 provides companies with important opportunities to reduce their costs and increase their productivity. The internet of things, robot technology and automation opportunities allow companies that are in competition to profit from the competition. With Industry 4.0, the competitive advantage of states such as Germany, the United States and Japan began to gradually pass into the hands of countries such as China and India. For this reason, the competition of developed countries has started to increase more on the basis of Industry 4.0. In addition, Industry 4.0 offers great opportunities for developing countries to move to a higher class. Countries that can shape their technological infrastructure, workforce and technological capabilities according to Industry 4.0 will be able to benefit from these opportunities (Kılıç & Alkan, 2018)

Germany, one of the leading countries of Industry 4.0, has gained a great momentum in global competitiveness with Industry 4.0 applications. According to the analysis, with Industry 4.0, Germany will achieve an efficiency gain of 90-150 billion Euros in a period of 10 years, with a 5-8% decrease in production costs. With Industry 4.0, it is aimed to reduce the processing costs by 20%, excluding material costs, in the German economy (TUSIAD, 2016).

In this study, it was thought that it would be appropriate to make comparisons with some selected countries in order to understand the position of Turkey in terms of Industry 4.0 and the effects of Industry 4.0 on the country's economy. In this context, the situation of Germany, Japan, Greece, China and Turkey within the framework of Industry 4.0 and the contribution of this situation to their economies will be discussed comparatively.

There are a number of universal indices used to see the efficiency and competitiveness of countries in international markets. Competitiveness of countries is evaluated through some factors such as real wage increase, labor productivity, real return of capital and position in world trade (Zengin & Sagir, 2019). Some indicators have been added. In this respect, it would be useful to first look at the situation of these 5 countries in the Global Competitiveness index. The scores of these 5 countries in the 2019 World Competitiveness Index are shown in Figure 21.

Figure 21. 2019 Global Competitiveness Index of Selected Countries

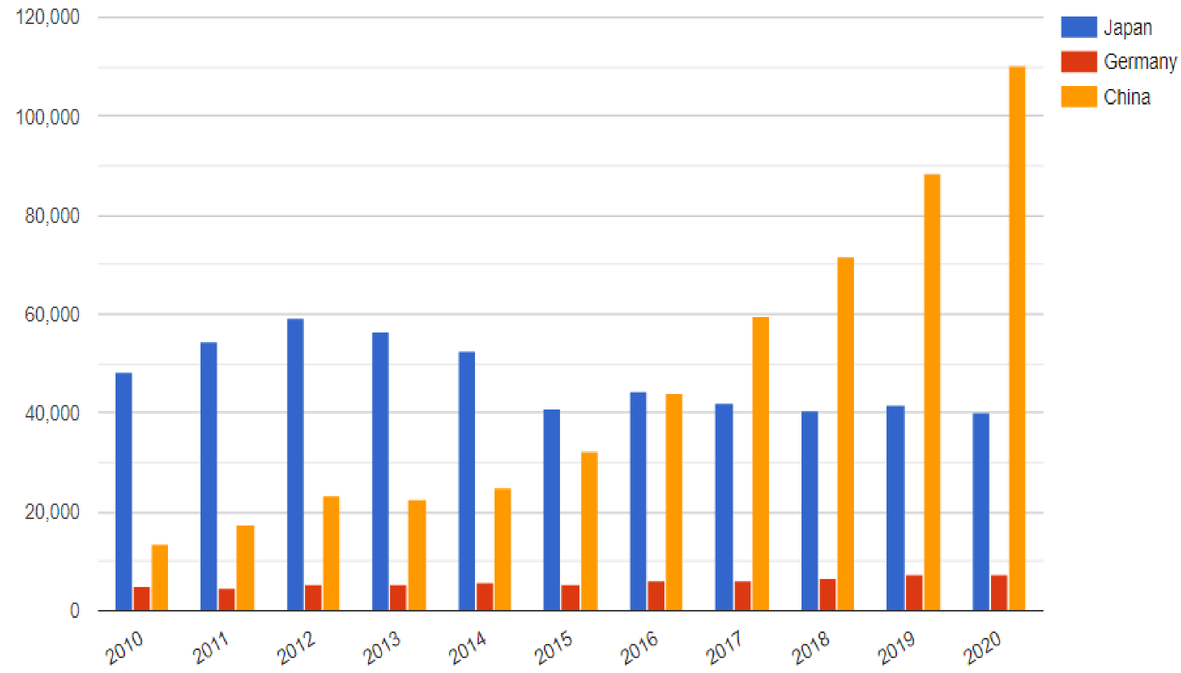


Source: World Economic Forum, 2020

Japan is ranked 6th out of 141 countries in the 2019 Global competitiveness index, Germany is ranked 7th, China is ranked 28th, Turkey is ranked 61st, and Greece is ranked 59nd.

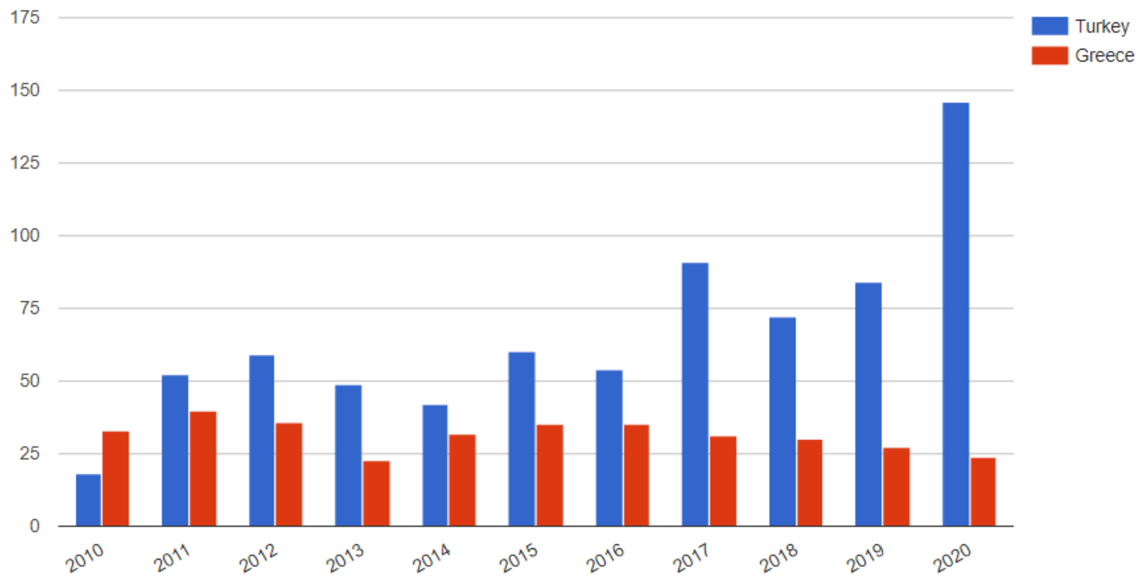
In terms of the total number of technology patents of these five countries between 2010 and 2020, China, Japan and Germany differ greatly from Greece and Turkey. Especially in the technology field of China, there are more than 100 thousand patents in only four categories in 2020. Therefore, Japan, China and Germany are shown in a separate chart, and Japan and Turkey are shown in a separate chart. Among the technology patents, visual and audio technologies, computer technologies, information technologies for digital communication and management categories were taken. For these four categories, the patent numbers of Japan, China and Germany are shown in Figure 22, and the patent numbers of Greece and Turkey between 2010-2020 in Figure 23.

Figure 22. 2010-2020 The technology Patents of Selected Countries (China, Japan, Germany)



Source: OECD, 2022

Figure 23. 2010-2020 The technology Patents of Selected Countries (Turkey, Greece)

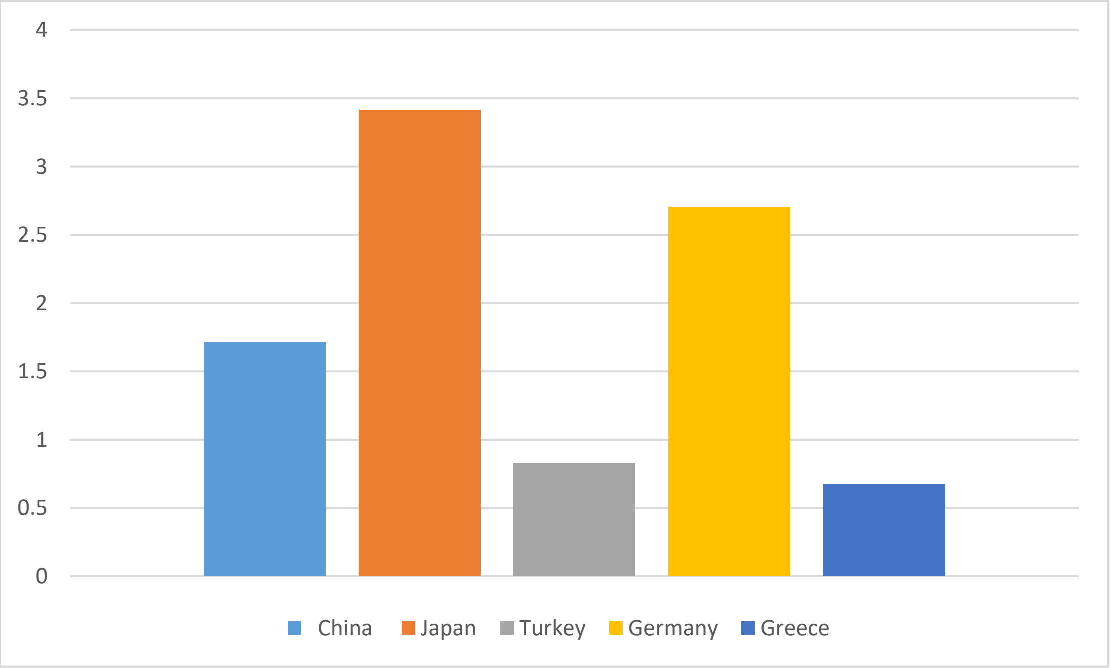


Source: OECD, 2022

Looking at Figure 21 and Figure 22, while there has been a decrease in the number of patents in Japan since 2015, there has been a significant increase in China and Turkey since 2015. Especially in China, a double increase in 5 years draws attention. In Germany and Greece, it is seen that a certain routine is continued. When an evaluation is made according to the population of the countries, it is seen that the number of patents in Japan is high compared to the population, while Turkey's is quite low. Although the number of patents according to the population ratio of China is less than Japan, it is observed that there is a serious increase in the number of patents in China, although there is a decrease in Japan.

In the science, technology and innovation indicators published by the OECD to show how much countries contribute to science and innovation with the help of policy and other tools, how much share countries allocate from GDP to science, technology and innovation is published as a percentage of GDP. The data updated in 2016 includes data from 2006 to 2014. The published report includes data for Japan, China, Germany, Turkey and Greece. The average of these four countries for the years 2006-2014 is shown in Figure 24.

Figure 24. Science, Technology and Innovation Index of Selected Countries (2006-2014)

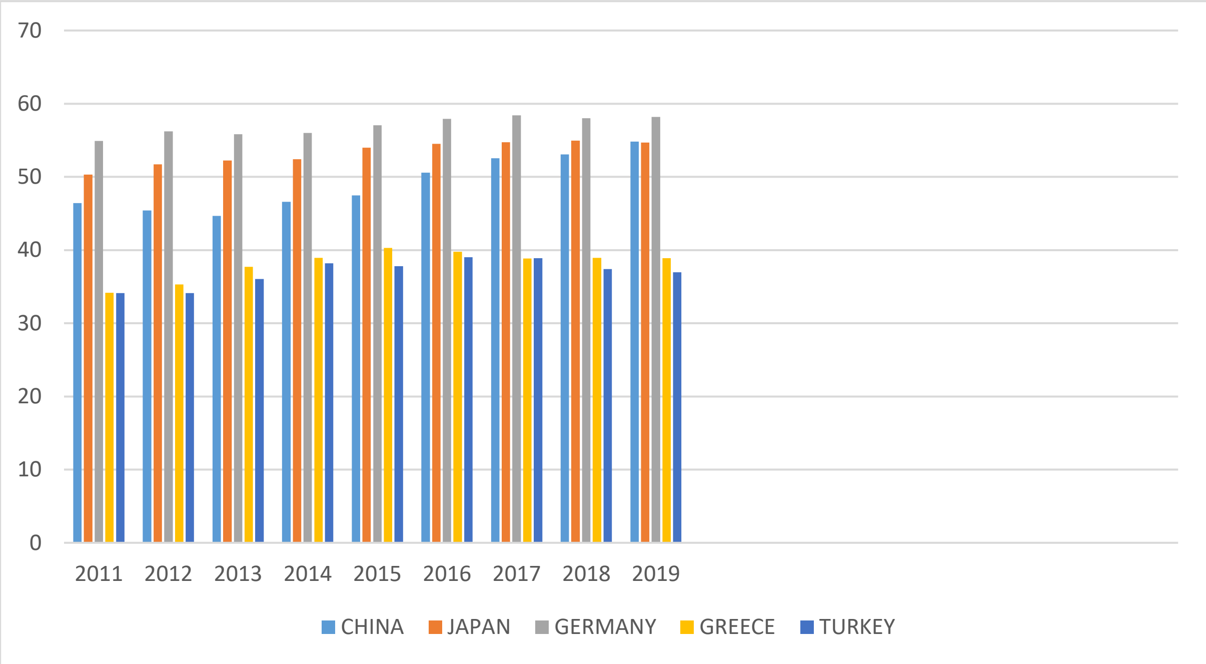


Source: OECD,2016

In Figure 23, it is seen that Japan has the highest share of science, technology and innovation in GDP, followed by Germany, third China. Turkey is the fourth country with 0.8, and lastly Greece has %0.6.

One of the most important concepts that shows the situation of countries in terms of Industry 4.0 is innovation indicators. The Global Innovation index, published annually by the World Intellectual Property Organization and Institut Européen D'administration des Affaires (INSEAD), is an important indicator in this regard. There are many different indicators that affect innovation in this index. Among these indicators, there are many different factors such as human capital, number of research, infrastructure and markets. In addition, different indicators are added and removed every year according to the development of technological opportunities. The change in the Global Innovation Index scores of the 5 countries selected for this study between 2011 and 2019 is shown in Figure 25.

Figure 25. Global Innovation Index of Selected Countries (2011-2019)



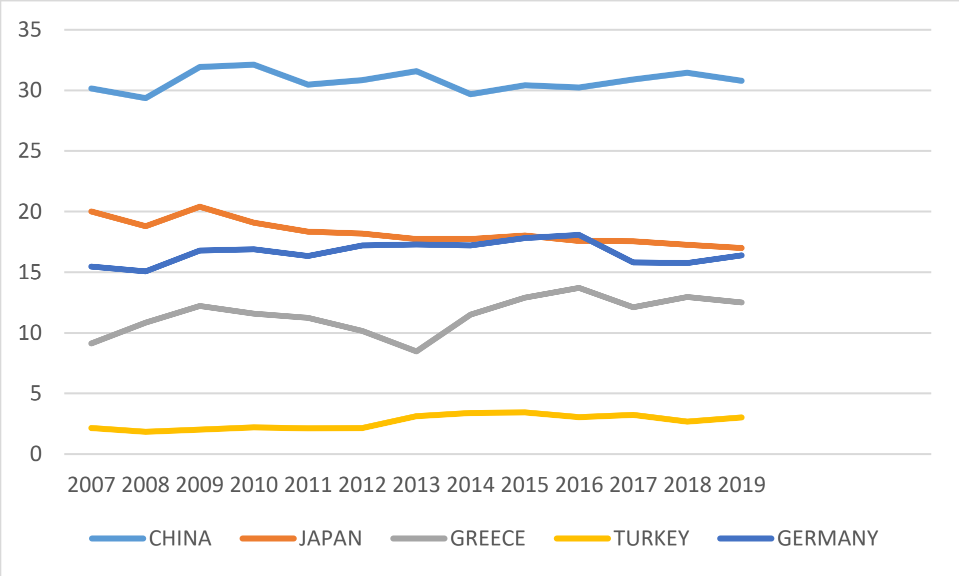
Source: WIPO, 2022

According to the Global Innovation Indexes given in Figure 24, it is seen that Germany has the highest score every year between 2011-2019, China has been on the rise since 2012013 and has caught up with Japan, and the scores of Turkey and Greece are very close to each other.

Other important parameters among the Industry 4.0 indicators of the countries are the share of High Technology exports in total production exports and the share of R&D expenditures in GDP. The graphs of the five selected countries regarding these parameters are shown in Figure 25 and Figure 26.

According to the share of high technology exports in total production exports given in Figure 26. The classification among export products by the OECD is made over four categories. These categories are high, medium-high, medium-low, and low-tech. While making this classification, the gross output and added value obtained from the products are taken as basis. For example, exports of high value-added products such as aircraft, computers and pharmaceuticals are included in the category of high technology exports.

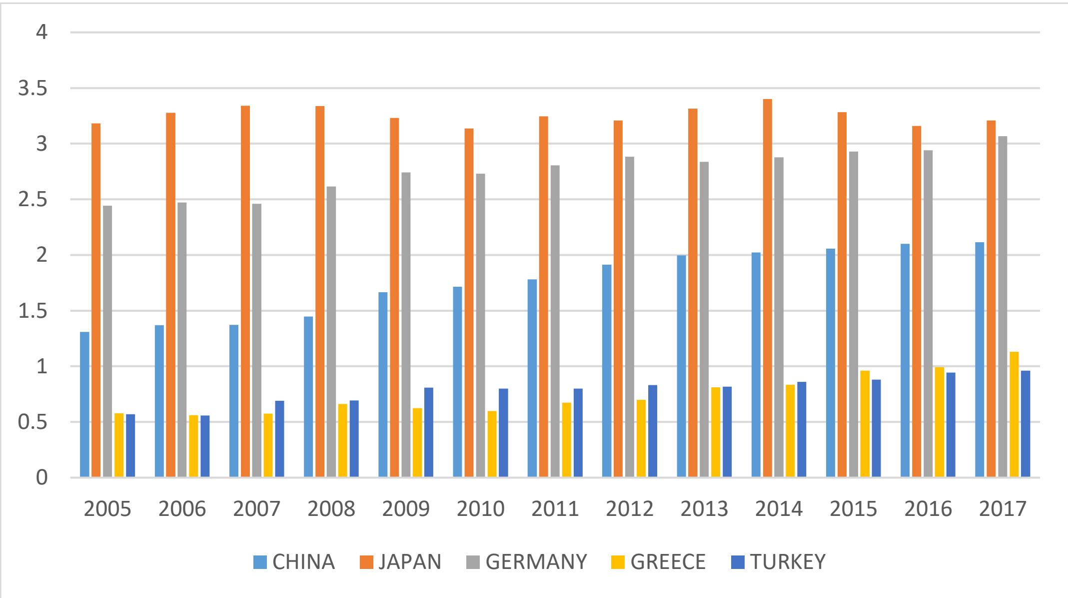
Figure 26. High-Technology Exports (% of Manufactured Exports) (2007-2019)



Source: World Bank,2022

It is seen that China has a very high share in high technology exports compared to other countries. From Figure 26, it is seen that Turkey is far behind in High Technology exports compared to other countries.

Figure 27. R&D Expenditures (% of GDP)(2005-2017)



Source: World Bank,2022

In Figure 27, where the share of R&D expenditures in GDP is given, it is seen that R&D investments have a significant share in the budgets of Japan and Germany. It is seen that the R&D Investments of Turkey and Greece are quite low when compared to other countries, but they are in an increasing trend, albeit slightly.

3.4.3 Data Set

In the analysis, the Global Innovation Index, R&D Expenditures (% of GDP), Number of Patent Applications, and High Technology exports (% of manufactured exports) which are evaluated to show the contribution of Industry 4.0 to the countries and GDP (growth) data as an economic indicator %) data is used. Information on the data set used is shown in Table 2. By this data set, it will be evaluated whether Industry 4.0 has a direct effect on the dependent variable, the GDP growth rate, with independent variables.

Table 2. Description of Data Set

Variable Name	Description	Source
GDP	GDP Growth(%)	World Bank
R&D	R&D Expenditures(%GDP)	World Bank
HTE	High-Technology Exports(%Total Manufactured Exports)	World Bank
PA	Total Patent Number	World Bank
GII	Global Inovation Index Score	WIPO Global Inovation Index

3.4.4 Descriptive Statistics

The descriptive statistics of countries' Global Innovation Index, R&D Expenditures (% of GDP), Number of Patent Applications, High Technology Export (% of Manufactured Exports) and GDP (% of growth) data are shown in Table 3.

Table 3. Descriptive Statistics

	GDP	GII	HTE	PA	R&D
Mean	3.022010	46.86578	15.96239	196546.7	1.893218
Median	2.005100	47.47000	16.78982	47785.00	1.912140
Maximum	14.23086	58.39000	32.12365	1393815.	3.400220
Minimum	-10.14931	34.10000	1.837563	356.0000	0.557490
Std. Dev.	4.718634	8.411800	9.317619	322012.3	1.038285

Table 4 contains descriptive statistics for the variables considered in the analysis. Between 2005 and 2019, the average GDP growth rate of these 5 countries was 3.02%, GII averages were 46.86, HTE averages were 15.9%, patent uncles averaged 196546, and lastly, the ratio of R&D expenditures to GDP was 1.89%. appears to be.

3.4.5 Panel Unit Root Test Results

Since the data we have chosen to perform the econometric analysis is stationary, it will give healthier results (to prevent the problem of false regression), so the stationarity tests of the variables used in the model have been performed. In this study, the stationarity of the series was tested with the Augmented Dickey Fuller (ADF) unit root test. In the light of these data, the results of the unit root test applied to the variables are shown in Table 4.

Table 4. Unit Root Test Results

Variable	At level statistics	Prob.	1st level statistics	Prob.
GDP	41.1486	0.0000	60.3852	0.0000
GII	1.13457	0.9997	26.9046	0.0027
HTE	16.1973	0.0941	45.3722	0.0000
PA	23.6957	0.0085	46.3275	0.0000
R&D	0.78939	0.9999	20.8397	0.0222

As a result of the Unit Root Tests of the variables, it was seen that the GDP and PA variables were stationary at the level, and the HTE, PA and GII variables were stationary at the first level.

3.4.6 Pedroni Cointegration Tests

Pedroni used multivariate regression models by making use of bivariate models while performing cointegration analysis in 1995-1997 (Pedroni, 1999: 653). All tests used by Pedroni consist of residuals obtained from the equation below. Therefore, the residuals obtained from the first stage cointegration regression are calculated (Pedroni, 1999: 656). In the panel cointegration test, cointegration was tested with a total of seven different approaches, four of which were within-group and three of which were between-group approaches. The results are shown in separate tables as the test of each variable with the data of the growth variable. Our hypotheses for this test;

H0: No cointegration Between Series.

H1: There is cointegration between the series.

Table 5. GDP-GII Cointegration Test

Pedroni Cointegration Test	Statistic	Prob.
Panel v-Statistic	0.276230	0.3912
Panel rho-Statistic	-1.464649	0.0715
Panel PP-Statistic	-3.453932	0.0003
Panel ADF-Statistic	-3.480551	0.0003
Group rho-Statistic	-0.540869	0.2943
Group PP-Statistic	-4.769674	0.0000
Group ADF-Statistic	-4.283177	0.0000

According to Table 5, the H1 hypothesis is accepted in 4 out of 7 tests ($p<0.005$). Therefore, it is concluded that there is cointegration between the series.

Table 6. GDP-HTE Cointegration Test

Pedroni Cointegration Test	Statistic	Prob.
Panel v-Statistic	1.320343	0.0934
Panel rho-Statistic	-2.801054	0.0025
Panel PP-Statistic	-3.416302	0.0003
Panel ADF-Statistic	-3.757750	0.0001
Group rho-Statistic	-1.302995	0.0963
Group PP-Statistic	-5.568307	0.0000
Group ADF-Statistic	-5.573172	0.0000

According to Table 6, the H1 hypothesis is accepted in 5 out of 7 tests ($p<0.005$). Therefore, it is concluded that there is cointegration between the series.

Table 7. GDP-R&D Cointegration Test

Pedroni Cointegration Test	Statistic	Prob.
Panel v-Statistic	1.495097	0.0674
Panel rho-Statistic	-1.471052	0.0706
Panel PP-Statistic	-2.882308	0.0020
Panel ADF-Statistic	-3.501325	0.0002
Group rho-Statistic	-0.373188	0.3545
Group PP-Statistic	-5.807815	0.0000
Group ADF-Statistic	-4.843081	0.0000

According to Table 7, the H1 hypothesis is accepted in 4 out of 7 tests ($p<0.005$). Therefore, it is concluded that there is cointegration between the series.

Table 8. GDP-PA Cointegration Test

Pedroni Cointegration Test	Statistic	Prob.
Panel v-Statistic	0.051021	0.4797
Panel rho-Statistic	-0.908967	0.1817
Panel PP-Statistic	-2.095796	0.0181
Panel ADF-Statistic	-2.540999	0.0055
Group rho-Statistic	-0.639517	0.2612
Group PP-Statistic	-5.618156	0.0000
Group ADF-Statistic	-5.131382	0.0000

According to Table 8, the H1 hypothesis is accepted in 4 out of 7 tests ($p<0.005$). Therefore, it is concluded that there is cointegration between the series.

3.4.7 Panel Data Analyses Results

For Panel Analysis, it is necessary to choose one of the random or fixed effect models first. Therefore, the Hausman test should be applied. The Hausmann Test result applied on random effects is shown in Table 8.

Table 9. Hausman Test Results

Correlated Random Effects - Hausman Test			
Test cross-section random effects			
Test Summary	**Chi-Sq. Statistic**	**Chi-Sq. d.f.**	**Prob.**
Cross-section random	82.761162	4	0.0000

In the Hausman test, the null hypothesis is "random effects model" and the alternative hypothesis is "fixed effects model". According to the Hausman test, the results of which can be seen in Table 9, the acceptance of H1, that is, the panel analysis should be done by using the fixed effects model.

Table 10. Fixed Model Panel Data Estimation Results

Dependent Variable: GDP				
Method: Panel Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
GII	0.182459	0.241720	0.754838	0.4562
HTE	0.235188	0.414622	0.567234	0.5748
PA	-6.25E-06	2.93E-06	-2.133368	0.0412
R_D	7.606695	3.962603	1.919621	0.0645
C	-23.36629	10.33527	-2.260831	0.0312
R-squared	0.797450	**Mean dependent var**		2.872968
Adjusted R-squared	0.743436	**S.D. dependent var**		4.287130
S.E. of regression	2.171522	**Akaike info criterion**		4.587908
Sum squared resid	141.4653	**Schwarz criterion**		4.971807
Log likelihood	-80.46421	**Hannan-Quinn criter.**		4.725648
F-statistic	14.76392	**Durbin-Watson stat**		1.429093
Prob(F-statistic)	0.000000			

According to these results, the significance level of the test (R_Squared) was 79%. Among the variables, only the PA variable was found to be significant ($p<0.005$). When we look at the probability value of the F statistic, it is seen that all the variables are statistically significant collectively.

3.4.8 Granger Causality Test Results

Granger causality test is one of the tests that is frequently used in the literature to determine the relationship between variables in economic analyzes bilaterally. In this study, the relationship between the variables was also made with the Granger Causality test, and the results are shown in Table 11 and Table 12. The causal relationship between the dependent variables determined as a result of this test and the independent variables will be observed. In other words, it will be understood to what extent these variables are the cause of each other.

Table 11. Granger Casualty Test Results

Dependent variable: GDP		
Excluded	**Chi-sq**	**Prob.**
GII	0.009042	0.9955
HTE	4.356928	0.1132
PA	0.916804	0.6323
R_D	2.826708	0.2433
All	18.79094	0.0160
Dependent variable: GII		
Excluded	**Chi-sq**	**Prob.**
GDP	5.188881	0.0747
HTE	3.606434	0.1648
PA	**7.897146**	**0.0193**
R_D	2.786578	0.2483
All	15.31004	0.0534
Dependent variable: HTE		
Excluded	**Chi-sq**	**Prob.**
GDP	0.284125	0.8676
GII	2.087038	0.3522
PA	0.658230	0.7196
R_D	2.420114	0.2982
All	6.349265	0.6082
Dependent variable: PA		
Excluded	**Chi-sq**	**Prob.**
GDP	**6.670696**	**0.0356**
GII	0.265257	0.8758
HTE	**10.44759**	**0.0054**
R_D	1.991762	0.3694
All	19.70863	0.0115
Dependent variable: R&D		
Excluded	**Chi-sq**	**Prob.**
GDP	2.886858	0.2361
GII	1.656473	0.4368
HTE	0.189065	0.9098
PA	0.105912	0.9484
All	7.416797	0.4924

Looking at Table 9, it is concluded that the HTE variable and the GDP variable are the cause of PA, while PA is the cause of the Global Innovation Index ($p<0.05$).

4 Results and Discussion

In this study, which examines Turkey's position in Industry 4.0, although there has been an increase in data such as R&D expenditures, number of patents, broadband internet users, Global Innovation Index over the years, it is still compared to the rest of the world, its geographical location and potential. It has been found to be quite backwards.

The results obtained from the comparison of Turkey's place in Industry 4.0 with other selected countries are as follows:

• Considering that although it is close to Greece in terms of Global Competitiveness index scoring and world ranking, it is far behind China, Japan and Germany, and it is also ranked 61st in the world ranking, according to its geographical location, population potential and targets appears to be low.

• Although there is an improvement in the number of patents, it is seen that the number of patents is quite low compared to the other four countries when compared to the population.

• Although it is close to Greece in the Science, Technology and Innovation index, it is far behind China, Japan and Germany.

• Despite being close to Greece in the Global Innovation Index, it is far behind China, Japan and Germany.

• It is at the lowest level among the five countries in High Technology Exports.

• According to the ratio of R&D expenditures to GDP, it is close to Greece and the distance to other countries is long.

As a result of the empirical analysis made in the fourth chapter, High Technology Exports, Global Innovation Index, Patent numbers and R&D expenditures, which were determined as the Industry 4.0 indicator, were not the cause of the GDP growth rate. However, in the co-integration tests, it was also understood that the variables affected each other in the long term with the GDP. However, in the causality tests, it was concluded that only High Technology Exports and GDP were the cause of the Patent numbers, while the number of Patents was caused by the Global Global Index. The biggest reason for this is thought to be the long-term effect of indicators such as countries' R&D investments, number of patents and Innovation on economic growth.

Öztürk and Alaşahan (2019) in their study on Turkey, Japan, Germany, Canada, Korea, United Kingdom, United States of America, Denmark, Switzerland and Singapore with the same variables, that GDP is the reason for Global Innovation and Patent applications are the reason for the Global Innovation Index. concluded that. In the cointegration tests conducted by the researchers, as in this study, a long-term relationship was determined between the variables.

Lee and Hong (2010) conducted a large study in which a total of 71 countries were taken as samples. As a result of this study, they have obtained the conclusion that the economic growth of the countries that export more high technology is faster than the other countries. Researchers examining the economic growth of Asian countries in their studies pointed out that education reforms and improvements in property freedom, along with R&D investments, have an important place among the reasons for this economic growth.

Burmaoğlu (2012), on the other hand, examined the relationship between the innovation indicators of countries and their logistics performance. Taking the variables of human resources, research systems, finance and support, firm investments, connections and entrepreneurship, intellectual assets, innovators and economic effects as innovation indicators, the researcher concluded that the innovations made as a result of the research positively affect the logistics performance of the countries.

Amaghouss and Ibourk (2013) examined the effects of entrepreneurship and innovation activities on economic growth by taking OECD countries as a sample. As a result of this study, researchers concluded that entrepreneurship and innovation have positive effects on economic growth.

Koca (2018) in his study examining the opportunities that Turkey can obtain from Industry 4.0, stated that when Turkey completes the transition to Industry 4.0, it will cause an increase in productivity between 4% and 7% in production. Koca also stated that with Industry 4.0, competition in the economy will revive and this will bring a 3% growth in production.

Bozkurt (2016), on the other hand, states that one of the biggest obstacles in front of Turkey in the Industry 4.0 process is China. Bozkurt explains that the reason for this is that China has created a great unfair competition in the market due to the low production costs, and therefore a price-based cheapness approach has emerged in the market. However, the researcher emphasizes that Turkey can seize a serious opportunity from Industry 4.0 due to its geographical advantage, and that particular attention should be paid to sensor production.

In their study on Turkey's innovation indicators, Bulut and Akçacı (2017) revealed that Turkey's R&D expenditures contributed positively to technology exports. At the end of their studies, researchers emphasized that it is very important to develop technology products and increase technology exports in order for Turkey to increase its competitiveness within the scope of Industry 4.0. In addition, researchers have pointed out the benefit of establishing a commission to follow the developments by working towards the application of Industry 4.0 developments to the industry in Turkey, as in Germany and the USA.

Yuksekbilgili and Cevik (2018) examined Turkey's position in Industry 4.0 in their studies. The results of the researchers are similar to this study. Researchers have also made the assessment that Turkey is still in the pre-investment planning stage in Industry 4.0. They emphasized that Turkey's place in Industry 4.0 is quite behind, especially when compared to developed countries. Similarly, in our study, it was concluded that Turkey still has a long way to go about Industry 4.0.

In the Industry 4.0 report of TUSIAD(2016), it has been stated that Turkey is still in the early stages of Industry 4.0 and urgent measures should be taken in this regard. In this report, it was emphasized that Turkey lags behind countries such as Germany and China in Industry 4.0 and that awareness on Industry 4.0 should be increased in order not to fall behind in commercial competition. In this respect, it is seen that our study has a parallel result with the report of TUSIAD.

5 Conclusion

Although the Industrial revolutions in the world are the ones that reveal the development and efficiency of production technologies that started in the industry, they show their effects in all economic, social and political areas of the countries over time and cause a complete change. When we look at history, we see that this change first happened when people started farming. Mankind, who moved to agriculture, started to socialize and settle in time, and the fate of humanity has been shaped on agricultural resources for centuries. Agriculture has brought people to a settled life and humanity has undergone many social changes with agriculture. The second change after agriculture has been with mechanization. The invention of machines has led to the emergence of factories, increased transportation opportunities, and again, great changes have occurred in social structures over time. People living in rural areas and dealing with agriculture have started to migrate to cities, the number of people working in factories has started to increase, and the search for resources has shifted to industrial products such as iron and steel. Thus, the competition between countries was shaped to reach these raw materials, and the world also met with world wars in this period.

The industrial revolution, which started with mechanization, did not last as long as the agricultural revolution. Mankind has made very rapid developments in this period, and the fierce competition of countries has also had an impact on this. The spread of electricity and later the invention of the computer marked the beginning of a new era called the informatics age. Especially the invention of the computer and then the internet has accelerated the globalization of the world and caused great developments in logistics and communication opportunities. The informatics age has also been the pioneer of a new revolution. The name of this new revolution, which was first expressed in Germany in 2013, is Industry 4.0.

Industry 4.0 refers to a form of production that emerged with the development of computer and internet technologies, such as the internet of things, robotic technologies, cloud computing technology, big data, and cyber-physical systems. With the use of these technologies, companies are expected to increase their productivity by reducing their costs. Although there were concerns at first that there would be problems in employment and unemployment would increase with Industry 4.0, this concern was eliminated with the new job opportunities created by Industry 4.0. Because the technologies that form the basis of Industry 4.0 also need human resources. However, it is also known that the human resources required by Industry 4.0 are more knowledgeable and competent workforce than in the past. For this reason, it should be noted that countries need some reforms in education about Industry 4.0.

Industry 4.0, as in other industrial revolutions, has greatly changed the markets in which countries compete and the way of production. For this reason, countries that want to protect their competitiveness have tried to act more proactively in Industry 4.0, and some countries have made great strides in competition with Industry 4.0 compared to previous years. At the forefront of these countries are Asian countries such as China, India and South Korea. Countries such as the USA, Germany and England, which had a competitive advantage for many years, started to lose their dominance in many sectors with Industry 4.0, and the superiority began to pass to other countries that are more active in Industry 4.0.

In this study, Turkey's position in there has been an increase in Turkey's R&D expenditures and innovation indicators in the last 10 years, it has not been able to cover enough progress in Industry 4.0 yet. However, in the empirical analysis, the Global Innovation Index, which is considered as the indicators of Industry 4.0, the number of patents of countries, the effect of High Technology Exports and R&D Expenditures on GDP growth rates were examined, although a long-term relationship was determined between these indicators, the causality relationship was only with the Global Innovation Index. It has been determined in the number of patents and the number of patents with the GDP Growth rate. It is evaluated that the findings do not yield fruitful results due to the fact that Industry 4.0 is not a very old concept yet and the data are scarce.

As a result of the study, it has been determined that Turkey has not made enough progress on Industry 4.0, but it is partially progressing with applications such as R&D incentives and tax supports given to companies in this regard, and it is behind in Industry 4.0 compared to developed countries such as Germany, China and Japan. seen. Among the reasons for this are the lack of qualified personnel, the long-term gain from the investments made, infrastructure deficiencies and economic inadequacies. In this respect, it is considered that making changes in the education system and raising awareness on this issue throughout the country and increasing the amount of incentives given to companies will be beneficial.

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7 Appendix

The data set used in the study is shown below.

Table 12. Data set of The Practical Part(1)

Countries	Variables	2005	2006	2007	2008	2009	2010	2011	2012
CHINA	GII							46,43	45,4
	HTE			30,1508	29,36366	31,93779	32,12365	30,48393	30,84868
	R&D EXPENDITURES	1,30792	1,36854	1,37369	1,44592	1,6648	1,71372	1,78034	1,91214
	TOTAL PATENTS	93485	122318	153060	194579	229096	293066	415829	535313
	GDP	11,39459	12,72096	14,23086	9,650679	9,398726	10,63587	9,550832	7,863736
JAPAN	GII							50,32	51,7
	HTE			20,01903	18,7855	20,40424	19,08106	18,34932	18,20157
	R&D EXPENDITURES	3,18099	3,27844	3,3396	3,33718	3,2314	3,13708	3,24477	3,20908
	TOTAL PATENTS	367960	347060	333498	330110	295315	290081	287580	287013
	GDP	1,803901	1,37235	1,483969	-1,22429	-5,69324	4,097918	0,02381	1,374751
GERMANY	GII							54,89	56,2
	HTE			15,45554	15,07046	16,78982	16,88486	16,33754	17,22154
	R&D EXPENDITURES	2,44193	2,47232	2,46048	2,61513	2,74266	2,73024	2,80555	2,88166
	TOTAL PATENTS	48367	48012	47853	49240	47859	47047	46986	46620
	GDP	0,731707	3,816442	2,976455	0,959879	-5,69384	4,179882	3,925193	0,418498

Table 13. Data set of The Practical Part(2)

Countries	Variables	2013	2014	2015	2016	2017	2018	2019
CHINA	**GII**	44,66	46,57	47,47	50,57	52,54	53,06	54,82
	HTE	31,57436	29,69541	30,42194	30,24264	30,90724	31,4675	30,78337
	R&D EXPENDITURES	1,99786	2,02243	2,05701	2,10033	2,11603	2,14058	
	TOTAL PATENTS	704936	801135	968252	1204981	1245709	1393815	1243568
	GDP	7,76615	7,425764	7,041329	6,848762	6,947201	6,749774	5,949714
JAPAN	**GII**	52,23	52,41	53,97	54,52	54,72	54,95	54,68
	HTE	17,72721	17,75128	18,01897	17,59211	17,56551	17,26924	17,00016
	R&D EXPENDITURES	3,31496	3,40022	3,28165	3,15786	3,20798	3,27512	
	TOTAL PATENTS	271731	265959	258839	260244	260292	253630	245372
	GDP	2,0051	0,296206	1,560627	0,753827	1,675332	0,558851	0,270305
GERMANY	**GII**	55,83	56,02	57,05	57,94	58,39	58,03	58,19
	HTE	17,29433	17,20602	17,82123	18,07933	15,80791	15,74446	16,38465
	R&D EXPENDITURES	2,83599	2,87784	2,93003	2,94099	3,06792	3,13267	
	TOTAL PATENTS	47353	48154	47384	48480	47785	46617	46632
	GDP	0,437591	2,209543	1,491932	2,23	2,680231	1,086025	1,055508

Table 14. Data set of The Practical Part (3)

Countries	Variables	2005	2006	2007	2008	2009	2010	2011	2012
GREECE	GII							34,18	35,3
	HTE			9,113217	10,84962	12,22523	11,59453	11,25014	10,14318
	R&D EXPENDITURES	0,57896	0,56118	0,57655	0,66183	0,62557	0,59838	0,67196	0,69957
	TOTAL PATENTS	462	532	575	628	698	728	721	628
	GDP	0,599142	5,652434	3,273747	-0,33517	-4,30073	-5,47863	-10,1493	-7,0867
TURKEY	GII							34,11	34,1
	HTE			2,138261	1,837563	2,005525	2,194655	2,110565	2,154743
	R&D EXPENDITURES	0,56931	0,55749	0,69182	0,69292	0,8094	0,79892	0,79988	0,83217
	TOTAL PATENTS	928	1072	1810	2221	2555	3180	3885	4434
	GDP	8,992305	6,947988	5,043508	0,815025	-4,82315	8,427104	11,20011	4,788493

Table 15. Data set of The Practical Part (4)

Countries	Variables	2013	2014	2015	2016	2017	2018	2019
GREECE	GII	37,71	38,95	40,28	39,75	38,85	38,93	38,9
	HTE	8,467576	11,49629	12,90897	13,70957	12,10896	12,94978	12,51482
	R&D EXPENDITURES	0,81131	0,8333	0,96121	0,99394	1,13109	1,17732	
	TOTAL PATENTS	698	651	550	606	498	430	356
	GDP	-2,516	0,475696	-0,19609	-0,48717	1,092149	1,668429	1,803595
TURKEY	GII	36,03	38,2	37,81	39,03	38,9	37,42	36,95
	HTE	3,130233	3,379641	3,436024	3,038096	3,232696	2,673519	3,028138
	R&D EXPENDITURES	0,81821	0,86077	0,8815	0,94464	0,95978		
	TOTAL PATENTS	4392	4766	5352	6230	8175	7156	7871
	GDP	8,485817	4,939715	6,084487	3,323084	7,501997	2,979885	0,889585