TRANSFORMATION OF TECHNOLOGY POLICIES AND ITS ECONOMIC EFFECTS IN TÜRKİYE

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Abstract

Technological development, which consists of invention, innovation and diffusion processes, is used synonymously with productivity increase and can be expressed as the emergence of various information that provides the opportunity to produce output in larger quantities, superior and quality output from a certain source. The technology levels of the economies are also the determinants of their ability to compete with each other and their economic development rankings. Economists emphasize the necessity of technological innovations, which are the product of human capital accumulation, for long-term productivity growth. So much so that the benefit obtained from the products obtained by the methods brought forward by the technological development may be greater than the costs incurred for the new methods of production. Because the expenditures made on technological development are an investment and no other investment can provide the benefit that they provide in the long run. Because every technology investment can have continuity with a process that can feed each other.

In many scientific studies, the place of technological development for economic growth is emphasized with different expressions. While pointing out the "mental labor of people" or "technological innovations that are the product of creative intelligence" as the source of economic growth, it is stated that "qualified technological production and investment amount" is at the top of the development criteria of countries. Moreover, instead of the inadequacy of financial and real capital, factors such as inaccessibility to new information, inability to use existing technology, and insufficient human capital are put forward as the cause of underdevelopment.

Various indicators are used in the technological competencies of countries such as the share allocated to R&D expenditures; number of scientists-technical personnel working in R&D services; the number of patents received; the number of scientific publications produced; the number of users of computers, internet and communication tools, and the rate of technology-intensive products with high added value in total exports. On the other hand, the innovation skills or technological development rankings of countries are measured through the "Global Innovation Index". Statistical results show that the Turkish economy has made slow progress in the development of science and technology policies, and is far from the average of OECD countries. Similarly, when the indicators are compared with the averages of E7 countries, although Türkiye's place is in the middle, it is understood that it is above the levels determined as threshold values in some indicators and may be in a better position in the future. In the global innovation index ranking, while Türkiye ranks 41st out of 131 countries, it is observed that the scoring difference between them and the first country is about two times.

Keywords
Technology policies, Technological development, Economic growth, Innovation, Research & Development

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1. Introduction

The most important one of the many economic variables that determine the performance of an economy is whether an economy can reveal its own dynamics. It is stated in the relevant literature that there are technological developments that include knowledge, R&D activities, human capital level, qualified workforce and innovation processes. Advances in technology are preparing the environment more suitable for economic development. The favor gained from the products obtained through the methods the technological development brought forward may be greater than the costs incurred for the new methods of production. This is because the expenditures made on technological development are considered an investment and no other investment can provide the benefit they provide in the long run (Yücel, 1997), and every R&D investment can have continuity with a process that can feed each other (Ağır et al., 2019, p. 90).

The level of development of an economy is measured by the amount of information, that is, the level of technology obtained, processed, transmitted, and stored with information technologies (Yıldız et al., 2010, p. 1). The export of high-tech products have great importance in terms of showing the development levels of countries. It is understood that the production of high-tech products, which contribute to the country's economy by increasing investments and create added-value, is considered as the locomotive of economic growth and has become the primary goal of countries.

In many scientific studies, the place of technological development for economic growth is emphasized with different expressions. As the source of economic growth, "human mental labor" or "technological innovations that are the product of creative intelligence" (Gurak, 2006, p. 18) are pointed out, while "qualified technological production and investment amount" are development criteria for countries (Kutlu and Taban, 2007, p. 200) is stated. It is stated that the competitive advantage of countries in international markets depends on keeping up with technological advances, developing and commercializing new technology (Guan & Ma, 2003, p. 738); as the share allocated to R&D and innovation from the national income increases, the production of value-added and technological products is ensured, and economic growth is realized through the increase in exports (Biçen, 2019, p. 184). Moreover, factors such as inaccessibility to new information, inability to use existing technology, and lack of adequate human capital, rather than the inadequacy of financial and real capital, are suggested as the causes of underdevelopment (Ağır, 2010, p. 43).

Various indicators are used to determine the technological competence of countries: the ratio of R&D expenditures to GNP; the number of scientists-technical personnel working in R&D services; the number of patents received; the number of scientific publications produced; the ratio of those who use computers, internet and communication tools; and high value-added, technology-intensive products in total exports (Ağır, 2010, p. 46). On the other hand, the global innovation index, which is obtained by using 80 different indicators in measuring the innovation capabilities of countries, which reveals the innovative activities of a country in depth, also ranks the countries by measuring them in terms of innovation skills.

The aim of this study is to descriptively discuss the indicators listed as science and technology indicators that consist of R&D expenditures, total number of patents, the number of scientific and technical publications, total number of researchers, the number of users of computers and internet tools, and the share of high-tech product exports in total exports of goods, and finally to evaluate that using the global innovation index, in the case of Türkiye, E7 and OECD countries. In line with these purposes, first of all, the conceptual and theoretical aspects of technological development will be discussed. After mentioning the development of Türkiye's technology policies, the global innovation index ranking will be given by making a descriptive comparison with the indicators of Türkiye, E7 and OECD countries by using the science and technology indicators mentioned above.

2. The Concept of Technological Development

Conceptually, technology means the collection of knowledge, organization and techniques necessary for the production of a good or service, "knowledge necessary for production" or "productive knowledge" (Gurak, 2006, p. 10). Technological development, on the other hand, is to produce larger quantities of output. It can be stated as the emergence of various information that provides the opportunity to produce superior and higher quality output from a certain source. There is also a strong link between the development of technology and productivity, and technology can often mean increased productivity (Taymaz & Suiçmez, 2005, p. 4). Technological development is analyzed in three stages, including the processes of invention, innovation and diffusion and their sum. The introduction of a new idea signifies invention; the use and commercialization of the invention refers to innovation; and the process of admiration and retention of innovation between companies and users means diffusion (Acun, 2000).

Technology policies can be defined as the development of scientific and technological efforts according to the current needs and future planned goals of a country in the social, political, economic and military fields (Öztaş, 2001, p. 11), and the policies determined for the commercialization, development or adaptation of new technologies (Mowery, 1995, p. 514). These policies directly affect the welfare levels of countries all over the world. Due to this feature of technology, all countries are in competition to access, use and develop technology. It can be said that there has been a paradigm shift with the increase in the economic value of knowledge and the fact that information and production technology have become policy tools all over the world (Seyrek & Sarıkaya, 2008, p. 54).

The technology levels of the economies are also the determinants of their ability to compete with each other and their economic development rankings. The basic condition of being able to compete and maintain its existence in the international arena is to produce cheap and high-quality products. Producing low-cost and high-quality goods depends on the renewal and development of production technology. The technological innovations that are the product of human capital accumulation are required for long-term productivity growth (Gurak, 2006). In the technological competencies of countries, various indicators are used such as the share of R&D expenditures, the number of scientists-technical personnel working in R&D services, the number of patents received, the number of scientific publications produced, the number of users of computers, internet and communication tools, and the share of technology-intensive products with high added-value in total exports (Ağır, 2010, p. 46).

The importance an economy attaches to technological development is associated with the abundance of that country's R&D expenditures. The 1% share of GNP allocated to R&D and the number of 15 full-time research personnel per 10,000 economically active population are listed as the threshold values for the shares allocated to R&D (Yücel, 1997, p. 15). In developed countries, these rates are more than 40 full-time researcher personnel and shares above 2 percent of GNP (Bulut, 2005, p. 81). While less than 1 percent of the

GNP is allocated to R&D in developing countries, there are less than 15 full-time researchers (Girgin & Arıoğlu, 2001).

The Global Innovation Index, which reveals in depth the comparative "innovation" activities of a country, makes annual evaluations for 131 countries using 80 different indicators under seven main headings (TİM, 2020). With the improvement of data such as R&D activities, the number of patents, the number of scientific articles, which are among the 80 sub-indicators, the ranking of the relevant country in the Global Innovation Index rises. Therefore, it is expected that the general economic outlook of the countries that have risen to the top of the index will improve (Global Innovation Index, 2020).

The Global Innovation Index indicates the political stability of countries in general in terms of supporting innovative activities, countries' human capital in terms of improving the education system and increasing the interest in qualified manpower, countries' infrastructure and information communication technologies through making innovation easier, indicators such as entrepreneurial activities, access to financial institutions, diversity of financial instruments, level of competition, the development of their markets, their commercial development, which indicates the general quality of domestic production and services, information and technology outputs in order to reveal whether countries can develop products and services with high added-value, it also uses creative outputs in order to reveal innovation and measure creativity. Therefore, outputs such as trademark applications and industrial design applications are considered important for countries to be at the forefront of the Global Innovation Index (Global Innovation Index, 2020).

3. Technological Development and Economic Growth

The classical economists gave importance to the quality of production factors and accepted that productivity could increase with the division of labor and technological development and affect economic growth. However, classical and neo-classical economists assumed the technological development as external in the economic growth model and could not explain the source of the technology. According to them, technology is a resource that fell from the sky. Schumpeter (1912), who used technological innovations for the first time in economic growth, accepted that technological innovations are the internal elements of the economy (Barış, 2019).

Endogeneus Growth Theory, which was first developed by Romer (1986) as an alternative to neo-classical growth theories, accepts that technology is not exogenous to the model, that there may be an increased return on capital, including human capital, and that this increased return will not reduce growth in the long run (Sala-i Martin, 1990). Until Romer (1986), it is stated that the concepts related to the quality of labor, technological innovations and economic growth were not in the growth literature (Gurak, 2006, p. 126). In New Growth Theories, on the other hand, different areas that can be sources of increased returns are pointed out; some of them (Agir & Utlu, 2011, p. 270) are human capital (Lucas, 1988), cumulative capital (Rebelo, 1991), activities related to R&D (Romer, 1986; 1990), public expenditure policies (Barro, 1990) and financial markets (Pagano, 1993).

In Romer's (1986) model, he argues that investments increase technological knowledge as a by-product, and this new knowledge is used as free information input in other production processes, which spreads across the industry as a result of spillovers. Romer's (1986) theory is based on Arrow's (1962) idea of "learning by doing". Arrow (1962) observed that as time progressed, production costs decreased, quality increased, and production accelerated in some sectors, and he named this as "learning by doing", attributing to his knowledge.

According to Romer (1990), the R&D sector makes new ideas and improved designs that enter the production process through the machines used in the production of the final product. These new designs will also increase the total stock of knowledge in the economy, the efficiency of human capital and the efficiency of machinery used in production. It is also argued that the theoretical framework in which knowledge and technological development are associated in this way can explain the development gap between countries.

Romer (1994) emphasizes that for growth, governments must implement policies that will create the institutional framework that supports technological development and attaches importance to public policies. Grossman and Helpman (1989, 1990) emphasize that the R&D sector, which can benefit from the opportunities brought by foreign trade, can trigger growth by giving a comparative advantage to the country's economy. Grossman and Helpman (1992) point to productivity gains resulting from internal technological innovations as the source of growth.

Aghion and Howitt (1992) point to the research of competitive firms as the source of growth. With R&D, each innovation causes the production of a new intermediate product, and the patents obtained can direct the company to new R&D studies due to the monopoly profit to be created. In the model, the growth rate is associated with the amount of innovations and skilled labor and the efficiency of R&D.

4. The Development of Science - Technology Policies in Türkiye

With the understanding of the importance of technology in social development in Türkiye, the State Planning Organization (SPO) was established in 1960. The main framework of science and technology policies began to be formed with the planned period. TÜBİTAK was established in 1963 as the first institutional structure to play a role in directing scientific activities. In 1965, the National Productivity Center (NPC) was established and activities related to productivity were started.

In the early 1970s, the subjects of "technological development and technology transfer" were mentioned. Technology policies were first mentioned in the Fourth Five-Year Development Plan (1973-1977) and increasing production-oriented R&D activities was determined as the main target. In this process, the importance of university-industry cooperation in technology policies was emphasized (DPT, 1979). However, these policies could not be implemented in this period, and the targeted objectives could not be realized due to the inability of resources to focus on technological activities and investments that would increase competitiveness in goods with high added-value (Işık, 2000). In the 1960s and 1970s, Türkiye's main policy in the field of science and technology was to support basic and applied research in the natural sciences without any national priority for creating economic and social benefits (Göker, 2002, p. 2-4).

In the 1980s, some important areas were determined and industrial strategies were tried to be formed (Soyak, 2002). The efforts to establish a technology development zone coincide with these years. In 1983, the Science and Technology Supreme Council (STSC) was established in order to pursue the national science policy, and with the document "Turkish Science Policy: 1983-2003", a detailed science and technology policy was tried to be put forward for the first time. In this document, technology was considered as the main subject and technology areas to be prioritized were determined, but could not be implemented. "Türkiye's Science and Technology Policy" was only approved in 1997, and its work after 1993 was given its final shape. However, STSC's plans for the establishment of the National

Innovation System in 1998 and 1999 meetings could not be successful because they could not be dealt with decisively.

KOSGEB and technology centers were established in the 1990s. In 1991, the Technology Development Foundation of Türkiye (TTGV) was established in cooperation with the public-private sector. TTGV is involved in technology, innovation and R&D studies by supporting the technology and innovation activities of the private sector in Türkiye. Collaborations have been established for the solution of Türkiye's energy problem, and working groups have been formed for the preparation of technologies, innovative activities and R&D programs that will provide energy efficiency (Türkeş, 2002, p. 35).

According to December 2021 statistics, the number of technology development zones in Türkiye is 92, and 73 of them are actively operating. In these regions, 7,331 R&D companies employ over 75 thousand personnel. The number of patents registered in these regions is 1,409, and the number of patents in progress is 3,013. While the number of completed projects in the technology development zones is 43,527, the projects worked on are announced as 12,131 (TGBD, 2021).

In the 2000s, while the national innovation system was the main theme of the Eighth Development Plan, the concept of innovation was emphasized in the Ninth Development Plan. In the plan, it was decided to establish technology transfer centers and to encourage entrepreneurship to develop technology. The "E-Transformation Türkiye Project" was put into practice, and the use of information and communication technologies in public services was expanded (TÜBİTAK, 2010). In terms of technology policies, the Tenth Development Plan aims to commercialize research findings, increase private sector-based technological activities, and reach high competitiveness with globally branded technology-intensive products by creating an innovation-based eco-system (Ministry of Development, 2015).

Objectives such as expanding the capacity to produce and use information, and increasing R&D and innovation activities to support high value-added products were included in the Eleventh Development Plan (CSBB, 2019). In this plan, Türkiye's strengthening in the field of aviation and space for its global competitive advantage, increasing the institutional capacity and effectiveness of the Turkish Space Agency and putting the National Space Program into practice were determined as the main targets (Dinç, 2020).

It is understood that in this process, importance is given to areas such as space, aviation, software and informatics, especially defense industry technology. In this context, TEKNOFEST Aviation, Space and Technology Festival, which was held for the first time in Türkiye in 2018, has an important place in terms of the development of national technology and raising public awareness. TEKNOFEST, whose primary goal is to contribute to Türkiye's engineering-based human resources, is the world's most important aviation, space and technology festival organized with the partnership of institutions and organizations that have critical importance in the development of national technology.

Increasing defense expenditures in the world and in Türkiye directly affect the defense and aerospace industry and lead to an increase in investments in related fields. The fact that the said investments are directed towards R&D, innovation and technological activities through TEKNOFEST, TÜBİTAK, TTGV, NPC and related institutions and organizations increases the effectiveness of the investments. This situation plays an important role in the realization of sustainable economic growth targets. In this context, it can be stated that the sales revenues, exports and R&D expenditures of Turkish companies operating in the defense industry have increased significantly (Kudar, 2021, p. 160).

5. The Comparison of Science and Technology Indicators

In this section, science and technology indicators will be evaluated by using statistics from Türkiye, E7 and OECD countries. In this context, indicators consisting of R&D expenditures, the total number of patents, the number of scientific and technical publications, the total number of researchers, the number of computer and internet users, the shares of high-tech product exports, and the global innovation index will be included descriptively.

It can be said that a country's competitive advantage depends on its ability to keep up with technological advances, develop new technology and commercialize it (Guan & Ma, 2003, p. 738). As the share allocated to R&D from income increases, the production of value-added and technological products is ensured, so economic growth can be realized through the increase in exports (Biçen, 2019, p. 184).

According to Table 1, the countries that allocates the highest share from GDP to R&D expenditures in 2020 are Israel with 5.4%; Korea with 4.8%; USA with 3.5%; Japan with 3.3% and Austria comes with 3.2%. While Türkiye allocated 0.8% of its GDP to R&D in 2010, it has started to transfer resources over 1% since 2017. This ratio shows that the share allocated to R&D expenditures for Türkiye exceeds the threshold value.

Table 1. *The Share of R&D Expenditures in GDP in Some OECD Countries, (%)*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Austria	2.7	2.7	2.9	3.0	3.1	3.0	3.1	3.1	3.1	3.1	3.2
Canada	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.7
Finland	3.7	3.6	3.4	3.3	3.1	2.9	2.7	2.7	2.8	2.8	2.9
France	2.2	2.2	2.2	2.2	2.3	2.2	2.2	2.2	2.2	2.2	2.4
Germany	2.7	2.8	2.9	2.8	2.9	2.9	2.9	3.0	3.1	3.2	3.1
Hungary	1.1	1.2	1.3	1.4	1.3	1.3	1.2	1.3	1.5	1.5	1.6
Ireland	1.6	1.6	1.6	1.6	1.5	1.2	1.2	1.3	1.2	1.2	1.2
Israel	3.9	4.0	4.1	4.1	4.2	4.3	4.5	4.7	4.8	5.1	5.4
Italy	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.5	1.5
Japan	3.1	3.2	3.2	3.3	3.4	3.2	3.1	3.2	3.2	3.2	3.3
Korea	3.3	3.6	3.9	4.0	4.1	4.0	4.0	4.3	4.5	4.6	4.8
Netherlands	1.7	1.9	1.9	2.2	2.2	2.1	2.2	2.2	2.1	2.2	2.3
Poland	0.7	0.7	0.9	0.9	0.9	1.0	1.0	1.0	1.2	1.3	1.4
Portugal	1.5	1.5	1.4	1.3	1.3	1.2	1.3	1.3	1.3	1.4	1.6
Slovakia	0.6	0.7	0.8	0.8	0.9	1.2	0.8	0.9	0.8	0.8	0.9
Spain	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.3	1.4
Türkiye	0.8	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.1	1.1
USA	2.7	2.8	2.7	2.7	2.7	2.8	2.9	2.9	3.0	3.2	3.5

Source: Created by authors, using data from OECD, 2022, https://stats.oecd.org/.

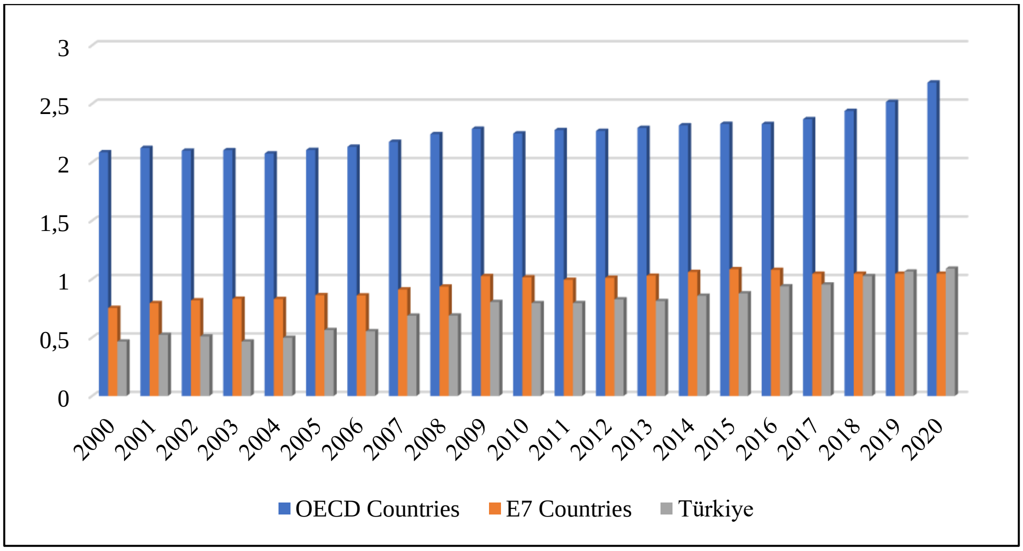

Figure 1. *The Share of R&D Expenditures of OECD, E7 Countries and Türkiye in GDP, 2000-2020 (%)*
Source: Created by the authors using data from World Bank, WorldBank Data, 2022, https://databank.worldbank.org/; OECD, 2022, https://stats.oecd.org/.

In Figure 1, the share of R&D expenditures as of 2020 is 2.68% on average in OECD countries; It is seen that it is 1.04% in E7 countries and 1.1% of GDP in Türkiye. Accordingly, Türkiye ranks below OECD countries but above E7 countries in terms of average R&D expenditures. The share of R&D expenditures has been increasing in Türkiye since the beginning of the 2000s. However, it can be stated that it should allocate more shares to R&D compared to developed countries.

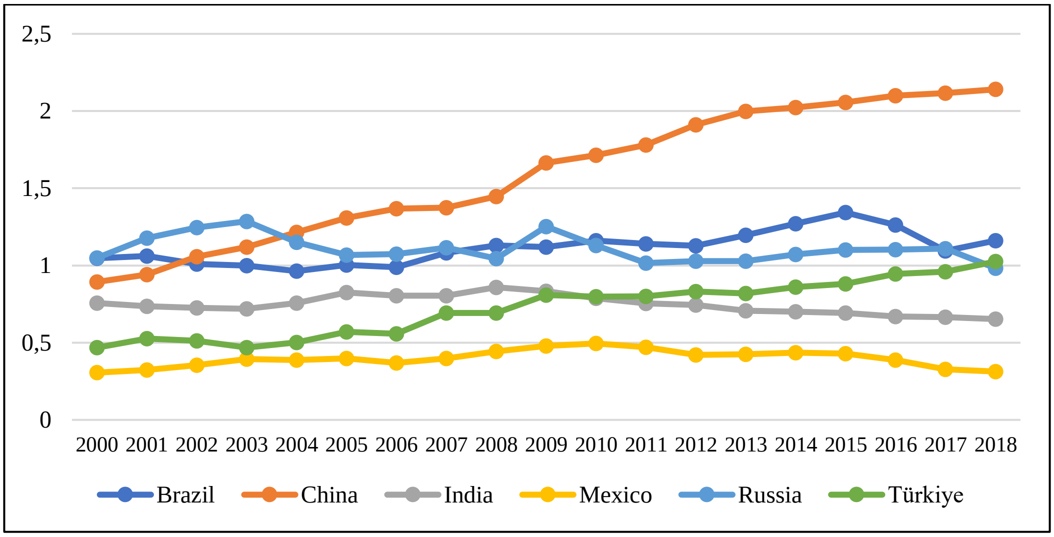

Figure 2. *The Share of R&D Expenditures of E7 Countries in GDP, 2000-2018 (%)*
Source: Created by the authors using data from World Bank, WorldBank Data, 2022, https://databank.worldbank.org/; OECD, 2022, https://stats.oecd.org/

In Figure 2, the increase in the share of China's R&D expenditures between 2000 and 2018 draws attention. In China, at the beginning of the 2000s, it was observed that 0.9% of the GDP was allocated to R&D expenditures on average; it is understood that this rate reached 2.14% in 2018. While there is a dynamism in Türkiye in the given period, it can be stated that there has not been a significant increase in the share allocated to R&D expenditures in Brazil, India, Mexico and Russia in the last 19 years.

The number of patents of the countries is also considered as one of the factors that determine the export of high technology products and economic growth rates of an economy (Koçakoğlu and Bayraktar, 2019, p.124).

Table 2 shows that in the 2000-2020 period, the number of patents in China increased approximately 30 times and reached 1.5 million levels, raising the averages of E7 countries. The source of other significant increases is seen as India, Indonesia and Türkiye. While there is no significant improvement in the number of patents in Mexico and Russia, Brazil shows a higher increase compared to these two countries.

Table 2. *The Total Number of Patents for E7 Countries, 2000-2020.*

	Brazil	China	India	Indonesia	Mexico	Russia	Türkiye
2000	17283	51906	8538	3890	13061	32337	3433
2001	17849	63450	10592	3926	13565	34090	3212
2002	16685	80232	11465	3843	13062	33308	1838
2003	16411	105317	12613	3300	12207	34870	837
2004	16713	130384	17466	3668	13198	30190	917
2005	18498	173327	24382	4304	14435	32253	1146
2006	19842	210501	28928	4612	15505	37691	1232
2007	21663	245161	35218	5134	16599	39439	2021
2008	23170	289838	36812	5133	16581	41849	2397
2009	22406	314604	34287	4518	14281	38564	2732
2010	24999	391177	39762	5630	14576	42500	3357
2011	28649	526412	42291	5830	14055	41414	4113
2012	30435	652777	43955	5830	15314	44211	4666
2013	30884	825136	43031	7450	15444	44914	4661
2014	30342	928177	42854	8023	16135	40308	5097
2015	30219	1101864	45658	9153	18071	45517	5841
2016	28010	1338503	45057	9639	17413	41587	6848
2017	25658	1381594	46582	9303	17184	36883	8555
2018	24857	1542002	50055	9754	16424	37957	7466
2019	25396	1400661	53627	11481	15941	35511	8088
2020	24338	1497159	56771	8160	14312	34984	8158

Source: Created by the authors using data from the World Intellectual Property Organization, WIPO IP Statistics, 2022, https://www3.wipo.int/ipstats/.

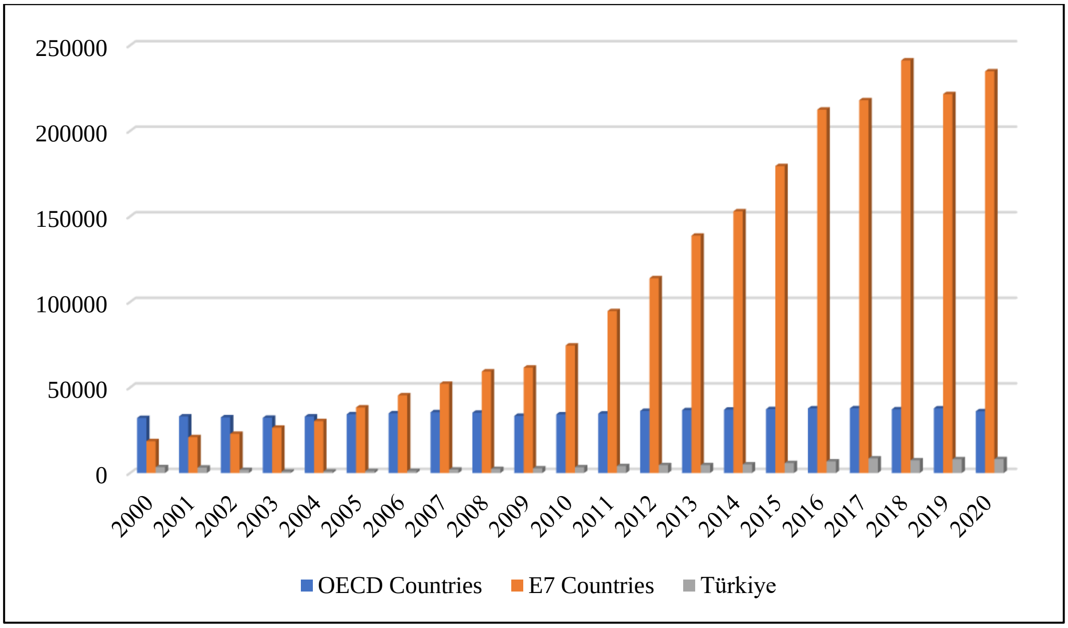

Figure 3. *The Total Number of Patents for OECD Countries, E7 Countries and Türkiye, 2000-2020.*

Source: Created by the authors using data from the World Intellectual Property Organization, WIPO IP Statistics, 2022, https://www3.wipo.int/ipstats/.

The data in Figure 3 show that there was no significant increase in the number of patents in 30 OECD countries during the 2000-2020 period, but there was a very high increase in the average number of patents in the E7 countries in the same period. In Türkiye, it is seen that the number of patents, which was 3,433 in 2000, reached 8,158 in 2020. Despite this increase, it is understood that Türkiye's patent number statistics remain below the average of OECD and E7 countries.

The number of scientific and technical publications, as well as the number of patents, is seen as an important variable affecting the economic growth rates.

Table 3. *The Number of Scientific and Technical Publications Belonging to E7 Countries, 1996-2020.*

Year	Brazil	China	India	Indonesia	Mexico	Russia	Türkiye
2000	12800	53285	21409	398	5027	32707	6815
2001	13915	70676	22533	330	5435	36555	8592
2002	16157	75171	24313	386	5962	36336	10971
2004	19845	120947	28780	450	7285	34981	16026
2005	22311	165404	32885	578	8316	34439	17795
2006	28458	192393	38131	711	9433	29944	19561
2008	35400	247545	48135	739	10418	32401	22022
2009	38335	285496	53557	1064	10662	33283	25022
2010	41501	308769	60555	1405	11269	33855	26424
2012	47867	328127	77746	2043	12580	35792	28322
2013	50027	356356	82779	2751	13215	38295	30326
2014	51803	385178	91337	3044	14085	43836	31005
2016	55010	436079	107193	6734	15030	60205	35163
2017	58114	468045	112505	12432	16017	67397	33240
2018	61797	531110	127527	21264	16927	76146	33686
2019	64377	610459	129550	30446	18496	87168	37430
2020	70292	669744	149213	32554	20074	89967	42623

Source: Created by the authors using data from the National Science Foundation, Science and Engineering Indicators, 2022, https://ncses.nsf.gov/.

According to Table 3, it is seen that the number of scientific and technical publications in Brazil was 12,800 in 2000, 53,285 in China, 21,409 in India, 398 in Indonesia, 5,027 in Mexico, 32,707 in Russia and 6,815 in Türkiye. By 2020, the number of scientific and technical publications in China has increased nearly twenty times and approached 670 thousand, and 70 thousand in Brazil. It is understood that there were 150 thousand in India and 42.6 thousand in Türkiye at that time.

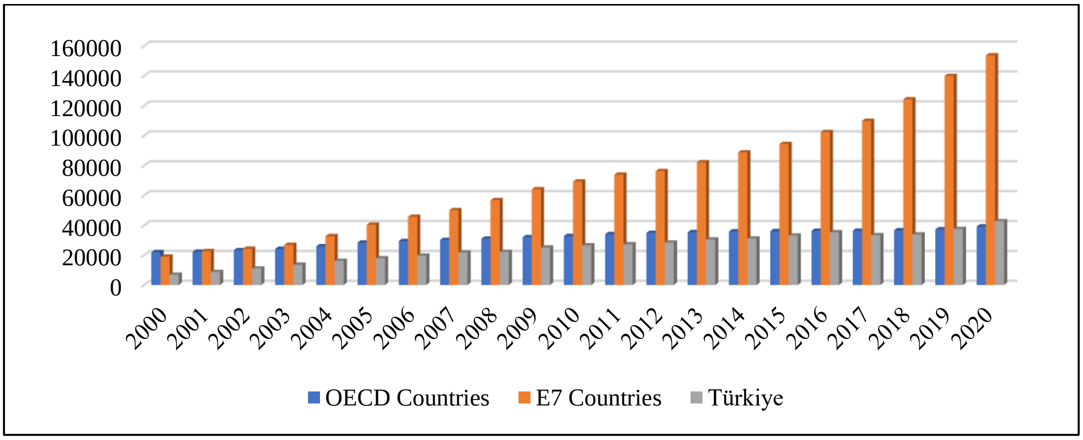

Figure 4. *The Number of Scientific and Technical Publications on OECD Countries, E7 Countries and Türkiye, 2000-2020.*

Source: Created by authors using data from National Science Foundation, Science and Engineering Indicators, National Science Foundation, Science and Engineering Indicators, 2022, https://ncses.nsf.gov.

The average number of scientific and technical publications of OECD, E7 Countries and Türkiye for the 2000-2020 period in Figure 4 shows that there is a significant increase in E7 and Türkiye, while the average of OECD countries is on a relatively low rise. Moreover, the number of scientific and technical publications in Türkiye in the recent period is above the OECD average.

Table 4. *The Total Number of Researchers in OECD Countries Between 2010-2020 (Per Ten Thousand Total Employment).*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Belgium	90.9	93.8	99.7	101.7	111.0	115.2	116.1	113.7	119.3	123.9	136.2
Czech Rep.	57.8	60.8	65.6	67.5	70.5	73.5	70.9	73.3	76.0	78.2	82.8
Denmark	134.3	140.6	144.9	144.1	148.4	151.4	155.8	150.5	148.2	148.7	149.4
Estonia	71.6	78.4	77.2	73.4	70.9	67.2	69.4	72.9	76.5	77.2	80.6
France	90.7	92.1	95.4	97.6	99.4	102.0	103.6	106.4	108.6	110.1	114.1
Germany	79.9	81.5	83.9	83.7	82.4	90.0	91.5	94.8	96.7	99.6	100.7
Hungary	54.0	58.3	59.8	62.1	62.1	58.7	57.7	62.4	80.6	83.3	90.1
Ireland	75.2	82.8	121.9	125.4	126.3	122.0	116.8	113.9	103.1	103.4	106.5
Italy	41.7	42.7	44.7	47.7	48.5	51.3	53.8	55.8	60.1	63.1	64.8
Japan	100.2	100.3	99.2	100.8	103.6	100.0	99.6	100.2	98.8	98.5	100.3
Korea	109.9	117.8	126.5	127.2	133.4	136.2	136.8	143.3	152.3	158.8	166.0
Lithuania	68.9	66.8	62.7	66.0	68.6	60.9	62.1	64.2	64.7	69.4	74.3
Latvia	46.2	46.1	44.9	40.8	42.8	40.6	35.6	39.3	38.4	40.4	46.4
Mexico	11.1	11.3	8.0	8.2	8.5	9.1	10.2	10.1	10.0	10.6	12.4
Netherlands	61.2	69.3	82.9	94.8	95.9	94.8	98.0	99.4	101.6	102.0	106.3
Norway	103.8	105.4	105.6	106.2	108.5	113.2	117.6	122.4	123.0	126.6	130.0
Poland	42.0	41.5	43.3	46.2	50.0	51.7	54.8	70.2	71.8	73.7	75.9
Portugal	85.2	92.2	92.8	85.0	84.5	84.5	88.9	93.6	97.0	101.3	109.4
Slovakia	70.0	69.4	69.1	67.2	66.3	63.5	61.0	64.2	67.5	69.4	72.0
Slovenia	80.0	92.6	94.7	93.9	92.0	83.7	84.5	94.0	98.6	100.4	98.6
Spain	69.0	68.5	69.5	69.2	68.0	66.2	67.1	68.7	70.7	70.7	74.4
Sweden	109.9	106.0	106.5	137.4	140.7	138.8	143.7	145.8	147.4	153.3	158.2
Türkiye	29.3	30.9	34.1	35.9	35.0	36.1	37.2	40.1	44.3	48.8	56.5

Source: Created by authors using data from OECD, 2022, https://stats.oecd.org/

Table 4 shows the number of researchers per 10,000 total employment. In the data period, it is understood that the number of researchers could not be increased in countries such as Japan, Latvia, Mexico and Slovakia, while there was a significant increase in countries such as Belgium, Korea, Netherlands, Sweden and Türkiye. On the other hand, in 2020, it was determined as 166 in Korea, 158 in Sweden, 149 in Denmark, 136 in Belgium and 130 in Norway.

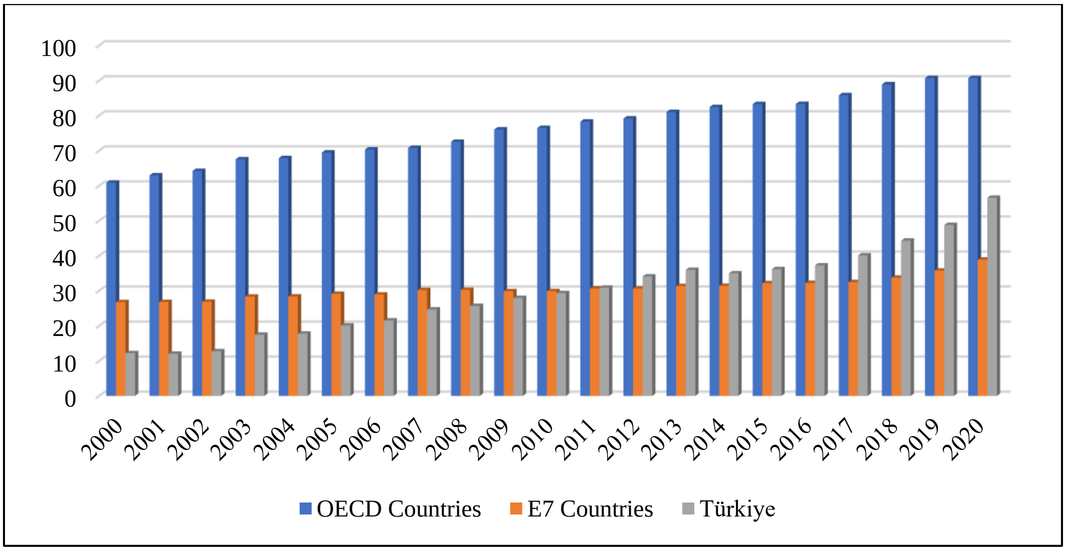

Figure 5. *The Total Number of Researchers in OECD Countries, E7 Countries and Türkiye between 2000-2020, (per ten thousand total employment)*

Source: Created by the authors using data from OECD, 2022, https://stats.oecd.org/) was.

In the comparison that placed in Figure 5, the movement of Türkiye is remarkable. It is understood that Türkiye increased the number of researchers from approximately 12 to 56 in the 2000-2020 period. This data is approximately 90 for OECD countries in 2020, it is about 39 researchers for E7 countries.

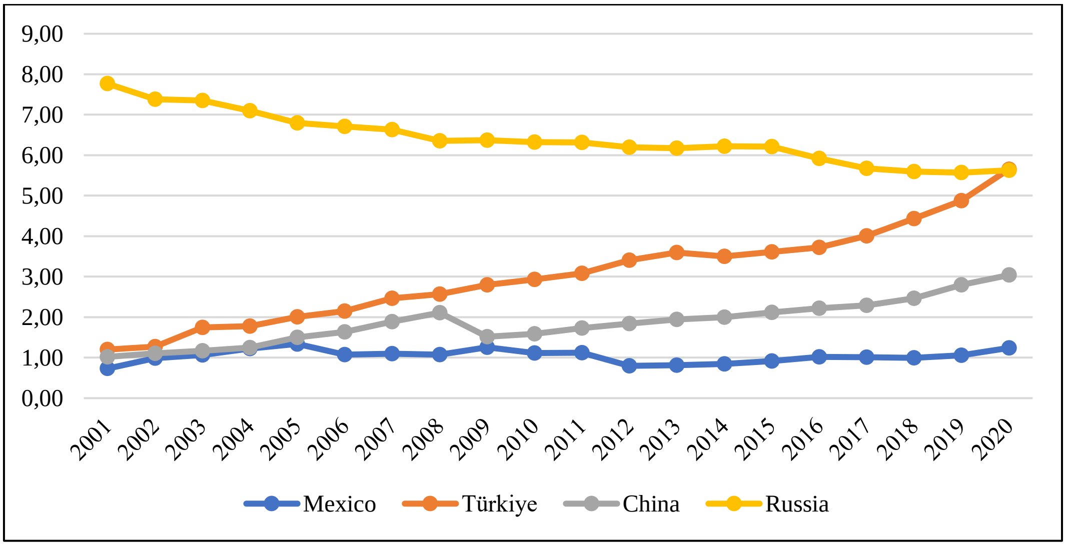

Figure 6. *The Total Number of Researchers in E7 Countries between 2001-2020, (Per thousand total employment)*

Source: Created by the authors using data from OECD, 2022, https://stats.oecd.org/

The number of researchers in E7 countries with data in Figure 6, despite the decrease in Russia during the data period, is increasing in Mexico and China, with the highest in Türkiye.

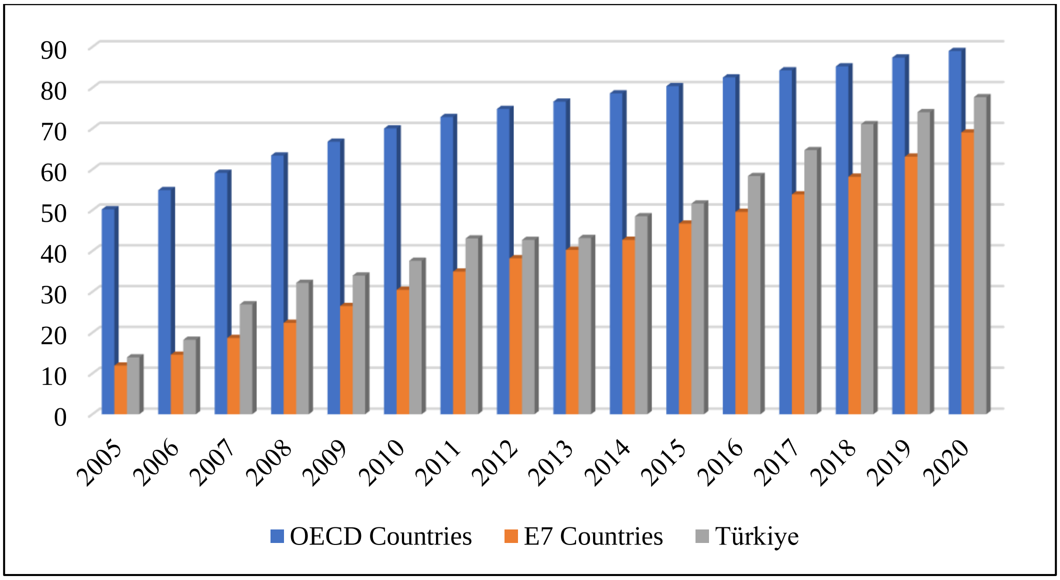

Figure 7. *The Ratio of Internet Users to Population (%) in OECD Countries, E7 Countries and Türkiye between 2005-2020, (16-74 years old)*

Source: Created by authors using data from International Telecommunication Union, ITU, 2022, https://www.itu.int/ and OECD, 2022, https://stats.oecd.org/

The indicators in Figure 7 show that the population using the internet has increased. For country groups, while 50% of the population in OECD countries used the internet on average in 2005, this rate was 12% in E7 countries and 14% in Türkiye. By 2020, the average for countries is 89%, 69% and 77%, respectively.

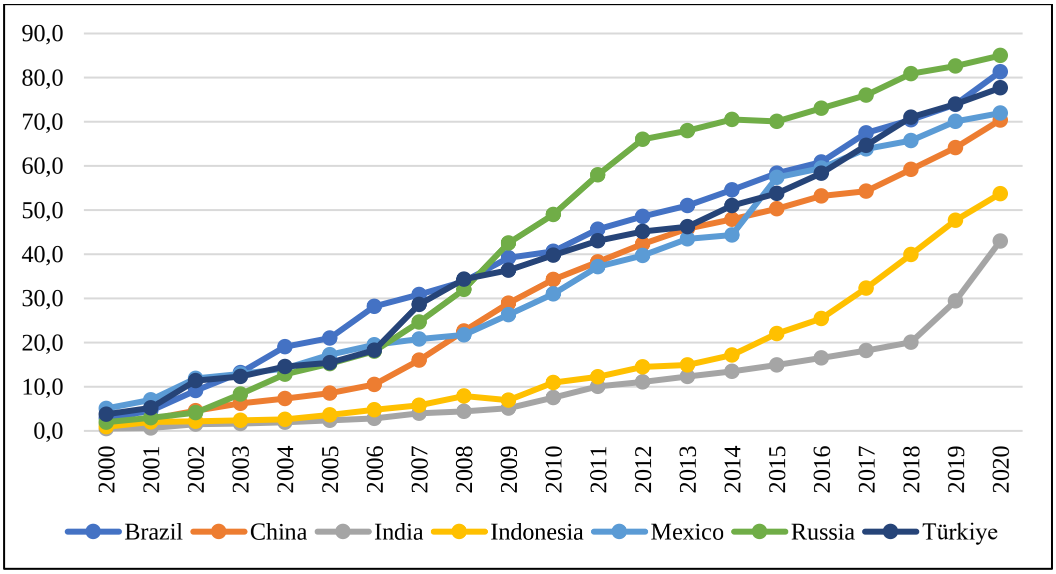

Figure 8. *The Ratio of Internet Users to Population in E7 Countries Between 2000-2020, Ages 16-74 (%).*

Source: Composed by the authors using data from the International Telecommunication Union, ITU, 2022, https://www.itu.int/ and OECD, 2022, https://stats.oecd.org/.

Figure 8 shows the ratio of individuals using the internet to their population for E7 countries. It can be said that the rate of internet usage in E7 countries has been increasing rapidly in the last 20 years. On the other hand, the highest rates among these seven countries belong to Russia and Brazil, while the lowest rates are in India and Indonesia, respectively. Türkiye has a value above the E7 average.

Table 5. *The Ratio of Individuals Using Computers to Population in OECD Countries Between 2005-2015 (%), (16-74 years old).*

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Austria	63.4	68.2	73.0	76.2	75.4	76.9	80.8	82.0	82.0	81.0	83.8
Czech Rep.	42.0	51.8	55.0	63.4	63.9	68.7	72.2	74.0	73.9	78.9	80.0
Denmark	82.5	85.8	83.8	85.6	87.0	88.6	90.2	92.8	95.1	96.1	95.9
Estonia	59.2	61.8	64.9	65.8	71.0	74.3	76.3	78.4	80.0	84.2	88.3
Finland	76.5	79.7	80.8	84.4	84.2	87.6	89.4	90.9	92.3	92.4	92.9
France	52.2	55.3	67.3	71.2	73.9	75.9	77.9	79.7	80.7	81.7	82.2
Germany	73.2	76.3	78.1	80.0	80.7	83.0	83.5	83.9	85.5	87.1	88.0
Greece	28.8	37.6	40.2	44.4	47.3	48.4	54.3	55.5	60.4	63.3	66.6
Hungary	42.1	53.8	58.0	62.5	61.9	63.3	68.7	71.5	73.0	76.0	72.3
Iceland	87.6	89.7	91.3	92.2	93.0	94.6	95.6	96.7	97.0	98.2	98.2
Ireland	43.9	58.2	62.8	67.0	67.6	69.9	76.0	77.1	78.1	78.4	77.3
Italy	40.6	42.7	42.5	45.6	49.0	53.2	55.0	56.0	58.2	59.1	61.3
Korea	73.6	78.8	78.3	79.2	82.8	82.8	83.2	83.5	79.9	78.9	77.5
Latvia	47.1	53.3	57.9	62.6	65.1	67.3	70.0	73.4	75.2	75.9	78.1
Lithuania	41.5	46.7	51.8	55.7	59.9	62.1	63.0	66.5	68.9	72.2	71.0
Luxemburg	77.4	75.6	80.4	82.6	87.8	90.0	90.7	92.6	93.9	93.5	97.0
Mexico	26.5	28.0	29.1	30.7	32.9	36.7	38.5	40.3	43.5	43.0	48.5
Netherlands	82.9	83.8	86.6	88.4	89.9	91.1	92.5	93.4	94.2	92.8	92.3
Norway	83.1	85.2	89.7	89.9	91.1	93.5	93.7	95.0	95.1	95.3	94.8
Poland	44.6	48.1	51.6	54.8	59.4	61.9	64.0	63.8	63.9	67.2	68.3
Portugal	39.6	42.5	45.8	45.9	51.4	55.4	58.2	62.4	64.0	65.8	69.2
Slovakia	62.5	60.9	63.9	71.8	74.4	78.4	76.3	77.6	79.2	80.0	77.4
Slovenia	52.2	56.5	58.1	60.5	65.2	69.8	69.9	70.3	73.2	72.6	73.1
Spain	52.1	53.4	56.5	60.2	62.3	66.8	68.7	72.0	72.1	73.3	73.8
Sweden	84.1	87.4	87.5	89.5	90.9	91.9	93.2	93.2	95.0	93.3	90.5
Türkiye	17.7	23.5	29.6	34.0	35.6	39.1	40.2	43.5	44.3	46.9	46.5
United Kingdom	72.5	72.7	78.0	79.6	84.2	85.7	86.8	88.5	89.7	91.2	90.2

Source: Created by authors using data from OECD, 2022, https://stats.oecd.org/.

Table 5 shows that the country with the highest computer usage rate in 2015 was Iceland with 98.2%. Luxembourg followed Iceland with 97%, respectively; Denmark with 95.9%, it is followed by Norway with 94.8% and Finland with 92.9%. It is seen that Türkiye lags behind OECD countries with 46.5% as of 2015.

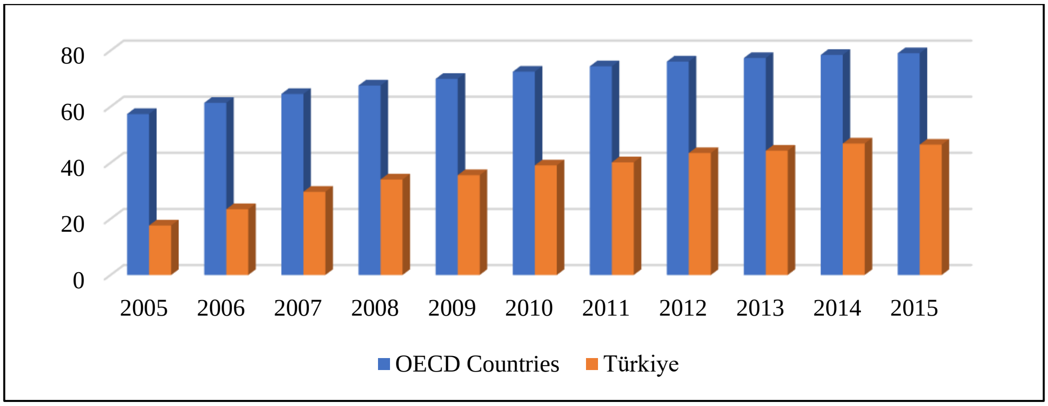

Figure 9. *The Ratio of Individuals Using Computers to Population (%) in OECD Countries and Türkiye Between 2005-2015*

Source: OECD, 2022, https://stats.oecd.org/ was created by the authors using data.

In Figure 9, computer usage rates in Türkiye and 27 OECD countries during the 2005-2015 period are given. In 2005, approximately 57% of the population aged 16-74 in OECD and 17% in Türkiye were using computers. It is understood that this rate was determined as 79% in OECD countries and 46% in Türkiye in 2015.

It is known that the production of high-tech products, which contribute to the country's economy by increasing investments and create added-value, is considered as the locomotive of economic growth and has become the priority target of countries. Figure 10 and Figure 11 show the share of high technology product exports in total manufactured goods exports in OECD Countries, Türkiye and E7 countries.

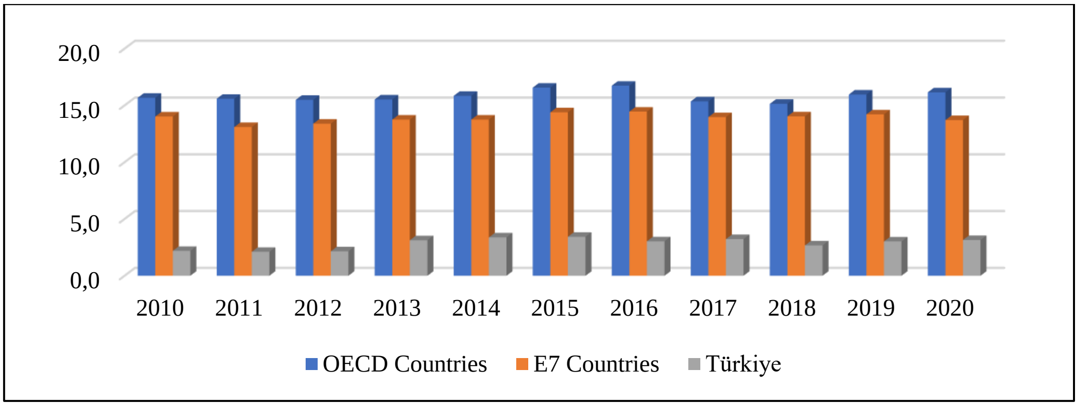

Figure 10. *The Share of High Technology Product Exports in Total Manufactured Goods Exports in OECD Countries, E7 Countries and Türkiye, 2010-2020 (%)*

Source: Created by the authors using data from World Bank, WorldBank Data, 2022, https://databank.worldbank.org/

In Figure 10, it is seen that the share of exports of high technology products in total exports of manufactured goods is quite low in Türkiye compared to OECD and E7 countries. This situation can be perceived as an aspect of Türkiye that is open to development. The Turkish economy will be able to increase its economic growth in the coming years, depending on the progress in the production of high-tech products.

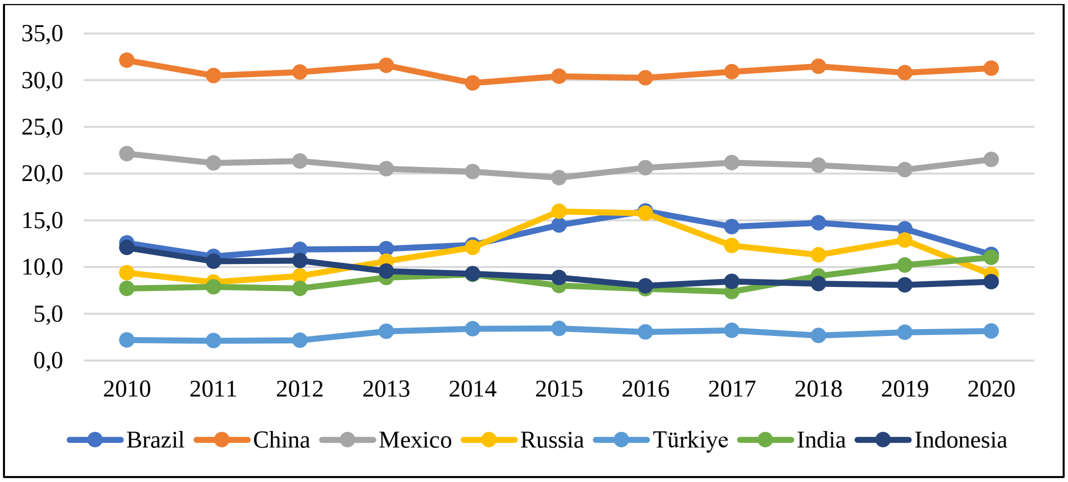

Figure 11. *The Share of High Technology Product Exports in Total Manufactured Goods Exports in E7 Countries, 2010-2020 (%)*
Source: Created by the authors using data from the World Bank, WorldBank Data, 2022, https://databank.worldbank.org/

Figure 11 includes high-tech product export statistics for E7 countries. Although the starting levels in E7 countries differ between countries during the data period, it is not possible to talk about a country that can exhibit a distinctive increase. However, China's leadership above 30% and Türkiye's statistics below 5% stand out as the highest and lowest values. Although there is a 1% increase in exports of high technology products in Türkiye between 2010 and 2020, it is understood that among the E7 countries, Türkiye's high-tech product export performance lags behind.

After the evaluations of science and technology indicators so far, it is important to evaluate the ranking of innovation skills of countries. Table 6 includes the Global Innovation Index statistics for the last four years for upper-middle-income countries, including Türkiye. These statistics cover the top 10 countries in the upper-middle income group according to the 2021 Global Innovation Index.

Table 6. *Global Innovation Index in Upper-Middle Income Countries*

	2018		2019		2020		2021	
Countries	**Ranking**	**Score**	**Ranking**	**Score**	**Ranking**	**Score**	**Ranking**	**Score**
China	17	53.1	14	54.8	14	53.3	12	54.8
Bulgaria	37	42.6	40	40.3	37	40	35	42.4
Malaysia	35	43	35	42.7	33	42.4	36	41.9
Türkiye	50	37.4	49	36.9	51	34.9	41	38.3
Thailand	44	38	43	38.6	44	36.7	43	37.2
Russia	46	37.9	46	37.6	47	35.6	45	36.6
Montenegro	52	36.4	45	37.7	49	35.3	50	35.4
Serbia	55	35.5	57	35.7	53	34.3	54	35.0
Mexico	56	35.3	56	36.0	55	33.6	55	34.5
Costa Rica	54	35.7	55	36.1	56	33.5	56	34.5
Brazil	64	33.4	66	33.8	62	31.9	57	34.2

Source: Created by the authors, using data from the Global Innovation Index (2018-2021).

Table 6 shows that China, one of the upper-middle-income countries, is the leading country in the 2021 global innovation index ranking with 54.8 points. It is understood that Türkiye ranks 4th in the upper-middle-income country group with 38.3 points in 2021.

Table 7. *Global Innovation Index in OECD Countries*

	2018		2019		2020		2021	
Countries	**Ranking**	**Score**	**Ranking**	**Score**	**Ranking**	**Score**	**Ranking**	**Score**
Switzerland	1	68.4	1	67.2	1	66.0	1	65.5
Sweden	3	63.0	2	63.6	2	62.4	2	63.1
USA	6	59.8	3	61.7	3	60.5	3	61.3
United K.	4	60.1	5	61.3	4	59.7	4	59.8
Korea	12	56.6	11	56.5	10	56.1	5	59.3
Netherlands	2	63.3	4	61.4	5	58.7	6	58.6
Finland	7	59.6	6	59.8	7	57.0	7	58.4
Denmark	8	58.3	7	58.4	6	57.5	9	57.3
Germany	9	58.0	9	58.1	9	56.5	10	57.3
France	16	54.3	16	54.2	12	53.6	11	55.0
Japan	13	54.9	15	54.6	16	52.7	13	54.5
Israel	11	56.7	10	57.4	13	53.5	15	53.4
Canada	18	52.9	17	53.8	17	52.2	16	53.1
Belgium	25	50.5	23	50.1	22	49.1	22	49.2
Luxemburg	15	54.5	18	53.4	18	50.8	23	49.0
Italy	31	46.3	30	46.3	28	45.7	29	45.7
Spain	28	48.6	29	47.8	30	45.6	30	45.4
Poland	39	41.6	39	41.3	28	39.9	40	39.9
Türkiye	50	37.4	49	36.9	51	34.9	41	38.3
Greece	42	38.9	41	38.9	43	36.7	47	36.3

Source: Created by the authors, using data from the Global Innovation Index (2018-2021).

Considering the global innovation index ranking of OECD countries in Table 7, it is understood that Switzerland has 65.5 points in 2021 and has led the last four years. The other two countries with a score above 60 are Sweden and the USA. Germany ranks 10th with a score of 57.3 in 2021, while Israel ranks 15th with a score of 53.4 in the same year. Türkiye, on the other hand, is in the 41st place with a score of 38.3 in the same year, significantly increasing its ranking compared to previous years.

6. Conclusion

Economists emphasize the place of technological development among many determinants of economic growth. While the most important source of economic growth is technological innovations, which are the products of human mental labor or creative intelligence, it is stated that qualified technological production and investment amount come first among the development criteria. It is stated that countries' gaining competitive advantage in international markets depends on their ability to keep up with technological advances, develop and commercialize new technologies, and as the share allocated to R&D and innovation from national income increases, the production of value-added and technological products is provided. Thus, economic growth is achieved through export growth. However, instead of the inadequacy of financial and real capital as the cause of underdevelopment, factors such as inaccessibility to new information, inability to use existing technology, and insufficient human capital are put forward, and the importance of science and technology policies is emphasized from a different perspective.

In this study, science and technology indicators were compared by using statistics from Türkiye, E7 and OECD countries. Data on R&D expenditures, the total number of patents, the number of scientific and technical publications, the total number of researchers, the number of computer and internet users, and the exports of high-tech products are presented in a descriptive manner as time series. It is understood that Türkiye's science and technology indicators have improved compared to previous years, and more and more importance is given to science and technology policies. However, while it is observed that the Turkish economy remains below the average of OECD countries in most indicators, it is understood that it can surpass the averages of E7 countries in some indicators. On the other hand, it is understood that Türkiye's place in the global innovation index rankings is upwards and is improving.

The Turkish economy should attach more importance to science and technology policies in order to gain a larger share in global trade and increase economic growth. Technical education should be supported in order to raise a qualified workforce. Organizations like TEKNOFEST in recent years are very important in terms of showing the potential of the Turkish economy and encouraging technological development. TEKNOFEST and similar organizations should be diversified. In order to increase the production of qualified knowledge, the Turkish economy should set its goals, increase R&D supports, and attach importance to technology-intensive production with high added-value.

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