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AN INTERNATIONAL COMPARATIVE ANALYSIS OF STRATEGIC INDICATORS FOR THE DEVELOPMENT OF TÜRKİYE'S INNOVATION CAPACITY

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ABSTRACT

This study provides a comprehensive analysis of Türkiye's innovation capacity by tracing its historical evolution through five-year development plans and assessing its position within the global innovation ecosystem. Focusing on key indicators such as R&D investments, the role of the private sector, the quality of advanced scientific outputs, researcher density, and international collaborations, the research draws on panel data from GII, OECD, UNESCO, TurkStat, and Scopus. The findings reveal notable progress in Türkiye's innovation landscape—particularly in creative outputs and private R&D spending—yet highlight persistent challenges in the impact and visibility of scientific publications. The study concludes with strategic policy recommendations to enhance Türkiye's innovation performance, emphasizing inclusive, interdisciplinary and globally integrated research and development efforts.

Keywords: *Innovation capacity, R&D investments, scientific publication performance, research density, internationally co-authored publications, panel data.*

INTRODUCTION

Innovation is one of the most important drivers supporting economic development and growth, particularly in upper-middle-income countries (Özbay, Arıcan, & Oguzturk, 2021; Özer & Ünlü, 2020). With the transition from traditional production-based economies to knowledge-based economies in the 21st century, innovation plays a critical role in enabling firms and countries to achieve sustainable competitive advantage. Today, along with technological advancements, innovation has become one of the fundamental determinants of economic growth, social welfare, and international positioning. According to a study covering 131 countries (Salahodjaev & Otajonov, 2022), a 1% increase in R&D expenditures leads to a 1.13-point rise in the Social Progress Index. The study highlights that this effect is particularly more significant in middle-income countries and reveals that innovation improves social indicators such as health, education, and quality of life.

Technological advancement, human capital, and R&D investments—highlighted as the fundamental pillars of competitive and innovative economies—are among the key factors enhancing countries' competitiveness in the international arena. A study conducted on European Union countries demonstrates that innovation plays a pivotal role in strengthening global competitiveness and highlights the need for stronger collaborations in scientific and technological fields (Çetin, 2024). Particularly, advancements in digitalization, artificial intelligence, green technology, sustainability and knowledge-intensive sectors are reshaping the dynamics of competition, while increasing the long-term success potential of firms with high innovation capabilities. In this context, innovation stands out as a critical and strategic element at the core of today's economic development strategies.

The institutionalization of innovation policies in Türkiye began simultaneously with the initiation of the planned development process in 1963, and the establishment of TÜBİTAK enabled research and development (R&D) support mechanisms to become systematic. The five-year development plans, serving as key strategic documents, have brought science, technology, and innovation to the core of policy agendas in light of changing conditions over time. Particularly since the 2000s, the significant rise

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in R&D expenditures led by the private sector and the increase in the number of researchers have been important indicators of Türkiye's efforts to strengthen its innovation capacity. However, despite quantitative progress, the country has not yet achieved the desired level in qualitative indicators such as high-impact scientific outputs, citations per publication, and international scientific collaborations. In this context, the main objective of this study is to provide a comprehensive evaluation of Türkiye's innovation ecosystem, identify structural differences compared to developed countries, and offer forward-looking policy recommendations.

In Türkiye, innovation, R&D, and digitalization have long been emphasized as strategic priorities in national development plans. However, the extent to which these objectives have been achieved, the areas in which implementation has fallen short, and the structural constraints encountered have often not been analyzed in a comprehensive manner. This study aims to fill this gap in the literature by comparing the historical evolution of these policies with current outcomes. Moreover, it seeks to offer an original, data-driven contribution to the literature on the relationship between national innovation systems and development planning.

This study first addresses the national innovation system within the framework of the Triple Helix model. In order to analyze the historical development of innovation in Türkiye, it examines how science and technology production, research and development (R&D) activities, and innovation outputs have been reflected in the country's five-year development plans. By comparing the goals set out in these strategic documents—which guide domestic policy priorities—with actual outcomes, the study evaluates the impact of policy-level orientations. The following section analyzes Türkiye's current global standing in terms of innovation indicators, in light of this historical background. The analysis specifically focuses on key indicators such as the share of private sector in R&D investments, the quality of advanced scientific outputs, researcher density, and internationally co-authored scientific publications. Türkiye's global position is assessed through a comparative analysis based on panel data drawn from the Global Innovation Index, OECD, UNESCO, TurkStat, and Scopus databases. Panel data is particularly important for providing detailed cross-country comparisons of outputs from units such as countries and firms over different time periods. As it includes both cross-sectional and time series dimensions, it is a preferred data type in international comparative studies. In the conclusion, policy recommendations aimed at strengthening innovation capacity are presented based on the findings.

LITERATURE REVIEW

National Innovation System and the Triple Helix Model

The National Innovation System (NIS) is a systematic development model that involves the use of science and technology as tools to enhance a country's national competitiveness and to develop a long-term technological vision (Özdemir, 2008). The core actors that determine a country's innovation capacity include private and public institutions, universities, government bodies, and research organizations. The NIS framework explains the processes of knowledge generation, diffusion, utilization and distribution within national borders by emphasizing the interactions and mutual learning among these actors. Key components of the national innovation system include R&D infrastructure, public policies and support mechanisms, knowledge creation and dissemination, intellectual capital, a learning economy structure, a qualified labor force and technology transfer. This system highlights the importance of institutional learning capacity, talent development programs, and structural arrangements that strengthen interactions among actors in order to effectively implement innovation processes—especially for developing countries—where knowledge and learning lie at the core (Lundvall, 2007).

It can be said that the theoretical foundation of this system is based on the view of the German economist Friedrich List (1856), who claimed that Germany—as a developing country of its time—did not have equal conditions for industrialization and national development compared to Britain, which was the developed country of the 1800s (as cited in Özdemir, 2008). In this context, List advocated that in order for developing countries to become competitive with developed nations, they must first protect and strengthen their domestic industrial sectors.

In the academic literature, the "Triple Helix Model" developed by Etzkowitz and Leydesdorff (2000) stands out as an interaction model in which the roles of key actors become increasingly intertwined and the traditional functional boundaries are blurred within today's dynamic structure. The Triple Helix

model, which focuses on the university–industry–government interaction from an innovation perspective, has offered a groundbreaking approach in the scholarly domain. Since its introduction, it has generated high interdisciplinary impact and has become a fundamental theoretical framework for understanding the direction of innovation and the transformation of institutional roles in the contemporary world. According to this model, universities can assume industrial functions by engaging in entrepreneurial activities through incubation centers and similar structures; meanwhile, the industry can become integrated into academic functions by providing financial support to universities' research and education processes and contributing to the transformation of knowledge into patents. The government, on the other hand, ensures the overall coordination and balance of the system by strengthening both academia and industry through various incentive and support mechanisms. This model emphasizes that widespread strategic collaborations, intense interaction and flexible role dynamics among these actors make it possible for innovation to become a driving force that enhances societal welfare and supports economic growth.

The 1960s can be considered the beginning of Türkiye's planned development era. Since 1963, five-year development plans have been prepared with the aim of achieving Türkiye's development goals—such as sustainable growth and competitive strength—through comprehensive, long-term, and well-structured policy frameworks. In other words, it can be argued that development plans serve as concrete examples of strategic interventions within the framework of the National Innovation System, helping to realize Türkiye's objectives in technological advancement and economic development. In this context, the following section provides a detailed analysis of five-year development plans as strategic implementation tools in the operationalization of the National Innovation System in Türkiye.

Planned Development and Innovative Efforts in Türkiye

The historical development of innovation and innovativeness in Türkiye has evolved in parallel with both domestic dynamics and shifts in the international conjuncture. A major turning point in this process was the establishment of the European Economic Community (EEC) in 1957 and Türkiye's application for association in 1959. The signing of the Ankara Agreement in 1963 not only institutionalized relations with Europe but also marked the beginning of Türkiye's first planned development period (Republic of Türkiye Ministry of Foreign Affairs, 2020)

In the same year, TÜBİTAK (The Scientific and Technological Research Council of Türkiye) was established to support scientific research and encourage young researchers. However, in the early stages, the targeted level of university-industry collaboration could not be achieved, and the integration of R&D activities into the industrial sector remained limited. To address this gap, the Industrial Research Institute was founded in 1967. With the signing of the Additional Protocol in 1970—entered into force in 1973—Türkiye's relations with Europe deepened further. During this period, while Türkiye took steps to strengthen its industrial infrastructure, it was unable to reach the desired capacity in technology production. It can be stated that the 1980s were characterized by an inward-oriented, low-efficiency, and small-scale industrial structure.

In terms of the institutional development of innovation, five-year development plans stand out as the most fundamental policy documents in this process. These plans were prepared with a long-term perspective (15 years) and guided the state's science, technology, and innovation policies during each five-year period. The priorities outlined in the plans were shaped by the political, economic, and global developments of their respective periods. During the planned development era, which began in the 1960s, Türkiye's primary objective was to accelerate economic development in a planned and balanced manner. To this end, the State Planning Organization was established in 1960, and the first Five-Year Development Plan was put into practice in 1963.

The first four development plans covered the 20-year period from 1963 to 1983 (State Planning Organization, 1963, 1968, 1973, 1979). In the period defined as the 'years of stagnation' extending up to the 1960s, Türkiye faced significant challenges in meeting basic needs, and the manufacturing and industrial sectors remained underdeveloped. During the implementation of the First Five-Year Development Plan, socio-economic conditions such as low literacy rates, a predominantly rural population, and inadequate infrastructure prevented technology-related concepts from becoming part of the policy agenda. The import substitution industrialization (ISI) strategy adopted by Türkiye in the late 1950s continued until the 1980s; however, this approach failed to deliver the expected outcomes in terms

of production capacity and efficiency. From the 1970s onward, industrialization, urbanization, and technology transfer were targeted, but progress was limited due to the small-scale nature of production, trade deficits, and political instability. Although the establishment of the Supreme Council for Science and Technology in 1983 provided an institutional framework for innovation policies, the intended results were not fully achieved in practice (TÜSİAD, 2003).

Between 1985 and 2005, the Fifth to Eighth Five-Year Development Plans constituted the core strategic documents guiding Türkiye's development policies throughout the second 20-year period. While the Fifth Plan (State Planning Organization, 1984) aimed to increase the share of the industrial sector, it remained relatively limited in scope compared to previous plans. During the Sixth Plan period (1990–1994), in line with the objective of integration with the European Economic Community (EEC), priorities included the modernization of information systems and increasing focus on R&D (State Planning Organization, 1989). A target was set to raise R&D expenditures to 1% of GDP; however, by 1997, this figure remained at just 0.5%, revealing the unrealistic nature of the target (TÜBİTAK, 2001). During the same period, goals were articulated regarding the transition to an information society, expanding access to information and promoting computer literacy among managerial staff.

The Seventh Development Plan (1996–2000) identified technological innovation as a primary engine of economic growth and introduced the establishment of technoparks to promote university-industry collaboration (State Planning Organization, 1995). However, difficulties were encountered in the holistic implementation of these policies. The Eighth Plan (2001–2005) aimed to establish a National Innovation System and support creative thinking and entrepreneurship (State Planning Organization, 2000). Nevertheless, the 2001 economic crisis and high inflation significantly hindered the realization of these objectives.

The period between the Ninth and Twelfth Development Plans, covering the years 2007–2028, represents the third 21-year cycle of Türkiye's development planning. The Ninth Development Plan (2007–2013) was prepared as a strategic document intended to contribute to the EU accession process, emphasizing structural reforms and private sector–driven growth (State Planning Organization, 2006). However, deficiencies persisted in R&D and advanced technology indicators. In the Tenth Development Plan (2014–2018), themes such as digital transformation, cybersecurity, and innovative production were emphasized, and the vision of "Digital Türkiye" gained momentum in the digitalization of public services (Republic of Türkiye Ministry of Development, 2013).

With the Eleventh Plan (2019–2023), advanced technologies such as artificial intelligence, blockchain and augmented reality were integrated into development policies, with R&D and innovation being prioritized (Republic of Türkiye Presidency, 2019). Although R&D expenditures fell short of targets, the share contributed by the private sector came close to expectations. The Twelfth Plan (2024–2028), developed within the framework of the "Century of Türkiye" vision, aims for high value-added and environmentally sustainable production, and introduces new strategic areas such as combating brain drain, open science, and innovative financing models (Republic of Türkiye Presidency, 2023).

To comprehensively analyze the country's international position, it is essential to consider global innovation indices, scientific publication metrics and comparative performance reports. Accordingly, the next section of this study will assess Türkiye's global position in terms of innovation indicators, drawing on comparative international data.

A COMPARATIVE ANALYSIS OF TURKIYE'S INNOVATION CAPACITY

In examining the historical development of innovation in Türkiye, developing a comparative global perspective alongside domestic dynamics is undoubtedly essential for a comprehensive understanding of the topic. To approach the issue at a global level, the Global Innovation Index (GII) serves as a guiding reference. As of 2024, the index evaluates the innovation ecosystem performance of 133 economies, including Türkiye, while also tracking the latest global innovation trends (WIPO, 2024). In the 2024 Global Innovation Index overall ranking, Türkiye was placed 37th. Having ranked 68th in 2013, Türkiye has shown significant progress over the past decade and is noted as one of the countries with the most substantial improvement. According to the 2024 report, Türkiye was listed for the first time among the top three most innovative economies in the upper-middle-income group, following China and Malaysia.

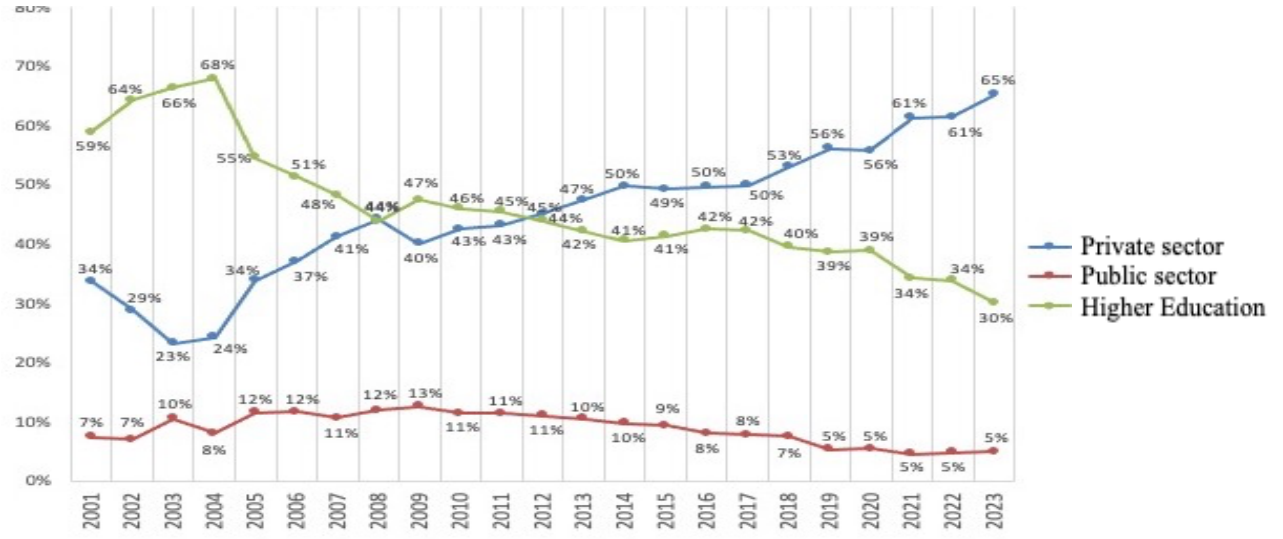
This indicates a remarkable advancement in Türkiye's innovation capacity, R&D infrastructure, and knowledge production potential. In the ranking of the top three most innovative economies by region (excluding island countries), Türkiye was placed third after Israel and the United Arab Emirates.

Türkiye demonstrates strong performance particularly in areas such as higher education, the share of engineering graduates, creative outputs, and digital services exports. The report also highlights a notable increase in creative output indicators, including trademark applications and industrial designs. In addition to these developments, the areas in which Türkiye needs to improve its innovation capacity can be listed as follows: the contribution of the private sector to R&D investments, the quality of high-level scientific outputs, researcher intensity, and internationally co-authored scientific publications.

The Contribution of the Private Sector to R&D Investments

This ratio, which reflects the strength of market-based innovation production, also indicates the extent to which innovative activities have been internalized within the national economy. At the same time, it demonstrates how innovative efforts have translated into tangible economic outputs, directly contributing to the development of products, services, and processes. Figure 1 below illustrates the changes in the share of public sector, private sector, and higher education institutions in the financing of R&D expenditures in Türkiye between 2001 and 2023.

Figure 1. Historical Change in the Distribution of R&D Funding Sources in Türkiye



Source: Created by the author using data from TÜİK (2024).

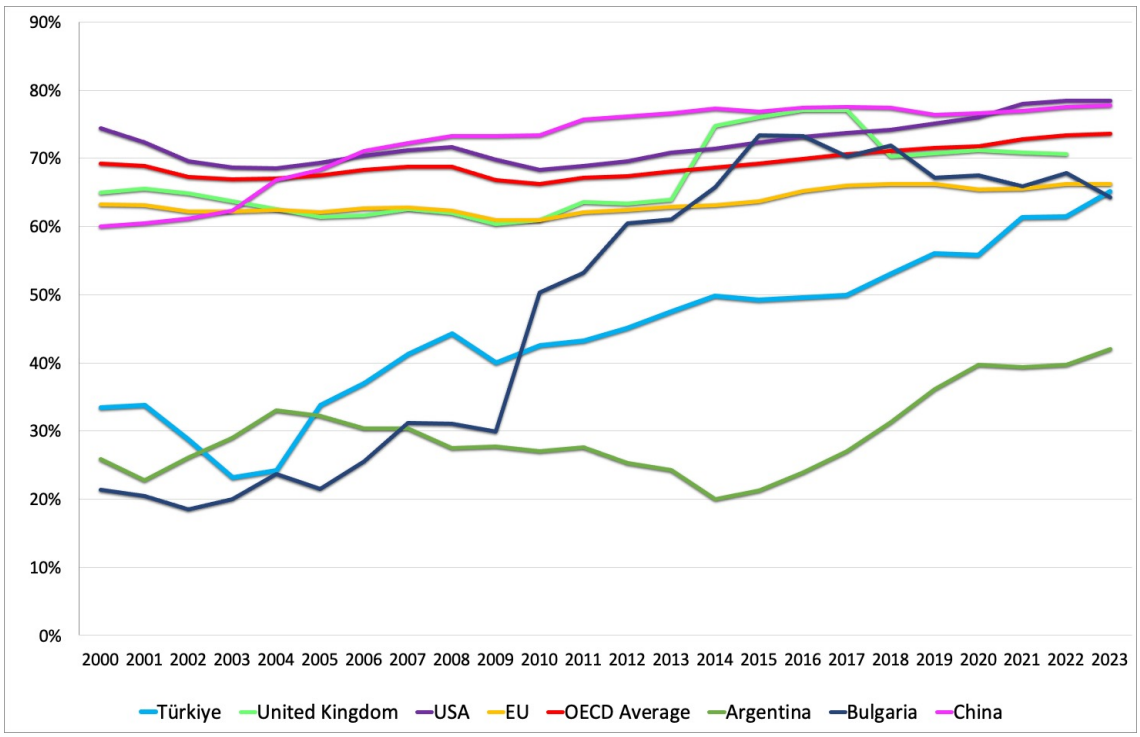
This figure shows that the share of the private sector in R&D expenditures in Türkiye has experienced rapid growth over the past 20 years, making it the leading contributor to R&D investments. Private sector R&D spending showed a steady increase after 2004, surpassed the share of higher education in 2012, and entered a renewed upward trend after 2017. While private sector R&D expenditures amounted to approximately 700 million TRY in 2004, they exceeded 5 billion TRY in 2012 and reached approximately 246 billion TRY by 2023. This indicates that state-supported incentives have effectively strengthened the private sector's role in R&D investments. Since 2012, the private sector has constituted the largest share of R&D expenditures in Türkiye, similar to the patterns observed in developed countries (Eurostat, 2023).

The share of the public sector in R&D expenditures, which has remained relatively lower, has been on a declining trend since 2009. Public sector R&D spending was 230 million TRY in 2004, exceeded 1 billion TRY for the first time in 2009, and reached approximately 18 billion TRY by 2023. The steady share of public sector R&D spending between 2019 and 2023 may indicate a focus on maintaining existing levels rather than expanding capacity. The public sector can thus be seen as playing a supportive role in R&D efforts.

Lastly, R&D expenditures of higher education institutions, which exceeded 1 billion TRY in 2002, held the highest share of total R&D investments until 2011. However, starting from 2012, their share in total expenditure has shown a declining trend, accounting for 113 billion TRY or 30% of total expenditures in 2023. As centers for both fundamental and applied research, higher education institutions are expected to lead efforts in producing scientific publications, patents, and new technologies, while training a qualified workforce in priority areas that generate long-term social benefits.

Evaluating the historical distribution of a country's R&D expenditures is crucial for understanding the evolution of its national innovation capacity over time. However, to conduct a more comprehensive and holistic analysis, comparisons must be made with other countries in similar income groups, developed countries, and nations involved in cooperation mechanisms such as the OECD and the EU. Figure 2 displays the share of the private sector in R&D expenditures across various countries between 2000 and 2023.

Figure 2. The Share of the Private Sector in R&D Expenditures in Different Countries (2000–2023)



Source: Created by the author using data from OECD (2025).

This figure illustrates that in developed countries, the private sector has assigned strategic importance to developing innovative products, services, or processes to enhance competitiveness, with this share consistently remaining above 60% over the past two decades. While the share of the private sector in R&D expenditures in Türkiye has shown a sustainable upward trend over time, it surpassed the 60% threshold for the first time only in 2021. Countries where this share is high are typically those with strong industrial bases, producers of high-tech goods, and exporters of technology.

In this context, Türkiye must continue its policies aimed at increasing private sector R&D expenditures in a lasting and comprehensive manner through support mechanisms that directly assist enterprises, improve the investment climate, and strengthen R&D capacity. Although Türkiye is still in the early stages of catching up with the average level of developed countries, maintaining its current momentum and progressing steadily is of critical importance.

The Quality of High-Level Scientific Outputs

Universities are among the key actors at the center of technological advancement, serving as fundamental components of innovation through the systematic production of scientific knowledge. While they were traditionally viewed as institutions focused solely on education, over time they have also become central to research and innovation activities. According to OECD (1998), over 60% of basic research in leading scientific nations—such as the United States, Japan, Germany, France, and the United Kingdom—was conducted by universities. While the private sector tends to focus on short-term product development, universities contribute to the early stages of the innovation chain through long-term scientific discovery.

Indeed, transformative developments in fields such as information and communication technologies, biotechnology, health, energy, materials science, and environmental sustainability have largely stemmed from university-based research. For instance, the development of ARPANET, the creation of ENIAC, and the foundational algorithms behind Google all originated in university environments. In this sense, universities are not only centers of knowledge production but also play a vital role in sustainable technology transfer through collaborations with industry, thereby strengthening the broader innovation ecosystem (Terán-Bustamante, Martínez-Velasco, & López-Fernández, 2021).

Throughout history, original academic publications that generated new knowledge have laid the foundation for inventions and patents. According to a study by Veugelers and Wang (2019), which examined the impact of scientific research on technology production through patent citations of academic publications, the contributions of original and innovative publications are not limited to the specific field in which they are produced but often provide broader, multidisciplinary benefits. Compared to non-original studies, high-impact research contributes more directly to patents and indirectly facilitates technological advancement through academic citations.

The impact factor is a widely used metric that evaluates the scientific influence and prestige of academic journals, based on the frequency with which their articles are cited by other academic works. Articles published in high-impact factor journals are thus considered highly credible and are regarded as leading reference sources in scientific discourse. These high-quality academic outputs—often termed "advanced scientific outputs"—open pathways for the accumulation of foundational knowledge, breakthroughs that can foster university-industry collaborations, the generation of new patents, and the emergence of innovative start-ups. Having such advantages increases a country's prestige within global scientific networks, creates a snowball effect by attracting more researchers and investors, and acts as an incentive for further scientific production.

The SCImago Journal & Country Rank (SCImago, 2025), based on Elsevier's Scopus database, is a globally respected platform that assesses the scientific publication performance of countries and journals. As of 2025, the top five countries in terms of the number of citable scientific documents are the United States, China, the United Kingdom, Germany, and Japan. Türkiye ranks 19th in this category. In the ranking of total citation counts for academic publications from 1996 to 2024, Canada replaces Japan in the fifth position, while Türkiye falls to the 27th place. This drop—from 19th in publication quantity to 27th in citation count—indicates that while Türkiye is productive in quantitative output, it lags in terms of the qualitative impact of those publications.

As of 2025, Türkiye’s average number of citations per document stands at 16, which is below the global average of 23. Table 1 provides a comparative overview of countries’ scientific publication performance in terms of both quality and quantity. The analysis includes countries with at least 100,000 citable publications, to eliminate distortions that may arise from small-population countries with few but highly cited publications. Based on this criterion, the updated global average citation per document is calculated as 21. Only countries exceeding this average are included in the final ranking. With 16 citations per document, Türkiye does not meet this threshold and thus does not appear in the ranked list, placing 28th overall and remaining below the global average.

Table 1. Scientific Publication Performance Indicators by Country (1996–2024)

Rank	Country	Region	Number of Citable Documents	Number of Citations	Citations per Document	H-Index
1	Switzerland	Western Europe	959,406	40,611,905	42	1,369
2	USA	North America	14,617,353	564,191,398	39	3,213
3	United Kingdom	Western Europe	4,196,657	158,900,978	38	2,048
4	Canada	North America	2,275,692	82,451,695	36	1,659
5	Singapore	Asia	422,353	14,810,923	35	873
6	Israel	Middle East	489,626	17,125,142	35	962
7	Australia	Pacific	1,865,552	65,188,977	35	1,475
8	Hong Kong	Asia	464,238	15,790,931	34	863
9	New Zealand	Pacific	315,819	10,661,993	34	758
10	Norway	Western Europe	443,666	14,946,021	34	896
11	EU	Western Europe	1,191,274	37,769,375	32	1,109
12	South Africa	Africa	433,104	9,916,908	23	702
13	Argentina	Latin America	292,678	6,612,157	23	611
14	Japan	Asia	3,442,416	76,400,180	22	1,364
15	Chile	Latin America	250,831	5,451,459	22	555
16	South Korea	Asia	1,660,476	35,304,573	21	1,004
17	Taiwan	Asia	889,288	18,681,477	21	738
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28	Türkiye	Middle East	929,722	15,238,939	16	647

Source: Created by the author using Scopus (2025) data.

First of all, It is surprising to see Switzerland at the top of this list, despite not ranking in the top five in either of the previously mentioned SCImago Journal and Country Rankings. Although Switzerland has a number of citable publications similar to Türkiye, it has over 40 million citations, indicating that the quality and scientific impact of publications produced in Switzerland are remarkably high. The fact that a country with a similar volume of publications to Türkiye ranks at the top of the list is a result of its strong global research networks, greater involvement in international collaborations, and a higher rate of publications in high-impact journals. The top five countries in this ranking are Switzerland, the United States, the United Kingdom, Canada, and Singapore. Despite having less than half the number of citable publications compared to Türkiye, Singapore's total citation count is nearly equal to that of Türkiye. Similar to Switzerland, Singapore serves as an example due to these comparable factors.

From a regional perspective, Israel is the only country from the Middle East, including Türkiye, that appears in the ranking. Israel demonstrates strong performance, ranking 6th. Other regions with countries performing above the global average of 21 citations per publication include Argentina and Chile from Latin America, South Africa from Africa, and Australia and New Zealand from the Pacific. Like Argentina and Chile, these countries achieve strong citation performance despite having relatively fewer publications.

The relatively low scientific impact of publications in Türkiye may be attributed to several factors: the tendency to publish in journals with lower impact factors, limited availability of open-access publications that enhance visibility and accessibility, and a low number of internationally co-authored scientific articles. Therefore, it is essential for Türkiye to both systematically increase the number of citable publications over time and to implement policies that enhance the scientific quality and impact of its publications. In addition, creating mechanisms that encourage and support researchers is crucial to improving its standing in the global rankings.

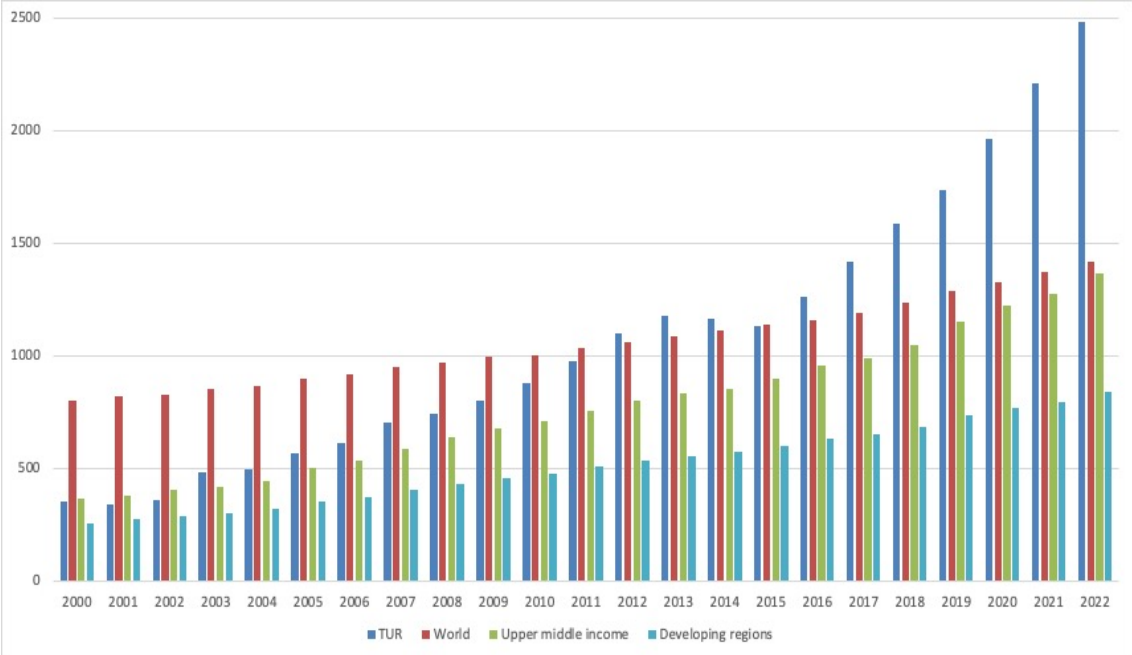
Researcher Density

In 2015, the United Nations (UN) identified 17 Sustainable Development Goals (SDGs) aimed at "ending poverty, protecting the planet, and ensuring peace and prosperity for all people by 2030." The ninth of these goals—Industry, Innovation, and Infrastructure—focuses particularly on strengthening R&D

capacity in developing countries, promoting scientific research and innovation, and minimizing the digital divide between nations to ensure equitable access to information.

In this context, data published under the "Science, Technology and Innovation" category by UNESCO (2025) has been used to examine Türkiye's capacity for knowledge creation and scientific research. The graph below illustrates the number of active researchers per million people, covering the years 2000–2022, to represent researcher density in Türkiye compared to global benchmarks.

Figure 3. Researcher Density – Türkiye and Global Comparison (2000–2022)



Source: Created by the author using UNESCO (2025) data.

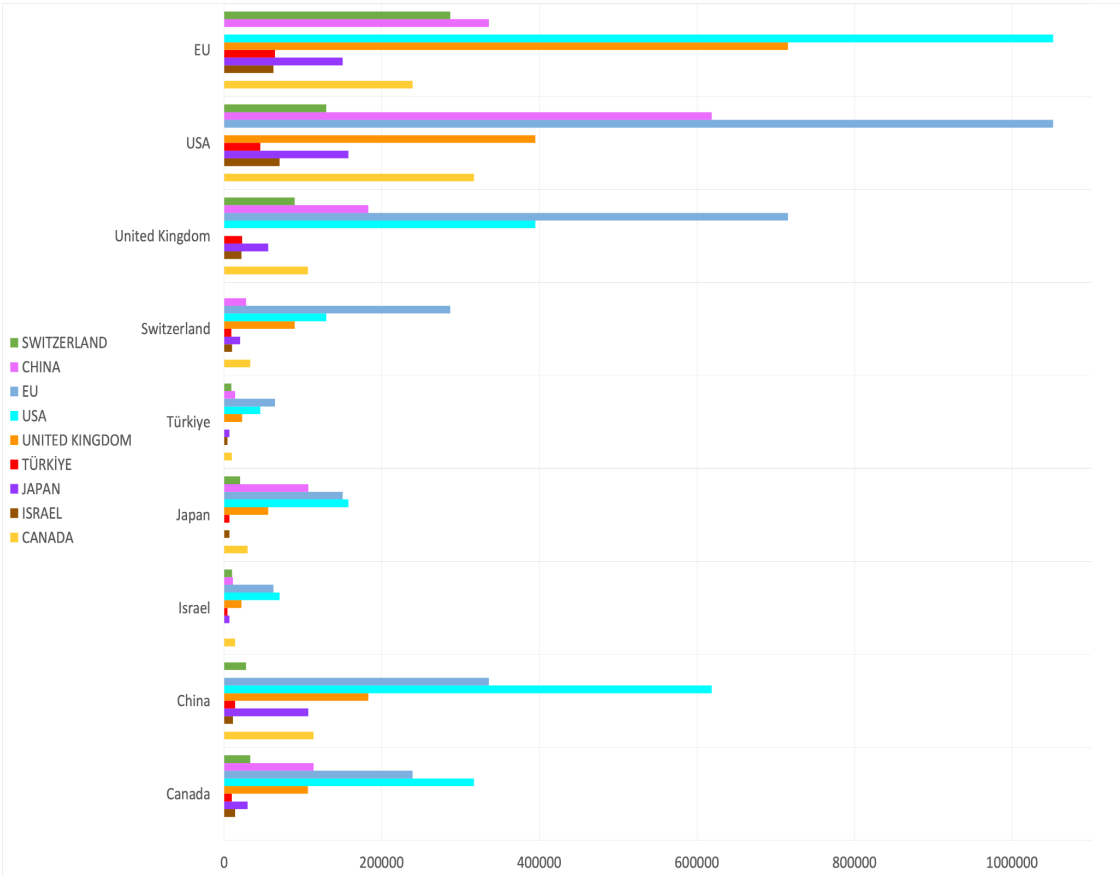
Türkiye's number of researchers per million inhabitants increased from 355 in 2000 to 2,479 in 2022, showing a significant rise compared to other upper-middle-income countries. For nearly two decades, Türkiye has had a higher number of researchers than both the upper-middle-income country group average and most developing regions. Since 2012, Türkiye has also outperformed the global average, marking a notable improvement in researcher density.

When compared to developed countries, Türkiye's 2022 figure of 2,479 researchers per million people is approximately equivalent to Europe's 2000 level (2,457). However, it still lags behind the 2000 figures of high-income and highly developed regions, which exceeded 3,000 researchers per million. Despite commendable national progress, Türkiye must continue to take strategic steps to increase its researcher density in order to improve its scientific and technological performance on the international stage. In terms of gender distribution, the ratio has remained relatively stable over the past two decades. As of 2022, female researchers represent 34%, while male researchers account for 66%—a trend consistent with Türkiye's 21-year average (UNESCO, 2025).

Internationally Co-Authored Scientific Publications

To analyze Türkiye's position in international scientific collaborations, a bibliometric dataset from the OECD based on Scopus (OECD, 2025) was examined. This dataset includes co-authored publications involving authors or institutions from at least two different countries. Figure 4 illustrates the total volume of international collaboration in scientific publications between Türkiye and leading countries or country groups. It also presents the collaboration volume among other countries and groups between 2010 and 2023.

Figure 4. International Scientific Collaborations Between Türkiye and Selected Countries/Country Groups (2010–2023)



Source: Created by the author using data from OECD (2025).

The figure demonstrates that the United States, as a leading country in the production of high-impact scientific publications, collaborates most extensively with the European Union (1,051,951 publications). The second-largest collaboration volume is between the EU and the United Kingdom (715,630 publications). This is followed by collaborations between the U.S. and China (618,812 publications), the U.S. and the UK (394,803 publications), and the EU and China (335,908 publications). Türkiye's most frequent scientific collaborations have been with the EU (64,635 publications), the United States (45,873 publications), the United Kingdom (22,982 publications), China (14,095 publications), and Canada (9,672 publications).

Efforts to enhance Türkiye's international scientific collaboration have largely been supported by government initiatives, primarily through TÜBİTAK. A significant example is Türkiye's participation in Horizon Europe, the European Union's largest research and innovation framework program for the period 2021–2027. Compared to its predecessor, Horizon 2020, Horizon Europe has been allocated a substantially larger budget and is coordinated in Türkiye by TÜBİTAK. The program allows Turkish researchers and institutions to participate under the same conditions as EU member states, fostering stronger integration into European research networks. Under the Horizon 2020 Program, Türkiye was involved in 812 projects with contributions from 1,190 Turkish partners, receiving a total of €277.4 million in EU grant funding (Republic of Türkiye Ministry of Foreign Affairs – Directorate for EU Affairs, 2021). Türkiye's engagement in such programs contributes significantly to the development of institutional partnerships and international scientific visibility.

CONCLUSION

Tracing the historical development of innovation in Türkiye through development plans is not only critical for evaluating past efforts but also for designing more coherent and sustainable policy frameworks for the future. These documents have aimed to address evolving technological needs conceptually and have included goals in areas such as innovation, R&D, and digitalization. However, implementation has

often been hindered by instability, discontinuities in policy, and institutional weaknesses, significantly limiting the transformation of these goals into tangible and lasting outcomes.

The impact of innovation on economic growth and prosperity is not merely a matter of resource allocation but is closely tied to the presence of inclusive, learning-oriented, and participatory institutional structures. As emphasized by Acemoglu and Robinson (2012), inclusive institutions enable entrepreneurial and innovative activities to be more widely distributed across society, creating a more stable and sustainable foundation for development. In this context, it is clear that Türkiye needs not only large-scale investments but also holistic policies that encompass SMEs, startups, universities, and young entrepreneurs to boost its innovation capacity.

In recent years, Türkiye's efforts to strengthen its innovation capacity have been supported both by increased national R&D investments and by intensified international collaborations. The significant improvement in Türkiye's ranking in the Global Innovation Index over the past decade reflects progress in areas such as creative outputs, higher education graduation rates, and digital service exports. The growing role of the private sector in R&D spending indicates a shift toward a more market-oriented innovation ecosystem. However, in terms of the quality and international visibility of advanced scientific outputs, Türkiye still lags behind the global average. Strengthening Türkiye's innovation ecosystem requires policy efforts to go beyond technological investment; emphasizing the diffusion of scientific awareness and an innovation-oriented culture across society. Institutionalizing innovation through a multi-actor framework and reconceptualizing technoparks and incubation hubs as platforms for intellectual and socio-cultural exchange can significantly broaden access to research environments and support the qualitative enhancement of human capital. These structural and inclusive strategies are thought to be vital for improving both the quality and the global impact of scientific output.

Although the number of international co-authored publications has increased, the relatively low citation performance points to a need for more qualified publishing strategies and deeper international collaborations. Participation in large-scale international research programs like Horizon Europe presents a strategic opportunity for Türkiye —not only in terms of funding but also for enhancing research quality and gaining greater visibility in international scientific networks. Therefore, policies implemented through government-supported programs and institutions such as TÜBİTAK should be restructured to improve the quality of academic outputs and foster stronger interaction between higher education institutions and the private sector. To maintain its steady progress in scientific production and innovation, Türkiye must promote a multi-actor, interdisciplinary, and globally interactive research environment.

For future directions, several areas deserve closer examination to strengthen Türkiye's innovation ecosystem. Comparative analyses of the publication policies of universities and research institutions in Türkiye could offer valuable insights, particularly in terms of scientific impact, collaboration intensity, and interdisciplinary contributions. Furthermore, examining the disciplinary diversity and scientific alignment between Türkiye and its international collaborators would enhance understanding of strategic partnership dynamics. Evaluating the efficiency, broader impacts, and contributions to institutional learning capacities of funding programs such as those supported by TÜBİTAK and Horizon Europe could be pursued through both quantitative and qualitative methods. Additionally, assessing the effectiveness of strategies aimed at increasing the proportion of female researchers and addressing regional disparities in researcher distribution would be instrumental in promoting a more inclusive and balanced national research landscape.

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