İSTANBUL UNIVERSITY PRESS

Acta Infologica
acin 2023
DOI: 10.26650/acin.1352261

Research Article / Araştırma Makalesi

Digital Transformation and Innovation in Health for Future Health Services: Turkey Global Innovation Index Time Series Analysis Between 2018 and 2022

Geleceğin Sağlık Hizmetleri için Sağlıkta Dijital Dönüşüm ve Inovasyon: 2018-2022 Yılları Arası Türkiye Inovasyon Indeksi Zaman Serileri Analizi

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ABSTRACT

Health significantly impacts an individual's overall well-being, ability to sustain life, and life experience. The field of healthcare is currently undergoing a digital transformation, with innovations and advancements. Digitising patient records, e-prescriptions, telehealth, and medical imaging technologies provide better healthcare services and more effective tools. The aim is to improve the early detection of diseases, optimize treatment processes, personalize treatment plans, and make healthcare more accessible. Innovations such as robotic surgery, biotechnology, artificial intelligence, and gene editing make surgical interventions more precise and effective, while improving diagnosis and treatment processes. The process of drug development is accelerating, with promising approaches emerging for the treatment of genetic diseases, and the development of health technologies and service models. The widespread adoption of innovative solutions and transformations in the healthcare sector is aimed at positively impacting the outcomes of future health services. The article examines digital transformation and innovation in healthcare, analyzing time series data for Turkey's global innovation indicators between 2018 and 2022 and forecasting values for 2023. The study investigates our rank in the world, innovation potential, positive and negative indicators, and correlations between indicators for each measure. The results have significant importance in understanding and evaluating our country's innovation performance and its contribution to digital transformation in healthcare, as well as the future innovation strategies. The aim of the study is to provide guidance for researching ways to transform our healthcare systems and provide more effective healthcare services.

Keywords: Digital transformation in healthcare, healthcare ınnovation, time series analysis

Submitted/Başvuru : 31.08.2023
Revision Requested/ Revizyon Talebi : 25.09.2023
Last Revision Received/ Son Revizyon : 26.09.2023
Accepted/Kabul : 06.10.2023
Pulished Online/ Online Yayın : 25.10.2023

1. INTRODUCTION

Today, the healthcare sector is undergoing a profound transformation brought about by the rapid development of digital technologies and innovative methodologies. The convergence of health and technology, commonly referred to as health technology, has already begun and will continue to reshape the delivery, accessibility, and experience of healthcare. This transformation in healthcare involves not only the expansion of traditional medical practices but also the creation of novel solutions to complex health-related problems. At the core of this transformation are two key concepts: Digital Transformation and Innovation in Healthcare "*Digital Transformation in Healthcare*" refers to the use of information and communication technologies for healthcare processes, while "*Innovation in Healthcare*" refers to the application of innovative approaches to healthcare services. Digital Transformation and Health Economics: A Bibliometric Analysis on Digital Health, Tunçsiper (2023) reached various results. When the author analysed the studies on digital health in three different axes as the countries where the authors are located, authors and keywords in more detail, he found that the most frequently used words and phrases in the studies of the authors are keywords such as "innovation", "digital transformation", "digital health" and "artificial intelligence".

Many of the transformative technologies in healthcare have their roots in advances in information and communication technologies. It is worth noting that the considerable success of healthcare services owes much to these information and communication technologies. As the world increasingly uses technology to reshape healthcare systems, fostering a dynamic interaction between digital transformation and innovation, nations are turning to these areas to improve patient care and healthcare outcomes.

In the past century, enhancements in healthcare have resulted in a twofold increase in life expectancy in both high-income and developing economies (Roser, 2019; Ma, 2019; Shetty, 2019). The increase in life expectancy has contributed to the enlargement of the global labor force, spurred economic growth, and enhanced the quality of life for numerous individuals (WIPO, 2015a; Sampat, 2019). As societies experience economic growth, prosperity enables improved health and an elevated quality of life, thereby extending access to functional healthcare systems for a greater number of individuals in low- and middle-income economies (Kenny, 2011; WIPO, 2015a).

Historically, the arenas for health innovation, along with the innovation pathways themselves, have predominantly been centered in high-income economies, primarily within Europe and North America (Tannoury et al., 2017). Some of the leading countries in pharmaceutical patents include Switzerland, the United Kingdom, and the United States. The Netherlands and the United States are the leading countries for medical technology patents, while Switzerland and the United Kingdom are the leading countries for biotechnology patents. The spread of medical innovation to developing economies depends on their ability to foster innovation, and thereby economic growth. In terms of global sectoral investment, healthcare investments are second only to information technology (IT). Pharmaceutical, biotechnology, and medical device companies rank among the primary global corporate contributors to research and development (R&D), collectively dedicating more than US$100 billion each year. This amount constitutes nearly 20% of the annual R&D outlays by the leading 2,500 R&D firms globally across various sectors (Hernández et al., 2018, R&D Magazine, 2018.—Top investors such as Roche (Switzerland), Johnson and Johnson (U.S.) and Merck US (U.S.) invested on average around US$10 billion in R&D last year). This positions medical technologies within the top five rapidly expanding technology domains since 2016, with the remaining four IT-related fields (WIPO, 2018. — see Patent applications and grants worldwide WIPO [World Intellectual Property Organization] (2018). World Intellectual Property Indicators 2018. Geneva: World Intellectual Property Organization).

However, medical technologies are increasingly innovating in adjacent health-related sectors such as IT and software applications, including innovations such as mechanical heart valves, artificial organs, digital health technologies, and 3D devices. The majority of medical innovations are concentrated in developed countries, where these innovations further strengthen their already robust economies. We desire to shift medical innovation to developing countries, including Turkey. This study attempts to assess Turkey's efforts in digital transformation and innovation in healthcare, using global innovation indicators. The paper analyzes Turkey's progress in innovation, its achievements in healthcare, and the challenges it faces. In addition, the study provides insights into Turkey's positioning in global innovation rankings and the impact of digital transformation on these rankings.

This article provides a comprehensive assessment of Turkey's performance in global innovation indices, with a particular focus on the implications for innovation in healthcare. The research findings have significant implications for Turkey's digital transformation and innovation initiatives in terms of healthcare infrastructure, investments, and goals. As a result, Turkey's digital transformation and innovation in healthcare efforts have the potential to improve the quality of national healthcare services while enhancing the country's standing in global innovation rankings. The primary objective of this study is to shed light on Turkey's achievements or shortcomings in this area and to answer the

following questions for shaping future innovation strategies: What is Turkey's comparative position in each indicator and sub-indicator of the Global Innovation Index? What are the areas of notable progress, areas of regression, and areas of minimal change over the five years? What are the potential societal and economic impacts of innovation in healthcare? What are the barriers that must be overcome to fully realize this potential?

While digital transformation and innovation in healthcare hold great promise, they bring about certain challenges. It is paramount that healthcare professionals, including physicians, nurses, lab technicians, and operators of imaging equipment such as MRIs, gain the skills, understanding, and aptitude to use these evolving technologies. Comprehensive education, and training on issues such as digitization, data security, patient confidentiality, and adapting to new technologies is essential for all healthcare professionals in all settings to enable digital transformation. The collaboration between healthcare professionals, technologists, and managers is emerging as a key determinant for the success of this transformation.

The process of digital transformation and innovation in healthcare is of great significance as it strives to improve the quality of healthcare services, enhance the patient experience, and achieve favorable health outcomes. Advances in these areas will enable a future healthcare paradigm that is not only more effective, higher quality, and economically viable, but also sustainable, accessible, and personalized. These advances, in turn, generate economic growth and contribute to an improved quality of life for citizens. It is noteworthy that many countries around the world devote a significant proportion of their GDP to healthcare, a proportion that will continue to grow as populations age, placing a significant burden on both the economy and the labor, social, and psychological fabric of these countries. Immediate investment in innovation in healthcare delivery is therefore essential to alleviate these burdens.

2. HEALTHCARE AND KEY GOALS

The World Health Organization (WHO) established a definition of health in its Constitution, ratified in 1948. Accordingly, "Health is not merely the absence of disease or infirmity, but a state of complete physical, mental and social well-being." Health refers to a state of complete physical, mental, and social well-being. This extensive definition encompasses the condition of the individual, reflecting not only the absence of disease or physical infirmity but also the presence of mental and social well-being. Healthcare embodies a holistic state in which physiological, psychological, and social elements converge to influence an individual's daily functioning and ability to lead a fulfilling life. Therefore, healthcare is a fundamental concept that profoundly shapes an individual's overall well-being and life experiences.

The WHO categorizes healthcare into four primary dimensions: diagnosis, treatment, outcome, and health. Today, remarkable changes and innovations are seen in these four health domains due to the emergence of cutting-edge technologies, including electronic health records (EHRs), TeleHealth, mobile health applications, data analytics, cloud technology, Internet, artificial intelligence (AI), machine learning, 3D printing, robotic surgery, wearable technologies, e-prescribing systems, and e-drug tracking, as shown in Table 1.

Table 1. *Current innovations in the four steps to a healthy planet (The Global Innovation Index 2019)*

Diagnosis	Treatment	Outcome	Wellness
•Two-way data transmission from the patient •Wearable tech for monitoring •AI for diagnosis, reducing skill needed •Telehealth, reducing need for proximity	•Focused factories (Industrialization •Digital therapeutics •AI for treatment selection •Data on social determinants of health •Drug discovery in silica •Faster global trials •Cell and gene therapies •Oncology advances •Precision medicine	•Real-world evidence •Value-based care	•Prevention incentives •Interventions for social determinants of health

3. DIGITAL TRANSFORMATION AND INNOVATION IN HEALTHCARE

The foundation of digital transformation and innovation in healthcare lies in information and communication technologies.

3.1. Digital Transformation in Healthcare

Digital transformation in healthcare refers to the modernization of healthcare systems and the increased integration of digital technologies to improve the efficiency, effectiveness, accessibility, and patient-centeredness of healthcare

services. This transformation involves technology-enabled changes that have various implications for healthcare systems around the world, which include the adoption of ***Electronic Health Records*** (EHRs), the establishment of TeleHealth platforms, the integration of artificial intelligence (AI)-enabled diagnostic tools and the proliferation of wearable health devices.

The range of applications is vast. Electronic Health Records (EHRs) facilitate the digital storage and sharing of patients' medical data, streamline patients' access to their health history, facilitate information exchange among physicians, and improve the management of treatment processes. ***TeleHealth***, which extends remote healthcare services, especially to people who live in remote areas or face accessibility challenges, facilitates consultations and treatment through video or audio communications that connect patients with healthcare professionals. ***Mobile Health Applications*** empower individuals to monitor and manage their health, with features such as health tracking, healthy lifestyle promotion, and medication reminders. ***Data Analytics*** supports early disease detection and the development of more effective treatments by providing insights into disease trends, epidemiological data, and treatment outcomes through comprehensive analysis of big data. ***Artificial Intelligence and Machine Learning*** are helpful in correct and quick medical decision-making, particularly in areas such as medical image analysis, disease diagnosis, and treatment recommendations. ***Robotic Surgery*** systems reduce surgical risks and enable surgeons to perform more precise and controlled procedures. ***E-Prescribing and E-Medication Tracking*** enable digital prescribing by physicians and allow patients to obtain medications from pharmacies. This process may facilitate medication reminders and side-effect monitoring. Finally, ***Blockchain Technology*** strengthens data privacy and security, ensuring the secure storage and exchange of patients' health data.

3.2. Innovation in Healthcare

Healthcare innovation encompasses the complex process of conceiving, cultivating, and implementing novel concepts, procedures, products, or services in the healthcare sector. The convergence of healthcare and innovation seeks to improve patient care, facilitate early disease detection, advance precision medicine, refine treatment modalities, optimize healthcare delivery, expand access to healthcare services, and improve the overall efficiency of healthcare systems, which has the potential to be a major catalyst for transforming healthcare systems. Innovation spans multiple dimensions, including novel treatment modalities, cutting-edge medical technologies, innovative medical procedures, advances in pharmaceuticals, drone-based drug delivery services, innovative care delivery models, streamlined operational workflows, and the seamless integration of cutting-edge technologies. Innovation in healthcare manifests itself in three primary areas: medicine, technology, management, and service delivery.

The range of applications is vast. ***Medical Technology Advancements*** aim to improve the effectiveness and precision of patient care through the development of novel medical devices, diagnostic techniques, and treatment methods. ***Digital Health Applications*** introduce innovations in areas such as mobile health applications, patient monitoring, promotion of healthy lifestyles, and management of patient-drug interactions. ***Genetic Research and Personalized Medicine*** aim to predict disease susceptibility and tailor treatment strategies based on an individual's unique genetic makeup. ***TeleHealth and Remote Care*** provide remote patient monitoring, counseling, and treatment options to improve patient access to healthcare services. ***Data Analytics*** uses the scrutiny of vast data sets to identify disease trends, conduct epidemiological studies, and evaluate treatment outcomes. ***Nanotechnology and Drug Development*** uses technologies such as nanoparticles and microfluidic devices to drive innovation in the development of more effective and precisely targeted drugs. ***Robotic Surgery and Artificial Intelligence-Assisted Diagnostics*** are beneficial to improve surgical precision and speed up and improve the accuracy of diagnostic procedures. ***Healthcare Management and Efficiency*** are driving innovation in new management paradigms and business processes to improve the efficiency of hospital management and healthcare delivery. Finally, the integration of innovation into healthcare practice holds the promise of early disease detection, tailored interventions, and expanded access to healthcare services.

3.3. Distinguishing Digital Transformation and Innovation in Healthcare

Digital transformation and innovation in healthcare are distinct but interrelated concepts. Despite their similar goals, digital health transformation and innovation in healthcare represent discrete approaches and focal points in improving healthcare services. These two concepts can be distinguished along three key aspects. First, their focus differs. Digital transformation primarily seeks to integrate technology into healthcare processes, while innovation primarily seeks to create novel and more effective solutions. Second, their methodologies differ. Digital transformation focuses on digitizing existing healthcare practices and creating data-driven workflows, while innovation requires inventive thinking and disruptive approaches. Finally, their areas of application differ. Digital transformation involves technology-enabled

solutions such as electronic health records, TeleHealth applications, and medical devices, while innovation covers a broader spectrum, ranging from medical treatments to healthcare administration.

Digital transformation in healthcare refers to the transition from traditional methods to digital platforms, which involves the use of digital technologies to promote data-centric processes aimed at making healthcare services more efficient, accessible, and coordinated. This process includes actions such as digitizing health-related data, automating hospital operations, and implementing electronic health records. For example, the conversion of paper-based patient records to electronic health records (EHRs) enables better management and secure sharing of healthcare services, such as the secure storage of medical data on digital platforms.

Conversely, innovation in healthcare seeks to improve the effectiveness and efficiency of healthcare services by integrating innovative ideas, methods, or technologies into the healthcare landscape. Technological advances in informatics contribute to innovation in healthcare. Artificial intelligence, robotics, remote diagnostics, genomics, big data analytics, mobile healthcare, stem cell research, regenerative medicine, biomarkers, and nanotechnology applications are all paving the way for advances in healthcare. Innovation aims to refine healthcare, optimize disease management, and improve the patient experience. For example, a pharmaceutical company's development of a cancer treatment that offers an alternative to conventional therapies is an example of innovation in healthcare. The creation of the mRNA vaccine for COVID-19 during the pandemic is an example of innovation in healthcare.

Innovation in healthcare can be achieved in several areas, including medicine, technology, management, and service delivery. Figures 1, 2, and 3 illustrate the potential for innovation in each of these three areas. These three figures were highlighted in the GII-2019 report as "Promising Fields for Medical Innovation and Technologies."

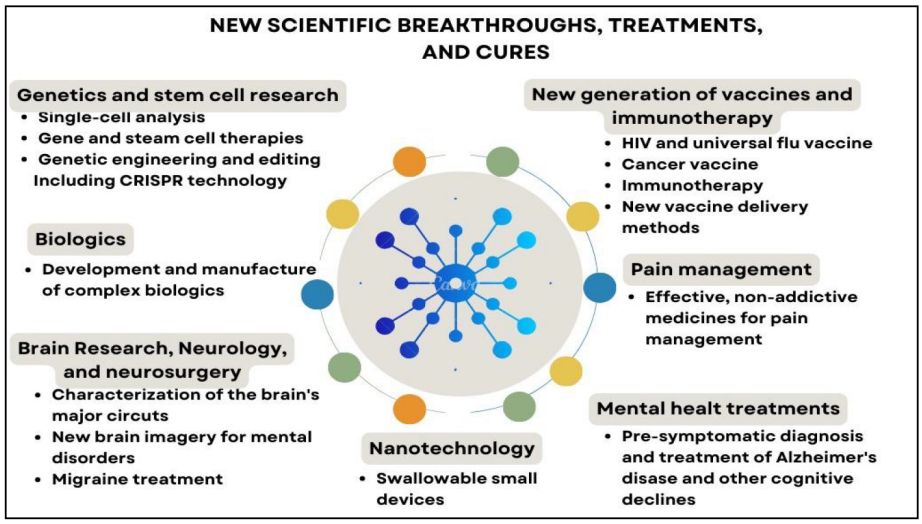

Figure 1. New scientific breakthroughs, treatments, and cures (The Global Innovation Index 2019)

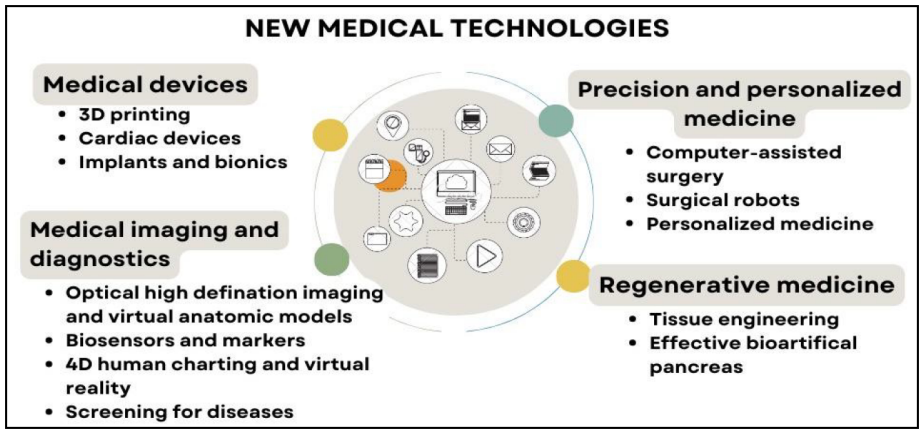

Figure 2. New medical technologies (The Global Innovation Index 2019)

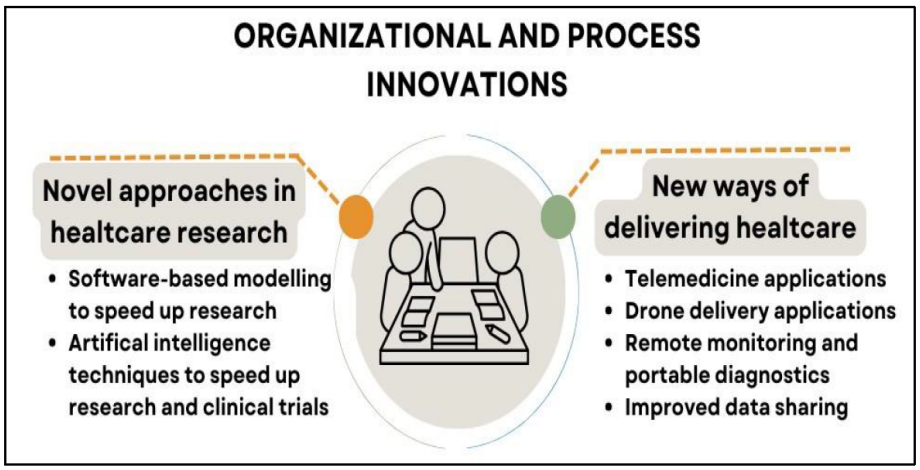

Figure 3. Organizational and process innovations (The Global Innovation Index 2019)

The future of medical innovation and its role in improving health outcomes, including reducing mortality and increasing productivity and quality of life, will depend on the policies and institutions established by national and global stakeholders to support research and innovation efforts. Technological progress is widely recognized as a key source of long-term economic growth. The Nobel laureate William Nordhaus has quantified the economic value of the increase in life expectancy over the past century, claiming that it rivals the economic growth of all other sectors combined To illustrate, treatments for depression and advances in hip replacements have significantly reduced morbidity and improved overall quality of life. Certain emerging medical technologies, for instance, contraceptive pills, have profoundly transformed the workforce and societal structures (Bailey, 2006). Presently, a substantial body of scholarly work scrutinizes the feasibility and sustainability of the "technological imperative" in the field of medicine (Cutler et al., 2001). This has the potential to open new avenues for disease prevention, diagnosis, and treatment in healthcare.

4. GLOBAL INNOVATION INDEX TURKEY AND TIME SERIES ANALYSIS

4.1. Materials: The Global Innovation Index (GII)

This study relies on data from the years 2018 to 2022, inclusive of the "Global Innovation Index (GII)" reports released in 2022. These reports are a collaborative effort involving Cornell University, The Business School for the World (INSEAD), the Confederation of Indian Industry (CII), and the World Intellectual Property Organization (WIPO), a specialized agency of the United Nations. It's noteworthy that this report has been consistently published since 2007. The details of the 2022 reports are at this website: . You can find previous reports on the About the GII | Global Innovation Index page.

The principal objective of the Global Innovation Index (GII) report is to evaluate the preparedness of nations in terms of promoting innovation and to furnish valuable insights for governments, corporations, and individuals, aiding them in optimizing the benefits of innovation. The report assigns scores to diverse sub-indicators, covering domains such as organizational innovation, human capital, and business development within each country. Subsequently, it ranks nations based on these scores. Furthermore, the report encompasses a range of policies and recent findings that are relevant to creating an environment conducive to innovation, with the aim of inspiring countries to embrace innovative practices.

The Global Innovation Index (GII) is structured around two fundamental components: the Innovation Input Sub-index (IISI) and the Innovation Output Sub-index (IOSI). The IISI comprises five essential dimensions: institutions, human capital & and research, infrastructure, market sophistication, and business sophistication. These five foundational pillars encompass various aspects of a nation's economic framework that facilitate and nurture activities driven by innovation. The IOSI is divided into two distinct segments: knowledge technology output and creative output. Innovation outputs represent the concrete results arising from innovative activities occurring within the economy. Within each pillar, there exist three sub-pillars, each comprising individual indicators. The collective indicators for each year culminate in a comprehensive assessment. Indicator scores are assessed on a scale ranging from 1 to 7, where 7 denotes an exceptional performance, and 1 signifies a lower standing. Countries are then ranked based on these scores, with the highest-ranking country securing the 1st position. A lower rank index value corresponds to a more favorable indicator, while higher values indicate areas for improvement. Table 2 offers an exhaustive breakdown of the main and subsidiary

Table 2. *Global Innovation Index*

Global Innovation Index	4.3.1. Applies tariff rate, weighted mean, %
Innovation Output Sub-Index	4.3.2. Non-agricultural mkt access weighted tariff, %
Innovation Input Sub-Index	4.3.3. Intensity of local competition
Innovation Efficiency Ratio	**5. Business sophistication**
1. iristi t ut i ons	5.1. Knowledge workers
1.1. Political Environment	5.1.1. Knowledge-intensive employment, %
1.1.1. Political stability*	5.1.2. Firms offering format training, % firms
1.1.2. Government effectiveness*	5.1.3. GERD perfbrmed by business, %GDP
1.1.3. Press Freedom*	5.1.4. GERD fınanced by business, %
1.2. Regulatory environment	5.1.5. GMAT test takers/mnpop. 20-34
1.2.1. Regulatory quality*	5.2. Innovation linkages
1.2.2. Rule of law*	5.2.1. University/Industry research collaboratioıı[1]
1.2.3. Cost of redundancy dismissal, salary weeks	5.2.2. State of cluster developmeııt[1]
1.3. Business environment	5.2.3. GERD fınanced by abroad, %
1.3.1. Ease of starting a business*	5.2.4. JV-slrategic alliance deals/tr PPP$ GDP
1.3.2. Ease ofresolving insolvency*	5.2.5. Patent families fıled in 3+ offices/bn PPP$ GDP
1.3.3. Ease of paying taxes*	5.3. Knowledge absorption
2. [Ilıman Capital & research	5.3.1. Royalty & license fees payments, % total trade
2.1. Education	5.3.2. High-tech imports less re-imports, %
2.1.1. Expenditure on education, "oGDP	5.3.3. Comm.computer&info.services imp., %total trade
2.1.2. Gov't expenditure/pupils,secondary,%GDP/cap	5.3.4. FDI net inflows, % GDP
2.1.3. School life expectancy, years	**6. Knowledge&technology outputs**
2.1.4. PISA scales in reading, maths, & Science	6.1. Knowledge creation
2.1.5. Pupil-teacher ratio, secondary	6.1.1. Domestic resident patent app/tr PPP$ GDP
2.2. Tertiary education	6.1.2. PCT resident patent app./tr PPP
2.2.1. Tertiary enrolment, "ogross	6.1.3. Domestic res utility model app./tr PPP$ GDP
2.2.2. Graduates in science&engineering, %	6.1.4. Scientifıc & technical articles/bn PPP$ GDP
2.2.3. Tertiary inbound mobility, %	6.1.5. Citable documents H index
2.3. Research&development(R&D)	6.2. Knowledge impact
2.3.1. Researchers, headcounts/mn pop	6.2.1. Growth rate of PPPS GDP/worker, %
2.3.2. Gross expenditure on R&D, "oGDP	6.2.2. Newbusinesses/th pop. 15-64
2.3.3. QS university ranking, average scope top 3*	6.2.3. Computer software spending, %GDP
3. Infrastructure	6.2.4. ISO 9001 quality certificates/bn PPP$ GDP
3.1. Infonnation&communication technologies (ICTs)	6.2.5. High-&medium-high-tech manufactures, %
3.1.1. ICT access*	6.3. Knowledge diffusion
3.1.2. ICTuse*	6.3.1. Royalty & license-fees receipts, % total trade
3.1.3. Government's Online service*	6.3.2. High-tech exports less re-exports, %
3.1.4. E-participation*	6.3.3. Comm. computer& info. Services exp., % total trade
3.2. General infrastructure	6.3.4. FDInet outflows, % GDP
3.2.1. Electricity output, kWh/cap	**7. Creative outputs**
3.2.2. Logistics perfonnance*	7.1. Intangible assets
3.2.3. Gross Capital fonnation, "oGDP	7.1.1. Domestic res trademark app/bn PPP$ GDP
3.3. Ecological sustainability	7.1.2. Madrid trademark app. Holders/bn PPP$ GDP
3.3.1. GDP/unit of energy use, 2005 PPP$/kg oil eq	7.1.3. ICTs & business model creation[1]
3.3.2. Environmental perfonnance*	7.1.4. ICTs & organizational model creation[1]
3.3.3. ISO 14001 environmental certifıcates/bn PPPS GDP	7.2. Creative goods & services
4. Market sophistication	7.2.1. Cultural & Creative services exports, % total trade
4.1. Credit	7.2.2. National feature fılms/mn pop. 15-69
4.1.1. Ease of getting credit*	7.2.3. Global ent. & media output/th pop. 15-69
4.1.2. Domestic creditto private sector, "oGDP	7.2.4. Printing & publishingmanufactures, %
4.1.3. Microfınance gross loans, "oGDP	7.2.5. Creative goods exports, % total trade
4.2. Investment	7.3. Online creativity
4.2.1. Ease of protecting investors*	7.3.1. Generic top-level domains (TLDd)/th pop. 15-69
4.2.2. Market capitalization, " oGDP	7.3.2. Country-code TLDs/th pop.15-69
4.2.3. Total value of stocks traded, " oGDP	7.3.3. Wikipedia edits/pop. 15-69
4.2.4. Venture Capital deals/tr PPPS GDP	7.3.4. Video uploads on YouTube/pop. 15-69
4.3. Trade & competition	* an index ! a survey question

The sign (*) in the relevant indicators indicates the index values obtained by various organizations. The sign (!) indicates the values obtained from the survey questions. Some indicator values were obtained from the data of national organizations.

topics encompassed within the Global Innovation Index (GII). Each entry in this table is assigned a numerical value, which is used in the time series analysis.

4.2. Methods: Time Series

Time series analysis constitutes a discipline within the field of statistics and, occasionally, within the realm of econometrics. However, its methodologies find application across virtually every scientific domain. A time series refers to a sequence of measurements that are recorded over successive intervals of time (Akdi, 2003). Essentially, a time series comprises numeric data points representing the values of variables that are observed sequentially from one time period to the next. While continuous realization of these observed values is not mandatory, it is essential for monitoring the progression of the series at consistent time intervals (Granger and Newbold, 1977). Time series data are analyzed and used for forecasting through various statistical models. In our study, we applied appropriate models, including ARIMA (AutoRegressive Integrated Moving Average), Holt's Exponential Smoothing, and Brown's Single Exponential Smoothing, tailored to the specific structure of our data. ARIMA models are used for analyzing time series data and forecasting future values. These models capture elements such as level, trend, and seasonal variation of the time series data for forecasting future values. When properly fitted to the data, the ARIMA model provides reliable forecasts based on historical data. Holt's exponential smoothing method analyzes time series data and extracts level and trend components, with the primary objective of identifying and encapsulating these specific characteristics of the time series. Brown's Single Exponential Smoothing method forecasts time series data only concerning the level component, focusing on detecting variations in the level component of the time series. It does not incorporate seasonal or trend components and is typically used to analyze less complex time series data (Gardner Jr., E. S., 1985).

This study involved the construction of a time series model based on Turkey's rankings among 126 countries in 2018, 126 countries in 2019, 131 countries in 2020, 131 countries in 2021, and 132 countries in 2022, as determined by "The Global Innovation Index" spanning the years 2018 to 2022. To perform forecasting on this time series data, the ARIMA, Holt, and Brown statistical methods were employed.

The time series analysis focused on modeling Turkey's "The Global Innovation Index" rank values from 2018 to 2022. It encompassed rank estimations for each year within the 2018-2022 period, along with forecasting values for the year 2023, presented with confidence intervals. In addition, the P values of the indicators within the forecasting models were categorized into four groups: best (1), no change (2), potential change (3), and worst (4), based on the trend observed in the graphs. Statistical analysis was conducted using the SPSS 21.0 software package.

5. RESULTS

Given the large number of indicators, the results of this study are concisely summarized and presented in tables and graphs. These results are systematically organized and interpreted, taking into account the items corresponding to each sub-index.

Table 3. Global Innovation Index, Innovation Output and Input Sub-Indexes - Rankings and Forecasts for 2023

	2018	2019	2020	2021	2022	2023 Forecasting (95% C.I)	p
GII	50 (53)	49 (50)	51 (46)	41 (43)	37 (40)	36 (23-49)	0.746
IOSI	43 (44)	56 (44)	52 (44)	45 (44)	49 (44)	44 (22-65)	<0.001
IISI	62 (62)	56 (58)	52 (54)	45 (49)	49 (44)	42 (29-55)	0.396

Observed (Predicted)

Table 3 summarizes the 5-year rankings of the Global Innovation Index (GII), Innovation Output, and Input sub-indexes, along with projections for 2023. Turkey's rank in the Global Innovation Index (GII) was 50 out of 126 countries in 2018, maintained a relatively similar position at 49 in 2019, and moved slightly to 51 out of 131 countries in 2020. However, after 2021, the GII scores showed a remarkable momentum, exceeding the expected forecast among 131 countries, and this momentum continued in 2022. The forecast for 2023, which indicates an improvement in Turkey's GII ranking to 36th, seems to indicate a positive trend. However, a statistical analysis of the model shows that there is no statistically significant momentum in Turkey's ranking over the years (Figure 4A) ($p>0.05$).

Regarding the ranking value of the Innovation Output Sub-Index (IOSI), Turkey's ranking was 43 in 2018 and experienced a significant decline in 2019. Since 2020, there has been an upward trend in the ranking. In 2021, Turkey's ranking was close to that of 2018, with a slight decline in 2022. The projection for 2023 shows an increase in rankings, indicating an improving trend for Turkey, with a rapid improvement (Figure 4B) ($p<0.05$).

Regarding the ranking value of the Innovation Input Sub-Index (IISI), Turkey's position was 62 in 2018, with subsequent increases in subsequent years, but a decline in 2022. For the projected year 2023, the expected rank value is

42, which is an improvement compared to the previous years. Nevertheless, the p-value of the model does not indicate any significant positive or negative progress (Figure 4C) (p>0.10).

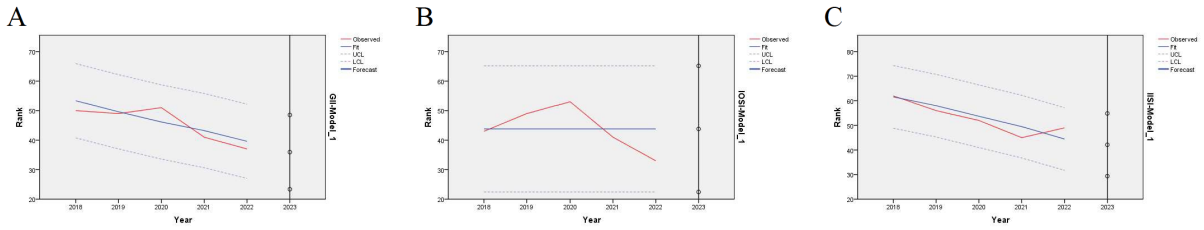

Figure 4. Global Innovation Index (A); Innovation Output Sub-Index (B); and, Innovation Input Sub-Index (C) Time Series Graphics and 2023 Forecasting

The study includes separate assessments of Turkey's rankings in the fundamental indicators of the GII, IISI, and IOSI. Due to the large number of sub-indicators, as opposed to individual assessments for the subsequent index scores of the five core sub-indicators within IISI and the two core sub-indicators within IOSI, they are examined collectively as integral sub-indicators, signifying either Turkey's negative progress, positive progress, or stable positioning.

Table 4. *Institutions - Rankings and Forecasts for 2023*

	2018	2019	2020	2021	2022	2023 Forecasting (95% C.I)	p
1.	96 (94)	85 (94)	94 (94)	93 (94)	101 (94)	94 (78-110)	**<0.001**
1.1.	102 (81)	69 (81)	77 (81)	75 (81)	81 (81)	81 (46-116)	**<0.001**
1.1.1.	124 (94)	79 (94)	92 (94)	89 (94)	87 (94)	94 (46-142)	**<0.001**
1.1.2.	68 (67)	67 (68)	71 (69)	70 (71)	73 (72)	73 (69-78)	0.731
1.2.	97 (97)	102 (102)	108 (107)	109 (114)	109 (110)	109 (102-116)	**0.003**
1.2.1.	60 (na)	67 (64)	74 (71)	72 (78)	74 (76)	78 (64-91)	0.207
1.2.2.	71 (72)	76 (74)	82 (77)	78 (81)	83 (83)	85 (75-96)	0.540
1.2.3.	111 (111)	115 (115)	117 (119)	118 (119)	119 (119)	120 (117-123)	**<0.001**
1.3.	97 (91)	82 (91)	91 (91)	91 (91)	92 (91)	91 (76-106)	**<0.001**
1.3.1.	66 (61)	63 (68)	62 (74)	62 (78)	99 (81)	91 (41-142)	0.643
1.3.2.	112 (112)	96 (99)	104 (87)	104 (76)	47 (67)	53 (-17-123)	0.738

Observed (Predicted)

Table 4 illustrates the 5-year rankings of institutions and projections for 2023 in terms of the basic input indicator. Thus, it shows that Turkey's ranking in 2022 showed a significant decline compared to the previous years. However, the forecast for 2023 predicts an improvement of 7 positions to reach 94th place. The statistical model for institutions suggests that Turkey has made positive progress, although precautions are needed regarding the policies implemented in 2022 (p<0.05). Within the core institutions indicator, sub-indices 1.1 Political Environment and 1.2 Regulatory Environment show stationary momentum. However, the forecast predicts a slight improvement in the 1.3 Business Environment indicator, moving from 92nd to 91st place. In particular, among the institutional indicators, a decline is expected in 2023 for both 1.1.1 Political Stability and 1.2.3 Cost of Redundancy Dismissal, and Salary Weeks. However, this decline, particularly in political stability, is significant given Turkey's already high ranking in this area.

Table 5. *Human capital and research - Rankings and Forecasts for 2023*

	2018	2019	2020	2021	2022	2023 Forecasting (95% C.I)	p
2.	49 (41)	46 (41)	42 (41)	26 (41)	41 (41)	41 (16-65)	0.001
2.1.	82 (47)	73 (47)	7 (47)	6 (47)	66 (47)	47 (-57-150)	0.048
2.1.1.	69	70		65		No estimation	-
2.1.2.	82 (86)	90 (86)			87 (86)	86 (69-104)	0.001
2.1.3.	14 (14)	14 (13)	12 (13)	11 (12)	11 (11)	10 (7-12)	0.360
2.1.4.	49 (50)	49 (47)	41 (45)	41 (42)	41 (39)	37 (28-47)	0.481
2.1.5.	79 (80)	81 (80)	84 (80)	80 (80)	77 (80)	80 (73-87)	<0.001
2.2.	49 (53)	43 (53)	91 (53)	24 (53)	56 (53)	53 (-16-121)	0.009
2.2.1.	3 (3)	3 (3)		2 (2)	2 (2)	2 (0-3)	0.400
2.2.2.	58 (54)	65 (63)	73 (72)	75 (81)	97 (89)	99 (79-119)	0.722
2.2.3.	78 (79)	82 (79)	80 (79)	80 (80)	78 (80)	79 (74-85)	0.448
2.3.	36 (38)	39 (38)	40 (38)	38 (38)	36 (38)	38 (33-43)	<0.001
2.3.1.	46 (46)	44 (45)	46 (44)	43 (44)	42 (43)	42 (37-46)	0.779
2.3.2.	38 (38)	37 (38)	39 (38)	36 (38)	39 (38)	38 (34-41)	<0.001
2.3.3.	27 (29)	31 (29)	33 (29)	29 (29)	29 (29)	29 (23-36)	0.852
2.3.4.	41 (42)	44 (43)	45 (44)	45 (45)	46 (46)	47 (44-51)	0.508

Observed (Predicted)

Table 5 shows the 5-year rankings of human capital and research, along with projections for 2023, as a basic input indicator, it shows that Turkey's ranking in 2021 showed a significant improvement compared to the previous years. However, there was a decline in 2022, with the forecast for 2023 suggesting no substantial progress ($p<0.05$). Within sub-index 2.1 Education, there was a significant increase in rankings in 2020 and 2021 (the pandemic period), but a rapid decline in 2022. The forecast for 2023 shows an improvement over the previous year. The sub-index 2.2 Tertiary education saw significant progress in 2021, but this was not sustained in 2022. The projection for 2023 foresees a slight increase in the tertiary education index. The 2.3 Research and Development (R&D) sub-index has shown modest fluctuations over the years, with the last 5-year rankings close to the expected ranking of 38. A slight decline is expected in 2023 compared to the previous year. Forecasts for the 2023 rankings in 2.1.2 Government expenditure/pupil (secondary), GDP% per capita, and 2.3.2 Gross expenditure on R&D, GDP% show significant improvements compared to 2022. Regrettably, no meaningful model could be constructed for 2.1.1 Expenditure on education, GDP%, which precluded any forecast.

Table 6. *Infrastructure - Rankings and Forecasts for 2023*

	2018	2019	2020	2021	2022	2023 Forecasting (95% C.I)	p
3.	52 (49)	41 (49)	54 (49)	48 (49)	48 (49)	49 (35-62)	<0.001
3.1.	65 (63)	49 (57)	49 (50)	47 (44)	38 (39)	33 (16-51)	0.487
3.1.1.	67 (69)	69 (68)	66 (67)	66 (66)	64 (65)	64 (60-68)	0.998
3.1.2.	67 (68)	68 (66)	61 (65)	64 (63)	60 (61)	59 (50-68)	0.689
3.1.3.	64 (56)	27 (49)	27 (35)	22 (25)	22 (15)	8 (-39-55)	0.440
3.1.4.	59 (56)	37 (48)	37 (36)	23 (28)	23 (18)	11 (-14-36)	0.436
3.2.	33 (42)	38 (42)	57 (42)	42 (42)	41 (42)	42 (17-67)	<0.001
3.2.1.	56 (56)	54 (56)	54 (56)	57 (56)	57 (56)	56 (51-60)	<0.001
3.2.2.	33 (43)	46 (43)	46 (43)	46 (43)	44 (43)	43 (27-59)	<0.001
3.2.3.	21 (26)	20 (26)	47 (26)	26 (26)	16 (26)	26 (-8-60)	0.009
3.3.	54 (53)	52 (54)	55 (56)	54 (57)	61 (59)	60 (51-69)	0.768
3.3.1.	16 (17)	19 (17)	16 (17)	19 (17)	17 (17)	17 (13-22)	<0.001
3.3.2.	87 (94)	88 (94)	84 (94)	84 (94)	125 (94)	94 (45-143)	<0.001
3.3.3.	70 (65)	67 (65)	57 (65)	66 (65)	66 (65)	65 (52-79)	<0.001

Observed (Predicted)

Table 6 presents an overview of the 5-year infrastructure ranking and offers projections for 2023 as a basic input indicator. Accordingly, Turkey's ranking was 41st in 2019, but the following years showed a decline. The projection for 2023 predicts a slight decline from the previous year. Looking at the sub-indices, a statistically significant decrease similar to the basic input indicator is expected for 3.2 General Infrastructure.

Within the sub-index 3.2.3 Gross capital formation, GDP%, there was a significant decline in 2020, followed by a gradual recovery in the following years. The projection for 2023 foresees a decrease of 10 units compared to the previous year. On the other hand, for the sub-index 3.3.1 GDP/unit of energy use, 2005 PPP$/kg oil equivalent, Turkey's ranking has shown consistency over the past 5 years, and this ranking is expected to be maintained in 2023. For the sub-indices 3.2.1 Electricity output, kWh/capacity, 3.2.2 Logistics performance, and 3.3.3 ISO 14001 environmental certificates/billion PPP$ GDP, the forecasts for 2023 show a slight decrease compared to the previous year, while a rapid improvement is expected for the sub-index 3.3.2 Environmental performance.

Table 7. *Market Sophistication - Rankings and Forecasts for 2023*

	2018	2019	2020	2021	2022	2023 Forecasting (95% C.I)	p
4.	55 (44)	52 (44)	28 (44)	49 (44)	37 (44)	44 (13-76)	0.001
4.1.	95 (92)	66 (81)	66 (69)	68 (57)	39 (47)	36 (-3-74)	0.738
4.1.1.	70 (40)	29 (40)	34 (40)	34 (40)	35 (40)	40 (-6-87)	0.006
4.1.2.	45 (46)	44 (46)	46 (46)	51 (46)	44 (46)	46 (38-54)	<0.001
4.1.3.	77 (77)	78 (77)	76 (77)	77 (77)		77 (74-80)	<0.001
4.2.	77 (75)	87 (75)	44 (75)	105 (75)	61 (75)	75 (10-140)	0.002
4.2.1.	20 (21)	24 (21)	21 (21)	21 (21)		21 (15-27)	0.958
4.2.2.	61 (60)	56 (58)	54 (56)	55 (54)	53 (53)	51 (44-58)	0.443
4.2.3.	78 (79)	78 (79)		85 (79)	76 (79)	79 (67-92)	<0.001
4.3.	9 (10)	15 (10)	7 (10)	10 (10)	11 (10)	10 (2-19)	0.001
4.3.1.	60 (65)	67 (65)	62 (65)	63 (65)	71 (65)	65 (52-77)	<0.001
4.3.2.	8 (8)	6 (7)	6 (5)	4 (4)	3 (3)	2 (0-4)	0.337
4.3.3.	13 (13)	13 (13)	13 (12)	13 (12)	11 (12)	11 (9-14)	0.691

Observed (Predicted)

Table 7 illustrates the 5-year rankings for market sophistication and presents forecasts for 2023 as a basic input indicator. Accordingly, Turkey's ranking was 28 in 2020, followed by a rapid decline in 2021. Turkey's ranking shows a notable increase in 2022, followed by a predicted decline in 2023. Looking at the 4.2 Investment sub-index, a decline is expected in 2023, similar to the trends observed in the primary inputs index. In the 4.3 Trade & Competition sub-index, on the other hand, Turkey has maintained a commendable ranking over the past 5 years, with further improvements predicted for 2023. However, for the subindices 4.1.1 Ease of getting credit, 4.1.2 Domestic credit to the private sector, GDP%, and 4.2.3 Total value of stocks traded, %GDP, Turkey's ranking is expected to decline in 2023 compared to the previous year, while no significant improvement or regression is expected for the subindex 4.1.3 Microfinance gross loans, GDP%. Subindex 4.3.1 Applies tariff rate, weighted average, % showed a sharp decline in 2022; however, projections for 2023 suggest an increase in the ranking.

Table 8. *Business Sophistication - Rankings and Forecasts for 2023*

	2018	2019	2020	2021	2022	2023 Forecasting (95% C.I)	p
5.	72 (75)	71 (67)	57 (61)	46 (52)	47 (43)	37 (18-55)	0.333
5.1.	71 (74)	72 (67)	59 (63)	49 (55)	52 (47)	43 (23-62)	0.395
5.1.1.	72 (73)	71 (71)	73 (69)	69 (67)	63 (65)	63 (54-72)	0.997
5.1.2.	52 (51)	53 (51)	48 (51)	50 (51)	54 (51)	51 (45-58)	<0.001
5.1.3.	36 (37)	37 (36)	36 (35)	33 (34)	33 (33)	32 (28-36)	0.539
5.1.4.	19 (22)	27 (22)	28 (22)	18 (22)	17 (22)	22 (7-36)	0.001
5.1.5.	70 (72)	72 (71)	71 (70)	69 (69)	68 (69)	68 (64-72)	0.999
5.2.	102 (104)	97 (96)	91 (89)	79 (83)	75 (74)	67 (59-76)	0.278
5.2.1.	63 (68)	88 (68)	70 (68)	62 (68)	68 (68)	68 (38-98)	1.000
5.2.2.	56 (60)	76 (60)	64 (60)	48 (60)	58 (60)	60 (31-89)	<0.001
5.2.3.	90 (70)	68 (70)	59 (70)	71 (70)	60 (70)	70 (35-104)	<0.001
5.2.4.	92 (90)	95 (98)	106 (103)	115 (111)	116 (119)	125 (113-137)	0.318
5.2.5.	42 (41)	43 (41)	50 (41)	33 (41)	38 (41)	41 (24-59)	<0.001
5.3.	57 (60)	57 (54)	48 (50)	36 (45)	44 (38)	35 (13-57)	0.450
5.3.1.	71 (80)	74 (73)	76 (66)	56 (58)	44 (51)	44 (15-73)	0.999
5.3.2.	21 (21)	33 (33)	55 (45)	62 (77)	51 (69)	40 (5-75)	0.027
5.3.3.	121 (133)	124 (120)	124 (111)	84 (104)	92 (90)	81 (32-130)	0.529
5.3.4.	88 (93)	89 (93)	97 (93)	100 (93)	91 (93)	93 (78-108)	<0.001
5.3.5.	25 (26)	19 (21)	19 (16)	9 (12)	25 (26)	2 (-7-11)	0.360

Observed (Predicted)

Table 8 shows the 5-year rankings for business sophistication and provides projections for 2023. In terms of the basic input indicator, significant improvements were observed over the past 5 years, and the projections for 2023 suggest that this positive trend will continue, although without statistical significance (p>0.05). Subindices 5.1.4 GERD financed by business, %, 5.2.2 Status of cluster development, 5.2.3 GERD financed from abroad, %, 5.2.5 Patent families filed in 3+ offices/billion PPP$ GDP, and 5.3.4 Net FDI inflows, % GDP are projected to decline in 2023 compared to the previous year. On the other hand, sub-index 5.1.2 Firms offering formal training, % firms has shown marginal fluctuations over the past 5 years and is expected to show a slight improvement in 2023 compared to the previous year. Sub-index 5.3.2 High-tech imports fewer re-imports, %, shows a decline from 2018 to 2021 but starts to recover in 2022. This is also reflected in the projections for 2023, which anticipate an improvement in rankings.

Table 9. *Knowledge & Technology Outputs - Rankings and Forecasts for 2023*

	2018	2019	2020	2021	2022	2023 Forecasting (95% C.I)	p
6.	52 (53)	59 (53)	57 (53)	50 (53)	47 (53)	53 (39-67)	<0.001
6.1.	41 (41)	38 (40)	40 (39)	37 (38)	37 (37)	36 (31-41)	0.577
6.1.1.	30 (30)	27 (29)	30 (27)	24 (26)	24 (24)	23 (15-30)	0.616
6.1.2.	32 (31)	32 (31)	28 (31)	31 (31)	31 (31)	31 (26-35)	<0.001
6.1.3.	16 (18)	17 (18)	20 (18)	20 (18)	17 (18)	18 (13-23)	<0.001
6.1.4.	59 (57)	60 (57)	54 (57)	52 (57)	60 (57)	57 (47-67)	<0.001
6.1.5.	35 (35)	35 (35)	35 (35)	35 (35)	35 (35)	35 (35-35)	-
6.2.	53 (56)	57 (51)	42 (48)	38 (41)	39 (36)	32 (13-51)	0.484
6.2.1.	33 (47)	46 (38)	37 (31)	12 (23)	10 (14)	6 (-34-45)	0.699
6.2.2.	66 (67)	66 (66)	65 (65)	65 (64)	63 (64)	63 (61-65)	0.999
6.2.3.	20 (20)	20 (20)	20 (20)	20 (20)	20 (20)	20 (20-20)	-
6.2.4.	73 (72)	80 (72)	67 (72)	70 (72)	70 (72)	72 (58-86)	<0.001
6.2.5.	41 (45)	44 (44)	42 (45)	55 (44)		46 (27-65)	0.157
6.3.	90 (107)	112 (97)	96 (90)	73 (82)	67 (73)	64 (16-112)	0.802
6.3.1.		96 (98)	90 (87)	76 (78)		56 (43-69)	0.302
6.3.2.	63 (63)	63 (63)	64 (63)	61 (63)	63 (63)	63 (60-66)	1.000
6.3.3.	122 (131)	122 (120)	124 (112)	94 (106)	93 (95)	86 (51-121)	0.564
6.3.4.	63 (63)	73 (71)	81 (80)	94 (89)	93 (99)	105 (90-120)	0.446

Observed (Predicted)

Table 9 presents an overview of the 5-year Knowledge & Technology outputs ranking and offers projections for 2023. As a basic input indicator, there was an increasing trend after 2019, but projections for 2023 show a decline compared to 2022. Sub-indices including 6.1 Knowledge Creation, 6.2 Knowledge Impact, and 6.3 Knowledge Diffusion are projected to increase in the 2023 forecasts compared to previous years, although these trends lack statistical significance. On the other hand, the sub-indices 6.1.3 Domestic res utility model app./tr PPP$ GDP and 6.2.4 ISO 9001 quality certificates/bn PPP$ GDP are expected to experience slight decreases compared to 2022. However, the sub-index 6.1.2 PCT resident patent app./tr PPP is expected to have the same rank. In particular, the subindex 6.1.4 Scientific & technical articles/bn PPP$ GDP achieved its best ranking in the last 5 years, reaching 52nd place in 2021. Forecasts for 2023 suggest a slight improvement over 2022.

Table 10. *Creative Outputs - Rankings and Forecasts for 2023*

	2018	2019	2020	2021	2022	2023 Forecasting (95% C.I)	p
7.	39 (na)	40 (33)	50 (34)	35 (44)	15 (29)	9 (-35-53)	0.452
7.1.	11 (17)	20 (17)	31 (17)	18 (17)	4 (17)	17 (-11-45)	0.021
7.1.1.	14 (11)	13 (11)	17 (11)	6 (11)	6 (11)	11 (-3-25)	0.007
7.1.2.	1 (3)	1 (3)	6 (3)	5 (3)	1 (3)	3 (-4-10)	0.066
7.1.3.	53 (53)	72 (53)	44 (53)	45 (53)	51 (53)	53 (22-84)	<0.001
7.1.4.	75 (93)	98 (93)	100 (93)	100 (93)		93 (54-132)	0.001
7.2.	60 (59)	60 (61)	60 (64)	61 (66)	72 (68)	71 (57-85)	0.722
7.2.1.	75 (74)	46 (74)	92 (74)	82 (74)	77 (74)	74 (27-122)	0.001
7.2.2.	58 (60)	59 (57)	62 (55)	62 (54)	44 (53)	49 (23-75)	0.604
7.2.3.	43 (44)	46 (45)	48 (46)	47 (48)	48 (49)	50 (45-54)	0.561
7.2.4.	62 (62)	71 (71)	73 (80)	75 (75)	70 (77)	65 (51-79)	0.001
7.2.5.	18 (19)	21 (19)	19 (19)	19 (19)	19 (19)	19 (16-22)	<0.001
7.3.	56 (56)	55 (56)	69 (56)	50 (56)	48 (56)	56 (33-78)	<0.001
7.3.1.	36 (36)	36 (36)	36 (36)	36 (36)	37 (37)	37 (36-38)	0.691
7.3.2.	66 (66)	68 (68)	69 (70)	68 (70)	67 (67)	66 (63-69)	0.002
7.3.3.	85 (80)	85 (80)	101 (80)	61 (80)	68 (80)	80 (36-124)	<0.001
7.3.4.	36 (36)	23 (23)	19 (10)	18 (15)	17 (17)	16 (3-29)	<0.001

Observed (Predicted)

Table 10 shows the 5-year rankings and 2023 forecasts for Creative output. As a basic input indicator, a rapid increase was observed in 2022 compared to previous years, and it is predicted to rise to 9th place in the 2023 forecast. Conversely, the 7.1 Intangible Assets and 7.3 Online Creativity sub-indices show significant declines in 2020, followed by improvements. Nevertheless, the forecasts for 2023 show a decline compared to the previous year. The sub-indices include 7.1.1 Domestic Trademark Apps/billion PPP$ GDP, 7.1.3 ICTs & Business Model Creation and 7.3.3 Wikipedia Edits/pop. 15-69 are expected to decline in 2023. Conversely, the 7.2.5 Creative goods exports, % of total trade sub-index is expected to remain constant in 2023 compared to 2022. In addition, sub-indices such as 7.2.1 Cultural and creative services exports, % total trade, 7.2.4 Printing and publishing manufactures, %, 7.3.2 Country code TLDs/th pop.15-69, and 7.3.4 Video uploads to YouTube/pop. 15-69 are projected to increase slightly in 2023 compared to 2022, while the 7.1.4 ICTs & and organizational model creation sub-index is projected to increase compared to 2021.

Table 11. *Status of the Global Innovation Index and its sub-indexes according to P values*

Status	P value	Curve direction	Description
1	<0.05		Appropriate policies are being implemented, and it is recommended to maintain the current system.
2	<0.05		The present policies do not have a positive or negative effect. The 2023 criteria indicators can be improved with additional support along with the implementation of short-term action plans.
3	>0.05		The existing policies have been ineffective, and there has been no progress, neither positive nor negative. It is necessary to develop new policies and comprehensive action plans and to implement them.
4	<0.05		Wrong policies have led to a negative trend, hence requiring urgent action plans.

Table 12. *Status of Turkey according to P values of Global Innovation Index and sub-indexes (for 1,2,3,4)*

	1	2	3	4
Basic	IOSI		GII IISI	
1. Institutions	1 1.3	1.1 1.2	1.1.2 1.2.1 1.2.2 1.3.1 1.3.2	1.1.1 1.2.3
2. Human Capital&Research	2.1 2.1.2 2.2 2.3.2	2	2.1.3 2.1.4 2.2.1 2.2.2 2.2.3 2.3.1 2.3.3 2.3.4	2.1.5 2.3
3. Infrastructure	3.2.1 3.2.2 3.3.2 3.3.3	3.3.1	3.1 3.1.1 3.1.2 3.1.3 3.1.4 3.3	3 3.2 3.2.3
4. Market Sophistication	4.3 4.3.1	4.1.3	4.1 4.2.1 4.2.2 4.3.2 4.3.3	4 4.1.1 4.1.2 4.2 4.2.3
5. Business Sophistication	5.1.2 5.3.2	-	5 5.1 5.1.1 5.1.3 5.1.5 5.2 5.2.1 5.2.4 5.3 5.3.1 5.3.3 5.3.5	5.1.4 5.2.2 5.2.3 5.2.5 5.3.4
6. Knowledge & Technology Out.	6.1.4	6.1.2 6.1.5 6.2.3	6.1 6.1.1 6.1.5 6.2 6.2.1 6.2.2 6.2.3 6.2.5 6.3 6.3.1 6.3.2 6.3.3 6.3.4	6 6.1.3 6.2.4
7. Creative Outputs	7.1.4 7.2.1 7.2.4 7.3.2 7.3.4	7.2.5	7 7.1.2 7.2 7.2.2 7.2.3 7.3.1	7.1 7.1.1 7.1.3 7.3 7.3.3

Finally, Table 12 shows the rankings of the grouped innovation indicators in an evaluation that takes into account the direction of the curves formed based on the p-values of the predicted values in the models created for 2023. This evaluation aims to clarify Turkey's position in terms of the Global Innovation Index and its sub-indices and to provide clearer insights into the areas in which the country needs to improve. The 2023 criteria indicators can be improved with additional support along with the implementation of short-term action plans.

6. CONCLUSIONS AND EVALUATIONS

This study provides an in-depth analysis of Turkey's performance on global innovation indicators from 2018 to 2022, in the context of digital transformation and innovation in healthcare. This analysis reveals the intricate dynamics between Turkey's digital transformation initiatives in healthcare, its innovation efforts, and the resulting innovation capability outcomes. By exploring Turkey's future within the global innovation ecosystem, valuable insights into the interaction between digital transformation and innovation in healthcare have emerged, contributing to a better understanding of Turkey's innovation trajectory. Moreover, this research provides important guidance for future strategic directions aimed at leveraging digital technologies and innovation to improve healthcare services and outcomes for Turkey's population. Turkey's position within the global innovation landscape also serves as an indicator of the synergy between digitalization and innovation in healthcare, and their collective influence on Turkey's health innovation standing, and its performance on the global innovation stage.

The study has identified Turkey's strengthening, weakening, and no progress areas across the indicators and sub-

indicators of the Global Innovation Index Due to the large number of indicators in the index, the results are not interpreted individually for each indicator and are categorized into four different situations for analysis, as shown in Table 12. A careful examination and interpretation of Table 12 is essential for understanding the results of the study. In terms of the index and sub-index values in the first column, appropriate policies should be implemented and the existing system should be maintained. In terms of the index and sub-index values in the second column, there were no significant positive or negative impacts of current policies. The benchmark indicators for 2023 can be improved through additional support and the implementation of short-term action plans. Regarding the index and subindex values in column 3, we see that our current policies are ineffective and there is neither positive nor negative progress. As shown in the table, most of the indices and sub-indices are grouped under this column. These indicators require new policies and comprehensive action plans. This column requires thorough analysis and evaluation, and urgent action should be taken to improve innovation scores. Finally, in the fourth column, where adverse trends have emerged due to misguided policies, immediate action plans are imperative to rectify the situation for the specified index and sub-index values.

In Japan, one of the leading countries in innovation, the role of education and training, along with related social innovations, is one of the four key components within the national innovation system (Freeman, 1987:4). Tunçsiper, Ç. & Bakar, A. (2023) stated that in order for a country to have a healthy society, its economy should be strong, economic growth should be ensured and made sustainable and health services should be provided to meet the needs of the society. Similarly, Turkey needs an innovation miracle to strengthen not only the health sector but all other industries, to stimulate economic growth, to move from the league of developing countries to the league of developed countries, to have a competitive edge, and to carve out a distinctive global identity. To achieve this, significant emphasis must be placed on R&D and education, particularly in the area of digital transformation in education. Turkey still has a long way to go in terms of innovation.

Enterprises and policymakers should emphasize the process of converting research outcomes into commercially feasible applications, which might necessitate the initiation of partnerships between the public and private sectors, fostering an entrepreneurial environment within public research institutions, encouraging the establishment of academic spin-off ventures, and establishing business incubators and centers of excellence (Gelijns et al., 1994; Thune et al., 2016). To provide higher quality healthcare to a larger population at a low cost, it is imperative to accelerate the transformation of healthcare, in a more personalized, digitally integrated, and collaborative manner. IT-driven innovation should play a key role in expanding essential healthcare services and narrowing the existing gap between developed and developing countries.

Turkey has not reached to the point of satisfaction with respect to innovation. For this to materialize, the various health system actors will have to create and use better channels and to transmit relevant information and feedback. (Barberá-Tomás et al., 2012.) To act as a bridge between research and the application of innovation in a real-life context, medical professionals with experience in research, training in the use of new hardware and software, and training in advanced research technologies—such as 3D modeling—are needed (CSIRO, 2017).

The actors involved in shaping medical innovation need to be reconsidered. Academic healthcare organizations, such as university hospitals, have traditionally been boundary-spanning organizations between care and science. 80. (Lander, 2016; Miller, 2016) The critical role of hospitals and doctors in future demand-led health innovation is undeniable.81(Gulbrandsen et al., 2016; Smits et al., 2008.)

For Turkey, the results of its innovation journey from 2018 to 2022 are of paramount importance. These findings highlight the extent to which Turkey has embraced innovation at the intersection of technology and healthcare. Our findings underscore the impact of Turkey's global innovation performance on digital transformation and innovation in healthcare. Our goal is to improve the healthcare services for individuals, improve expected outcomes, and serve as a guide for policymakers, academics, researchers, computer scientists, and healthcare professionals regarding future strategic paths and action plans. The study, which is expected to serve as a beacon for Turkey, is poised to catalyze transformations and innovations in healthcare.

Peer Review: Externally peer-reviewed.

Conflict of Interest: The author has no conflict of interest to declare.

Grant Support: The author declared that this study has received no financial support.

Author Contributions: Conception/Design of Study- A.A.Ö., Z.A.B.; Data Acquisition- A.A.Ö., Z.A.B.; Data Analysis/Interpretation- A.A.Ö., Z.A.B.; Drafting Manuscript- A.A.Ö., Z.A.B.; Critical Revision of Manuscript- A.A.Ö., Z.A.B.; Final Approval and Accountability- A.A.Ö., Z.A.B.; Material and Technical Support- A.A.Ö., Z.A.B.; Supervision- A.A.Ö., Z.A.B.

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How cite this article / Atıf Biçimi

Ozdemir, A.A., Alakoc Burma, Z. (2023). Digital transformation and innovation in health for future health services: Turkiye global innovation index time series analysis between 2018 and 2022. *Acta Infologica*. Advance Online Publication https://doi.org/10.26650/acin.1352261