



Analysis of Turkey's Innovation Performance in Pandemic Times: Comparison of The Performances in Pre-pandemic and Pandemic Times (2019–2021)

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ABSTRACT

The purpose of the study is to analyse innovation performance of Turkey in pandemic times. Descriptive research method was used in the study. In this study, investigation of different data sets from Europe and Turkey was done in terms of changes in human resources, firm investments, digitalization, number of R&D personals, R&D expenditure and number of approved patents by considering pandemic times. The results showed that significant decrease in number of innovators and innovation index after 2020. Moreover, firm investments regarding innovation decreased after 2020 while digitalization represented continuous increase during 8 years involving pandemic years. In addition, number of patents approved by authorities and number of R&D personnel have been increasing over time in spite of the pandemic, but R&D expenditure and innovation performance have not been changing in similar trend. The findings revealed that Turkey has been making improvements on number of R&D personnel, digitalization and number of patents in spite of the pandemic, however expected increases in innovation index value, R&D expenditure and number of innovators were not observed during the pandemic years. The findings of this study might contribute to policy makers for recovery of economy of Turkey after the pandemic.

I. INTRODUCTION

In new economic system of the world, innovation is the main accelerator of economic development and production in general. In Oslo Manual, innovation defined as “a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products

or processes and that has been made available to potential users (product) or brought into use by the unit (process)” (OECD/Eurostat, 2018) while European Innovation Scoreboard defines “innovation” as the process leading to the adoption and diffusion of new technologies, aimed at creating new processes, products and services (Sajeva et al., 2005). Innovation performances of the countries matters in terms of competitiveness,

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economic development and sustainability of economic development.

Innovation performances of developing countries are an important component of total innovation performance in the World. Since developing countries as a part of global trade and human resources have a direct effect on the World economy. Monitoring and analyzing innovation-related data regarding developing countries have importance in global economic world due to making in-time intervention for contributing to sustainable and manageable economy of the World. Innovation performance of these countries is also a part of economic recovery from the COVID-19 pandemic. Turkey as a developing country has been making investments and developing infrastructures for increasing innovation capacity and economic development (Çetindamar & Ulusoy, 2008; Gezici, Müderrisoğlu & Salihoğlu, 2021). However, development in innovation performance of Turkey is not high as expected as when the investments are considered (Sener & Tunalı, 2017). The data of European Union showed that Turkey's innovation performance is under the EU average from 2008 to 2015 (European Union, 2016). In the same report we see that human resources for innovation, establishment of research systems and intellectual assets are the most important aspects on which Turkey has limitations.

In 2011, INSEAD and European Commission Joint Research Center made a first comprehensive global innovation index study in spite of the previous innovation index studies made by INSEAD (Turan, 2018). After the release of the results on global innovation index in 2011, Turkey decided to make different policies, investments and regulations regarding innovation (Sener & Tunalı, 2017). Then, Turkey's investments and policies were affected by the COVID-19 pandemic after 2019. Beginning from 2011 Turkey's innovation performance reflects fluctuations due to global changes regarding human resources, economic activity limitations and health issues. Especially, the COVID-19 pandemic affected many aspects of economic life of Turkey. One of these aspects is innovation performance, monitoring and analyzing innovation performance of Turkey before and during the pandemic might contribute to policy

makers and firms for recovery of economy of Turkey after the pandemic. Hence, there is a need to examine Turkey's innovation performance based on innovation-related indicators reported by TUIK, European innovation scoreboard and published papers in terms of effects of COVID-19 pandemic. Human resources, number of innovators, number of doctorate graduates, firm investment, digitalisation, R&D expenditure, number of R&D personnel and number of patents approved by the authority were determined as indicators reflecting investment on human resources and finance regarding innovation and output of investments. Therefore, the purpose of this study is to examine Turkey's innovation performance by investigation of different data sets from Europe and Turkey in terms of changes in human resources, firm investments, digitalization, number of R&D personals, R&D expenditure and number of approved patents by considering pandemic years.

Improvement of economical situation of Turkey after the pandemic requires analyzing the innovation performance of the country in pandemic times and comparing the performance with pre-pandemic times. Moreover, policy development and decisions on innovation performance also need to see results of analysis regarding innovation performance of the country in pre-pandemic and pandemic times.

II. ANALYTICAL FRAMEWORK

In the literature, different research studies evaluated innovation performances of Turkey by focusing on different indicators. One of them was performed by Uzun (2001). The author examined technological innovation activities of 2100 Turkish firms and he found that 60-80% of the firms had been performing innovation activities during 1995-1997 period. It was reported that 51.2 % percent of the firms carried out R&D for innovation while 52.3 % of them collaborated with the EU countries. However, only 19% of them made patent applications. Another study was conducted by Cetindamar and Ulusoy (2008). The authors focused on R&D intensity, number of patents, number of trademark, number of utility models. They have found that 73 percent of 135 companies have less than five patents, 56 of

companies have no patent, 48 of them have no trademark and 85 of them have no utility model. Fındık and Beyhan (2015) examined Turkey's innovation performances in 2008-2009 years by using Turkish Statistical Institute data. They focused perceptions of firms regarding impact of innovations. Their findings showed that large firms focus more on process-oriented impact while smaller firms focus on product-oriented impact of innovation. Being an exporting firm makes an advantage for adopting process-oriented impact of innovation. The authors claimed that perceptions of firms regarding impacts of innovation are indicator for evaluating innovation performance of Turkey. Tezcan (2015) looked at the innovation performance from a different angle and she compared innovation performances of Europe countries and Turkey based on number of patents, trademarks, industrial designs and R&D density and R&D personnel. She used three different data sources involving World Bank, AB Innovation Association and WIPO. She found that Turkey's innovation performance is similar to the countries called as middle-level innovators and is found to be below the EU average. From similar perspective, Sener and Tunalı (2017) also compared innovation performances of Europe countries and Turkey. They used European Innovation Scoreboard 2016 data as data resource of the study. In the study, it was shown that innovation performance of Turkey is below the EU average in terms of human resources, research systems, finance and support, entrepreneurship, intellectual assets, number of innovators while the performance is above the EU average in terms of firm investments. In a recent study, innovation performance of Turkey was examined at regional level (Özen & Baycan, 2022). The authors used number of patent applications, utility model applications, trademark applications and design applications as indicators and utilized data of Turkish Patent and Trademark Office. They reported that Giresun, Sanliurfa and Kırıkkale regions experience decreases in innovation performance while Gaziantep, Aydın, Tekirdağ, Samsun, Çorum and Burdur increased their innovation performances. Another finding of the study showed that metropolitan regions have higher innovation performances than non-metropolitan

regions. In a comprehensive evaluation (Dutta, Lanvin, Leon & Wunsch-Vincent, 2021, p.161), Turkey improved the rank from 31st to 41st between 2020 and 2021 years in terms of global innovation index during pandemic years. The data of this study was based on surveys.

As seen in the literature, there are different studies evaluating Turkey's innovation performances for specific time periods, however no study examined innovation performances of Turkey in terms of;

- 1) 1.difference between pre-pandemic and pandemic years,
- 2) 2.comprehensive list of indicators reflecting expenditures, human resources, products and digitalisation,
- 3) 3.different data sources coming from both Europe and Turkey.

In this study, comparison of innovation performances of Turkey was conducted to contribute to both researchers and policy makers by making detailed analysis and comparisons. The research questions of this study are;

- 1) Is there any difference in innovation performances of Turkey in terms of human resources before and during the pandemic years?
- 2) Is there any difference in innovation performances of Turkey in terms of investments and digitalisation before and during the pandemic years?
- 3) Is there any difference in innovation performances of Turkey in terms of R&D expenditure, number of R&D personnel, number of approved patent and general innovation performance before and during the pandemic years?

III. METHODOLOGY

In this study, analysis of secondary data resources was adopted as a research strategy. The secondary data sources involved TUIK bulletin, European Innovation Scoreboard 2021 Database, different data represented in research papers, Global Economy Database and Strategy and Budget Department Data of Turkish Presidency. All of

the links regarding data sources are represented in Table 1. The indicators of the study were determined by considering human resources, investment and expenditure, digitalisation and product components of innovation. Based on these indicators, all of the data across the years was recorded in a separate table and graphics across the years were established to see changes before and during the pandemic years.

Table 1. Data Sources of the Study

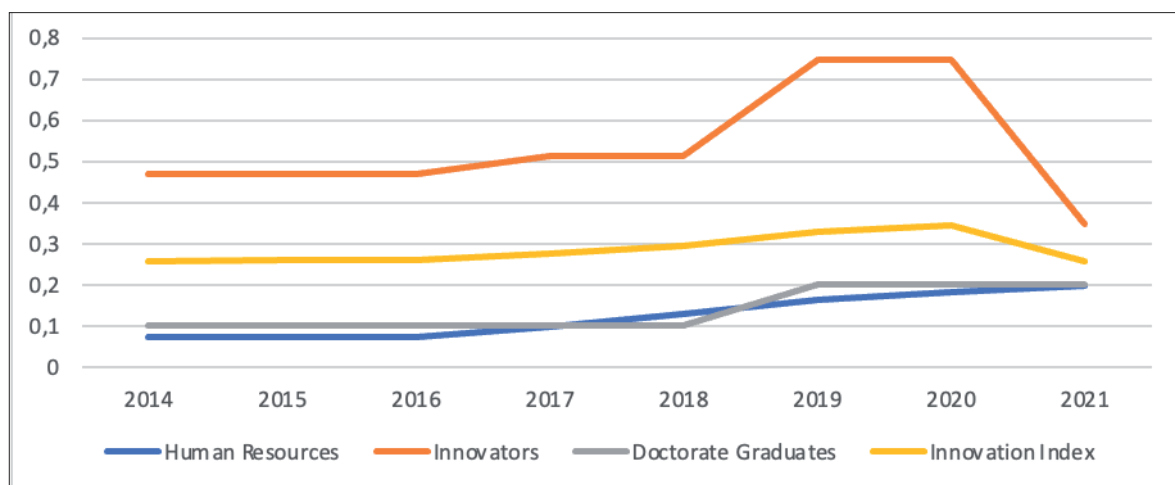
Data Resources
Ünlü, F. (2014). European Union Innovation Scoreboard And Turkey: A Comparative Assessment, <i>Erciyes Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi</i> , 42 (Temmuz-Aralık), 161-192.
https://fikrimulkiyet.com/dunyada-ve-ulkemizde-patent-sayilari/
https://data.tuik.gov.tr/Bulten/Index?p=Arastirma-Gelistirme-Faaliyetleri-Arastirmasi-2020-37439#:~:text=Tam%20 zaman%20e%C5%9Fde%C4%9Feri%20(TZE)%20 cinsinden,Ar%2DGe%20personeli%20olarak%20 %C3%A7a%C4%B1%C5%9Ft%C4%B1.
https://data.tuik.gov.tr/Bulten/Index?p=Arastirma-Gelistirme-Faaliyetleri-Arastirmasi-2020-37439#:~:text=T%C3%9C%C4%B0K%20 Kurumsal&text=Gayrisafi%20yurt%20i%C3%A7i%20 Ar%2DGe,957%20milyon%20TL'ye%20y%C3%BCkseldi.
https://www.researchgate.net/publication/340982591_Turkiye'de_2000-2011_Yillari_Arasinda_Gerceklesen_Ar-Ge_Faaliyetlerinin_Degerlendirilmesi
https://www.sbb.gov.tr/bilim-teknoloji-ve-yenilik-gostergeleri/
https://www.theglobaleconomy.com/Turkey/GII_Index/
https://ec.europa.eu/docsroom/documents/46934

For comparisons, year 2019 was accepted as beginning year of the pandemic and before and after the 2019 was accepted as pre-pandemic and pandemic years, respectively. In data analysis, each indicator was examined by comparing the quantitative data before and during the pandemic years.

IV. RESULTS

The results of the study are represented by human resources aspect, investment and expenditure, digitalisation and product components of innovation. All of the indicators were examined in terms of years before and during the pandemics. For the first research question (Is there any difference in innovation performances of Turkey in terms of human resources before and during the pandemic years?), the comparisons were conducted in terms of general innovation index, human resources, number of innovators and number of doctorate graduate in Turkey. The results are represented in Figure 1.

Figure 1 represents that there are parallel trends in increase of human resources, number of innovators, number of doctorate graduates and innovation index in Turkey up to 2018. However, a significant increase in number of innovators in 2018 has been observed whereas a significant decrease in number of innovators after 2020. For the second research question (Is there any difference in innovation performances of Turkey in



Resource: <https://ec.europa.eu/docsroom/documents/46934>

Figure 1. Innovation index, human resources, number of innovators and number of doctorate graduates in Turkey

terms of investments and digitalisation before and during the pandemic years?), the comparisons were performed in terms of general innovation index, firm investments and digitalisation. The findings are represented in Table 2.

Table 2. Values on innovation index, firm investments and digitalization in Turkey

Year	Innovation Index	Firm Investments	Digitalization
2014	0.257	0.470	0.326
2015	0.261	0.472	0.326
2016	0.261	0.477	0.326
2017	0.277	0.479	0.326
2018	0.294	0.488	0.392
2019	0.329	0.494	0.447
2020	0.344	0.504	0.456
2021	0.258	0.248	0.520

Note: Firm investment normalized score: R&D expenditure business sector, Non-R&D innovation expenditures, Innovation expenditure per person employed; Digitalization: Broadband penetration, individuals who have above basic overall digital skills; Innovation Index: Equally weighted indicators score (32 indicator).

Source: <https://ec.europa.eu/docsroom/documents/46934>

The table 2 represent data about three different indicators regarding innovation activities of Turkey across different years. The table revealed that innovation index scores of Turkey increased

up to 2020 in spite of its lower levels than EU average. However, the index score decreased in 2021. Similarly, firm investments regarding innovation increased while there was a clear decrease in 2021. In terms of digitalization, a continuous increase was observed. For the third research question (Is there any difference in innovation performances of Turkey in terms of R&D expenditure, number of R&D personnel, number of approved patent and general innovation performance before and during the pandemic years?), the comparisons were performed in terms of R&D expenditure, number of R&D personnel, number of approved patent and general innovation performance. The findings are represented in Table 3.

Table 2 revealed that Turkey's innovation performance increased slightly even if it is under the level of EU average. However, Turkey increased both number of R&D personnel and R&D expenditure, also number of patents increased over the time except for 2019. After 2018, a decline was observed in number of patent. Similarly, innovation performance of Turkey was declined in 2019. For looking picture and associations between the variables in detail, the following figure was developed (Figure 2).

Table 3. Turkey's Innovation Performance, Number of R&D Personals, R&D Expenditure and Number of Approved Patent Across Different Years between 2011 and 2020

Year	R&D Expenditure (Billion TL)	Number of R&D Personnel (x100)	Number of Patents Approved by Authority	Innovation Performance (0-1000)
2011	11,15	1374,52	714	341
2012	13,06	1551,33	879	341
2013	14,81	1660,97	1068	382
2014	17,6	1815,44	1141	378
2015	20,62	1907,84	1471	390
2016	24,64	1917,69	1563	389
2017	29,86	2107,69	1713	374
2018	38,53	2300,30	2558	369
2019	45,95	2437,73	1740	349
2020	54,95	2579,30	1903	383

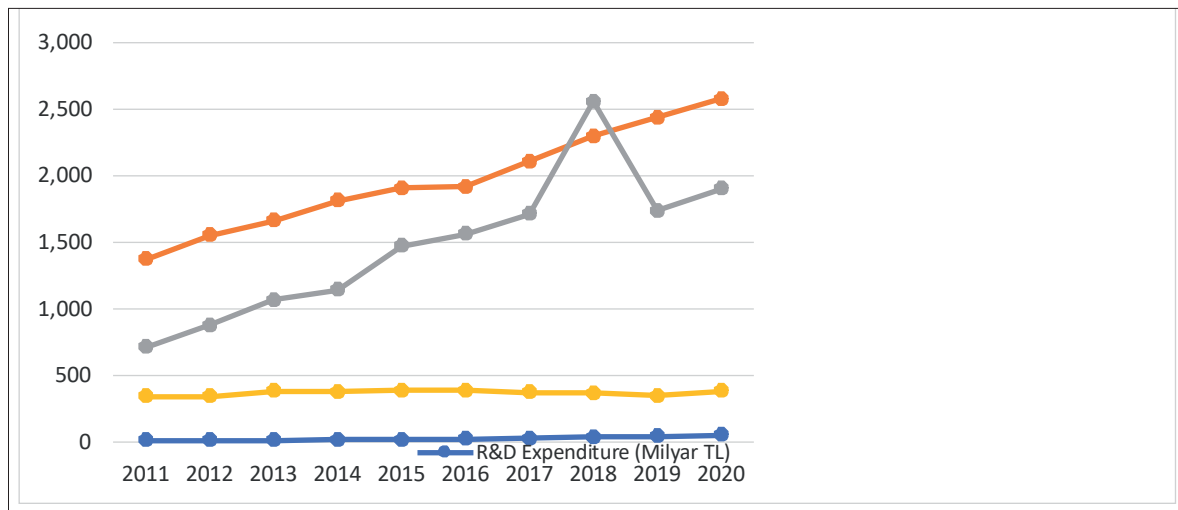


Figure 2. Distribution of Turkey's Innovation Performance, Number of R&D Personnel, R&D Expenditure and Number of Approved Patent Across Years between 2011 and 2020

In the Figure 2, it is seen that number of patents approved by authority and number of R&D personnel have been increasing over time, R&D expenditure and innovation performance have not been changing in similar trend. Another important point in the figure is about the decline after 2018 in terms of the number of approved patent. If we looked at the figure, it is also seen that increase in R&D expenditure was hold stable in 2018 and following years

V. DISCUSSION

The findings of the study revealed that the pandemic negatively affected the number of innovators, innovation index value, firm investment rates and number of patents approved by authority. However, number of R&D personnel, R&D expenditure, digitalisation and number of doctorate graduates in Turkey have not been affected in a negative way in pandemic conditions. Based on these findings, it can be said that pre-pandemic and pandemic years represented different trends in change in innovation performance indicators of Turkey in terms of number of R&D personnel, R&D expenditure, digitalisation and number of doctorate graduates. It is seen that there is no direct relationship between number of R&D personnel and number of approved patents and innovation performance. In other words, increasing number of R&D personnel does not

correspond to increasing number of innovators and innovation index value. This refers to failure of policy which targeted to increasing number of R&D personnel and human resources. Actually, this situation might be related to restricted movement of innovators to different countries due to COVID-19 pandemic conditions and staying in statistics record without making innovation activity. Kikkawa, et. al. (2021) stated that restrictions of COVID-19 pandemic showed its effect on labor mobility in employment, migration to rural and decreasing remittance flow. In developing countries, restricted labor mobility directed the migration from rural to local. Due to increases in life costs and unemployment rates, labor preferred to move their hometown. Gazzeh, Abubakar and Hammad (2022) also investigated the change in number of passengers during the pandemic across different regions of the World during the pandemic and they reported the decline of labor mobility in all regions of the World.

Another problem seen in the findings is that the decrease in number of innovators directly affected decrease in innovation index of Turkey. The main reason for this decrease might be related to abstain from making investment on innovations due to the fact that economic future of Turkey is not predictable. Innovators are in need of financial support from firms or official institutions. However, both firms and official institutions might not have been willing to support innova-

tions due to new economic changes in Turkey. Anisah (2021) reported decrease in investment Before and During the Covid-19 Pandemic and negative effects of it on economical activity. Also, direct foreign investments have been decreasing and inflation rate in Turkey has been increasing from 2018 to current date (TÜRMOB Ekonomik Rapor-2018, 2018). Hence it can be said that while human resources and doctorate graduates in Turkey were increasing innovators might not have found financial support for their ideas.

Another important finding is that there is no direct relationship between number of R&D personnel and number of approved patents and R&D expenditure in Turkey. This situation might be explained by lackness of a coherent policy between innovation, R&D activity, patenting and R&D expenditures. Peneder (2008) sees inconsistencies among policies as an important reason of system failure. Reflection of the system failure into the innovation systems is seen as dissociated components of the system involving no direct relationship between relationship between number of R&D personnel and number of approved patents and R&D expenditure.

As another important finding, number of patents approved by authority was decreased during the pandemic. Decrease in investment and increase in inflation might also have prevented entrepreneurs from starting new jobs using patents as their innovative activities. According to TÜRMOB Economic Report-2018, direct foreign investments in Turkey were decreased while inflation rate was increased from 2018 to current date (TÜRMOB Ekonomik Rapor-2018, 2018). R&D expenditure for patent producing and patent expenditure are two important components for making investment and also they carry out risk for investors. Limited capacity for investment prevents indirectly and directly new patent development.

If the findings are thought without thinking the pandemic situation, these findings have been indicating that increasing the number of R&D personnel and number of approved patent is not enough to higher level of innovation performance. When we looked at the literature, we can easily see that innovation has different aspects involv-

ing culture, networking, infrastructure and social change (Etzkowitz, 2019; Delbecq & Weiss, 2000). Silicon Valley is an important example for representing development of innovation culture. In Silicon Valley, availability of venture capital from large companies in Menlo park, close ties between business and local administration, flexible work environment, supportive networks between companies working in the same sector are observed (Perrin, 2002). Actually without investment on this kind of social structure and culture, innovation performance of a country cannot be easily increased. If only the increase in number of R&D personnel is considered, the main factors for increasing innovation performance of a country is not understood appropriately. In addition, quality of R&D personnel might be also be a reason for low level innovation performance of Turkey. Up to now, there is no information about quality of R&D personnel and categories of R&D personnel. Companies might record some workers as R&D personnel in spite of the fact that the workers have not been working in R&D activities.

In Turkey, development of innovation culture is behind the immediate financial benefits, since training, supporting and monitoring R&D personnel, providing flexible working conditions, giving value for activities regarding producing new goods and services are not considered in small or medium size companies. For example, existence of an R&D department in companies is not a common practice of Turkey's companies (Cetindamar & Ulusoy, 2008). Another important point for explaining gap between innovation performance of Turkey and, increasing number of approved patents and increasing number of R&D personnel is lack of R&D partnerships with foreign companies or outsourcing R&D activities. There is no clear information quality and quantity of R&D activities conducted with foreign companies. A company may not have any R&D department but it is possible that this company can make its R&D activities by cooperating and purchasing R&D support from another company located out of Turkey. Hence only reported number of R&D personnel can be seen while real innovation activities cannot be observed. Calculation of innovation performance

is very complicated and appropriate data should be collected by multiple resources from field studies rather than collecting data by nonly survey. Direct and indirect information and interaction of them make the calculations complicated. In this study, use of comprehensive models focusing on companies as unit of analysis in calculations are suggested, this way might provide a more concrete and systematic way for measurement of innovation performance of Turkey before and during the pandemic . Also, making calculations and evaluations from perspectives of different stakeholders might also provide different sides of the innovation performance of Turkey. Especially, after COVID-19 pandemic, by using different indicators, innovation performance of Turkey should be re-evaluated by authorities. After that time, changes caused by COVID-19 should also be added to the calculations of innovation performance.

VI. IMPLICATIONS

Based on the findings of this study, it can be suggested that alingment between policies regarding R&D personel, innovators, R&D expenditure, patenting and innovation support should be provided after the pandemic. Also, innovators and R&D personels should be attracted by providing rich ecosystems, appropriate payment policy and working conditions in the country. Fast screening system for innovation performance of the country should be developed. After the pandemic, changing sectors associated with innovation performance of the country should be examined and required changes in policies should be done.

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