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Araştırma Makalesi ● Research Article

Impact of the Technological Transformation in Employment and Export on Economic Growth in Turkey and the EU Countries in an Information Economy Projection: Dynamic Panel Data Analysis

Bilgi Ekonomisi Projeksiyonunda, Türkiye ve AB Ülkelerindeki İstihdam ile İhracatta Teknolojik Dönüşümün Ekonomik Büyüme Üzerindeki Etkisi: Dinamik Panel Veri Analizi

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ABSTRACT

The technological transformation experienced during the transition to the knowledge economy has made it necessary to increase the employment of R&D personnel and the export of high-tech products for countries that want to gain competitive advantage. This study was conducted to investigate the impact of the share of R&D personnel and researchers and the ratio of high-tech exports on economic growth in Turkey and 27 EU countries for the years 2007-2019. The results of the research using the Dynamic Panel Data Analysis method; It shows that the number of R&D personnel and researchers and high technology exports have a positive effect on economic growth, and the number of R&D personnel and researchers has a greater effect on growth.

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ÖZ

Bilgi ekonomisine geçiş sürecinde yaşanan teknolojik dönüşüm, rekabet üstünlüğü sağlamak isteyen ülkeler için Ar-Ge personeli istihdamını ve yüksek teknolojili ürün ihracatını artırmayı zorunlu hale getirmiştir. Bu çalışma, 2007-2019 dönemi için Türkiye ve 27 AB ülkesindeki Ar-Ge personel ve araştırmacı payı ile yüksek teknoloji ihracatı oranının ekonomik büyüme üzerindeki etkisini araştırmak amacıyla yapılmıştır. Dinamik Panel Veri Analizi yöntemi kullanılan araştırma sonuçları; Ar-Ge personel ve araştırmacı sayısı ile yüksek teknoloji ihracatının ekonomik büyümeyi pozitif etkilediğini, ayrıca Ar-Ge personel ve araştırmacı sayısının büyüme rakamları üzerindeki etkisinin daha büyük olduğunu göstermektedir.

1. Introduction

From past to present in the world history, societies have been exposed to many processes of change in the transition to the information economy. These processes are defined as agricultural society, industrial society and information society (Toffler and Toffler, 1996: 88). Developments in the field of science and technology within the scope of the transition to the information economy have had a positive impact on economic growth and enabled the revival of economic structures. Information economy is considered as the last stage of the process experienced in this context. The time between periods that have a significant impact on the economic life is getting shorter day by day because of the increase in the rate of progress and change (Erkan et al., 2013: 65). The information economy emerged in the 1950s. The economic obstacles that emerged in the industrial economy in the 1970s formed the development infrastructure

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of the information economy, and the information economy accelerated in the 1980-90s with the increase in the use of the information technologies. With the globalization after the 1980s, innovation began to be accepted as the driving force of quality, sustainable economic growth in terms of national economies, and contrary to the neo-classical economic view, technology was included in the model as an endogenous variable and entered the economics literature as an "Endogenous Growth Model" based on R&D. According to the Endogenous Growth Model, R&D activities, qualified human capital, new production technologies and products developed have begun to be accepted as the basic elements of economic growth.

In the endogenous growth theories, which became popular in the 1980s and were inspired by Schumpeter's theory of creative destruction, technology that will develop with the inventions and innovations in the economy is accepted as an endogenous variable, and it was also suggested that technology will be the driving force of international competition and economic growth (Fagerberg, 2003: 2-7). In the endogenous growth theories; qualified human capital, technological development, information, market width, R&D personnel and R&D activities are included in the endogenous variables (Aghion, 2000: 6). The process of accepting technology and R&D activities as an endogenous variable in economic growth theories that started with Schumpeter continued with the contributions of Romer (1989), Grossman and Helpman (1991), Aghion and Howitt (1992). It has been argued that the technological developments emerging as a result of R&D activities will increase the production and consumption levels in national economies by enabling more efficient use of scarce resources, and contribute positively to welfare level and economic growth (Verbic et al., 2011: 71). Technological developments and innovations not only increase economic growth with high-tech exports in terms of national economies, but also provide an increase in profitability, international competitive advantage, and market share. Thanks to the positive exogeneities that arise as a result of the creation of qualified human and physical capital by countries, long-term sustainable economic growth can be supported by providing returns increasing proportional to scale (Jones, 1995: 501).

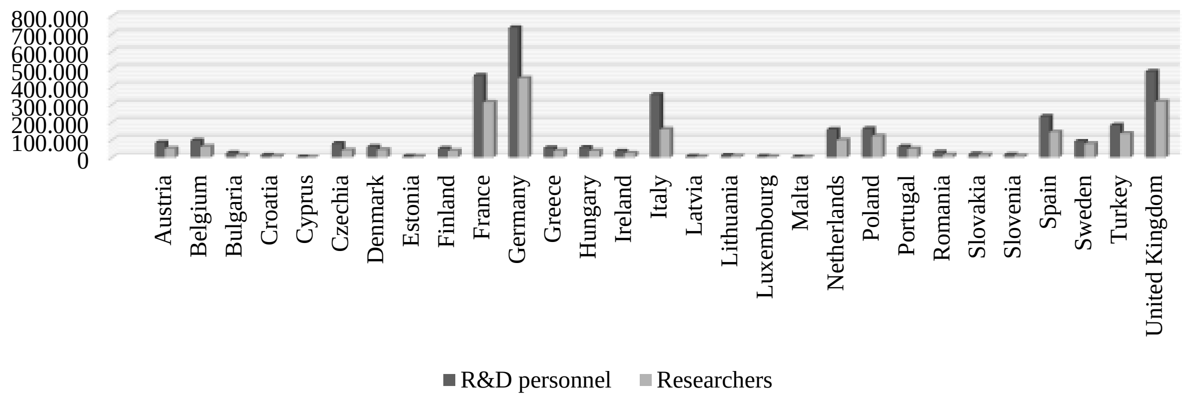
New products and technologies obtained as a result of R&D activities are offered to the foreign markets as well as the domestic market, and this enables national economies to export high technology. The fact that R&D investments appeal to international markets enables the realization of high-tech exports and encourages R&D activities by reducing their costs. Since this process makes the international competition arising from globalization dominant, it forces national economies to continuously develop new products and production methods, and to invest in qualified R&D personnel. Generally, R&D investments are made for industries such as defense, medicine, space technologies, information and communication sector, semiconductor and conductor metal, which use high technology production methods. Industries requiring high technology, such as those mentioned above, need qualified R&D personnel (Özer and Çiftçi, 2009: 40). In this context, information and communication technologies have an important place in terms of providing time and cost advantages by enabling production with lower costs in a shorter time since it accelerates the flow of information required in the production process (Bongo, 2005: 3). In terms of national economies, as a result of the increase in the production of the information and communication technologies, countries not only gain international competitive advantage, but also accelerate their economic growth with the increase in demand and productivity (Wangwe, 2007: 4). Despite this, underdeveloped or developing national economies may benefit from these technological advances at a limited level if they invest on information and communication technologies, but do not support these investments with investments on qualified human capital, physical infrastructure, education, law and health (Pohjola, 2000: 3). It is argued that increasing R&D expenditures and employment of qualified R&D personnel in national economies will increase the production and export of high-tech products, thus their total export and added value obtained from export will increase and the ratio of exports to imports will increase. It is advocated that as a natural result of this situation gross domestic product of national economies will increase with the positive impacts on foreign trade, and sustainable economic growth will be possible.

The orientation towards the information economy and innovation gains importance day by day in the world economy from the beginning 21st century to the present. Information economy refers to bringing information to the forefront in the production process and including it in production factors in order to enable it to contribute directly to economic growth and development. Information economy can have direct or indirect impacts on many micro and macroeconomic variables. In the microeconomic context, its impacts appear as a change in production, consumption and market structure. The use of information as an input in production not only contributes to technology development, but also brings an increase in output and productivity. In the macroeconomic context, its impacts appear as positive changes in the employment of qualified labor, foreign trade, and economic growth. Thanks to globalization and the information economy, while international borders can be eliminated and the producer-consumer can come together quickly and easily, the foreign trade volume of the countries can improve with the increase in export and import. In addition, the information economy also enables the employment of qualified labor force to increase by creating new businesses and occupational groups, as well as qualified labor productivity. The impact of the information economy on the economic growth in terms of national economy is attributed to creating new businesses and professions, supporting technological developments, increasing the employment of qualified labor force and productivity by transforming information into a production factor.

In the conjuncture of today's transition to the information economy, investment in R&D personnel and qualified personnel gains importance, but international interaction has become limitless thanks to the information and communication technologies (Masuda, 1990: 37). There are some basic factors that make up and develop the information economy. These factors are expressed as information workers, information and communication technologies, and globalization. Information workers are defined as qualified R&D personnel, who use and develop existing information and take a key role in accelerating the development of institutions/organizations by enabling them to use these information and technology they have developed. On the other hand, information and communication technologies are defined as an important factor that reduces the costs of accessing information by ensuring the use, storage, and dissemination of information. Globalization, which enables the aforementioned information and technologies to be developed and spread all over the world, is defined as the third fundamental factor (Yeloğlu, 2009: 322).

Although the concept of the information economy does not have a clear definition or limit, it is known that it expresses the post-industrial society and economy strategy, which is based on information and where information has a particularly important place. The information economy emerges as a new concept in addition to being an evolving and dynamic concept (Kırtay, 2020: 23; Teke, 2020: 10). There are three main features of the information economy. The first of these is the use of information as an economic resource. By using more information, organizations aim to promote innovation in addition to increase their productivity, competitive position, and effectiveness by improving the quality of the goods and services they produce. Second, information is more used by disseminating in all segments of the society. Third, information is developed within the economy. While the information industry functionally meets the demand that may arise for information services and facilities, this industry is growing faster than the economic growth in almost all information societies (Moore, 2008: 71-72).

Throughout its history, the technological transformation has played an important role in the realization of structural transformations in social and economic fields in terms of national economies. In today's world, with the development of technological transformation strategies by countries in order to become an information society, the technological transformation in the employment of qualified R&D personnel and exports not only transform production processes and social structure, but also bring a process that affects economic growth. This transformation process has an important place for national economies in terms of enabling them to make their economic growth sustainable and gain competitive power. As a matter of fact, most of both the developed and developing countries are trying to accelerate their R&D investments by increasing the employment of R&D personnel and researchers in order to be effective in this transformation process and to gain global competitiveness. EU countries, which show the most concrete examples of this effort, have set various targets in the field of science and technology, and produced policies in this direction. Aiming for a smart, inclusive, and sustainable economic growth with its "Europe 2020 strategy", the EU has aimed to increase its R&D expenditures above 3% of GDP (European Commission, 2020b: 2). In line with this goal, both the quantity and the quality of the R&D personnel and researchers employed in the labor market of the member countries are important in increasing R&D activities. Thus, aiming to reduce external dependency in the field of information and technology with the awareness of this fact, the EU targets to increase the number of its employees in the field of informatics and technology to 20 million by 2030 (European Commission, 2021: 5)



Graph 1. Total number of R&D personnel and researchers (2019)

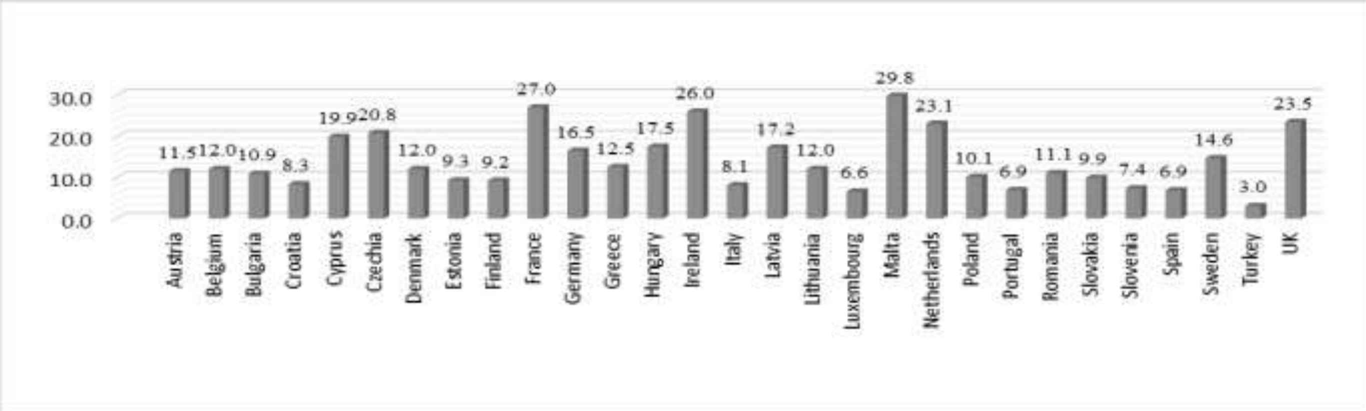
Source: Created by the authors, using the European Statistical Office (Eurostat) database. (Accessed on 12.01.2021) https://appsso.eurostat.ec.europa.eu/nui/show.do

Graph 1 shows the total number of R&D personnel and researchers employed in the active population of the EU countries in 2019 as full time equivalent (FTE) and provides the opportunity to evaluate the chance of the union to achieve its 2030 target. According to the European Statistical Office (Eurostat), 3,415,383 R&D personnel and 2,175,094 researchers were employed throughout the union in 2019 (https://appsso.eurostat.ec.europa.eu/nui/show.do).

According to the graph prepared with the data in the European Statistical Office's database, the highest number of R&D personnel and researchers are employed by Germany, and it is followed by the UK. It is likely that the UK's exit from the union in January 2020 will negatively affect the numbers of R&D personnel and researcher employed throughout the union. While France and Italy are among the countries with high numbers in the employment of R&D personnel and researchers, the employment of R&D personnel and researchers is at low levels in countries such as Malta, Estonia, Cyprus, Latvia and Luxembourg.

Graph 1 also includes data belonging to Turkey, which applies common policies with the EU in the field of technology. 182,847 R&D personnel and 135,515 researchers were employed by Turkey in 2019. According to these figures, Turkey is in front of many countries having advanced information and technology infrastructure such as Sweden, Finland, Luxembourg, Denmark and Holland. However, the population density of the countries should be considered while evaluating Graph 1.

In addition to the employment of R&D personnel, which has an important place in terms of its impact on economic growth and the welfare of countries, high-tech exports can fulfill their mission with the increase of productivity in today's world, where international competition has increased with globalization. The EU is behind the USA and China in critical technologies, and in order to close this gap it has given importance to the production of high-tech products because of the added value such products create.



Graph 2. High-tech Exports (%)

Source: Created by the authors, using the World Bank database. (Accessed on 10.01.2021) https://databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.MKTP.KD.ZG&country=#

Graph 2 shows the share of high-tech exports in the manufacturing industry in Turkey and the EU member states. According to the graph compiled by using the data in the World Bank database, the highest high-tech exports are carried out by Malta with a ratio of 29.78%. France, Ireland, the Netherlands, and the UK can be counted among the countries that show high performance in this field. However, as seen from the graph, Turkey shows the weakest performance on the export of technology with a ratio of 3.04%. Turkey is followed by countries such as Luxembourg, Spain, and Portugal.

Table 1. EU countries and Turkey by their innovation performances

Innovation Leaders	Strong Innovators	Moderate Innovators	Modest Innovators
		Croatia	
Sweden	Belgium	Cyprus	Bulgaria
Finland	Germany	Czechia	Romania
Denmark	Austria	Greece	
Netherlands	Ireland	Hungary	
Luxembourg	France	Italy	
	UK	Latvia	
	Estonia	Lithuania	
	Portugal	Malta	
		Poland	
		Slovakia	
		Slovenia	
		Spain	
		Turkey	

Source: (European Commission, 2020a: 8).

Turkey and the EU have created various programs under common policies to raise their competitiveness in the fields of information and technology, and to increase the use of information and technology in all areas. In addition to these common policies, countries have implemented policies for R&D activities within their own organizations. However, since the member countries differ in terms of population, area and development level, the policy results also vary from country to country. In this context, innovation performances occurring as a result of the R&D investments realized by the R&D personnel and researchers employed are in different dimensions in the union countries and Turkey. Considering these differences, countries have been classified and reported since 2001 with indicators consisting of various criteria under the supervision of the European Commission. In the report referred to, as the "European Innovation Scoreboard", the innovation performances of countries such as Turkey, Norway, Iceland, Israel, Serbia, and Switzerland in addition to the EU member states are also measured (European Commission, 2020a: 25). In performance measurement;

twenty-seven indicators are used within ten innovation dimensions under four activity types, consisting of staffing conditions, investments, innovation activities and impacts. Among these indicators there are items such as new PhD graduates, highly educated population between the ages of 25-34, lifelong learning activities, international joint scientific publications, foreign doctoral students, opportunity-oriented entrepreneurship, R&D expenditures of private and public sectors, non-R&D innovation expenditures, enterprises that train their personnel on information and technology applications, PCT patent applications, SMEs that make intellectual property, trademark applications, product and process innovations, SMEs with marketing and organizational innovations, SMEs with in-house innovations, innovative SMEs cooperating with other organizations, public-private joint publications, employment in information-intensive activities, medium and high technology product exports, information-intensive service exports. The performances of the EU countries and Turkey's innovation systems are measured by the "Summary Innovation Index", which is a compound indicator obtained by taking unweighted average of 27 indicators. According to this index, countries are classified into four performance groups as innovation leaders, strong innovators, moderate innovators, and modest innovators (European Commission, 2020a: 8). Table 1 shows the innovation performances of the EU countries and Turkey according to the summary innovation index score calculated lastly in 2018 by reference to the year 2012.

In the present study, the impact of R&D personnel and researchers employed in the EU countries and Turkey and high-tech product exports on economic growth is examined by considering the countries' innovation performances. Within the scope of the study, examples of previous studies on the subject were presented, and then econometric analysis was carried out using the dynamic panel data method. After interpreting the data obtained as a result of the econometric analysis, various policy recommendations are made in the conclusion part.

2. Literature Review

In this study, the impact of R&D personnel and researchers, and high-tech exports on economic growth was investigated for the EU countries and Turkey. Although there are many studies on this subject in the literature, these studies focus on the relationship between R&D expenditures and economic growth. However, it has been observed that studies on the relationship between the number of R&D personnel and economic growth are limited. The reason for focusing on the number of R&D personnel and researchers in the study is to draw attention to the expenditures of R&D personnel, which have the highest share in R&D expenditures. For example, Germany made a total of 99,553,616 million Euros R&D expenditure in 2017, and about 60% (59,779,431 million Euros) of this expenditure consists of labor costs (https://appsso.eurostat.ec.europa.eu/nui/submitViewTable Action.do). However, the share of personnel expenditures in total R&D expenditures made in 2019 by Turkey is 51.6% (https://tuikweb.tuik.gov.tr/PreHaberBultenleri.do?id=3367 6). In this context, assuming that the number of R&D personnel and the amount of R&D personnel expenditure are directly proportional, it can be concluded that the majority of the change in R&D expenditures is due to the change in the number of R&D personnel. Therefore, empirical studies dealing with the relationship between R&D expenditures and economic growth were also included in the literature review. In addition, scientific researches pointing to the relationship between high-tech exports that point to a technological transformation in exports and economic growth are also been included in the literature review.

In the study where they tested R&D-based economic growth models for the US economy, Aghion and Howitt (1992) found that there is no strong relationship between R&D expenditures and economic growth, but they did not reject the R&D-based endogenous growth model, and they argued that the share of R&D expenditures in GDP should be increased.

In the study by Lichtenberg (1993) in which the causality relationship between variables was analyzed by using private and public R&D expenditures and economic growth data sets for the years of 1964-1989 on 74 national economies, although causality relationship between private sector R&D expenditures and economic growth was found, there was no causality relationship between public sector R&D expenditures and economic growth.

In the study conducted by Landesmann and Pfaffermayr (1997) on the economies of OECD countries for the years 1967-1987, although it was found that R&D expenditures had a positive impact on exports in Japan, England and the USA, it was found that R&D expenditures had a negative impact on exports in France and Germany. This situation is attributed to the possibility that the increase in R&D expenditures cause a decreasing return in terms of the economies of the mentioned countries.

In the study conducted by Bassanini and Scarpetta (2001), the impact of R&D expenditures on economic growth in 21 OECD economies was analyzed by panel data analysis method, and it was determined that R&D expenditures have a positive impact on economic growth. It was found that a 1% increase in R&D expenditures causes an increase of 0.4% on economic growth.

In the study of Ülkü (2004) on the economies of 10 OECD non-member and 20 OECD member countries, the relation of innovation and R&D investments with per capita GDP was analyzed using panel data analysis method with the data sets for the years 1981-1997, and although a strong correlation between variables was obtained for both country groups, it was found that R&D investments in OECD member countries were supported by innovation investments.

In the analysis conducted by Wörz (2004) using the Dynamic Panel Regression Analysis method of the data sets of 45 OECD countries for the years 1981-1997, it was found that specialization in industrial export products positively affected economic growth.

In a study, Cuaresma and Wörz (2005) analyzed the data sets of 45 industrialized and developing national economies for the years 1981-1997 with the help of the Random Effects Model, it was concluded that high-tech product exports have a positive impact on economic growth.

In the study conducted by Değer (2007) using the Panel Data Regression Analysis method with the data sets of the middle-income countries for the years 1982-2004, it is found that high-tech exports have a positive impact on economic growth, and that the most significant impact on economic growth is the exports of the qualified labor-intensive manufacturing industry.

In the study, Braunerhjelm and Thulin (2008) analyzed the impact of R&D expenditures and high-tech product exports on economic growth using the panel data analysis method with the data sets of 19 OECD member countries for the years 1981-1999, it was found that a 1% increase in R&D expenditures led to a 3% increase in high-tech product exports. In addition, the study concluded that economic growth has no impact on high-tech exports.

In the study they investigated the impact of R&D expenditures on economic growth by using 2000-2006 data sets belonging to 30 developing countries, Samimi and Alerasoul (2009) investigated the impact of R&D expenditures on economic growth, and concluded that R&D expenditures do not affect economic growth.

In their study using advanced panel data technique, Özer and Çiftçi (2009) investigated the relationship between R&D expenditures and high-tech exports in OECD countries, and found that there is an intense and positive relationship between variables.

In the study they conducted by using VEC (Vector Error Correction) model, Altın and Kaya (2009) investigated the causality relationship between R&D expenditures and economic growth in Turkey's economy, and found that although there is no relationship between the variables in the short-term, R&D expenditures have an impact on economic growth in the long-term.

In a study, Erdil (2009) analyzed the relationship between high-tech exports and economic growth by using VEC (Vector Error Correction) method with the data sets of 131 national economies including Turkey for the years 1995-2006, and it was found that high-tech exports have a positive impact on economic growth by accepting that human and physical capital is a production factor.

In the study conducted by Lee and Hong (2010) using data sets of 71 national economies for the years 1970-2004, it was found that countries that export low technology and traditional products have lower economic growth rates compared to countries that export high technology. It has been concluded that the national economies that export high technology are more advantageous than other countries in terms of economic growth rate and international competitive advantage.

In the study in which Korkmaz (2010) investigated the relationship between R&D expenditures and economic growth by using Johansen cointegration method with the data sets belonging to Turkey for the years 1990-2008, although it was found that there is a significant relationship between the variables in the long-term, it was also found that there is a causality relationship from R&D expenditures to GDP as a result of the Granger causality test.

In the study Kılavuz and Altay Topçu (2012) analyzed the relationship between manufacturing industry exports and economic growth by using the data sets of 22 national economies including Turkey for the years 1998-2006, a significant and positive relationship between the variables were found in 22 countries included in the study.

In the study they conducted by using Panel Data Analysis with the data sets of G8 countries for the years 1996-2011, Kılıç et al. (2014) determined the share of real effective exchange rate and R&D expenditures in national income as explanatory variables. In the study, it was found that both variables gave positive and significant results, as well as a one-way causality relationship from R&D expenditures to exports.

In the study conducted by Telatar et al. (2016) using the data sets of Turkey's economy for the years 1996-2015, the impact of technology intensive goods and services exports on economic growth was analyzed. In the study, it was found that the export of low and medium technology products has a significant and positive impact on economic growth, and there is a one-way causality relationship from middle and high technology product exports to economic growth.

In the study Maradana et al. (2017) analyzed the relationship between innovation and GDP per capita by using the data sets of 19 EU countries for the years 1989-2014, it was found that there is a significant and positive relationship between innovation and GDP per capita variables.

Bayraktutan and Kethudaoğlu (2017) analyzed the impact of R&D expenditures and the number of R&D personnel on economic growth in 29 OECD countries, based on the period between the years 1996-2015. As a result of the empirical analysis, it was found that a 1% increase in R&D intensity increases the growth rate by 15.5%, and that a 1% increase in the number of researchers employed increases GDP per capita by 2.64%.

In the study Kızılkaya et al. (2017) analyzed the data sets of 12 developing national economies for the years 2000-2012 by using Panel Cointegration Test method; per capita income, patent applications, R&D expenditures, openness and direct investments were determined as explanatory variables. In the study, it was determined that all variables give significant and positive results.

Akarsu et al. (2020) empirically examined the effects of R&D expenditures and the number of patents on economic growth in 14 selected countries for the years 1996-2017. As a result, they estimated that a 1% increase in R&D expenditures increased economic growth by 0.87 points.

Kose and Gültekin (2020) empirically analyzed the relationship between R&D investments, high-tech product exports and economic growth in 12 OECD countries for the period 1996-2017 with panel data analysis. As a result, it has been determined that R&D investments and high technology exports interact with each other. Also, another finding is that the impact of R&D investments and high technology exports on economic growth was significant.

3. Economistic Application

3.1. Model Explored in Econometric Application, Purpose of the Model, and the Data Set

The purpose of this study is to examine the impact of the number of R&D personnel and researchers employed in Turkey and the EU between the years 2007-2019 and high-tech exports on economic growth. In the study, data of Turkey and 27 European Union (EU) countries including the UK but excluding Greece (due to the problem of finding data on the variables used in the model) were used. However, these countries were divided into two groups because of the difference in their invention and innovation creation performance. The first group consists of 13 countries as innovation leaders and strong inventors (UK, Sweden, Finland, Denmark, Netherlands, Luxembourg, Belgium, Germany, Austria, Ireland, France, Estonia, Portugal) where the second group covers 15 countries as moderate and modest inventors (Spain, Slovenia, Cyprus, Czech Republic, Malta, Italy, Lithuania, Romania, Slovakia, Hungary, Latvia, Poland, Croatia, Bulgaria and Turkey). The ratio of the number of full-time equivalent R&D personnel and researchers employed in all sectors to the active population taken from the European Statistical Office (Eurostat) was used as an indicator of the number of R&D personnel and researchers (RDP) employed in the two different models established for these two groups. The share of high-tech product exports within the manufacturing industry products as an indicator of high-tech exports (HTE), and the annual increase rate in GDP as an indicator of economic growth (GDP) were obtained from the World Bank database.

3.2. Method and Application Results Used in the Econometric Application

First stationary of the variables were examined in order to achieve healthy results in the study where the impact of R&D personnel and researchers employed in Turkey and the EU, and high-tech exports on economic growth was investigated by using the dynamic panel data method. Stationarity is found by determining how the value of the series in the previous period affects its current value. In order to determine this interaction, the unit root tests of Levin, Lin & Chu (LLC) (2002), and Im, Pesaran and Shin (IPS) (2003), which are frequently encountered in the literature, were applied to the variables.

Table 2 shows the unit root test results of Levin, Lin and Chu (LLC), and Im, Pesaran and Shin (IPS) applied to fixed and fixed + trend models of GDP, RDP and HTE series belonging to innovation leader and strong innovator countries. According to the test results applied to both the level and first difference taken values of the series, the GDP and HTE series are stationary at the level of both tests. However, RDP series is not stationary at level [I(0)] and contains unit root. Therefore, the first difference of the series was taken, and Levin, Lin and Chu (LLC), and Im, Pesaran and Shin (IPS) tests were performed again, and it was determined that the series did not become stationary again. As a result of this situation, the second difference of the series was taken and the unit root in the series was eliminated.

Table 2. Panel unit root test results for innovation leader and strong innovator countries

Variable	Levin, Lin and Chu (LLC)			
	I (0)		**I(1)**	
	Fixed	Fixed +Trend	Fixed	Fixed +Trend
GDP	-8.65928 (0.0000)	-17.9091 (0.0000)	-31.4797 (0.0000)	-37.3011 (0.0000)
HTE	-7.03514 (0.0000)	-8.06922 (0.0000)	-7.72598 (0.0000)	-7.16781 (0.0000)
RDP	5.05342 (1.0000)	3.65371 (0.9999)	1.00915 (0.8435)	-1.05537 (0,1456)
	I(2)			
	Fixed		**Fixed +Trend**	
	-2.73346 (0.0031)		-2.15720 (0.0155)	
Variable	**Im, Pesaran and Shin (IPS)**			
	I (0)		**I(1)**	
	Fixed	Fixed +Trend	Fixed	Fixed +Trend
GDP	-5.53486 (0.0000)	-9.84461 (0.0000)	-20.3714 (0.0000)	-19.8984 (0.0000)
HTE	-2.91735 (0.0018)	-1.98665 0.0235	-4.72677 (0.0000)	-3.46298 (0.0003)
RDP	5.68823 (1.0000)	2.22910 (0.9871)	-1.65859 (0.0486)	-0.74487 (0.2282)
	I(2)			
	Fixed		**Fixed +Trend**	
	-5.46663 (0.0000)		-2.20683 (0.0137)	

LLC and IPS unit root test results applied to fixed and fixed + trend models of GDP, RDP and HTE series belonging to moderate innovator and modest innovator countries are reported in Table 3. According to the Levin, Lin and Chu (LLC) test, while GDP and HTE series are stationary at the level, RDP series becomes stationary when the first difference is taken. The IPS test of the GDP series also gave similar results to the LLC test. According to the results of the IPS test, the HTE series is stationary at the level of the fixed model at the 5% significance level, while it is not stationary at the level at the fixed and trend model. However, when the first difference of the said series is taken, it is seen that it becomes stationary according to the same test and gets rid of unit root. The Im, Pesaran and Shin (IPS) unit root test applied to the RDP series shows that the series is not stationary at the level, and it is stationary when the first difference is taken in the fixed model, and includes unit root in the trend model.

Tablo 3. Panel unit root test results for moderate and modest innovator countries

Variable	Levin, Lin and Chu (LLC)			
	I (0)		I(1)	
	Fixed	Fixed +Trend	Fixed	Fixed +Trend
GDP	-8.10968 (0.0000)	-21.9489 (0.0000)	-32.0911 (0.0000)	-28.2346 (0.0000)
RDP	1.70576 (0.9560)	-2.72583 (0.0032)	-4.09251 (0.0000)	-4.29943 (0,0000)
HTE	-4.14114 (0.0000)	-4.36868 (0.0000)	-8.88759 (0.0000)	-7.99312 (0.0000)
Variable	**Im, Pesaran and Shin (IPS)**			
	I (0)		**I(1)**	
	Fixed	**Fixed +Trend**	**Fixed**	**Fixed +Trend**
GDP	-5.37888 (0.0000)	-13.1234 (0.0000)	-21.7035 (0.0000)	-16.3948 (0.0000)
RDP	2.69987 (0.9965)	0.23651 (0.5935)	-2.30835 (0.0105)	-1.37337 (0.0848)
HTE	-1.97454 (0.0242)	-1.60333 (0.0544)	-5.90684 (0.0000)	-3.56966 (0.0002)

After investigating stabilities of the series with panel unit root tests, the impact of R&D personnel and researchers employed in Turkey and the EU, and high-tech product exports on economic growth was estimated by the difference “Generalized Moment Method” (Difference-GMM) suggested by Arellano and Bond (1991), and the “Generalized Moments Method” (System-GMM) developed by Arellona and Bover (1995), which are among dynamic panel data methods. These estimators are methods in which the time frame is short, but the cross section is large, and the present value of the dependent variable is affected by its past values (Roodman, 2009: 86). Dynamic panel data model in which lagged values of the dependent variable are included in the model as explanatory variable, and the error term are shown by Baltagi (2005: 135) as in the following equations (1, 2).

$$y_{it= \delta\, y_{it-1}} + x'_{it-1}\beta + u_{it} \quad (1)$$

$$u_{it} = \mu_i + v_{it} \quad (2)$$

The Arellano and Bond Generalized Moments method is also suitable for the models where the error terms are autocorrelated, and the first difference model is transformed with the instrumental variable matrix, and this new model is estimated using the generalized least squares method. Therefore, this method is also called “two-stage instrumental variables estimator” (Yerdelen Tatoğlu, 2018: 129).

The first difference transformation in the Arellano and Bond Generalized Moments method has weaknesses such as increasing the deficiencies in unbalanced panels. For example, if some y_{it}s are missing, both Δy_{it} and Δy_{it-1} are missing in the transformed model (Roodman, 2009: 104). In addition, the Arellano and Bover (1995) orthogonal deviations estimator is more useful when there are many autoregressive parameters in the model and the ratio of the variance of the heterogeneity specific to cross-sections to variance of the error is large. In this method, the data loss caused by the first differences method is minimized by taking the difference of the average of all possible future values of a variable (Yerdelen Tatoğlu, 2018: 136).

The Arellano and Bover method was developed in the following years by Blundell and Bond (1998). Blundell and Bond reviewed the importance of utilizing the initial condition in generating efficient estimators in the dynamic panel data model with a small time dimension (t), and stated that an additional slight stationarity constraint can be added to the initial conditions process.

The models estimated by the Difference-GMM and System-GMM methods in the study are as follows (3 and 4):

Model 1: $gdp_{it} = a_0 + \beta_1 gdp_{it-1} + \beta_2 agp_{it} + u_{it}$ (3)

Model 2: $gdp_{it} = a_0 + \beta_1 gdp_{it-1} + \beta_2 yti_{it} + \varepsilon_{it}$ (4)

Table 4 shows the Difference-GMM and System-GMM estimate results of model 1 and model 2 for 13 EU countries (UK, Sweden, Finland, Denmark, Netherlands, Luxembourg, Belgium, Germany, Austria, Ireland, France, Estonia, Portugal) comprising innovation leaders and strong innovators. As can be seen in the table, the impact of the number of R&D personnel and researchers on economic growth was analyzed in model 1. In model 1, the lagged value of the dependent variable (GDP) is positive and significant at 1% significance level according to both the Difference-GMM and System-GMM estimation results. In addition, the impact of the number of R&D personnel and researchers employed in 13 EU countries with quite good innovation performance on economic growth is statistically significant at the 5% significance level in the Difference-GMM method and 1% in the System-GMM method, and is positive in line with the expectations.

In model 2, the impact of high-tech exports on economic growth was analyzed, and the results are reported in Table 4. Accordingly, the lagged value of the dependent variable

(GDP) is positive and significant at 1% significance level according to both the Difference-GMM and System-GMM estimation results. In addition, the estimation results obtained in both methods of high-tech exports indicated with the HTE symbol are positive, that is, high-tech exports contribute positively to economic growth. However, this result is significant at the 5% significance level in the Difference-GMM method, while it is significant at the 1% significance level in the System-GMM method.

When the results of model 1 and model 2 in Table 4 are examined, it can be seen that the coefficients of the RGP and HTE variables are positive and significant. However, it seems that the coefficient of the RGP variable is much higher than the HTE variable. This situation can be interpreted as the increase in the employment of R&D personnel and researchers will contribute to economic growth at a higher rate than high-tech exports.

Table 4 also shows the diagnostic test results performed to test the consistency of model 1 and model 2 estimated by two different panels GMM. While the Sargan test determines whether the instrumental variables have an endogeneity problem or not, that is whether they are exogenous, the Arellano-Bond (AB) test was used to determine whether there is a 1st or 2nd degree autocorrelation problem in the model. According to results of the Sargan test, which tested the H_o hypothesis as “Instrumental variables are exogenous”, the mentioned hypothesis was accepted because the probability values in both GMM methods in model 1 and model 2 were greater than 0.05 (p> 0.05). Test results of the Arellano-Bond (AB) test, which tested the H_o hypothesis as “There is no autocorrelation”, support that there is no autocorrelation problem in the model. As a matter of fact, the probability values of AR(1) and AR(2) test statistics of the estimation results obtained for model 1, made according to the Difference-GMM method, are greater than 0.05. According to the results obtained for model 2, while there is a first-order autocorrelation problem in the model, there is no second-order autocorrelation.

Table 4. Dynamic Panel GMM Estimation Results for innovation leader and strong innovator countries

Explanatory Variables	**Difference GMM**		**System GMM**	
	Two-stage GMM		**Two-stage GMM**	
	Model 1 (Dependent Variable GDP)	Model 2 (Dependent Variable GDP)	Model 1 (Dependent Variable GDP)	Model 2 (Dependent Variable GDP)
GDP	0.078539 (0.0002) ***	0.218399 (0.0000) ***	0.084795 (0.0000) ***	0.221649 (0.0000) ***
RDP	3.446476 (0.0241) **	-	2.818145 (0.0097) ***	-
HTE	-	0.118243 (0.0377) **	-	0.105371 (0.0016) ***
	Diagnostic Tests			
	Model 1	Model 2	Model 1	Model 2
Sargan Test	10.48257 (0.399222)	12.50940 (0.326595)	10.59082 (0.390272)	11.74443 (0.383157)
AR (1) test	-1.02555 (0.3051)	-2.607706 (0.0091)	-	
AR (2)test	-1.79109 (0.0733	-1.426322 (0.1538)	-	

• Means significance at * 10%, ** 5%, *** 1% levels.

Table 5 reports the Difference-GMM and System-GMM estimation results of model 1 and model 2 for 15 countries including Turkey consisting of moderate and modest innovators (Spain, Slovenia, Cyprus, Czech Republic, Malta, Italy, Lithuania, Romania, Slovakia, Hungary, Latvia, Poland, Croatia, Bulgaria and Turkey). The table shows that the lagged value of the dependent variable (GDP) in model 1 is positive and significant at 1% significance level according to both the Difference-GMM and System-GMM estimation results. The impact of the number of R&D personnel and researchers on economic growth is statistically significant at 1% significance level in both GMM methods, and their coefficients are quite high and positive.

According to the Difference-GMM and System-GMM results of model 2 in Table 5, the lagged value of the dependent variable (GDP) is positive and significant at 1% significance level according to both GMM estimation results. According to the panel GMM results of high-tech exports, shown with the HTE symbol, the contribution of high-tech products to economic growth is positive, and this result is significant at 1% significance level in both GMM methods.

Table 5. Table GMM Estimation Resulstf for moderate and modest innovator countries

Explanatory Variables	**Difference GMM**		**System GMM**	
	Two-stage GMM		**Two-stage GMM**	
	Model 1 (Dependent Variable GDP)	Model 2 (Dependent Variable GDP)	Model 1 (Dependent Variable GDP)	Model 2 (Dependent Variable GDP)
GDP	0.184609 (0.0000) ***	0.259825 (0.0000) ***	0.180156 (0.0000) ***	0.274548 (0.0000) ***
RDP	25.60872 (0.0000) ***	-	23.76838 (0.0000) ***	-
HTE	-	0.183424 (0.0000) ***	-	0.099682 (0.0038) ***
	Diagnostic Tests			
	Model 1	Model 2	Model 1	Model 2
Sargan Test	14.7592 (0.321550)	13.89250 (0.307625)	14.72481 (0.324846)	14.48208 (0.270988)
AR (1) test	-1.79400 (0.0728)	-2.644445 (0.0082)	-	
AR (2)test	-1.73436 (0.0829)	-1.09459 (0.2051)	-	

• Means significance at * 10%, ** 5%, *** 1% levels.

The results of model 1 and model 2 in Table 5 are parallel to the results in Table 4, and the coefficients of AGP and HTE variables are positive and significant. Another similarity between the two tables is that the coefficient of the AGP variable is higher than the HTE variable. However, the coefficient of the AGP variable in Table 4, which shows the panel GMM results of 15 countries consisting of moderate Table 5, also includes the Sargan and Arellano-Bond (AB) test results in which the consistency of the model was investigated. According to the Sargan test results, the instrumental variables in the model are exogenous, and according to the results of the Arellano-Bond (AB) test, it is confirmed that there is no 1st and 2nd order autocorrelation problem in model 1. In model 2, while there is a 1st order autocorrelation, there is no 2nd order autocorrelation.

4. Conclusion and Suggestions

In this study, which was conducted to investigate the impact of employment and technological transformation on economic growth in Turkey and the EU countries, first the stages of the transition to the information economy, and then the importance of using information and technological innovations in the global marketplace in this context is analyzed. In addition, information is provided about the number of R&D personnel and researchers, high-tech exports and innovation performance as a result of the mentioned activities in Turkey and the EU countries by highlighting the importance of R&D activities to improve the level of information and technology.

The impact of the number of R&D personnel and researchers, and high-tech product exports on economic growth in Turkey and the EU countries for the years 2007-2019 is analyzed in the empirical part of the study. 27 EU countries including the UK but excluding Greece because of the lack of data, and Turkey were divided into two different groups by taking into account their innovation performances. The first group consists of 13 countries (UK, Sweden, Finland, Denmark, Netherlands, Luxembourg, Belgium, Germany, Austria, Ireland, France, Estonia, Portugal) as innovation leaders and strong innovators, while the other group consists of 15 countries (Spain, Slovenia, Cyprus, Czech Republic, Malta, Italy, Lithuania, Romania, Slovakia, Hungary, Latvia, Poland, Croatia, Bulgaria and Turkey) as moderate and modest innovators. First, Levin, Lin & Chu (LLC) and Im, Pesaran and Shin (IPS) unit root tests were performed for the variables of the countries in these groups and their stationarities were investigated, and necessary Procedures were performed to eliminate the unit root from the non-stationary series. Then, the impact of the number of R&D personnel and researchers, and high-tech exports on economic growth in Turkey and the EU was investigated by using two different dynamic panel data analysis method as Difference-GMM and System-GMM.

In the econometric analysis conducted, the impact of the number of R&D personnel and researchers employed on economic growth in 13 countries, consisting of innovation leaders and strong innovators, was found as significant at 5% significance level in the Difference-GMM method and 1% in the System-GMM method and as positive. In addition, the estimation results obtained in both methods for the high-tech exports of these countries were positive and this result was

and modest innovators, is quite high compared to the GMM estimation results of the panel GMM estimation results of 13 EU countries consisting of innovation leaders and strong innovators. This situation can be interpreted as the employment of R&D personnel and researchers in moderate and modest countries contribute more to economic growth than other 13 EU countries with high innovation power.

significant at 5% significance level according to the Difference-GMM method, while it was significant at 1% significance level in the System-GMM method. Another finding obtained from the analysis of the results was that the coefficient of the RDP (R&D Personnel) variable was much higher than the HTE (High Technology Product Export) variable. This finding can be interpreted as the increase in the employment of R&D personnel, and researchers will contribute to economic growth at a higher rate than high-tech exports.

According to the Difference-GMM and System-GMM estimation results of the 15 countries including Turkey consisting of moderate and modest innovators, the impact of R&D personnel and researchers on economic growth was statistically significant at 1% significant level and the level of this impact was quite high and positive. In addition, according to the Difference-GMM and System-GMM results of high-tech exports for these countries, the contribution of high-tech products to economic growth was positive, and this result was significant at 1% significance level. Again, according to the same estimation results, the coefficient of the variable of the number of R&D personnel and researchers was higher than the coefficient of the high-tech exports variable.

Another issue that takes attention in the result of the EU countries and Turkey separated into two groups according to their innovation performances was the fact that the coefficient of the number of R&D personnel and researchers variable for the 15 EU countries was quite higher than the coefficient of the same variable for the 13 EU countries consisting of moderate and modest innovators. This finding can be interpreted as the employment of R&D personnel and researchers in the moderate and modest countries contribute more to economic growth than other 13 EU countries with high innovation power.

In today's societies where the information economy is dominant, fields such as technology, innovation, qualified human capital, production and export of high-tech products are very important. Although these issues are the key of the future world, they also offer an important advantage to the countries, which progress better in the transition to the information economy compared to other countries, in terms of increasing their power in the globalizing world economy. In the process of globalization and information economy, the dimension of international competition has caused changes in the effectiveness of the factors national economies used in previous periods in terms of gaining advantage over each other. In this transformation process, economies of developing countries, such as Turkey must target innovative activities rather than traditional production factors, and focus on policies that emphasize innovation and especially on policies that increase the number of qualified R&D personnel in order to achieve sustainable economic growth and advance in international competition.

Considering the studies and research findings in the literature, it is seen that increasing the quality and quantity of R&D personnel directly contributes to the increase of high-tech product exports that have high added value. Especially for developing countries, such as Turkey, developing and implementing policies that target to be high-tech product producer and exporter not only has positive impact on economic growth, but also an advantage in international competition. A high level in quality and added value of high-tech product production depends on the employment of workforce with a high level of human capital and qualified R&D personnel, as well as the provision of the necessary legal and economic infrastructure. Before these conditions are fulfilled, profit maximization with the production of quality technology with high added value does not seem possible. In addition, attracting direct investments to a national economy is attributed to an increase in the quality and quantity R&D personnel. Because, in order to maximize their profitability, companies that make international direct investments prefer to direct their investments to countries that produce and export high technology with the aim of benefiting from the positive technology exogeneity and qualified human capital created as a result of the clustering of certain products.

As a result, it is especially important for the economies of all countries to encourage the production and export of high technology, and to increase the employment of R&D personnel qualified in terms of quantity and quality, which is a prerequisite of this process. In this context, it is necessary to expand the university-industry cooperation in order to increase the number of qualified R&D personnel and to make the necessary training processes sustainable. In addition, establishing the necessary infrastructures for the widespread use of technology both in the education and employment process will increase the skills of technology use and production. In order to encourage companies to employ and train qualified R&D personnel, policy makers may provide tax benefits and improve the incentive policies implemented.

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