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EMPIRICAL ANALYSIS OF CAUSALITY BETWEEN R&D EXPENDITURES AND ECONOMIC GROWTH: A STUDY ON TURKEY, ITALY AND RUSSIA

Ar&Ge Harcamaları İle Ekonomik Büyüme Arasındaki Nedenselliğin Ampirik Analizi: Türkiye, İtalya Ve Rusya Ülkeleri Üzerine Bir İnceleme

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ABSTRACT

In recent years, the changes in the world economy and the emerging competitive environment have increased the interest in innovation and approaches to innovation. The reflection of the scientific production process in daily life occurs with developing a new product or production process. These emerging new products, production, or product processes represent activities carried out on Research and Development (R&D). For this reason, countries contribute to the development of their economies by producing new technologies and products with their research and development (R&D) expenditures.

This study aims to analyze the causal relationship between R&D expenditures and economic growth by using the Granger causality test, based on the annual data (WORLD BANK and Euro stat) of the 1990-2018 period for Turkey, Italy, and Russia. This study aims to analyze the causal relationship between R&D expenditures and economic growth by using the Granger causality test, based on the annual data of the 1990-2018 period for Turkey, Italy, and Russia. As a result of the analysis, a one-way causality relationship was determined between R&D expenditures and economic growth for Turkey and Russia. However, there was no causal relationship found between R&D expenditures and economic growth for Italy.

Key Words: R&D Expenditures, Economic Growth, Causality Analysis

ÖZET

Son yıllarda dünya ekonomisinde ortaya çıkan değişimler ve oluşan rekabet ortamı yenilik ve yeniliğe yönelik olan yaklaşımlara ilgiyi arttırmaktadır. Bilimsel üretim sürecinin güncel yaşamdaki karşılığı yeni bir ürünün veya üretim sürecinin ortaya çıkışını belirtmektedir. Ortaya çıkan bu yeni ürün, üretim veya ürün süreçleri ise Araştırma-Geliştirme (Ar&Ge) üzerine yürütülen etkinliklerin bir sonucunu temsil etmektedir. Bu nedenle ülkeler Araştırma-Geliştirme (Ar&Ge) harcamaları ile yeni teknolojilerin ve ürünlerin üretilmesini sağlayarak ekonomilerinin gelişmesine de katkıda bulunmaktadır.

Bu çalışmada Ar-Ge harcamaları ile ekonomik büyüme arasındaki nedensel bağıntının Türkiye, İtalya ve Rusya ülkeleri için 1990-2018 dönemine ait yıllık verilerden (Dünya Bankası ve Euro stat) hareketle Granger nedensellik testi kullanılarak analiz edilmesi amaçlanmaktadır. Analiz sonucunda, Türkiye ve Rusya'da Ar&Ge harcamaları ile ekonomik büyüme arasında tek yönlü bir nedensellik ilişkisinin olduğu tespit edilmiştir. Diğer taraftan İtalya'da ise nedensellik ilişkisine rastlanılmamıştır.

Anahtar Kelimeler: Ar&Ge Harcamaları, Ekonomik Büyüme, Nedensellik

1. INTRODUCTION

In the globalizing world, the competitive environment has become more challenging day by day. All countries need innovations constantly to maintain their competitiveness and economic growth. Nowadays, where innovation is so important, countries that can innovate and quickly turn their ideas into commercial and technical success can reach a significant position (Gültekin, 2020).Besides, innovation promotes

competitiveness in terms of technological and cost, serves as the primary driver of productivity, and plays a critical factor in explaining economies' growth (Crepsi & Pianta, 2008).

In terms of countries, competitiveness is the economy's ability to export goods and services sufficiently to reach external economic balance while assuring a continuous increase in income per capita (Heckova et al.,2016). In another definition by the World Economic Forum (WEF), competitiveness is the set of policies, institutions, and factors that determine the country's productivity level. The country's productivity is linked with countries' ability to maintain a high level of income, and it has a significant impact on the return on investment that reflects the growth potential of a specific economy (Schwab et al.,2017).

Nowadays, the growth of a nation is no longer determined by physical factors like labour and capital alone because there has been a drastic shift in the factors determining economic growth as depicted by the move towards endogenous growth models from exogenous growth models where the growth of a nation is determined by a number of factors like openness to trade, increasing returns to scale, international Research and Development Expenditure and human capital formation (Lucas 1988; Romer 1990). Of these factors underlying economic growth, the most efficient way to raise competitiveness in an economy is through the R&D activities undertaken by it, which can be most precisely measured by the R&D expenditure incurred by a particular country (Kim 2011). The EU is aware of it and shapes its current strategy of Europe 2020 accordingly that 3% of GDP should be allocated to R&D by 2020 at the latest, and this should boost innovation levels and give a chance the EU to become a top global economic leader (MacGregor Pelikánová, 2019).

Cohen and Levinthal (1989) stated that technological development has spread to the whole economy as a result of R&D activities and this result has grown the economies of countries. Economic growth is based on internal factors and especially technological innovation and R&D activities. Since technology is one of the most important factors determining the competitiveness of an economy, R&D expenditures are one of the main factors determining both the foreign trade performance and growth of the country (Romer 1986; Kaur &Sing, 2016).

For supporting R&D, most OECD/EU member countries apply direct and indirect measures, and also some countries developed or expanded financial instruments (European Commission, 2003; OECD, 2012). However, despite all efforts, the encountered financial crises forced many governments to implement severe fiscal consolidation measures, prioritizing other issues over R&D (OECD,2012). In this way, they will have difficulties building up a new economic structure based on long-term competitiveness (Habanik et al., 2016).

From classical growth models to the most recently developed endogenous growth theories, the effect of technology, naturally R&D expenditures, on growth has been discussed many times. Classical growth models have excluded technological development from growth by basing economic growth on factors such as natural resources, labor and capital accumulation. Joseph A. Schumpeter, on the other hand, drew attention to the concept of "innovation", which had not been emphasized until then, and showed innovation as the main source of economic growth. In his book Capitalism, Socialism and Democracy, he mentioned his views on innovation and development in the process of "creative destruction" (Schumpeter ,1911; Schumpeter, 2014).

2. LITERATURE REVIEW

Many researchers have examined factors influencing economic growth, and a growing number of empirical studies have accompanied theoretical approaches. Consistent with this study's purpose, the literature review is principally concentrated on the effect of R&D. Although various studies in the literature mention that R&D activities have an essential role in increasing efficiency and competitiveness, considering the empirical studies that include the relationship between economic growth and R&D expenditures; there is no single agreed opinion on the relationship between variables, as the method of analysis used, the country and country groups examined, and the preferred indicators differ. There may be unidirectional and bidirectional causality relationships between variables, as well as studies in which no causality relationship could be found in the literature.

Sylwester (2001) examined the causality relationship between public and private sector R&D expenditures and economic growth in 20 OECD countries (1980-2000) using multivariate regression analysis. As a result of his research, there is no relationship between R&D expenditure and economic growth, but there is

a positive relationship between industrial R&D expenditures and growth among G7 countries. Falk (2007) conducted panel data analysis using data from 15 OECD countries between 1970 and 2004. He measured the relationship between R&D expenditures and high technology investments with per capita income in his study. As a result of his research, the increase in R&D expenditures and high technology R&D investments had a strong and positive effect on GDP per capita.

Using the cointegration and causality test, Yu-ming et al. (2007) investigated the relationship between R&D activities and China's economic growth. As a result of his research, a long-term bidirectional causality relationship between variables was determined. Eid (2012) conducted a panel analysis that includes 17 OECD countries for 1981-2006. His research aims to examine the effect of R&D expenditures on growth. It was observed that R&D expenditures have a significant and positive effect on growth in the years after the year in which they were spent.

Kim (2011) investigated in Korea the contribution effect of R&D stock for economic growth using the R&D-based Cobb-Douglas production function during the years 1976- 2009. In addition to the past literature, this paper estimates the contribution of two sourced R&D stocks for economic growth. The traditional production factors — labor and capital — contribute about 65% to economic growth based on the empirical results. Also, the contribution ratio of overall R&D stock to economic growth is about 35%. In detail, public and private R&D stocks account for economic growth of about 16% and 19%, respectively.

Wang et al. (2013) studied the impact of R&D expenditures on economic growth for 23 OECD countries and Taiwan in the period 1991-2006. The quantile regression technique was used as a method. Findings show that high-tech R&D spending has a positive and strong impact on GDP per capita.

Silaghi et al. (2014) examined the effect of private and public R&D expenditures on Central and Eastern European countries' growth rate in the period, including 1998-2008, using a dynamic panel data technique Arellano-Bond's Generalized Moments Method (GMM). According to the findings, a 1% increase in the R&D intensity of the enterprises increased the growth in the relevant countries by 0.050 in the short term and 0.213% in the long term. Public R&D expenditure was found to be statistically insignificant. It is also concluded that when the human capital variable is added to the model, the effect of R&D expenditure on growth decreases but remains significant.

Inekwe (2014) analyzed the role of R&D expenditures on economic growth for 66 countries by grouping them into middle-income and low-middle-income economies over 2000-2009. He analyzed the impact of R&D expenditures on these economies using dynamic system GMM, combined mean group, and three-stage least-squares GMM models. The result shows that R&D expenditures positively affect economic growth in upper-middle-income countries, but the effect of R&D expenditures on increasing growth in low-middle-income countries is meaningless.

Sokolov-Mladenović and friends (2016) investigated the influence of R&D expenditure on economic growth in the EU28 during 2002–2012. The obtained results unambiguously confirmed that investment in research and development positively affects the real economic growth rate under conditions of the financial crisis. Also, unambiguously confirmed under conditions of the financial crisis, investment in research and development positively affects the real economic growth rate.

The contribution of innovations and R&D activities to economic growth was not limited to only countries. On a small scale, innovation has an impact on the performance of companies in many ways. Gültekin (2020) studied the impact of innovation on company performance in 59 companies operating in the automotive industry in Bursa, Turkey. As a result of the study, two important conclusions were obtained. Marketing innovation has a statically positive impact on company performance, and Process innovation has a statically positive impact on company performance.

3. METHODOLOGY AND DATA SET

The main purpose of this study is to determine the effect of R&D expenditures on economic growth and to reveal the possible contribution of R&D expenditures to economic growth. Therefore, in line with the purpose of the study, the hypothesis "***Research & Development (R&D) expenditures have a positive effect on GDP*** " has been established.

In this study, the impact of R&D expenditures on the economic growth of Turkey, Italy, and Russia was particularly examined. As a GDP and annual R&D expenses of mentioned countries, the data of the years between 1990-2018 was used. The mentioned R&D expenditure and GDP data, which are considered indicators of economic growth, were obtained from the WORLD BANK and Euro stat database and summarized in Table 1. The value of variables (GDP and R&D expenses) was represented in dollar currency. The applied analysis was carried out on the logarithmic values of the variables. Eviews 10.0 program was utilized for the analysis.

Table 1. Variables

Variable	Time period	Definition
GDP	1990-2018	Gross Domestic Product
R&D	1990-2018	R&D Expenses
LOGGDP	1990-2018	Logarithm of GDP
LOGR&D	1990-2018	Logarithm of R&D Expenses
DLOGGDP	1990-2018	GDP 1st Difference
DLOGR&D	1990-2018	R&D 1st Difference

4. RESULTS

The development of a country and its importance attaches to science and technology can be understood by looking at the resource allocation allocated for R&D expenditures in GDP. The GDP figures of Turkey, Italy, and Russia between 1990-2018 are given in Figure 1 below.

When Figure 1 is examined, there are fluctuations in the GDP figures of all three countries, but there are significant increases in the GDP figures of all three countries after the 2000s. Although Italy has a more developed economy compared to Turkey and Russia, it is observed that there are fluctuations and structural breaks in the country. Parallel to this, it can be said that structural breaks and economic shocks are dominant in Russia.

It is observed that the increases in GDP figures were regular in Russia from 1999 through 2007. On the other hand, the country, which experienced economic declines in 2007-2009 and 2012-2016, started to increase its GDP figure as of 2016.

Turkey, whose GDP figures are much lower than Italy and Russia, experienced an increase in GDP in general between 1990 and 2007, but never achieved a sharp increase. The country, which experienced decreases in GDP figures from time to time, started to increase in 2009-2013. Turkey, which experienced a decrease in its GDP rate in 2013-2018, is still not at a satisfactory rate compared to the GDP figures of the other two countries.

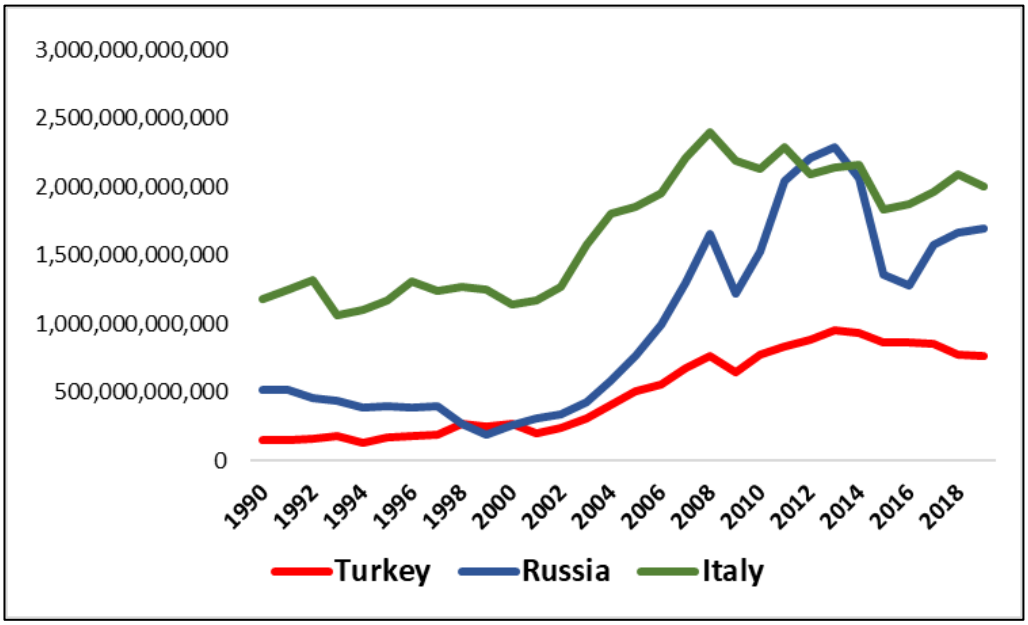

Figure 1. GDP Figures of Turkey, Italy and Russia by years ($ dollar)

As a developed country, Italy has a better national income compared to developing Turkey and Russia. Therefore, it can be said that there will be a big difference between the ratio of Italy's R&D expenditures to national income compared to Turkey and Russia.

R&D expenditure figures of Turkey, Italy, and Russia from 1990 through 2018 are given in Figure 2.

When Figure 2 is explicitly examined for Turkey, there has been a significant increase in the resources allocated to R&D and innovation in Turkey between 1990-2018. According to the R&D Magazine, Turkey ranked 18th globally in the 2014-2015 and 2016 R&D estimated gross expenditure list.

Based on Figure 2, Italy's R&D expenditure is generally increasing between 1990-2018. According to the R&D Magazine, the country ranked 13th in the world in 2014-2015 and 2016 R&D estimate gross expenditure. Italy increases its economic growth by increasing the amount of resources it allocates to R&D and innovation every year.

Between 1990 and 2018, Russia's R&D expenditure fluctuated in general. R&D investments in the country increased in 1998-2003 compared to the previous year. Similarly, R&D investments increased in Russia in 2013- 2017 compared to the previous year, but the resource allocated decreased compared to 2017 due to the economic changes experienced in 2018. The country ranked 8th in the world during 2014-2015 and 2016 R&D estimated gross expenditure according to R&D Magazine. As can be understood, this ranking also overlaps with Figure 2, which was created based on world bank data.

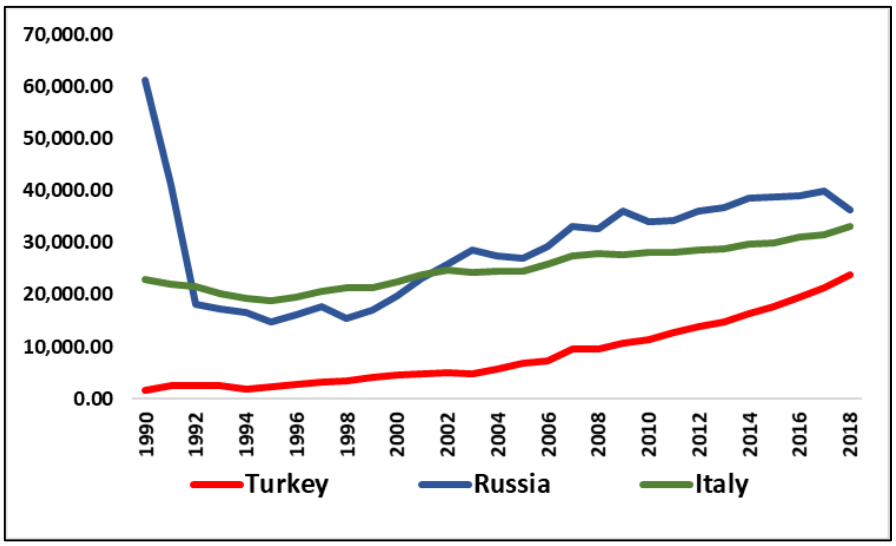

Figure 2. R&D Expenses of Countries by years ($ dollar)

The percentage of R&D expenditures in GDP was given in Figure 3 for Turkey, Italy, and Russia between the years 1990-2018.

According to Figure 3, Turkey has a continuously increasing trend between 2013-2018. Especially between the years 1990-2018, the country made noticeable progress despite being behind the average of Russia and Italy. For example, the ratio of gross R&D expenditures to GDP, which was 0.325 percent in 1990, increased to 1.03 percent by 2018. The percentage increase cannot be underestimated, but the country is still behind other countries by the quantity. For this reason, Turkey has to take some serious measures to protect its competitive position globally by allocating more resources for R&D for the upcoming years like other developing and developed countries.

Although Italy's R&D expenditures decreased until the mid-90s, the country caught an increasing trend after 1998. After 2011, the country moved its R&D investments to a different level and contributed significantly to its percentage within the GDP.

Between the years 1990-1992, there was a significant decrease in Russia's R&D expenditures in the GDP. Subsequently, there have been significant fluctuations in spending over the years. However, in 2018, the share of R&D within the GDP decreased significantly, which was less than in Turkey and Italy.

Apart from the figures explained above, countries need to analyze the link between R&D expenses and economic growth while planning their future strategies.

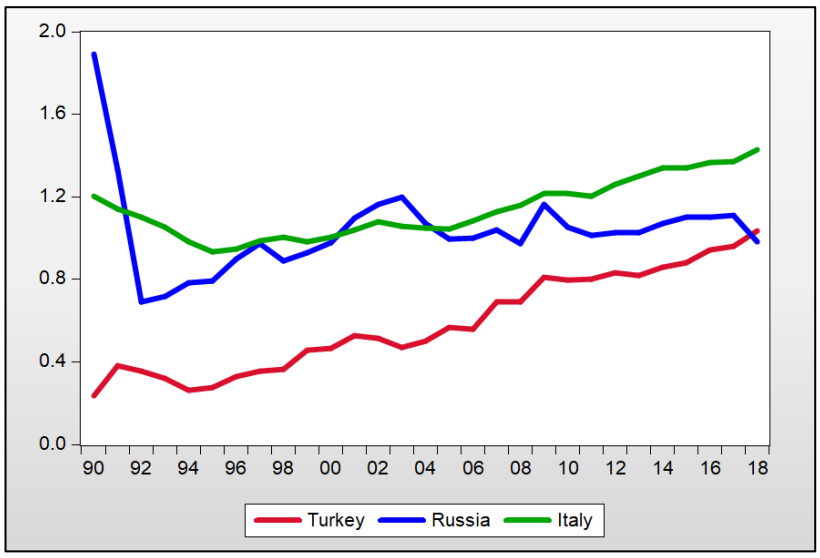

Figure 3. Countries' Share of R&D Expenditure in GDP by years (%)

When examining the causality relationship between R&D expenses and economic growth for the countries Turkey, Italy, and Russia, the stationarity of the series was investigated first. For this reason, the Augmented Dickey Fuller-ADF (Dickey & Fuller, 1981) unit root test was utilized to determine the stationarity of the variables of the countries examined in the study. Below are the hypotheses for the extended Dickey Fuller unit root test;

H_0: p >= 1 (The series is not stationary. The series has a unit root).
H_1: p < 1 (The series is stationary. The series has no unit root).
p = 1 Yt has a unit root and is not stationary.

In the Augmented Dickey Fuller (ADF) unit root test, if the ADF t statistic value is less than the critical values of 0.01, 0.05, and 0.10 in absolute terms, the H_0 hypothesis must be rejected. In this case, the series is not stationary, and the first differences must be taken.

The ADF test results of LOGGDP and LOGR & D variables belonging to Turkey, Russia, and Italy are summarized in Tables 2 and 3.

The lag length was taken as 1 in ADF test applications for the R&D and GDP series. To understand whether the series is stationary or not, P *, t-statistics, and critical values were taken into consideration.

If the p-value is less than 0.05, the series is stationary. Apart from this, if the absolute value of the critical value is less than the ADF t-statistics value, the series is also stationary, and there is no unit root. Series other than those specified are not stationary, but the 1st difference can be taken to make them stationary.

According to Table 2, the LOGGDP variables of Turkey, Russia and Italy were found stationary in the 1st difference value. Therefore, the GDP variable used in the three countries has changed over time.

Table 2. ADF Root Test Result of LOGGDP

Country	Variable	Include in test equation	ADF t-statistics	Test critical values		p*
TURKEY	LOGGDP	Intercept	-0.964556	1%	-3.689194	0.7517
				5%	-2.971853	
				10%	-2.625121	
		Trend and intercept	-1.614506	1%	-4.323979	0.7612
				5%	-3.580623	
				10%	-3.225334	
	DLOGGDP	Intercept	-5.563900	1%	-3.699871	**0.0001***
				5%	-2.976263	
				10%	-2.627420	
		Trend and intercept	-5.537910	1%	-4.339330	**0.0006***
				5%	-3.587527	
				10%	-3.229230	
RUSSIA	LOGGDP	Intercept	-0.843430	1%	-3.699871	0.7902
				5%	-2.976263	
				10%	-2.627420	

		Trend and intercept	-2.277103	1%	-4.339330	0.4313
				5%	-3.587527	
				10%	-3.229230	
	DLOGGDP	Intercept	-3.434754	1%	-3.699871	**0.0184***
				5%	-2.976263	
				10%	-2.627420	
		Trend and intercept	-3.408975	1%	-3.339330	**0.0412***
				5%	-2.587527	
				10%	-2.229230	
ITALY	LOGGDP	Intercept	-0.954545	1%	-3.689194	0.7551
				5%	-2.971853	
				10%	-2.625121	
		Trend and intercept	-1.573166	1%	-4.323979	0.7779
				5%	-3.580623	
				10%	-3.225334	
	DLOGGDP	Intercept	-4.367909	1%	-3.699871	**0.0020***
				5%	-2.976263	
				10%	-2.627420	
		Trend and intercept	-4.270631	1%	-4.339330	**0.0117***
				5%	-3.587527	
				10%	-3.229230	

* %5 significance level.

Similarly, in Table 3, the LOGR&D variables of Turkey, Russia and Italy were found stationary in the 1st difference value.

Table 3. ADF Root Test Results for LOGR&D Expenditures

Country	Variable	Include in test equation	ADF t-statistics	Test critical values		p*
TURKEY	LOGR&D	Intercept	-0.572818	1%	-3.689194	0.8614
				5%	-2.971853	
				10%	-2.625121	
		Trend and intercept	-3.215407	1%	-4.323979	0.1019
				5%	-3.580623	
				10%	-3.225334	
	DLOGR&D	Intercept	-6.602008	1%	-3.699871	**0.0000***
				5%	-2.976263	
				10%	-2.627420	
		Trend and intercept	-6.597926	1%	-4.339330	**0.0010***
				5%	-3.587527	
				10%	-3.229230	
RUSSIA	LOGR&D	Intercept	-3.300565	1%	-4.769597	0.3152
				5%	-3.664861	
				10%	-3.742242	
		Trend and intercept	-1.557273	1%	-4.440739	0.7768
				5%	-3.632896	
				10%	-3.254671	
	DLOGR&D	Intercept	-3.564331	1%	-3.699871	**0.0137***
				5%	-2.976263	
				10%	-2.627420	
		Trend and intercept	-3.914466	1%	-4.440739	**0.0290***
				5%	-3.632896	
				10%	-3.254671	
ITALY	LOGR&D	Intercept	-0.954545	1%	-3.689194	0.7551
				5%	-2.971853	
				10%	-2.625121	
		Trend and intercept	-1.573166	1%	-4.323979	0.7779
				5%	-3.580623	
				10%	-3.225334	
	DLOGR&D	Intercept	-4.367909	1%	-3.699871	**0.0020***
				5%	-2.976263	
				10%	-2.627420	
		Trend and intercept	-4.270631	1%	-4.339330	**0.0117***
				5%	-3.587527	
				10%	-3.229230	

* %5 significance level.

The ADF unit root test provides information on whether a time series is trend stationary or difference stationary (Gujarati & Porter, 1995). This information is necessary for determining the impact of economic shocks in the country. While economic shocks are temporary in trend stationary processes, economic shocks in difference stationary processes are continuous (Duman &Aydın, 2018).

In this study, based on the result of the ADF test applied, the stationarity of variables was obtained by taking the 1st difference. The test results showed that the economic fluctuations were experienced in Turkey, Russia, and Italy between 1990-2018.

After discovering that the series examined in Turkey, Russia, and Italy are stationary at the first level, it is essential to figure out the relationship between the series in the long term. For this reason, the Johansen Cointegration test, constructed based on the Vector Autoregression (VAR) model, was utilized to determine the optimal lag length between series accurately and reliably (Sevüktekin & Nargeleçekenler, 2007).

As a first step, the VAR model consisting of LOGGDP and LOGR & D variables were created for each country to reach the lag lengths.

The lag length of Turkey, Russia, and Italy countries concerning Akaike (AIC), FBE, AIC, SC, and HQ information criteria is summarized in Table 4. According to established VAR models in the study, optimal and non-autocorrelated lag lengths were found as 1 for three country models (the maximum value with * sign indicates the lag length).

Table 4. Lag Length by Country

TURKEY	**Lag**	**LL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
	0	-20.91780	NA	0.023148	1.909817	2.007988	1.935861
	1	**46.46008**	**117.9113***	**0.000118***	**-3.371674***	**-3.077160***	**-3.293539***
	2	47.16730	1.119757	0.000157	-3.097275	-2.606419	-2.967051
	3	50.27199	4.398306	0.000173	-3.022665	-2.335467	-2.840352
	4	51.10980	1.047272	0.000235	-2.759150	-1.875610	-2.524747
RUSSIA	**Lag**	**LL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
	0	-19.12749	NA	0.018584	1.690200	1.787710	1.717245
	1	**35.23033**	**95.66976***	**0.000332***	**-2.338426***	**-2.045896***	**-2.257291***
	2	37.09213	2.978891	0.000397	-2.167371	-1.679820	-2.032145
	3	38.51294	2.045964	0.000497	-1.961035	-1.278465	-1.771719
	4	43.33627	6.173862	0.000483	-2.026902	-1.149311	-1.783495
ITALY	**Lag**	**LL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
	0	23.71297	NA	0.000604	-1.737037	-1.639527	-1.709992
	1	**83.29080**	**104.8570***	**7.09e-06**	**-6.183264***	**-5.890734***	**-6.102129**
	2	88.27506	7.974816	6.61e-06*	-6.37287	-5.774454	-6.126779*
	3	89.50187	1.766599	8.42e-06	-6.040149	-5.357579	-5.850833
	4	91.71787	2.836485	1.01e-05	-5.897429	-5.019839	-5.654023

* Shows the lag length according to the selected criteria.

For each country, one star was placed next to each of the Akaike (AIC) and Schwarz (SC) models. When deciding between models, the one with a lower value should be chosen because it is more significant than the other. For Turkey, while the value in the AIC model is -3.371674, it is -3.077160 in the SC model. For Russia, the value is -2.338426 in the AIC model and -2.045896 in the SC model. Finally, for Italy, the value in the AIC model is -6.183264, while in the SC model, it is -5.890734.

According to the results, the Akaike model should be selected for three countries. In this case, the VAR (1) model was established to analyze Johansen Cointegration according to the Trace and Max-Eigen Value test statistics. The results are shown in Table 5.

The Cointegration hypotheses are as follows (Duman & Aydın, 2018);

H_0: There is no long-term relationship between the variables (No cointegration).

H_1: There is a long-term relationship between the variables (There is cointegration).

The p-value is vital for deciding whether cointegration exists or not. If the p-value is higher than 0.05, then cointegration exists, and there is a long-term relationship between the variables.

According to Table 5, the value of p is higher than 0,05 in the "At Most 1" row for Turkey, Italy, and Russia. For this reason, it can be said that a long-term relationship was found between series, so the H_1 hypothesis is acceptable for the three countries.

In summary, there is a long-term relationship between R&D expenditures and economic growth for Turkey, Italy, and Russia.

Table 5. Johansen Cointegration Test Results

TURKEY	**Unrestricted Cointegration Rank Test (Trace)**				
	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
	None	0.558559	25.28996	25.87211	0.0489
	At most 1	0.112152	3.211787	12.51798	0.8504
	Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
	None	0.558559	22.07817	19.38704	0.0198
	At most 1	0.112152	3.211787	12.51798	0.8504
RUSSIA	**Unrestricted Cointegration Rank Test (Trace)**				
	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
	None	0.755774	43.91165	25.87211	0.0001
	At most 1	0.194827	5.850844	12.51798	0.4795
	Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
	None	0.755774	38.0608	19.38704	0.0000
	At most 1	0.194827	5.850844	12.51798	0.4795
ITALY	**Unrestricted Cointegration Rank Test (Trace)**				
	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
	None	0.411507	18.56639	25.87211	0.0371
	At most 1	0.145684	4.251275	12.51798	0.7055
	Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
	None	0.411507	14.31512	19.38704	0.0237
	At most 1	0.145684	4.251275	12.51798	0.6545

* %5 significance level.

Using Granger's causality analysis, it is possible to examine the causality relationship between the R&D expenditures of Turkey, Russia, and Italy and economic growth.

Granger's causality test examines the causality of variables according to the estimation of their past and present values (Duman & Aydın, 2018). The direction of causality determines the direction of the relationship between the variables.

Granger's causality test hypotheses are as follows;

H_0: There is no causality between the variables.

H_1: There is causality between the variables.

The results of the Granger causality test and acceptance situation of each hypothesis for Turkey, Russia, and Italy can be observed in Table 6.

According to Table 6, GDP causes an increase in R&D expenditures in Turkey. However, R&D Expenditures do not cause an increase in GDP. Therefore, among GDP and R&D expenditure, there is only a one-way causality available and its direction from GDP to R&D.

In Russia, GDP causes an increase in R&D Expenditures. Like Turkey, there is one-way causality available for Russia and its direction from GDP to R&D, as shown in Table 6.

Finally, there is no causality relationship available for Italy between GDP and R&D expenditures.

Table 6. Granger Causality Test Results

Country	Null hypothesis	F	p	Direction	
TURKEY	R&D expenditures do not cause GDP growth.	0.3771	0.5392	Accepted	**GDP→ R&D**
	GDP growth does not cause an increase in R&D expenditures.	5.164662	**0.0231***	**Not Accepted**	
RUSSIA	R&D expenditures do not cause GDP growth.	1.37279	0.2413	Accepted	**GDP→ R&D**
	GDP growth does not cause an increase in R&D expenditures.	6.609667	**0.0101***	**Not Accepted**	
ITALY	R&D expenditures do not cause GDP growth.	1.985552	0.1588	Accepted	-
	GDP growth does not cause an increase in R&D expenditures.	0.407917	0.5230	Accepted	

* %5 significance level.

5. CONCLUSION

The development of a country and its importance attaches to science and technology can be understood by looking at the resource allocation allocated for R&D expenditures in GDP. There are fluctuations in the GDP figures of all three countries, but there are significant increases in the GDP figures of all three countries after the 2000s. Italy has a more developed economy compared to Turkey and Russia. Turkey's GDP figures are much lower than Italy and Russia's, and the progress is still not at a satisfactory rate compared to the GDP figures of the other two countries.

Based on the analysis findings, there is a long-term relationship between R&D expenditures and economic growth for Turkey, Italy, and Russia.

In Turkey, GDP causes an increase in R&D expenditures. However, it has been seen that R&D expenditures do not cause an increase in GDP. In Russia, GDP causes an increase in R&D expenditures. Like Turkey, there is one-way causality available in Russia. Finally, there is no causality relationship was found for Italy.

It is suggested that there is an obvious need to increase R&D investments to reach sustainable economic growth in long term for Russia and Turkey.

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