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THE RELATIONSHIP BETWEEN R&D EXPENDITURES AND ECONOMIC GROWTH: THE CASE OF TURKEY (1990-2014) [1]

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AR&GE HARCAMALARI İLE İKTİSADİ BÜYÜME ARASINDAKİ İLİŞKİ: TÜRKİYE ÖRNEĞİ (1990–2014)

Abstract

The concept of growth has been debated since the emergence of economics. Along with globalization, changes in the determinants of economic growth have occured. Growth theories have begun to be popular after the 1980s, highlighted the growing role of technology and research and development. Today, research and development is one of the most important variables that show the level of technology and level of development of a country. To spend much more on expence of R&D leads to promote technological improvements, besides productivity and growth increase. In this study, the relationship between R&D expenditures and economic growth is analyzed with ARDL model for Turkish economy in the period 1990-2014. This is the aim of the study consist of four parts. The first chapter ‘’entrance’’ part consist of. In the second part, the studies in the literature and theoretical foundations of relationship between R&D and economic growth are discussed. ‘’Methodology and Terminology’’ in the third section, belongs to a part of the study methods and data applications are introduced; the fourth section presents the results of practice tests are given. As a result of the findings obtained, it was concluded that spending on R&D affects positively the economic growth in the short and long term. It is important for the Turkish Economy to increase the expence of R&D sistematically in the long term in order to achieve sustainability.

Keywords: R&D Expenditures, Economic Growth, ARDL Bound Test.

Öz

Büyüme kavramı iktisat biliminin ortaya çıkışından itibaren çokça tartışılmıştır. Küreselleşme ile birlikte iktisadi büyümenin belirleyicilerinde değişimler

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yaşanmıştır. Özellikle 1980'lerden sonra popüler hale gelen büyüme teorileri teknoloji ve Ar&Ge'nin büyümedeki rolünü ortaya koymuştur. Günümüzde ise Ar&Ge bir ülkenin teknoloji yeteneğini, gelişmişlik düzeyini gösteren en önemli değişkenlerden biridir. Ar&Ge harcamalarının arttırılması, teknolojik yeniliklerle birlikte verimlilik ve büyüme de artış meydana getirmektedir.Bu çalışma da, 1990-2014 dönemi Türkiye ekonomisi yıllık verileri kullanılarak Ar&Ge harcamalarının ekonomik büyüme üzerindeki etkisi ARDL modeli ile araştırılmıştır. Bu amaç doğrultusunda çalışma dört bölümden oluşmaktadır. Birinci bölüm Ar&Ge harcamaları ile iktisadi büyüme arasındaki teorik çerçeveden oluşmaktadır. İkinci bölümde, konuyla ilgili literatürde yer alan çalışmalara değinilmekte; "Model ve Veri" başlıklı üçüncü bölümde, çalışmanın uygulama kısmına ait yöntem ve veriler tanıtılmakta; dördüncü bölümde ise ampirik sonuçlara yer verilmektedir. Elde edilen bulgulardan neticesinde kısa ve uzun dönemde Ar&Ge harcamalarının iktisadi büyümeyi pozitif yönde etkilediği sonucuna varılmıştır. Büyümenin sürdürülebilirliği için uzun dönemde Ar&Ge harcamalarının planlı bir şekilde arttırılması Türkiye ekonomisi için önem taşımaktadır.

Anahtar Kelimeler: Ar&Ge Harcamaları, İktisadi Büyüme, ARDL Sınır Testi**.**

1. Introduction

Relationship between research and development (R&D) activities and economic growth are among the topics being very common and very important from the point of countries. R&D, that is primary source of technological developments and changes, are the works carried out within a system for the purpose of inventing new products, applications or ideas by using current information (Guellec and Potterie 2001: 104-105). In other words, R&D can be described as creative works and studies to create new products, develop current products and improve these products systematically. Quantitatively and Qualitatively, R&D activities have three subtitles as basic research, applied research and development (Ertürk 2000).

Economic growth is the main determinants of development level for the countries. Even if growth concept has been an important issue since its existence in related literature there is no any consensus among the economists about which factors prompt economic growth more than the others. Due to the nature of economics science, it is not possible to have a precise formula for economic growth and it cannot be put simply. But technology, improving and disseminating with the help of globalization, has become one of the main growth indicators of the countries today. To put it in a different way, technological level of any country gives an outline of economic development of the country. R&D activities are the main effect lying behind the technological improvements. Ideas revealing

as a result of R&D activities are converted into the product by being projected thereafter putting on the market by doing marketing. In this way, countries can have better growth performance than the others by generating new products and by reaching higher technological standards. Hence, countries should generalize the R&D activities and allocate more shares for R&D from their GDP.

The thought that R&D investments play an important role in the process of economic growth confront in the economic growth theories oftenly. Schumpeter, who is the first person investigating the effects of technology on economic growth systematically, asserts that R&D expenses increase the outcome per labor and this situation cause economic growth to raise. Ramsey and Solow, who put forward the neoclassical economic growth theory, point out that new machine and equipment investments dependent on the capital stock enabling the increase of product facilities will raise the production capacity and this will increase the economic growth. Additionally, Lucas (1988) and Romer (1986-1990), pioneering the endogenous economic growth models, adopt the idea that R&D activities create positive externalities decreasing marginal productivity of capital and preventing the increasing of capital/output ratio (Akıncı and Sevinç 2013: 3).

By considering the theories mentioned, it can be said that R&D expenses have a positive contribution on economic growth process and there is a high correlation between economic growth and R&D expenses. In this study, effect of R&D expenses on economic growth is examined with ARDL bound test between the period of 1990-2014 for Turkey by using yearly data. First section explains the theoretical frameworks for the relationship between R&D research and economic growth. Literature review related this topic is in the second section. Section 3 gives the information about models and data set used in this study. Empirical findings obtained from the model takes part in section 4. Last section includes the overall evaluation.

2. Theoretical Foundations of Relationship Between R&D and Economic Growth

Economic growth concept arose with industrial revolution and it became the most important indicators of macroeconomic performance for countries. First models about growth started to be suggested during 1930's and it has been a very popular topic among economists since 1980's. Solow (1956), expressing exogenous factors determine the growth especially between these periods, stresses that technological improvements have effect on economic growth. Increasing competition

together with globalization attracted considerable attention on technological developments. In the meantime, new growth models arose and technological developments were seen as engine of the economic growth. First model based on R&D activities in growth models is suggested by Romer (1990). Grossman and Helpman (1989-1990) and Aghion and Howitt (1992) improved this model with their studies.

Solow (1956) considers development and human capital technologically leading power power of growth and mentions that capital based on technology might be more valuable. According to Solow, technology has a positive effect on savings, capital and productivity in the long run. Model of Solow, called also neo-classical growth model, points out that production function has decreasing returns to scale and technology is an exogenous factor. Hence, growth follows a stationary path. The most important deficiency of the model is not to explain technological developments exactly.

Romer (1986) and Lucas (1988) assume that technology is an endogenous factor having impact on economic growth and develop endogenous growth model. Main source of endogenous growt model, explaining growth differences between countries better than Solow's model, are R&D activities and technological developments. Romer mentions that new information, products and services will be produced with R&D activities and this will be utilized by other companies. When knowledge is included into the production process and creates spreading effect on companies economic growth will realize (Ercan 2000: 131-132). Returns from investment tend to increase with the help of technological developments. In this way, the hypothesis that economic growth rates among countries will converge to each other is refuted since investments in developed countries gives better results than the others. There is divergences among countries rather than convergences (Bilbao-Osorio and Rodriguez-Peso 2004: 435).

In the model of Grossman and Helpman (1989, 1990), technological developments are endogenous and profit rates will not decrease depending on technological developments in the long run. Starting from this, productivity increases based on technological developments cause economic growth. Grossman and Helpman examine the model based on technological developments in the manner of effect of increase in the product diversity on economic growth and effect of public information on economic growth (Eaton and Kortum 2006: 13). In a nutshell, this model mentions that knowledge based on R&D and spreading of knowledge have positive effect on growth.

Aghion and Howitt model (1992) examine the impact of technological developments on economic growth. This model differs from other models since quality of the products carried out by vertical technological developments. This model developed by Aghion and Howitt is called as new creative destruction model. Reason for this mentioning of the model is that it is similar to Schumpeter's creative destruction concept. Most important factor in this model is improvement in the products quality enabled by technological developments and this developments' dynamic is patent competition (Cheng and Dinopoulos 1992: 409-410).

3.Literature Review

In the literature, a number of studies have been carried out which analyze the relationship between R&D and economic growth. In these studies, the expence of R&D and rates of growth have been used as an indicater of R&D. Especially, it is shown that there are positive effects of RD on the economic growth of developed countries.

Yu-ming studied on the causality between China's R&D expenditures and growth between1953-2004.In this study, the R&D expenditures and growth rates of the period are taken as basis. The study was conducted by VECM method, additionally ADF unit root test, Johansen cointegration test and error correction model were used. As a result of the findings, it was concluded that there is a causality between R&D expenditures and growth in the long-term.

Taban and Şengür examined whether there is a relationship between R&D expenditures and growth in their studies. In the study using 1990-2012 annual data, GDP, GDP share of R&D expenditures and the number of full time equivalent employees were considered as variables. Johansen cointegration and vector error correction model were used as the method. As a result of the findings, long-term R&D expenditures and full-time equivalent employees in R&D have affected economic growth positively. In the short term, the number of employees working in the R&D sector has a positive effect on economic growth, though the result of R&D expenditures does not have similar effect.

Altın and Kaya analyzed the relationship between R&D expenditures and growth for Turkey in the context of causality. R&D expenditures and growth rates were considered as variables in which study conducted by the annual data of the period 1990-2005.In the study, the causality relation was analyzed by the vector error correction model. As a result of findings, it was seen that there is a casuality in the long term from R&D expenditures to economic growth. In the short term, there has not found

casuality between R&D and economic growth. Some studies that analyze the relationship between R&D studies and growth in the literature are shown in Table 1.

Table 1: Literature on R&D and Economic Growth Relationships

Author(s)	Period	Method	Countries	Outcomes
Goel, Payne and Ram (2008)	1953-2000	Peseran Method	USA	Federal R&D expenses and economic growth relationship is stronger than non-federal R&D expenses and economic growth relationship.
Ülkü (2004)	1981-1997	Panel Data Analysis	30 Countries (20 OECD and 10 Non-OECD Countries)	In the countries in two groups, R&D expenses and economic growth have positive relationship.
Akıncı and Sevinç (2013)	1990-2011	Causality Test	Turkey	There is one directional causality relationship from R&D expenses to economic growth. But in the long term, there isn't any relationship between R&D expenses and growth.
Altın and Kaya (2009)	1990-2005	VEC Model	Turkey	In the short term, R&D expenses and economic growth have no any relationship but ın the long term, one directional causality exists from R&D expenses to growth.
Saraç (2009)	1983–2004	Panel Data Analysis	10 Developed OECD Countries	R&D expenses have positive effect on economic growth
Lichtenberg (1993)	1964-1989	Empirical Analysis	74 countries	Private sector R&D expenses and economic growth have an relationship but public sector R&D expenses have no any relations with growth.
Falk (2007)	1970-2004	Dinamik Panel Veri	15 OECD countries	R&D expenses and high-tech R&D investments have positive effect on GDP per capita.

4. Model and Data

In this study, real GDP and R&D expenses are used to examine the effect of R&D expenses on economic growth for Turkish economy in the period of 1990-2014 and data sets used in this study are in Turkish Lira. R&D expenses are considered in total base. Data for variables is obtained from the Turkish Statistical Institute (TUIK) and deflated by Consumer Price Index (CPI; 1998=100). Additionally, logarithmic form of the series are utilized to facilitate the analysis.

Table 2: Variables

Variables	Abbrevation	Explanation	Data	Period
Gross Domestic Product	GSYH	TL	TÜİK	1990-2014
R&D Expenses	ARGE	TL	TÜİK	1990-2014

Model used in this study is as below:

$$LGSYH = \beta_0 + \beta_1 large + e_t \quad (1)$$

In model, "t" shows the time, "LGSYH" mentions logarithmic value of GDP, "large" defines the R&D expenses in logarithmic form and "e" is error term.

β_0 is constant term and β_1 is the elasticity parameter obtained as a result of estimation. In this section, ARDL method utilized in this study is explained.

5. Ardl Bound Test

Different cointegration test are used to search for long run relationship between variables in time series analysis. But these tests have constraints such as stationarity. In ARDL model developed by Pesaran et. al. (1996), there is no any constraint related to stationarity of series. This approach improved has started to use in cointegration tests after Pesaran's proposition. One of the advantages of ARDL model, based on least squares method, is no need for unit root test, for classification of variables as I(0) or I(1) and it can be applied to small sample size (Sharifi-Renani, 2008: 4; Haug 2002). General form of ARDL bound test with two variables is shown below:

$$\Delta InY_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta InY_{t-1} + \sum_{i=0}^{n} \beta_{2i} \Delta InX_{t-i} + \beta_3 InY_{t-1} + \beta_4 InX_{t-1} + \varepsilon_t \quad (2)$$

Δ = First difference of series
n= lag length
Y= dependent variable
X=Independent variable

Appropriate lag length should be determined before the solution of the model. Akaike Information Criteria (AIC) or Schwarz Criteria (SC) are used to determine lag lengths. Of these two criteria, the smallest value should be chosen and model should be solved. Also, model solve with determined lag length should not have problems such as autocorrelation, heteroscedasticity and deviations from normality. In the existence of this kind of problems, the second smallest value should be considered. After the determination of lag length, cointegration relation is examined by using F test with the help of hypothesis in equation 3:

H_0: $\Phi_3 = \Phi_4 = 0$ (no cointegration) (3)

H_1: $\Phi_3 \neq 0$, $\Phi_4 \neq 0$ (cointegration)

Calculated F statistic is decided according to lower and upper critique values determined by Pesaran. If calculated F statistic is higher than the upper value H_1 hypothesis is excepted. If calculated value is smaller than the lower value then H_0 hypothesis is excepted. Some of the analysis shows that value of calculated F statistic is between lower and upper values. In this situation, it cannot be judged about the existence of cointegration (Pesaran vd. 2001: 289-290; Nazlıoğlu vd. 2014: 317-318).

Comment can be made by looking at long term relations between variables after cointegration relations. Equation below is utilized to examine the long term relation.

$$InY_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta InY_{t-1} + \sum_{i=0}^{k} \beta_{2i} \Delta InX_{1t-i} + \cdots + \sum_{i=0}^{p} \beta_{ki} In\Delta X_{kt-i}\ \varepsilon_t \quad (4)$$

In this study, by following the process in literature, after stationarity level of series determined cointegration analysis is conducted by determining the lag lengths. Afterwards, short and long-term relations of series is analyzed and CUSUM test is commented.

6. Empirical Findings

Stationarity is a very important concept in time series analysis. Whether or not series are stationary has importance for the progress of analysis. If series are non-stationary then spurious regression problem emerges (Granger et. al. 1974). This situation causes relationship between series to be misleading. Series should be made stationary to correctly estimate the relationship between series and overcome spurious regression problem(Kwiatkowski et al. 1992: 159-178). Following making stationarity of series, spurious regression problem disappears and results becomes more reliable (MacKinnon 1991: 266-267).

In this study, level of stationarity of time series are determined with ADF and PP unit root tests, being in the studies of Dickey and Fuller (1979) and Philips and Perron (1988) respectively, and lag length is determined by using AIC (Akaike Information Criteria). Table 3 shows the results of unit root test

Table 3: ADF and PP Unit Root Test Results

Variables	ADF Test Values	PP Test Values	Mackinnon Critical Value (%5)	
LGSYH	-2.83	-2.83	-3.61	-3.61
LARGE	-0.89	-0.90	-3.61	-3.61
∆LGSYH	-5.30	-5.32	-2.99	-2.99
∆LARGE	-0.89	-2.42	-3.00	-2.99
∆∆LGSYH	-7.98	-16.62	-3.00	-3.00
∆∆LARGE	-6.9	-7.06	-3.00	-3.00

Findings from ADF and PP unit root tests points out that LGSYS as dependent variable is stationarity in the first level for the model with trend and constant term for %5 significance level. LARGE is stationary for its second difference according to %5 significance level. That is, LGSYS series is I(1) and LARGE series is I(2).

There are stationarity problems of time series in the majority of the time series analysis and spurious regression exists all the time in these situations. One of the solutions to tackle this problem is to estimate series by taking their differences. But this method causes important amount of information losses due to taking the differences of series and long term relations don't give realistic results. Engle-Granger (1987) and Johansen (1988) develop cointegration approaches in different periods to eliminate these problems

Basic condition for both of models is to make series stationary by taking their differences. After that, it is came to the conclusion cointegration relationship can be examined without looking at the stationarity of series with bound test developed by Pesaran (2001). Also, Narayan (2006) and Shahbaz et. al. (2012) claim in their studies that cointegration results from bound test is more efficient and unbiased than the results obtained from Engle-Granger (1987) and Johansen (1988) and it gives more realistic results in small sample sizes. ARDL cointegration test is applied in this study by considering the unit root test results in table 3. Lag length

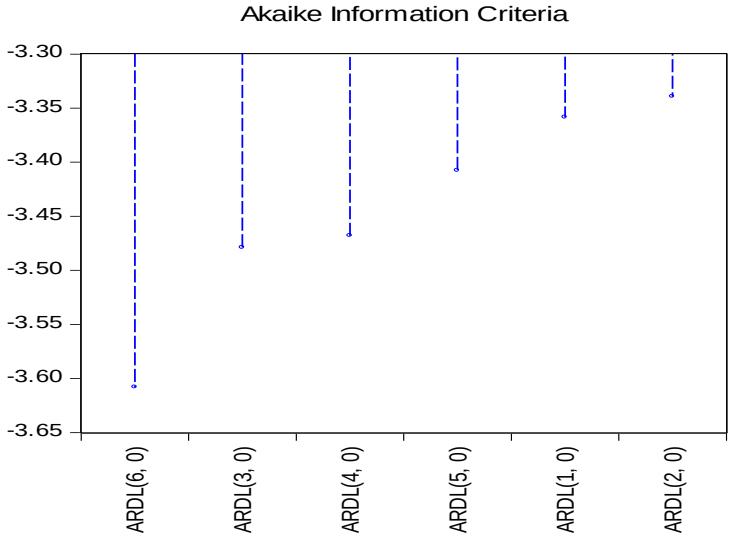
of model should be determined before cointegration test is applied. For determination of lag length fitted to the model, information criteria are utilized such as Akaike (AIC), Schwarz (SBC), Hannan-Quin (HQ). Akaike (AIC) information criteria is used in this study to have smallest value and autocorrelation is tested. Table 4 shows the lag length of ARDL model, AIC values and LM autocorrelation test results.

Table 4: Determination of Lag Length

Lag Length	AIC	Autocorrelation (LM)	Lag Length	AIC	Autocorrelation (LM)
(1,1)	-3.29	0.72 (0.49)	**(1,0)**	-3.37	0.93(0.41)
(2,2)	-3.17	1.01 (0.38)	**(2,0)**	-3.37	0.93(0.41)
(3,3)	-3.06	0.99(0.39)	**(3,0)**	-3.37	0.93(0.41)
(4,4)	-3.45	1.95(0.20)	**(4,0)**	-3.37	0.93(0.41)
(5,5)	-3.27	2.03(0.22)	**(5,0)**	-3.24	0.93(0.41)
(6,6)	-3.40	0.44(0.69)	**(6,0)****	-3.60	0.23(1.74)

Note: **, It shows the lag length being the smallest AIC value and not having autocorrelation problem.

Figure 1: Akaike Information Criteria



As it is seen in table 4 and figure 1, lag length for cointegration model is calculated according to AIC (6,0). After lag length is determined autocorrelation problem is detected by applying LM test. Findings from

LM test results don't indicate autocorrelation problem. Then, it is continued to search for cointegration relationship between series following determination of lag length. Table 5 indicates the results of bound test.

Table 5: Bound Test Results

	F Statistics	**%10**		**%5**	
k:1	7.56	**Lower Bound**	**Upper Bound**	**Lower Bound**	**Upper Bound**
n:24		5.59	6.26	6.56	7.3

k*, is the number of degrees of freedom. Critical values is obtained from Pesaran et. al. (2001:300). n* is the number of observations.

It is required for calculated F statistics to exceed upper bound mentioned by Pesaran for the determination of cointegration relationship. If the F statistics is below the lower bound there is no any cointegration relationship. Also, it cannot be interpreted if F statistics between these two limits. Calculated F statistics is higher than the upper bound value of Pesaran for %5 level which is seen in table 5. These results point out that there is a cointegration relationship between series. Long term relations between series are investigated in ARDL model after the determination of cointegration relations.

Long term estimation is made on the basis of lag length (6,0) determined by using AIC. Estimated model's test results don't indicate autocorrelation, heteroscedasticity and non-normality. Long term test results of models and long term coefficients are shown in Table 6.

According to results of ARDL model's long term test, growth and R&D expenses have significant long term relationship. Coefficient of R&D variable is negative and statistically significant. This situation shows R&D expenses has effect on economic growth of Turkey for the period 1990-2014.

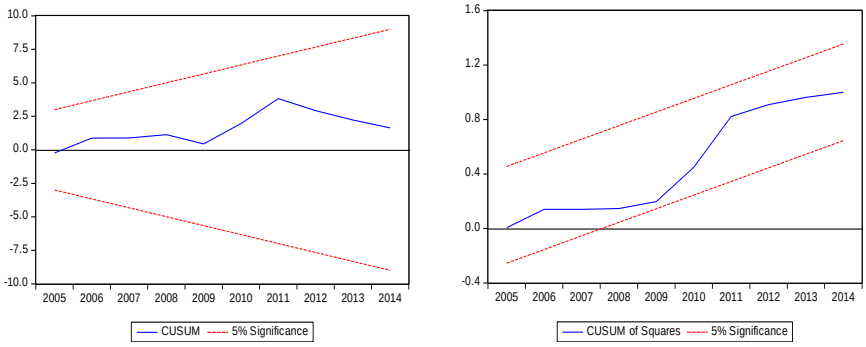
Table 6: ARDL (6,0) Long Term Model Results

Dependent Variable: **LGSYH**		
Independent Variables	**Coefficients**	**Probability Values**
LGSYH(-1)	1.21	0.0136
LGSYH(-2)	1.14	0.0115
LGSYH(-3)	0.69	0.0458
LGSYH(-4)	0.48	0.1013
LGSYH(-5)	0.44	0.0879
LARGE	-0.07	0.0114
@TREND	0.10	0.0026
C	-2.06	0.0029
Long Term Coefficients		
LARGE	-0.035	0.0027
C	24.99	0.0000
@TREND	0.04	0.0000
TESTS	**Probability Values**	
Heteroscedasticity	0.36	
Autocorrelation	0.23	
Normality	0.94	

One of the topics which should be dwelled on is stability of parameters. CUSUM and CUSUMQ tests are suggested by Brown et. al. (1975) to test long term parameter stability. Results of CUSUM and CUSUMQ test results are shown in Diagram 1.

In Diagram 1, parameter coefficients obtained from long term ARDL model isare between critical values for %5 significance level and long term coefficients are stable. In other words, model is stable for the related period and has no any structural break as results of CUSUM and CUSUMQ. After the long term relations are analyzed short term relations between R&D expenses and growth will be investigated in this part of the study.

Diagram 1: CUSUM and CUSUMQ Test Results



Short term relations between variables in ARDL model is solved with error correction model. Short term error correction model equation is as follows:

$$\Delta LGSYH = \beta_0 + \sum_{i=1}^{1} \beta_{1i} \Delta LGSYH_{t-i} + \sum_{i=0}^{0} \beta_{2i} \Delta LARGE_{t-i} + \theta ECT_{t-1} + \varepsilon_t$$

ECT_{t-1} variable is one period lagged value of error terms obtained from long term relation. Coefficient of ECT_{t-1} show how much of the instabilities might be corrected in the long term.

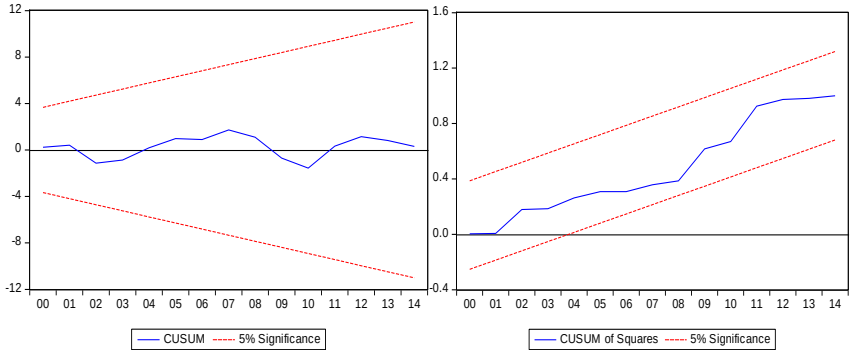
Error correction model coefficient is calculated as -0.92 as a result of error correction model. In reference to this result, %92 of deviations in the short term smooth following year. Error correction model coefficient has negative sign as expected and it is statistically significant for %5 level. This result demonstrate that R&D expenses have positive effect on economic growth in the short term. Besides, diagnostic test results don't indicate autocorrelation, heteroscedasticity and non-normality problems.

Table 7: ARDL (6,0) Error Correction Test Results

Dependent Variable: DLGSYH		
Independent Variable	**Coefficients**	**t-statistics**
DLARGE	-0.02	-0.44
ECT(-1)	-0.92	-2.39
C	0.04	2.51
TESTS	**Probability Values**	
Heteroscedasticity	0.22	
Autocorrelation	0.29	
Normality	0.76	

CUSUM and CUSUMQ test are applied to test whether or not parameter stability exists in the short term; i.e., existence of structural break.

Diagram 2: CUSUM and CUSUM-Q Test Results



CUSUM test graph in Diagram 2, variables are in confidence interval for %5 level of significance and have negative signs in some periods. In CUSUMQ test graph, coefficients are in confidence interval for %5 level significance and short term coefficients are stable and there is no any structural break.

7. Conclusion

Which factors affect economic growth concept diversifying with globalization is quite highly controversial topic among economist. Developing growth models after 1980's stress especially technological innovations and emphasize R&D activities in parallel with this. That R&D activity is an important factor in the emergence of technological innovations and that growth depends on this activity is underlie these growth models.

The creation of an economic value of the goods and services that will emerge on the basis of R&D activities will lead to emerge innovative firms. he increase in the number of innovative firms will provide opportunities for entrepreneurs, beside will provide new employment areas. The opening of new employment areas will prevent brain migration and will encourage citizens to invest in various areas. Thus, economic resources are used more efficiently, the level of development of the country will also increase. In this respect, it has become inevitable to increase R&D spending for countries seeking economic development.

In this study, R&D and growth relationship is investigated from the perspective of previously developed growth models. This work aims to test whether or not growth and R&D has a positive relationship in Turkey

for the period mentioned. Hence, ARDL bound test is utilized as econometric method. Orders mentioned in literature are applied using ARDL method. Existence of cointegration relationship in the long term between R&D expenses and economic growth is shown in this study for the period of 1990-2014. After that, test results indicate that R&D expenses have positive and significant impact on economic growth in the short and long term. It is important to increase R&D expense for the maintenance of economic growth in the long term for Turkey

For Turkey, long-term structural plans, efficient technology and innovation policies need to be produced. In particular, universities should be supported in R&D and opportunities should be provided for talented students to realize their ideas. In addition, the number of technoparks in universities should be increased to understand changing paradigms in the world. Lastly, the private sector should be encouraged to increase R&D investments and incentives should be given in this regard.

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