



## RESEARCH AND DEVELOPMENT ACTIVITIES AND ECONOMIC GROWTH RELATIONSHIP AMONG GIPPS COUNTRIES IN THE 2008 GLOBAL ECONOMIC CRISIS

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### ABSTRACT

Purpose of the study is to investigate the total ratio of high technology export, patent applications and research and development (R&D) spending to state expenditures and their ratio to national incomes as well as their relationship to economic growth levels among Greece, Ireland, Italy, Portugal and Spain that are known as the GIPPS countries. The study uses annual data between the years 1995 to 2016. Following the examination of dependency across cross sections, unit root test was applied. Four variables that were considered to be effective over economic growth levels were found significant and effective. According to the results, two most effective variables over economic growth levels were found to be the ratio of R&D spending to national income and high technology export based on co efficiency magnitude. The share of R&D in total state expenditure and patent applications were found to be less effective. Obtained results also put forward that all independent variables indicated a positive significant relationship over economic growth levels.

**Keywords:** Economic Growth, High Technology Export, R&D Spending

**JEL-Classification:** O52, O04, O30

## 2008 KÜRESEL EKONOMİK KRİZİNDE GIPPS ÜLKELERİNDE EKONOMİK BÜYÜME VE AR-GE FAALİYETLERİ ARASINDAKİ İLİŞKİ

### ÖZET

Bu çalışma Yunanistan, İrlanda, İtalya, Portekiz ve İspanya’da toplam ileri teknoloji ihracat oranı, patent başvuruları ve Ar-Ge harcamalarının kamu harcamalarına ve ulusal gelire oranı ve ayrıca ekonomik büyüme ile ilişkilerinin incelenmesini amaçlamaktadır. Çalışmada 1995’ten 2016’ya kadar yıllık veriler kullanılmaktadır. Veriler arasında bağımlılığın test edilmesinden sonra panel kök testi uygulanmıştır. Ekonomik büyüme oranları üzerinde etkili olduğu düşünülen dört değişken anlamlı ve etkili bulunmuştur. Sonuçlara göre, ekonomik büyüme üzerinde en etkili değişkenler Ar-Ge harcamalarının ulusal gelire oranı ve ileri teknoloji ihracatıdır. Ar-Ge harcamalarının toplam kamu harcamalarına oranı ve patent başvuruları daha az etkili olarak tespit edilmiştir. Elde edilen sonuçlar bağımsız değişkenlerin



tümünün ekonomik büyüme oranları üzerinde pozitif yönde anlamlı ilişki gösterdiğini ortaya koymaktadır.

**Anahtar Kelimeler:** Ekonomik Büyüme, İleri teknoloji İhracatı, Ar-Ge Harcamaları

## 1. INTRODUCTION

2008 Global economic crisis affected GDP and employment levels of many countries in the world. In the following years while many countries around the world recovered from the negative effects of the crisis, some European countries faced another financial problem which led to the European Debt Crisis.

The GIIPS countries, Greece, Ireland, Italy, Portugal and Spain were most adversely affected EU member countries from the global financial crisis in 2008. These countries had banking sector problems, credit crunches, government debt crises and deep downturns in their economies. During the financial crisis except for Italy, four of the countries had to obtain financial support from IMF and the European Union (Cuestas and Staehr, 2014:5). These countries still attempt to overcome the effects of the crisis yet; the studies demonstrate that their financial situation is still stable. A recent study Vries and Haan (2014) show that except for the GIIPS, credit ratings in the other EU member countries have changed to a great extent since 2012 (Vries and Haan, 2014:1).

Major and minor economies, regardless of their development levels attempt to obtain sustainable economic growth levels as it constitutes one of the fundamental economic problems. A great number of factors exist on the determinants of economic growth performance of countries; yet, an important role for economic growth is casted on R&D spending which forms the basic of technological progress. Technological knowledge as a result of R&D activities spills over whole economy and leads to economic growth (Zerenler et al., 2007: 657).

Neo-classical growth model, pioneered by Solow and Swan (1956) assumed technological progress to be exogenous. Inclusion of technology into the model is provided by improving the efficiency of labor by the development of technology. Growth models developed by Arrow (1962) and Uzawa (1965) also did not include technological progress (Ünlükaplan, 2009: 237). Innovation concept proposed by Schumpeter (1911) transformed into endogenous growth models by Romer (1986), Grosman and Helpman (1991), Aghion and Howit (1992) who considered that increased R&D spending contributed to economic growth levels and they included R&D spending into the model assuming that it supported continuous economic growth (Göçer, 2013: 218). Endogenous growth models assume that technology comes forward as an element that is developed by the inner dynamics of economy, contrary to the thought that it is exogenous as technological developments assumed to be exogenous by the Neo-classical economics. However they are considered to be an endogenous variable in the endogenous growth models (Özer and Çiftçi, 2009: 39). According to Romer, technological innovations are leading drivers of long term economic growth and for the technological innovations; utmost attention should be given to the R&D activities (Gülmez and Yardımcıoğlu, 2012: 337).

First part of the study consists of the relevant literature review about the relationship between economic growth and R&D activities. Then the model and its results are presented. Selected variables aim to seek answer to the question, whether the crisis caused negative affects over other economic variables other than the GDP shrinkage.

## 2. LITERATURE REVIEW

The direction and intensity of the relationship between R&D activities and economic growth change depending on the economic structure of the countries. The literature about the



relationship between R&D and economic growth indicate that R&D spending support economic growth and it is the dominant view. However, the intensity of the relationship is heavily affected by the efficiency of the R&D spending and domestic dynamics of the countries. Development of new products and services and production methods as a result of R&D spending increase the efficiency of production factors and support economic growth (Korkmaz, 2010: 3328). When R&D spending of countries is ranked, a list of high, middle and low income countries is obtained (Demir et al., 2005:184).

**Table 1: Literature Review about the Relationship between R&D and Economic Growth**

Author(s)	Country(s) and Period	Findings
Griliches (1998)	The USA	%10 increase in R&D spending caused %7 increase in the output.
Yu-Ming et al.	PRC 1953-2004	two way causality relationship existed between R&D and GDP.
Goel et al. (2008)	The USA 1953-2000	the relationship between economic growth and Federal R&D spending was stronger than the relationship between economic growth and non-federal R&D spending
Altın and Kaya (2009)	Turkey 1990-2005	long term causality was found from R&D spending to economic growth while no causality relationship was found in the short term.
Korkmaz (2010)	Turkey 1990-2008	while each variable affects one another in the long run, R&D spending affected GDP in the short run.
Yaylalı et al. (2010)	Turkey 1990-2009	between R&D investment spending and economic growth, a one way causality relationship was found running from R&D investment spending to economic growth.
Akıncı and Sevinç (2013)	Turkey 1990-2011	proposed a one way causality from R&D spending to economic growth
Lichtnberg (1993)	47 countries 1964-1989	a positive and significant relationship existed among private industry R&D spending, economic growth and productivity.
Goel and Ram (1994)	52 countries 1960-1980	found a significant relationship between R&D and economic growth in the long run, yet the direction of the causality could not be identified.
Park (1995)	10 OECD countries 1970-1978	concluded that local private industry R&D investments were important determinants of both local and foreign factor efficiency.
Coe and Helpman (1995)	24 countries 1971-1990	local and foreign R&D activities had strong and significant relationship with total factor efficiency
Freire-Seren (1999)	21 OECD countries 1965-1990	%1 increase in R&D spending provides %0,08 growth in GDP
Sylwester (2001)	20 OECD countries	concluded that no relationship existed between R&D spending and economic growth; yet, a positive relationship existed between industrial R&D spending and economic growth in the case of G7 countries
Bassanini and Scarpetta (2001)	21 countries	proposed that 1% increase in R&D spending caused 0.4% economic growth.
Guellec and Van Pottelsberghe (2004)	16 OECD countries 1980-1998	argued that R&D activities were significant determinants of productivity increase in the long run
Ülkü (2004)	30 countries 1981-1997	concluded that number of patents created by R&D industry had positive relationship with GDP per capita.



Zachariadis (2004)	10 OECD countries 1971-1995	put forward that increased R&D spending led to higher efficiency ratios and output levels.
Falk (2007)	15 OECD countries 1970-2004	argued that R&D spending and investment on high technology R&D had a strong positive relationship with both increased R&D investment, GDP per capita and the GDP per worker.
Wang (2007)	30 countries	proposed that countries with efficient R&D spending would obtain better economic performance.
Özer and Çiftçi (2008)	OECD countries 1990-2005	supported that R&D spending had a positive and significant effect on the GDP.
Saraç (2009)	10 OECD countries 1983-2004	stressed that R&D spending affected economic growth positively.
Samimi and Alerasoul (2009)	30 countries 2000-2006	argued that developing countries invested low amounts of financial resource to the R&D activities and it did not affect economic growth.
Alene (2010)	52 countries 1970-2004	1% increase in agricultural R&D spending increased total productivity by 0,20%.
Genç and Atasoy (2010)	34 countries 1997-2008	put forward a causative relationship from R&D spending to economic growth.
Horvath (2011)		R&D spending had a positive effect on long term economic growth.
Güloğlu ve Tekin (2012)	13 countries 1991-2007	two way causative relationship existed between technological innovation and economic growth.
Kirankabeş ve Erçakar (2012)	31 countries 1997-2007	put forward a positive significant relationship between R&D spending and patent applications.
Eid (2012)	17 countries 1981-2006	argued that following the year of R&D spending (delayed effect) it had a strong and positive effect on the productivity increase.
Göçer (2013)	11 countries 1996-2012	%1 increase in R&D spending contributed 6,5% increase in high technology product, 0,6% increase in information technologies export and 0,43% increase in economic growth rates.

**Reference:** Compiled from Gülmez and Yardımcıoğlu 2012:337-340; Göçer 2013: 223-225 and updated.

Table 1 demonstrates studies in the literature about the relationship between R&D spending and economic growth as well as R&D spending and economic output. As seen in the table there is a vast literature on this subject with studies commencing from 1950s.

### 3. EMPIRICAL RESULTS

The study first examined dependency among cross sections that formed the panel data to identify the relationship among the variables namely economic growth, high technology export, patent applications, the ratio of R&D spending in state expenditures, the ratio of total R&D spending to national income for 5 countries for the period 1995-2016 by using *CDLMadj* (Adjusted Cross-sectional Dependence Lagrange Multiplier) developed by Pesaran, Ulah and Yamagata (2008). Then PANKPSS (Panel Kwiatkowski, Phillips, Schmidt and Shin) test was applied to test whether the series were stationary developed by Carrion-i-Silvestre, Castro and Bazo (2005). The test also considered the horizontal section dependency and structural breaks in cointegration vector. Existence of cointegration relationship was examined by using the method developed by Basher and Westerlund (2009) that analyzed cross section dependency and structural breaks in cointegration vector. Cointegration coefficients were identified by the method of Panel AMG (Augmented Mean Group)



developed by Eberhardt and Bond (2009). Short term relationship among the series and mean difference of series and disturbance term of the series delayed one period, i.e. obtained by using disturbance term. Econometric data of study was obtained from World Bank and Eurostat database.

**Table 2: Explanation of Variables**

Variables	Indicator
GDP growth (annual %)	GDP
Patent applications	PA
Total GBAORD as a % of total general government expenditure	TGB
The ratio of total R&D spending to national income	ARGE
High-technology exports (% of manufactured exports)	HTE

Table 2 demonstrates variables used in the analysis. As seen in the table, GDP, PA, TGB, ARGE and HTE abbreviations are used in the study. They represent GDP growth (annual %), patent applications (PA), Total GBAORD as a % of total general government expenditure, the ratio of total R&D spending to national income and high technology exports (% of manufactured exports respectively).

### 3.1. Testing the Cross Sectional Dependency and Homogeneity

The study used  $CDLM_{adj}$  test to investigate existence of cross sectional dependency among the variables and in the cointegration equation. Mentioned test is based on the averages of error terms on cross section estimation multiple correlations. Null hypothesis is defined as “ $H_0$ : There is no cross section dependency”. Then the variables were tested by using Delta Test developed by Pesaran and Yamagata (2008). Delta tilde test was used to investigate the homogeneity of trend parameters related to cross sections. The test is proposed for variables with many cross sections and time dimension. According to the test results the trend differs among the cross sections (Sezgin, 2017). Obtained results are presented in Table 3.

**Table 3: Results of  $CDLM_{adj}$  Coefficient Homogeneity Tests**

	Test Statistics	Probability
<i>GDP</i>	7.349	0.001
<i>PA</i>	5.205	0.013
<i>TGB</i>	4.635	0.006
<i>ARGE</i>	5.882	0.003
<i>HTE</i>	6.284	0.017
<i>Coefficient Homogeneity Test (Statistical Value)</i>	41.56	0.002

The results in Table 3 demonstrated that cross sectional dependency existed among the countries that constituted the panel data and therefore the null hypothesis was rejected. In this case, an economic shock that occurs in one of the countries also affected others as well. While choosing the methods in the analysis process, test methods that take cross sectional dependency into consideration are required. Moreover, trend coefficients among the cross sections differ.

### 3.2. Panel Unit Root Test

First problem to faced in panel unit root test is whether cross sections that constituted the panel are independent from each other or not. On the other hand, the tests that ignore structural breaks although they exist in the series give false results that determine unit root existed in the series. In order to overcome this problem, the PANKPSS unit root test was developed by



Carrion-i-Silvestre et al (2005) that takes dependency among the horizontal sections and multiple breaks in the series into consideration. PANKPSS also let testing of stationary of the series in the existence of structural breaks in the averages and trends of the series. It also lets structural breaks in different dates and different numbers for each horizontal section unit that constituted the panel. The PANKPSS test is designed to permit five structural breaks. The test identifies the structural breaks for the points where the error sum of squares (SSR) are minimized as proposed by Bai and Perron (1998). While the test identifies the structural breaks, it uses the first stage for the model with trend and the second stage for the model without trend. The null hypothesis of test is “the series is stationary”. Calculated test statistics are compared to critical values calculated with bootstrap. The study examined the stationary of the series by using PANKPSS test since it found horizontal section dependency. It was found that the series were not stationary and first stage difference was taken into consideration to obtain stationary. Table 4 shows results obtained by taking first stage differences into consideration.

**Table 4: PANKPSS Unit Root Test Results**

Country	DGDP		DPA		DTGB		DARGE		DHTE	
	p	Breaks	p	Breaks	p	Breaks	p	Breaks	p	Breaks
<b>Greece</b>	0.114*	2008, 2010	0.162*	2005	0.192*	2008	0.174*	2009, 2010	0.09	2007, 2008
<b>Ireland</b>	0.135*	2001, 2008, 2010	0.213*	2001, 2008	0.134*	2008, 2009	0.133*	2008, 2009	0.08	2002, 2008
<b>Italy</b>	0.192*	2001, 2009	0.225*	2005, 2008	0.136*	2009, 2010	0.129*	2002, 2009	0.102	2003, 2009
<b>Portugal</b>	0.167*	2001, 2008	0.209*	2005, 2009	0.172*	2009, 2010	0.152*	2009, 2010	0.142	2009, 2010
<b>Spain</b>	0.103*	2009, 2010	0.218*	2009, 2010	0.137*	2004, 2010	0.137*	2008, 2009	0.173	2006, 2010
<b>Panel</b>	0.124*		0.237*		0.116*		0.145*		0.165*	

\* Stationary at %5 significance level.

The test method allows structural breaks at stationary and trend levels as a model. Critical values were generated by bootstrap with 1000 repetition. The panel was not stationary at general level and following the obtainment of first difference it became stationary. The test method successfully identified structural breaks.

The break in the economic growth rates of Greece, Ireland and Portugal marked to the point when the 2008 global economic crisis occurred. Therefore, it could be seen that Greece, Ireland and Portugal were affected by the crisis while Spain affected one year later (delayed effect). The test also showed that the ratio of total R&D spending in GDP in Greece, Italy, Portugal and Spain had consecutively breaks for the years 2009-2010, 2008-2009, 2002-2009, 2009-2010, 2008-2009. In the light of these results, it was seen that the effect of economic crisis had its effects on Greece, Italy, and Portugal with less planned spending.

### 3.3. Panel Cointegration Test with Structural Breaks



This test was developed by Basher and Westerlund (2009) and it can identify cointegration relationship among non-stationary series when cross section dependency and multiple structural breaks exist. The method allows three structural breaks in fixed term and trend. Null hypothesis of the test is “There is cointegration among the series”. The study used Basher and Westerlund panel cointegration test and the results were given in Table 5.

**Table 5: Test Results of Panel Cointegration Test with Structural Breaks**

	Test Statistic	Probability Value	Finding
Test result without structural breaks in fixed term and trend.	1.905	0.002	No cointegration
Test result with structural breaks in fixed term and trend.	24.072	0.147	Cointegration exists

Probability values were generated by bootstrap with 1000 repetition. The model was chosen since it allows structural breaks at stationary and trend levels. The panel was not stationary at general level and following the obtainment of first difference it became stationary. According to Table 5, no cointegration relationship among the series could be identified when the structural breaks were not taken into consideration. However, existence of cointegration relationship among the series was identified when the structural breaks were taken into consideration.

### 3.4. Estimation of Cointegration Coefficients

*Panel AMG* method was developed by Eberhardt and Bond (2009) and it not only takes dependency among the cross sections but it also estimates average group effect by weighing the general result of the panel and individual coefficients. Another advantage of this method it can allow estimation of different coefficients of section equations (parameter heterogeneity). Moreover, this method the method does not require the condition that the cointegration grades of variables need to be the same. So this method is quite reliable compared to many known method. Moreover, Panel AMG method takes common factors and dynamic effect in the series into consideration. It can provide effective results for unbalanced panels and used in the existence of endogeneity problem related to error term. The results are given in Table 6.

**Table 6: Cointegration Coefficients**

Variable	Coefficient	p
DPA	0.138	0.003*
DTGB	0.163	0.015*
DARGE	0.215	0.009*
DHTE	0.206	0.007*

\*Coefficient at 0.05 significance level.

The autocorrelation and changing variance problems in the estimations were eliminated by using Newey-West method. Four independent variables that were considered to be effective on the economic growth were found significant and effective. Based on the coefficient magnitudes the most effective two variables over economic growth were found to be ARGE and HTE. They were followed by TGB and PA variables. All discussed independent variables had positive and increasing effect on the GDP.



### 3.5. Short Term Analysis

Short term relationship among the series was analyzed by using error correction term:  $ECT_{t-1}$ . It represented one period delayed value of error term series obtained by long term analysis and weighed difference of the series.

**Table 7: Error Correction Model**

Variables	Coefficient	p	Coefficient of Error Correction Term
DPA	0.124*	0.002	-0.025*
DTGB	0.152*	0.016	-0.127*
DARGE	0.207*	0.008	-0.084*
DHTE	0.183*	0.003	-0.119

\*Coefficient at 0.05 significance level

Short term relationship among the series was estimated by using error correction model in Panel AMG method. The result of error correction term coefficients was found negative and statistically significant. This implies among the series that move together in the long term eliminate the short term variations and the series converge to long term balance value. This result also demonstrated that the series were cointegrated to each other which proved reliability of long term results of the analyses that were conducted with the mentioned series. Coefficients of error correction terms were minimized in absolute value and it meant that balancing speed of the series was slow.

## 4. CONCLUSION

The study investigated effects of four variables namely high technology export, patent applications, ratio of R&D spending in state expenditures and the ratio of total R&D spending to national income over national incomes of GIPPS countries; Greece, Ireland, Italy, Portugal and Spain. The results of the analyses put forward that R&D spending supported economic growth. This conclusion is similar to parallel case studies in the framework of endogenous growth models.

Based on the findings of the study it was seen that an economic shock in one of the GIPPS countries also affected other countries in this group. Therefore four selected countries have dependent economies to each other partly because they are members to the European Union's economic integration. When fixed term and structural breaks in the trend were ignored it was seen that cointegration relationship did not exist. However, when fixed term and structural breaks were taken into consideration it was seen that cointegration relationship existed. When the cointegration coefficients were taken into consideration; four variables, namely high technology export, patent applications, ratio of R&D spending in total state expenditures and the ratio of total R&D spending to national income had significant and positive effect over economic growth of GIPPS countries. This effect was found to be higher for the variables ratio of total R&D spending to national income and high technology export. Four variables that are used in the study had positive and significant effect over economic growth.

Short term relationship among the series was analyzed by using error correction term obtained from one stage delayed value error term series which was obtained by long term analysis of the difference of the series. Short term relationship among the series was estimated by using Panel AMG method within the framework of error correction model. The coefficients of error correction terms were found negative and statistically significant. This implies among the series that move together in the long term eliminate the short term variations and the series converge to long term balance value. This result also demonstrated that the series were





cointegrated to each other which proved reliability of long term results of the analyses that were conducted with the mentioned series.

Findings of the study give similar results to Özer and Çiftçi's (2009) study. The study supports positive and significant relationship between R&D activities and economic growth. Based on these findings, identifying R&D spending as a process to support economic growth and establishing policies that particularly target encouraging high technology production and its exportation come fore during the policy making process of economy policies for the countries to keep up and reach sustainable economic growth levels.

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