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THE EFFECT OF R&D EXPENDITURES ON HIGH-TECH MANUFACTURING INDUSTRY EXPORT: THE CASE OF OECD COUNTRIES

AR-GE HARCAMALARININ YÜKSEK TEKNOLOJİLİ İMALAT SANAYİ İHRACATI ÜZERİNDEKİ ETKİSİ: OECD ÜLKELERİ ÖRNEĞİ

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ABSTRACT

The aim of this study is to analyze the effect of R&D expenditures on high-tech manufacturing industry export for the 24 OECD countries in the period 1996-2015 with Panel Ordinary Least Squares (OLS), Fixed Effects (FE) and Random Effects (RE) Models. .

Although there are a lot of studies that analyzed the impact of R&D expenditures on total exports and high-tech export, there are few studies that analyzed the effect of on high-tech manufacturing industry export with the sub-sectors of manufacturing industry in the empirical literature. In the study, this effect is investigated according to Standard International Trade Classification (SITC Rev.3) by including 3-digit datas. Because of this reason, the study is important to contribute to literatüre.

According to the FE Model results which is the most appropriate model for data set, in the OECD countries considered, there is a significant and positive relationship between R&D expenditures and high-tech manufacturing industry export. Analysis results are largely consistent with theoretical and empirical literatüre.

Keywords: High-Tech Manufacturing Industry Export, R&D Expenditures, Panel Data Analysis.

ÖZ

Bu çalışmanın amacı, AR-GE harcamalarının yüksek teknolojili imalat sanayi ihracatı üzerindeki etkisini, 24 OECD ülkesi ve 1996-2015 dönemi için analiz etmektir. Çalışmada bu etkiyi belirlemek için Panel En Küçük Kareler, Sabit Etki ve Tesadüfi Etki modelleri kullanılmıştır.

Ampirik literatürde AR-GE harcamalarının toplam ihracat ve yüksek teknolojili ihracat üzerindeki etkisini araştıran çok sayıda çalışma olmasına rağmen, bu etkiyi imalat sanayi alt sektörleri ile analiz eden az sayıda çalışma mevcuttur. Bu çalışmada AR-GE harcamalarının yüksek teknolojili imalat sanayi ihracatı üzerindeki etkisi, Standart Uluslararası Ticaret Sınıflaması (SITC) Rev.3'e göre, 3 dijitli veriler ile analiz edilmiştir. Çalışma literatüre bu konuda katkı sağlamak açısından önem arz etmektedir.

Veri setine en uygun model olan Sabit Etki Model sonuçlarına göre, ele alınan OECD ülkelerinde AR-GE harcamaları ve yüksek teknolojili imalat sanayi ihracatı arasında önemli ve pozitif yönlü bir ilişki vardır. Ampirik sonuçlar bu konuda yapılan çalışmalar ile büyük ölçüde tutarlıdır.

Anahtar Kelimeler: Yüksek Teknolojili İmalat Sanayi İhracatı, AR-GE Harcamaları, Panel Veri Analizi

1. INTRODUCTION

It is argued that a rise in R&D ability of a country causes to a rise in the export of the country in the theoretical and empirical studies. The debate shows that it is only possible for the best companies to cope with foreign competition. So the most innovative domestic companies are companies that pruduct differentiated products and use the latest technology (Girma, Görg and Hanley, 2008).

R&D expenditures have a great importance in terms of achieving sustainable economic growth. According to the internal growth models, the effect of R&D expenditures on per capita income as well as economic growth is positive. The R&D expenditures firstly shift the export of one country from low-tech products to high-tech products (Özkan and Yılmaz, 2017). High-tech products create more added value, they increase the export revenues of the country and make an important contribution to economic growth (Kılavuz and Altay Topcu, 2012).

The aim of this paper is to determine the impact of R&D expenditures on high-tech manufacturing industry export according to SITC Rev.3 with 3 digit datas by using panel data analysis in the 1996-2015 period for 24 OECD countries. The contribution of this study is investigated the effect of R&D expenditures on manufacturing industry export by using 3 digit manufacturing industry datas.

The paper consists of 4 sections. Section 2 presents the empirical literature related with the relationship between R&D expenditures and total export and high-tech product export. Section 3 provides econometric model and findings. In this section is examined data set, panel unit root tests and model and panel analysis results. Finally, several conclusions are presented in Section 4.

2. LITERATURE RESEARCH

There are many studies that examined the effect of R&D expenditures on export and high-tech product export in the empirical studies. Despite the fact that the effect of R&D expenditures on export and high-tech product export has been widely studied, there are a few number of studies analyzed with the sub sectors of manufacturing industry. In the empirical literatüre some of the studies are as follows:

Özer and Çiftçi (2009) analyze the relationship between R&D expenditures, total export, information communication technologies export and high-tech product export in 19 OECD countries for the period 1993-2005 by using panel data analysis. The analysis results show that the effect of R&D expenditures on all of the export variables is significance and positive in the mentioned countries and time period.

Yıldırım and Kesikoğlu (2012) examine causality relationship between R&D and export by using a panel data set for the 25 sub-sectors with GMM estimation and Wald test in the period 1996-2008. According to the results of causality analysis, there is a one-way causality relationship from R&D to export, but there is not a causality relationship from export to R&D. That's why, R&D expenditures play an important role increasing competitive advantage.

Uzay, Demir and Yıldırım (2012) investigate the effect of R&D expenditures on manufacturing industry export for the period 1995-2005 in Turkey with panel data analysis. The study results indicate that R&D expenditures largely affect manufacturing industry export laggedly.

Göçer (2013) analyze the relationship between R&D expenditures, total export, information communication technology export, high technology export and economic growth for the period 1996-2012 in 11 developing Asian countries. The author also examines the relationship between high technology export and balance of foreign trade for the same countries and period. According to the panel data analysis results, an increase by 1% point in R&D expenditures raised the information-communication technology exports by 0,6% point, the high technology export by 6,5% point, and the economic growth by 0,43% point. As a result the effect of R&D expenditures on high technology export is greater than the effects of other variables.

The other findings show that the high-tech product export affects trade balance positively, but this effect is statistically meaningless. The effect of R&D expenditures on total goods and services export is positive, but meaningless; it's effect on economic growth is positive and statistically significant.

Kılıç, Bayar and Özekicioğlu (2014), analyze the relationship between R&D expenditures and high technology export in G-8 countries for the period 1996-2011 with panel data analysis. The analysis results show that the effect of R&D expenditures and real effective exchange rate on high technology export is positive and also there is two-way causality relationship between R&D expenditures and high technology

export and between R&D expenditures and real effective exchange rate. Additionally there is one-way causality relationship from high technology exports to real effective exchange rate.

Dam and Bulut (2016) examine the relationship between R&D expenditures and foreign trade by using 1996-2012 annual datas for 21 OECD countries. According to study results, export and R&D variables are co-integrated on the long term and in this respect one-way causality relation is observed from export to R&D. As a result of long term analysis, export of these countries 35% rise if R&D expenditures 100% increase. Moreover, error correction term coefficient this model's is negative and statistically significant.

Sungur, Aydın and Eren (2016) analyze the effects of R&D expenditures, patents and innovation activities, number of R&D researchers on export and economic growth for the period 1990-2013 in Turkey. In the study, two model were estimated. According to the Granger Causality test results, there is one-way causality relationship from patent number to growth in Model 1. The Model 2 results indicate that there is two-way causality relationship from export to share of R&D expenditures in GDP, from R&D labor force to export, from patents to export.

Özkan and Yılmaz (2017) analyze the relationships between the high-technology export, GDP and R&D expenditures with method of panel data analysis for the period 1996-2015 in Turkey and 12 member countries of the EU. According to panel analysis results, the R&D expenditures have a positive effect on high-technology export and GDP.

Sandu and Ciocanel (2014) analyze the effects of R&D expenditures and innovation on high-tech export for 26 EU countries in the period 2006-2010. The Analysis results show that the R&D expenditures have a positive effect on high-tech export in the majority of countries. Morever the effect of private R&D expenditures on high-tech export is stronger than the effect of public R&D expenditures on high-tech export.

Ito and Pucık (1993) examine between relationship the R&D expenditures, domestic competitive position, firm size and the export performances of Japanese manufacturing firms. According to the analysis results, the effects of R&D expenditures, firm size and average R&D intensity on export sales are positive. While the firm size increases the export ration, it does not increase the R&D intensities. Follower firms have higher export ratios than market leaders. The analysis results emphasize that there is a relationship between the patterns of domestic competition and the international competitiveness of Japanese firms.

Bojnec and Ferto (2011) examine between relationship R&D expenditures and manufacturing trade for the period 1995-2003 and in 18 OECD countries with the panel data analysis. According to the study results, R&D expenditures affect manufacturing trade positively for exporting countries. There is a non-linear relationship between R&D expenditures and manufacturing export for importing countries. The results show that R&D expenditures increase manufacturing industry export and may lead to import specialization. As a result, R&D expenditures are the best way encouraging of manufacturing export from developing to developed OECD countries.

Braunerhjelm and Thulin (2006) examine the effects of R&D expenditures and market size on the distribution of comparative advantage for the period 1981-1999 in 19 OECD countries. The analysis results show that an increase by 1% point in R&D expenditures rised the high-tech export 3% point, while the effect of market size on high-tech export is statisticaly insignificant.

Ortega, Benavente and Gonzalez (2013) analyze for the period 1997-2004 in Chilean aconomy the effect of R&D expenditures on productivity and export. The research results imply that the companies that invest in R&D are considerably more exporter. The export does not increase R&D expenditures while both export and R&D expenditures have a positive effect on improving productivity.

Caldera (2010) investigates the effect of innovation on the export behavior of firms with representative panel datas for Spanish firms in the period 1991-2002. According to the analysis results the firm innovation have a positive effect on the firm export. The results emphasize that the different types of innovations affect the firm export differently. In particular, product upgrading have a larger impact than cost-saving innovations on the firm export participation.

Hirsch and Bijaoui (1985) examine the effect of R&D expenditures on export for Israel economy in the period 1977-1983. According to the findings of the study, R&D expenditures affect export positively.

Landesmann and Pfaffermayr (1997) analyze the relationship between R&D expenditures and export for OECD countries in the period 1967-1987. According to some findings in the study, the effect of R&D expenditures on export is positive in the US, UK and Japan; this effect is negative in Germany and France.

Kagochi and Jolly (2010) evaluate the relationship between R&D expenditures, human capital, and the competitiveness of U.S. and it's rivals in the corn, cotton, wheat and soybeans products in the period 1971-2006. The export model is predicted with dynamic ordinary least squares (DOLS) with R&D expenditures, the Mickey Index of trade specialization and human capital ratios datas. According to the study results, there is a positive relationship between agricultural commodity export growth, domestic R&D expenditures and the Mickey Index of trade specialization.

The results show that the most competitive products are wheat and corn in United States while the most competitive products are cotton and soybean in Argentina and Australia. The research results indicate that R&D expenditures rise competitiveness of in the agricultural commodities for some countries.

In the empirical literatüre, the other some studies that have reached the conclusion that R&D expenditures have a positive effect on export are as follows: Hirsch, Kalish and Katznelson (1988), Zhao and Li (1997), Verspagen and Wakelin (1997), Sterlacchini (1998), Basile (2001) and Halpern and Muraközy (2011).

3. ECONOMETRIC MODEL AND ANALYSIS RESULTS

In this chapter, firstly, the information is given about the data set used in the study. Later, panel unit root tests was applied to determine whether the series are stagnant or not, and the results of OLS, FE and RE Models are evaluated.

3.1. Data Set

In this study, the effect of R&D expenditures on high-tech manufacturing export (HTX) was tested in 24 OECD countries for the period 1996-2015. The HTX and the R&D expenditures variables were analyzed as a percentage of the GDP. The R&D expenditures variable is obtained from World Bank World Development Indicators Database-WDI and the HTX variable International Trade Statistics Database-UN Comtrade.

According to the SITC Rev.3 classification used in the study, high-tech manufacturing industry sector codes and sector descriptions at the 3 digit level are shown in the Table 1.

Table 1: High-Tech Manufacturing Industry (SITC Rev. 3)

Sector Codes	Sector Descriptions
525	Radioactive and associated materials
541	Medicinal and pharmaceutical products, other than medicaments of group 542
542	Medicaments (including veterinary medicaments)
712	Steam turbines and other vapour turbines and parts thereof, n.e.s.
716	Rotating electric plant and parts thereof, n.e.s.
718	Power-generating machinery and parts thereof, n.e.s.
751	Office machines
752	Automatic data-processing machines and units thereof, n.e.s.
759	Parts and accessories for machines of groups 751, 752
761	Monitors and Projectors, Television reception apparatus, whether or not combined
764	Telecommunications equipment, n.e.s., and parts, n.e.s., and accessories of apparatus falling within division 76
771	Electric power machinery (other than rotating electric plant of group 716) and parts thereof
774	Electrodiagnostic apparatus for medical, surgical, dental or veterinary purposes, and radiological apparatus
776	Cathode valves and tubes
778	Electrical machinery and apparatus, n.e.s.
792	Aircraft and associated equipment; spacecraft (including satellites) and spacecraft launch vehicles; parts thereof
871	Optical instruments and apparatus, n.e.s.
874	Measuring, checking, analysing and controlling instruments and apparatus, n.e.s.
881	Photographic apparatus and equipment, n.e.s.

Source: UNCTAD, SITC Rev.3 Products, by Technological Categories (Lall (2000), http://unctadstat.unctad.org/EN/Classifications/DimSitcRev3Products_Ldc_Hierarchy.pdf, (06.02.2018).

The 24 OECD countries were analyzed according to the availability of datas are shown in Table 2.

Table 2. OECD Countries in Analysis

Australia	Korea
Latvia	Canada
Mexico	Denmark
Slovak Republic	Czech Republic
Slovenia	Netherlands
Finland	Poland
France	Portugal
Spain	Germany
Turkey	Italy
Ireland	Hungary
Israel	Japon
United Kingdom	United States

3.2. Panel Unit Root Tests

Table 3 shows the unit root analysis results of the R&D and HTX variables for intercept in the level value and first difference value.

Table 3. Panel Unit Root Analysis (For Intercept)

VARIABLES	**Level Value**			
	Levin,Lin & Chu t	Im, Peseran and Shin W-Stat	ADF-Fisher Chi-Square	PP-Fisher Chi-Square
HTX	-0.49131 (0.3116)	0.63294 (0.7366)	55.3738 (0.2164)	67.9948** (0.0303)
R&D	0.84476 (0.8009)	3.26704 (0.9995)	27.7039 (0.9917)	24.2551 (0.9983)
First Difference Value				
HTX	-12.6551* (0.0000)	-12.8057* (0.0000)	236.563* (0.0000)	294.581* (0.0000)
R&D	-6.96899* (0.0000)	-8.23546* (0.0000)	160.400* (0.0000)	436.304* (0.0000)

* and ** stand for significance at 1% and 5% confidence levels, respectively.
The numbers of delay were chosen via Schwarz Information Criterion.
The values in parentheses show the possibility values.

The all test results indicate that in Table 3, the R&D and HTX variables were non-stagnant except PP-Fisher Chi-Square test result for HTX variable in the level value. First differences of variables were taken to solve unit root problem. According to the all test results, R&D and HTX variables were stagnant in their own levels for significance at 1%.

3.3. OLS, FE and RE Model Results

The model which tested the effect of R&D expenditures on high-tech manufacturing industry export was estimated in 24 OECD countries with OLS, RE and FE methods in the study.

The model to be estimated was as follows:

$$HTX_{it} = \alpha + b_1 R\&D + e_{it}$$

The OLS, FE and RE model results indicate in Table 4.

Table 4. OLS, FE and RE Models Estimation Results

Variables	**OLS**	**RE**	**FE**
Constant	6.132002 (0.0000)*	2.766925 (0.0265)**	2.354692 (0.0005)*
R&D	0.124415 (0.6306)	2.039712 (0.0000)*	2.274342 (0.0000)*
R^2	0.000484	0.063822	0.815259
F Statistics	0.231543	32.58659*	83.66300*
Hausman Test		**3.9450****	
Breusch-Pagan LM Test		**2856.05***	
The Number of Observations	480		
The Number Of Countries	24		

* and ** statistically significant at the 1% and 5% levels, respectively.
The numbers in parentheses show the possibility values.

The results of the OLS Model indicate that the R&D expenditures variable is statistically meaningless in Table 4. Breusch-Pagan LM test was applied to choose between the OLS and RE Models. According to LM test result, the test statistics (2856.05) is statistically significant at the 1% level, and the null hypothesis is denied. That's why, the RE Model was preferred to the OLS Model. The RE test results show that, the effect of R&D expenditures variable on HTX variable is statistically significant and positive at the 1% level.

The Hausman Test was applied to choose between the RE and FE Models. According to the Hausman test results, the test statistics (3.9450) is statistically significant at the 5% level, the null hypothesis is denied, and the FE Model was preferred to the RE Model. As a result, the most appropriate model was the FE Model for data set in the study. According to the FE Model results, the effect of R&D expenditures variable on HTX variable is statistically significant and positive at the 1% level.

4. CONCLUSION

According to the literature, the countries that invest in R&D have a more comparative advantage and also the countries that have large R&D expenditures can use more advanced technology. These countries have more competitive advantages than the other countries to invent new products or new production processes. Because of this, the R&D behavior of a country affect the export performance of it positively (Kagochi and Jolly, 2010).

In this study, the effect of R&D expenditures on high-tech manufacturing industry export was investigated for 24 OECD countries for the 1996-2015 period by using OLS, RE and FE Models. According to the OLS estimation results, the effect of R&D expenditures variable on HTX variable is positive and statistically meaningless. RE estimation results are as follows: the effect of R&D expenditures variable on HTX variable is statistically significant and positive.

According to FE Model which is the most appropriate model for data set, the R&D expenditures variable is statistically significant and it affects the HTX variable positively. The FE Model results show that an increase by 1% point in R&D expenditures increased the high-technology manufacturing industry export 2.27% point. According to the F statistics value (83.66300), the model is meaningful as a whole at the 1% significance level. The R^2 value (0.815259) indicates that 81% of the changes in high-tech manufacturing industry export are caused by changes in R&D expenditures. The results of analysis are largely consistent with the theoretical and empirical literature.

According to the findings of this study, the countries should produce and export the advanced technology products that create high added value for *achieving sustainable* economic growth. For this, it can be said that the share of R&D expenditures in GDP should be increased and educational arrangements should be made to train high qualified workforce for increasing advanced technology products.

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