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INNOVATION EFFECT THROUGH RESEARCH AND DEVELOPMENT ON ECONOMIC GROWTH IN 35 OECD COUNTRIES

*Efeito da inovação através da pesquisa e desenvolvimento sobre o crescimento econômico em 35 países da
OECD*

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ABSTRACT

This paper analyzes the effect of research and development (R&D) expenditures on economic growth in the Organization of Economic Cooperation and Development (OECD) countries over the period 2000-2016. This study conducts an empirical analysis using a multiple regression model. The main findings confirm that an increase in research and development expenditure by 1% would generate an increase of real GDP growth rate to 2.83 %. The implication emerging from this study is that government and institutions need to increase investment in R&D expenditures to fulfill inclusive economic growth perspective.

Keywords: Research and development, Economic Growth, Innovation, OECD Countries.

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EFEITO DA INOVAÇÃO ATRAVÉS DA PESQUISA E DESENVOLVIMENTO SOBRE O CRESCIMENTO ECONÔMICO EM 35 PAÍSES DA OECD

Innovation effect through research and development on economic growth in 35 OECD countries

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RESUMO

Este artigo analisa o efeito dos gastos com pesquisa e desenvolvimento (P&D) sobre o crescimento econômico nos países da Organização para a Cooperação e Desenvolvimento Econômico (OCDE) no período de 2000-2016. Este estudo realiza uma análise empírica usando um modelo de regressão múltipla. As principais conclusões confirmam que um aumento de 1% nas despesas com investigação e desenvolvimento geraria um aumento da taxa de crescimento real do PIB para 2,83%. A implicação que surge deste estudo é que o governo e as instituições precisam aumentar o investimento em gastos com P&D para cumprir a perspectiva de crescimento econômico inclusivo.

Palavras-chave: Pesquisa e Desenvolvimento, Crescimento Econômico, Inovação, Países da OCDE.

INTRODUCTION

Economic growth models emphasize the importance of technical change and assert that technological development is the main driver of economic growth in the long run. Developed countries largely base their economic growth on the creation and use of knowledge. Knowledge, objectified in technological changes, has become a fundamental creator of competitive advantage of companies and countries on the world market (Lucas, 1993). The study of knowledge as a key determinant of economic growth is especially present in so-called new growth theory. The two most important directions of new growth theory are endogenous growth models and evolutionary approach to presenting the complex of technological change as a source of economic growth. The common thread is their attempt to arrive at a proper answer to the question of what are the key drivers of complex technological changes.

Endogenous growth models follow Schumpeter's idea of the importance of organized knowledge creation in generating economic growth based on research and development (Schumpeter, 1942). Romer (1987) marks a new theoretical approach to the analysis of economic growth factors, the so-called endogenous growth by formalizing the idea that knowledge leads to continuous economic growth. This feature of technological progress has been particularly studied by Grossman and Helpman (Grossman & Helpman, 1991) and Aghion and Howitt (Aghion & Howitt, 1998).

In Romer (1994) model, research and development plays an important role in innovation, increasing the productivity and economic growth. Therefore to achieve the long-term economic growth, investment in research and development is very important. Worldwide increased investment in R&D has attracted the attention of many academic researchers. From the theoretical aspects, R&D expenditures have a significant and positive effect on economic growth. However, from empirical aspects due to direct and indirect effects of different types of R&D there are problems in effect measure. So, to cope with this issue empirical studies differ greatly from sources of data (countries, periods, time), aggregated level (industries or companies) and measurements of key variables such as stocks. The findings of these studies cannot be compared directly; even theoretical assumptions are confirmed empirical.

Taking evidence from OECD countries, this paper investigates the effect of R&D expenditures on economic growth over the period 2000–2016. This objective is pursued through a multiple regression method based on a sample of 35 OECD countries. Numerous studies use panel data analysis in R&D and economic growth interrelation. The findings vary from country, time periods, variables, econometric methods and different panels. Guloglu and Tekin (2014) examine possible causal relations among R&D expenditures, innovation and economic growth in high income OECD countries. Their findings from bivariate panel causality test suggest that R&D expenditures Granger cause innovation, while technological innovations Granger cause economic growth.

Several studies examine the relationship between R&D expenditure and economic growth. A study conducted by Gumus and Celikay (2015) analyses the contribution of R&D expenditure on economic growth in developed and developing countries. Their findings show that R&D expenditure has a positive and significant effect on economic growth for all countries in the long run, but for developing countries the effect is weak in the short run but strong in the long run. Freimane and Balima (2016) investigate the empirical relationship between research and development expenditures and economic growth in the European Union member states. The main findings show a statistically significant impact of R&D expenditures on the economic growth in the EU countries. Yazgan and Yalcinkaya (2018) evaluate whether or not the economic performance of OECD-20 and OECD-9 countries have a sustainable structure that endogenize the technological advancements and occurs by the increments in average factor productivity. They find that R&D variables in different qualifications of the OECD-20 and OECD-9 group have statistically significant effects on the economic growth. However, the effect of R&D investments is bigger in the OECD-20 than in OECD-9.

From previous studies, the literature review shows there still questions about the effect of R&D expenditure on economic growth in the OECD countries. For this study, we expect a positive effect of R&D expenditure on economic growth in the OECD countries. In recent years, with the convergence speed and investment on R&D, the effect could have more significant effect.

The remainder of the paper is as follows: Section 2 describes data and methodology, Section 3 presents empirical results and the last section 4 summarizes conclusion.

1 DATA AND METHODOLOGY

The levels of innovation activities in national economy are an important factor in empirical research on the effect of innovation on economic growth rate. The share of research and development expenditure in GDP is the most used data on innovative activities in one country. This approach is highly acceptable because it is suitable for quantitative and qualitative analysis. The model use corresponds to the production function with R&D among others such as capital:

$$\ln Y_{i,t} = \beta_0 \ln Y_{i,t-1} + \beta_1 \ln GG_{i,t} + \beta_2 \ln GF_{i,t} + \beta_3 \ln RD_{i,t} + n_i + \varepsilon_{i,t} \quad (1)$$

The dependent variable is the real growth rate of gross domestic product as Y, GG is General government final consumption expenditure, GF is Gross fixed capital formation and RD is R&D expenditures. n_i represents the individual fixed effects of each countries and $\varepsilon_{i,t}$ is an error term.

The differenced generalized method of moments (GMM) with Arellano-Bond (1991) type is used to solve the heterogeneity and autocorrelation problems.

$$\Delta \ln Y_{i,t} = \beta_0 \Delta \ln Y_{i,t-1} + \beta_1 \Delta \ln GG_{i,t} + \beta_2 \Delta \ln GF_{i,t} + \beta_3 \Delta \ln RD_{i,t} + \Delta \varepsilon_{i,t} \quad (2)$$

Where Δ denotes first difference of variable. Data has been collected from the official statistics of OECD and World Bank data base. It is known that gross domestic product is a measure of economic activity in a national economy, measured by the value of output (goods and services). The aim of this study is to determine whether the research and development expenditure has an impact on economic growth in OECD countries.

2 EMPIRICAL RESULTS

The descriptive statistics of name variables are presented in **table 1**.

Table 1: Descriptive statistics and names of variables

Variable	Obs.	Mean	Std.dev.	Min	Max
Real GDP growth rate	275	1.891471	1.652292	-3.471759	4.089127
General government final consumption expenditure as a percentage of GDP	275	31.25807	5.092584	23.2	39.29872
Gross fixed capital formation as a percentage of GDP	275	9.771874	4.760953	2.27187	17.27188
R&D expenditures as a percentage of GDP	275	24.46158	5.077135	16.4	32.49569

Source: Research results

In this study, multiple regression models with fixed effect (FE) are used. The reason for such approach is to analyze the influence of selected variables change over time. The fixed effect explores the link between, on the one hand a dependent and on the other hand independent and control variables, within each entity individually in our case, the observed countries. Another important assumption of the FE model is that those time-invariant characteristics are unique to the entity, and should not be correlated with other entities' characteristics. Each entity is different, therefore, the entity's error term and the constant (which captures individual characteristics) should not be correlated with the others entity's error terms (Wooldridge, 2002).

Each country has some characteristics that influence real GDP growth differently. The mean is based on observations from all countries, and that could be the reason for a great standard deviation. When fixed effect model is used to get entity error, the error is correlated with other predictors in equity. Those entity errors are unobserved time invariant characteristics of every country.

First, simple linear regression is run. The dependent variable is real GDP growth rate. The independent variables are government final consumption expenditure, gross fixed capital formation and R&D as a percentage of GDP. The regression result output is presented in **Table 2**.

Table 2: Simple Linear Regression

Real GDP growth rate	Coef.	Std.Err	t	P>t	95%conf.interval
General government final consumption expenditure as a percentage of	7.499429	11.503	0.65	0.528	-17.818 32.817
GDP Gross fixed capital formation in %GDP	-29.90876	17.665	-1.69	0.119	-68.790 8.973
R&D expenditure percentage of GDP	22.49319	24.539	0.92	0.379	-31.516 76.503
-cons	505.9286	447.917	1.13	0.283	-479.93 1491.78

Source: Research results

Adjusted R-Squared has a similar interpretation, but taking into account the numbers of variables in our regression model. The study interested to find it out if there is any evidence between our independent variable and a dependent variable controlling for the other variables. The conclusion from Table 3 is that, with the clause *ceteris paribus*, an increase in the share of research and development expenditure in GDP by 1% will have an impact on the real growth rate of GDP by 1.21 percentage points in the observed economies in the observed period. In order to improve the validity and applicability of the model, i.e. that the variable government final consumption expenditure as a percentage of GDP has a lower p value, but also point to the growing importance of investment in research and development for economic growth, we performed the time adjustment of our control variables. Therefore, on the basis of a number of iterative steps, we constructed a multiple regression model, in which we observed the effects of fertility rates with a one-year lag (Table 4).

Table 3: Multiple regression using Fixed effect model

Real GDP growth rate	Coef.	Std.Er r	t	P>t	95%conf.interval
General government final consumption expenditure as a percentage of GDP	-0.3920452	0.2447 43	-2.89	0.059	-6.82554 0.00219
Gross fixed capital formation in %GDP	0.7057682	0.0637	11.75	0.002	.59391 .78125
R&D expenditure percentage of GDP	1.213281	86	3.62	0.035	.14568 3.08234
Dummy	-0.0565523	0.5952	-12.45	0.006	-0.06578 -0.0509
-cons	0.0891454	36	1.65	0.213	-0.02009 0.27229
Sigma-u	0.03895689	0.0056	(fraction	variati	due to u_i)
Sigma-e	0.65538660	35	of	on	=0000
Rho	(25,225)=6.5	0.0563		Prob>	
F test that all	2	58		F	
U_i=0					

Source: Research results

Table 4: Multiple regression using fixed effect model using time lag for one year

Real GDP growth rate	Coef.	Std.Er r	t	P>t	95%conf.interval
General government final consumption expenditure as a percentage of GDP	-0.419256	0.4547 83	-3.26	0.062	-7.85424 0.02159
Gross fixed capital formation in %GDP	0.8125768	0.0813 86	12.52	0.000	.63125 .81425
R&D expenditure percentage of GDP	2.831281	0.0795 36	4.29	0.005	.23568 3.8524
Dummy	-0.0654538	0.0075 65	-13.52	0.000	-0.07278 -0.02289
-cons	0.2489154	0.0586	3.15	0.008	-0.03209 0.32291
Sigma-u	0.03395687	(fraction		variatio	due to u_i)
Sigma-e	0.03536582	of		n	=0000
Rho	0.75360253	58		Prob>	
F test that all	(25,271)=5.8			F	
U_i=0	2				

Source: Research results

Table 4 result points to the conclusion that, with the clause *ceteris paribus*, an increase in the share of research and development expenditure in GDP by 1% will have an impact on the growth rate of real GDP by 2.83

percentage points. The coefficient of determination in this case is higher and by adding one model to this the fact that the F-test is a good value, all coefficients are different from zero. As descriptive statistics show R&D effect within the OECD countries, in further analysis it should be important to consider more factors that influence R&D effectiveness.

CONCLUSION

After reviewing the relevant literature and empirical studies that link the research and development with economic growth, in this paper we set the research question of whether the research and development expenditure in the period from 2000 to 2016 in the OECD countries had a positive effect on economic inclusive growth. For this purpose, a multiple regression model is constructed in which the dependent variable is the real rate of economic growth, and the independent variable the value of research and development expenditure as a percentage of GDP. The obtained results unambiguously confirm that research and development has a positive effect on the real economic growth rate. The constructed multiple regression model with fixed effects showed that, with the application of the clause *ceteris paribus*, an increase in the share of research and development expenditure in GDP by 1% causes GDP growth of 2.83 % in 35 countries of the OECD in the period 2000 to 2016. The results obtained in the study are consistent with theoretical and empirical findings of previous studies. These findings show that to ensure economic growth, it is necessary to allocate more resources to R&D activities.

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