GROSS DOMESTIC EXPENDITURE ON R&D AND PUBLIC FINANCE IMBALANCES IN THE EU COUNTRIES

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Abstract

The article's main goal is to assess the influence of fiscal imbalances, such as the relations between a deficit and debt and GDP and the level of nominal budget spending on research and development (R&D) in European Union member states.

In order to identify the factors influencing the amount of government expenditure on R&D in the European Union states, an econometric model for panel data has been created. The data come from the Eurostat database. The dependent variable is the amount of public sector expenditure on R&D in particular EU countries in years 2007-2016. The set of independent variables, on the other hand, contains variables referring to the condition of public finances, such as the public sector deficit and public debt. Other factors taken into consideration are a country's GDP, its level of development expressed with GDP *per capita*, and a variable describing the share of export in GDP. An important factor, whose influence is negative, is general government gross debt. A positive impact on the amount of public spending on R&D in the EU was discovered in the case of variables referring to the countries' economic growth, i.e. nominal gross domestic product and GDP *per capita*.

Key words: research and development, public expenditure, panel data models

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Introduction

The level of expenditure on Research and Development (R&D) in a given country is often considered to be an indicator of its development capacity. However, the level of those expenditures is influenced by many factors, whose analysis may provide important data, useful for building strategic objectives of a country's policy in terms of development and economy. At present, the frequency and severity of debt-related crises draws attention towards the connections between fiscal imbalances and development capacity in various countries.

As part of the total expenditure of the public and private sector on R&D the factors which influence them cannot take a different shape than if one were to analyze the expenditure of each of those sectors separately. In subject literature it is often emphasized that public spending on R&D has a multi-channel impact on the possibility of their funding by the private sector, along with the existence of a problem of substitution for those sources of funding. In this paper, the subject of analysis is the public part of expenditure on R&D, whereas the spending of private sector and the relations between the expenditure of both sectors are intended as the topic of other articles within a series.

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1 Mechanisms of influence of selected fiscal and general-economic factors on R&D expenditure

Significant spending on research and development influence innovativeness of economies, and consequently their international competitiveness (Łapińska, 2010). The relations between and factors such as budget imbalances, economic growth and pro-export attitude can work in a two-way manner – R&D influences them, or they influence R&D. In particular countries there can be differences in the force of the influence in one direction or another, but a more frequent research topic is the influence of R&D on those factors, rather than their influence of R&D (Yazgan, 2018).

The proportions between public and private expenses on R&D are considered relevant due to the fact that it is the public spending that funds research, whereas the private spending funds development. In the USA within the last few decades the total expenditure on R&D in relation to GDP have been stable, oscillating between 2.5%. With time, however, over half of the public spending on R&D has been gradually substituted with private one. There are thus growing concerns about the possible lack of publically-funded research for further stimulation of privately-funded development ideas (Bonvillian, 2017). This paper, however, has not studied the dependencies between the public and private spending on R&D in the EU countries in the context of fiscal imbalance, as in comparison to the USA the relations here are quite stable (Eurostat, 2016). An element which is particularly prone to substitution between public and private funding is the R&D in the military sector, which in the EU countries has lesser importance than other sectors, especially in comparison to the structure of

US economy (Cincera et al., 2011; Guellec & Pottelsberghe, 2016). The connections between the total level of R&D expenditure and the relations between the public and private channels of funding them have a more complex character and require explanation within another publication.

The challenges related to the size of R&D funding are both shot- and long-term in their nature. In the short-term perspective, in a given annual budget there can be exceptional expenditure which the authorities consider a priority, at the expense of R&D funding, such as for instance temporary increase in military spending. Long-term threats to sufficient R&D spending are a result of deeper socio-economic changes, which the authorities have limited influence on. Such a factor in many countries are various consequences of society ageing, generating higher public spending in the category of fixed expenditure, which due to legal, political and economic reasons cannot be easily reduced without a revolution in the area of social security (Bonvillian, 2017).

Appropriately funded and properly functioning R&D are commonly believed to be a potential source of economic growth thanks to technological innovations. It helps to alleviate the consequences of an increase in fixed expenditure and a public deficit generated, for example, by the aforementioned ageing of society, or other elements of pro-social policy, having influence on maintaining the potential for higher R&D expenditure. Comparing the expenses for R&D with GDP is a commonly accepted indicator of the level of investment of a given country in R&D, as proof of the country's innovative potential and innovation-instigated economic growth. GDP alone is often considered an unreliable measure of wealth (Donaldson, 2008). It can, however, serve as a source of information on the shaping of fiscal base, generating funds for R&D spending, and on the areas of spending which act as a competition for R&D (for example, a decline of GDP leads to growing unemployment, which in turn results in increased social spending). Not all state authorities, however, accept the theory of innovation-driven economic growth as part of their economic practice. Frequently, more attention is paid to the supply of capital or the supply of dependent labor than to the intensification of R&D (Bonvillian, 2017; Cova et al., 2017).

An important factor in terms of supporting economic growth in particular countries is appropriately large share of export in generating GDP. At the same time, research demonstrate mutual relations between the importance of export for a given economy and investments in R&D (Nevesa, et al., 2016). In the case of research of those relations in the EU countries as a whole, given the lack of any hidden mechanisms, one should not expect unambiguous results confirming the influence of pro-export attitude of an economy on R&D

expenditure. Particular EU countries have diverse shares of export in generating GDP. As a rule, large innovative countries are more self-reliant than small ones, which have to export in order to finance the import of many goods and services that they do not produce due to limited capabilities of their economies (Germany, France, Italy, in contrast to the Baltic States, Malta, or even Slovakia and Hungary). A factor of equal importance is the diversity of the export structures in the EU countries, as naturally stronger mutual connections between export and R&D appear along with a greater share of export of technologically advanced goods and services in the total export (Javed & Munir, 2016).

An important aspect of explaining the mechanisms of changes in the size of R&D funding by authorities in response to fiscal problems generated by negative economic phenomena is the analysis of differences in behaviors demonstrated by authorities of countries which are innovation leaders, in comparison to the countries with a moderate degree of innovations, and countries which consume innovations generated elsewhere. As proven by Pellens et al. (2016), countries which are innovation leaders predominantly demonstrate the policy of countercyclical R&D funding, which means that in the periods of economic stagnation R&D expenditure are protected against reduction, or even increased. The remaining two groups of less innovative countries demonstrate procyclical tendencies to save budget in the periods of poor economic situation at the expense of R&D spending. The European Union is a group which is heterogenic in terms of the degree of innovativeness.

If the EU demonstrated relative balance between countercyclical and procyclical approach of countries to R&D funding, the aggregated results should not provide an unambiguous answer to the question about the destructive influence of general government debts on the level of research and development expenditure, especially public ones. In case of discovering its influence on the level of R&D expenditure, it could serve as evidence of an advantage of the procyclical approach to R&D funding in the EU countries. It would be a consequence of the EU being dominated by those countries that for various reasons do not treat R&D funding as a priority investment in sustainable development. The impact of general government deficit within the aforementioned mechanism should not be so clear, as its increase can have the nature of operational fiscal imbalance, whereas increasing debt indicates structural fiscal imbalance (Pellens et al. 2016) It results in more radical decisions of authorities (a deficit is only one of the possible factors of debt increase).

2 Materials and theoretical hypotheses

In order to identify the factors influencing the amount of government expenditure on research and development in the European Union states, an econometric model for panel data has been created. The statistic data used in the model come from the Eurostat database and relate to the years 2007-2016.

The dependent variable is the amount of public sector expenditure on research and development in particular EU countries in the above-mentioned years. The set of independent variables, on the other hand, contains variables referring to the condition of public finances, such as the public sector deficit and public debt. Other factors taken into consideration are a country's GDP, its level of development expressed with GDP *per capita,* and a variable describing the share of export in GDP (del Rocio & Lorente, 2017; Khan et al., 2016; Yüksel, 2017). The aim was to verify the main research hypothesis, as well as three additional hypotheses, concerning the potential determinants influencing the amount of government spending on R&D in the European Union countries.

Main hypotheses:

H1: In EU member states nominal public expenditure on research and development decrease along with the increase of general government debt measured in relation to GDP.

H2: In EU member states the public expenditure on research and development decrease along with the increase of general government deficit measured in relation to GDP.

Additional hypotheses:

H3: There is a positive relationship between the size (level) of a country's GDP and its public expenditure on R&D.

H4: The level of a country's economic development measured with the size of GDP *per capita* is positively correlated with public expenditure on R&D.

H5: There is a positive relationship between the share of export in a country's GDP and its public expenditure on R&D.

3 Model Estimation

The theoretical hypotheses allowed for specifying the model for panel data:

$$GOVRD_{jt} = \alpha_0 + \alpha_1 DEBT_{jt} + \alpha_2 DEFICIT_{jt} + \alpha_3 GDP_{jt} + \alpha_4 PCI_j + \alpha_5 EXP\_to\_GDP_j + v_{jt} \quad (1)$$

$$v_{jt} = e_t + u_j + \varepsilon_{jt}, \quad (2)$$

The description of particular variables is presented in Table 1. All the data included come from the Eurostat database.

Tab. 1: Variables used in empirical investigation

Variables	Variables description
$GOVRD_{jt}$	Government budget appropriations or outlays on R&D (total GBAORD by NABS 2007 socio-economic objectives) in million euro (Eurostat code: gba_nabsfin07)
$DEBT_{jt}$	General government gross debt in % of GDP (Eurostat code: sdg_17_40)
$DEFICIT_{jt}$	General government deficit/surplus in % of GDP (Eurostat code: tec00127)
GDP_{jt}	Gross domestic product at market prices (current prices), million euro (Eurostat code: nama_10_gdp)
PCI_{jt}	Real GDP *per capita*, chain linked volumes (2010), euro *per capita*, (Eurostat code: sdg_08_10)
$EXP\_to\_GDP_{jt}$	Exports of goods and services in % of GDP (Eurostat code: tet00003)
v_{jt}	The random error in the object *j*, in the time period *t*, which consists of the following components: e_t – impulses affecting all observations in the time period *t*, u_j – impulses affecting all the observations in the object *j*, ε_{jt} –impulses affecting only observations in the object *j*, in the time period *t*.

Source: elaborated by the authors.

4 Results and Discussion

The estimation of panel data model defined by Formula (1) was conducted in *Gretl* program (*GNU Regression Econometrics Time-Series Library*). When attempting the estimation, no *a priori* assumption was made both in terms of the existence and the significance of individual effects themselves (fixed or random). The selection of the estimation method (*pooled OLS*, *fixed effects*, *random effects*) was conducted by means of decisive procedure proposed by subject literature from the field of econometrics (Baltagi, 2001). The model was estimated by means of a classical method of least squares, and diagnostic tests were conducted, providing the following values of test statistics: *Wald* test (F=41.4821; p-*value*<0.00001) *Breusch-Pagan* test (LM=721.673; p-*value*<0.00001) and *Hausman* test (H=10.7505; p-*value*=0.0131545).

On the basis of conducted diagnostic tests it has been finally established, with the risk of error at the level of 0.05 ($\alpha = 0.05$), that the appropriate model for describing the studied dependence is the one with fixed individual effects (*fixed effects, FE*). Thus, such a model has been estimated. However, further analysis of the model's properties, has confirmed the heteroskedasticity of the random component, which was why, in order to eliminate this flaw,

eventually the model was estimated by means of Weighted Least Squares method. Statistical values of relevant parameters of the model described by Formula (1) are presented in Table 2.

The model is statistically correct. Three out of five potential independent variables have turned out to be significant. All the signs of parameters estimation placed next to a given variable are in accordance with the theoretical assumptions.

Tab. 2: The results of estimation of the model describing the determinants of government expenditure on R&D in the EU countries

Dependent variable $GOVRD_{jt}$					
Independent variables	Coefficient	Std. Error	*t*-ratio	*p-value*	Significance[a)]
Constant	−124.255	18.5472	−6.699	<0.00001	***
$DEBT_{jt}$	−4.0559	0.384337	−10.55	<0.00001	***
GDP_{jt}	0.0071	<0.00001	70.87	<0.00001	***
PCI_{jt}	0.0110	0.0014	7.604	<0.00001	***
Observations		280			
Standard error of residuals		0.8734			
R^2		0.977605			
Adjusted R^2		0.977362			
F (3, 276) = 4016.097		*p-value* for test F< 0.00001			

[a)]*** The statistically significant variable at the level of 1%.
Source: own calculations based on Eurostat data.

The study results confirm that the factor which significantly, and at the same time negatively, influences the shaping of the dependent variable of government budget appropriations or outlays on R&D, was general government gross debt. The obtained value of α parameter for $DEBT_{jt}$ variable was −4.056. It indicates that in the European Union an increase in general government gross debt (measured in relation to GDP) by 1 percentage point results in a decrease in government budget appropriations or outlays on R&D, on average by over 4 million euro, assuming constant values of the remaining variables. H1 research hypothesis has thus been positively verified.

The factors which have significant, and at the same time positive, influence on government budget appropriations or outlays on R&D are the variables related to a country's economic growth, such as GDP_{jt} and GDP *per capita* PCI_{jt}. The study has confirmed that along with a growth in a country's nominal GDP and GDP *per capita*, the research and development expenditure grow as well. The α parameters next to the GDP_{jt}, and PCI_{jt} variables are 0.0071 and 0.011, respectively, which means, however, that the growth is much lower than proportional. H3 and H4 research hypotheses have thus been positively verified.

In the estimated model, the variables which turned out to be statistically insignificant were $DEFICIT_{jt}$ and $EXP\_to\_GDP_{jt}$. It is thus impossible to verify the H2 research hypothesis, concerning the influence of general government deficit on public R&D expenditure, as well as the H5 hypothesis, which assumed the existence of a positive dependence between the share of export in a country's GDP and the level of public sector expenditure of R&D.

Conclusion

Expenditure on research and development which are appropriate in terms of amount and structure are a crucial factor to the innovativeness of the whole economy. It makes this element of total public expenditure important in maintaining international position and proper functioning of every country in a long-term perspective.

The analyses conducted during this study indicate that the amount of public expenditure on research and development in the European Union countries is determined by a number of factors. An important one, whose influence is negative, is general government gross debt ($DEBT_{jt}$). A positive impact on the amount of public spending on research and development in the EU was discovered in the case of variables referring to the countries' economic growth, i.e. nominal gross domestic product (GDP_{jt}) and GDP *per capita* (PCI_{jt}). The tendencies shown by all the factors which determine the level of R&D expenditure in EU countries have turned out to be in line with the theoretical assumptions.

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