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Małgorzata Karczewska
Wrocław University of Economics

DIVERSITY OF THE GROSS EXPENDITURE ON R&D IN GDP BY SOURCES OF FUNDS IN POLAND AGAINST THE BACKGROUND OF THE EUROPEAN UNION

Summary: The purpose of this article is the analysis of trends estimation of gross expenditure on research and development in gross domestic product by the following sources of funds: the business enterprise sector, the government sector, the higher education sector, the private non-profit sector and the abroad sector. The research covered Poland and the group of the EU15 and the EU28 countries in the period 1995-2010.

Keywords: GERD indicator, expenditureon R&D by sectors of funds, the EU member states.

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1. Introduction

The economic and social growth of European Union countries depends mostly on the level of scientific research development, as well as the usage of its results (as the economy's driving force). Nowadays, many countries of the EU are in the forefront of a great challenge, which is to increase the competitiveness and innovativeness of the economy, which will have an impact R&D activities in particular countries.

Research and development activity is understood as systematically conducted creative works. They are accomplished with the purpose of increasing knowledge resources, including knowledge about human kind, culture and society, as well as finding new ways of implementing the knowledge which is newly discovered [*Nauka i technika*… 2003, p. 37].

The continuous increase of competitiveness in the world, especially the competitiveness of the emerging countries and the stable competitive dominance of the USA, prompted the European Union to pay particular attention to the gross expenditure on research and development in the economies of the member states. The need for implementing innovations (in a broad meaning of this word), which are the result of research and development activities are described in the Europe 2020 Strategy. The Strategy proposes an increase of expenditure on R&D of the EU member states to 3% of GDP share to the year 2020.

The aim of the article is the trend estimation analysis of gross expenditure on research and development in GDP by sources of funds in Poland and member states of the EU15 and EU28 in 1995-2010.

2. Sources of funds on research and development activities in European Union countries

Financing is an important matter for research and development, implementing innovation and economic growth. Access to the financing of R&D activities is usually an issue which has to be faced by a subject which wants to gain sources for R&D, as well as a subject which is the financing source. Governments of particular countries, seeing the need and advantages of investing in R&D, usually support the research and development activities of companies within their political boundaries. The various forms of support, not only governmental but also from private companies are:

- bank loans (i.e. technological loan),
- government grants,
- business angels,
- ”venture capital”,
- ”crowd funding”,
- different tax incentives.

The above mentioned funding sources can help to gain access to fund research and development activities. Moreover, thanks to them it is possible to overcome the problems connected with the risk of some innovation projects – because most forms of the given support are used at the beginning phase of R&D activities' realization [OECD 2011].

Other financing tools of R&D activities are abroad sources. An example is the European Union and its Operational Program “Innovative Economy” (Polish: *Program Operacyjny “Innowacyjna Gospodarka”*), prepared for Poland. The purpose of this program is to support companies in research and development activities and also in information and communication technologies.

According to the Eurostat database, the following sources of funds on research and development are:

- business enterprise sector (BES),
- government sector (GOV),
- higher education sector (HES),
- private non-profit sector (PNP),
- abroad sector (Abroad).

The business enterprise sector comprise all companies, organizations and institutions where the activity objective is to produce goods and services (except higher education) in order to sell them on the market. Also, there are private non-

profit institutions, which serve the above mentioned companies, organizations and institutions [Frascati Manual p. 454].

The government sector – all departments, offices and other organs which serve the general public (usually for free) and which are not connected with higher education. Those are non-commercial institutions controlled and financed mostly by government but not administrated by the higher education sector [Frascati Manual, p. 656].

The higher education sector covers all universities, technical colleges and other institutions which offer higher education programs, independent from their sources of funds and legal status. This sector includes are all research institutions, experimental stations and clinics working under the direct control of a higher education institution (and which are administrated or created by them) [Frascati Manual, p. 565].

The private non-profit sector comprises all non-market, non-profit private institutions working for households (this means the general public) as well as private persons and households [Frascati Manual, p. 545].

Abroad sector covers all institutions and private persons located outside the political boundaries of the particular country. These also include all international institutions and organizations (besides companies) as well as their activities within the area of a given country [Frascati Manual, p. 777].

In the European Union predominates R&D funding from the business enterprise sector. Funding from the government sector is typical for countries of a lower development, with a lower level of GDP per capita. In more developed countries, the R&D activity is financed mostly by the business enterprise sector [Domańska-Szaruga, Tomaszycki 2008, p. 43].

3. Trend estimation models of gross expenditure on R&D in GDP by sources of funds

The study subject of this article is the GERD indicator (gross expenditure on research and development in gross domestic product) by sources of funds. The analysis includes Poland, the European Union (28 countries) and the EU15. The time range of the research covers the period of 1995-2010. The statistical information used in the research was taken from the Eurostat internet database.

The research used econometric trend estimation models. For a selection of the analytical trend function we have used: the heuristic method, the visual assessment method and the segment approximation method (in cases when the distribution of empirical points was complicated).

On the basis of the GERD indicator value in Poland and the EU (EU15 and EU28), in 1995-2010, trends estimation models were built. The trend lines were marked on them, in most countries this is a linear trend estimation, for some of them a polynomial function was applied. In the case of the business enterprise sector, in

Poland, the EU15 and the EU28, a segment approximation was made. Because of the high data diversification in the case of Poland in the following sectors: government, higher education and private non-profit, there was no possibility to match the trend function. For this reason, scatter plots are presented. The trend estimation models fulfill the condition of admissibility, which means the coefficient of determination R^2 (the basis measure of model match) is not lower than 0,7 (see Table 1). This means that more than 70% of the gross expenditure on research and development by sources of funds were explained by the trend function.

Figure 1 presents the gross expenditure on research and development in the gross domestic product of Poland (GERD indicator) by sources of funds. The trend estimation of R&D funding from the business enterprise sector was very diversified and required the use of the segment approximation method. The first segment (polynomial trend estimation of the third grade, ascending-descending trend) covers 1995-2003, the second segment (polynomial trend estimation of the second grade, ascending-descending) describes changes in 2004-2010. The funding of research and development from the following sectors: government, higher education and private non-profit required to present scatter plots, because in the researched period it was impossible to match the analytical form of trend estimation. On the basis of statistical data concerning R&D funding from the abroad sector, a linear trend estimation model was built. In this sector the gross expenditure on R&D in GDP showed an ascending tendency.

In Figure 2, gross expenditure on research and development in gross domestic product of the EU15 by sources of funds is shown. Similarly to Poland, changes of trend estimation of expenditure from the business enterprise sector was very diversified and required the use of the segment approximation method. The first segment (linear, ascending function) covers 1995-2001, the second segment (polynomial trend estimation of the third grade, ascending-descending) – 2002-2010. Gross expenditure on R&D in GDP financed by the higher education sector is presented by the ascending linear function, the private non-profit sector by the ascending-descending polynomial trend estimation of the second grade. The trend estimation of gross expenditure on R&D in GDP financed by the abroad sector is shown by the ascending linear function.

Figure 3 shows the trend estimation of gross expenditure on R&D in GDP by sources of funds from five sectors in countries of the EU28. In the business enterprise sector, R&D funding was very diversified (both in Poland and the EU15) and required the use of the segment approximation method. The first segment (polynomial trend estimation of the second grade, ascending-descending) covers 1995-2002, the second segment (ascending-descending polynomial trend estimation of the second grade) – 2003-2010. In the researched period, gross expenditure on R&D in GDP by sources of funds was shaped according to a descending-ascending polynomial trend estimation of the second grade. Tendencies of changes in funding, both in the higher education sector and the abroad sector, were an adopted form of

the ascending linear function. In the private non-profit sector, the best match was the ascending-descending polynomial trend estimation of the second grade.

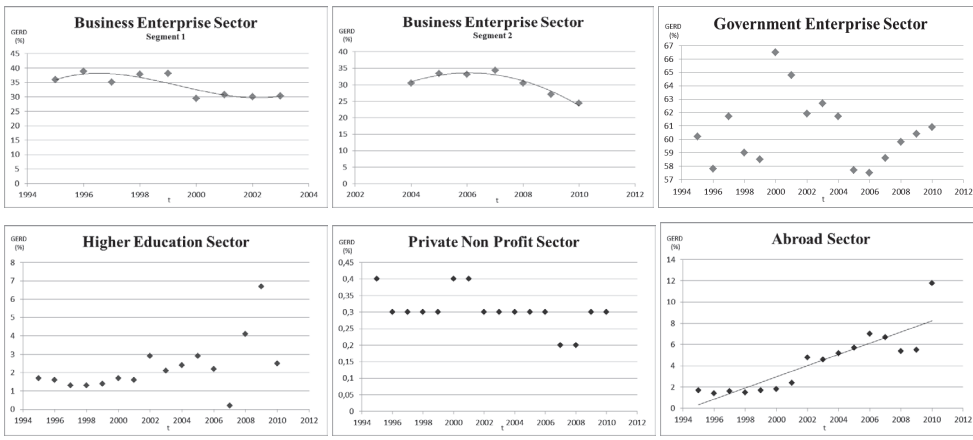

Figure 1. Trend estimations of gross expenditure on R&D in GDP by sources of funds in Poland 1995-2010

Source: own elaboration on the basis of the Eurostat database.

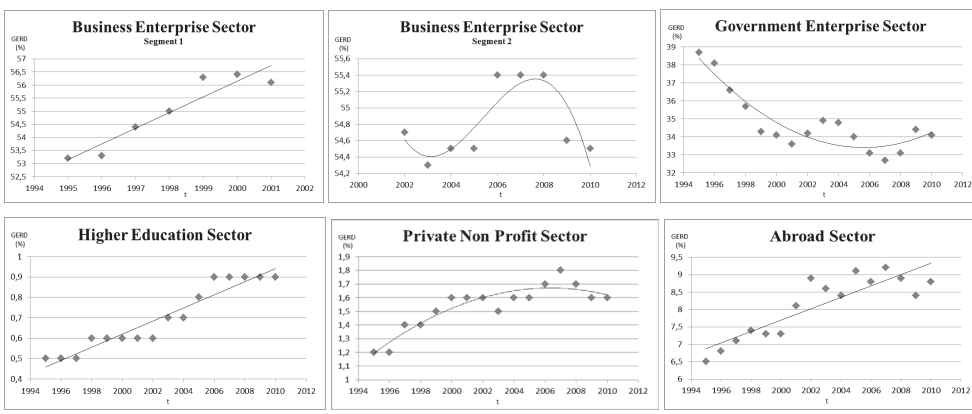

Figure 2. Trend estimations of gross expenditure on R&D in GDP by sources of funds in the EU15 1995-2010

Source: own elaboration on the basis of the Eurostat database.

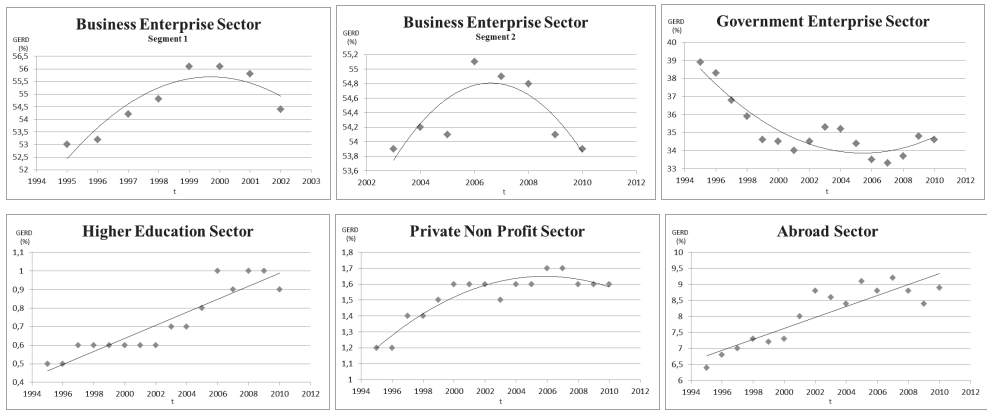

Figure 3. Trend estimations of gross expenditure on R&D in GDP by sources of funds in the EU28 1995-2010

Source: own elaboration on the basis of the Eurostat database.

Table 1 shows the trend functions for gross expenditure on research and development in gross domestic products by sources of funds (five sectors) in Poland, the EU15 and the EU28. Moreover, the Table presents the coefficient of determination R^2 and the significance of the parameters. Because of the lack of the appropriate trend estimation match for the government sector, the higher education sector and the private non-profit sector in Poland, it was not possible to determine the equation and R^2 coefficient. Furthermore, the structural parameters significance of the trends estimation models was tested. These parameters were not statistically significant for both segments of the business enterprise sector in Poland and the EU15, the higher education sector in the EU15 and the EU28, the abroad sector in the EU28.

Table 1. Models of trends estimation of gross expenditure on R&D in GDP by sources of funds in Poland, the EU15 and the EU28

Sector	Trend functions	R^2	Significance of parameters
1	2	3	4
Poland			
Business Enterprise	Segment 1: $t = 1…9$ $\hat{Y} = 0{,}0946t^3 - 567{,}49t^2 + 1134622{,}54t - 756169189{,}34$	0,74	NO
	Segment 2: $t = 10…16$ $\hat{Y} = -0{,}6369t^2 + 2555{,}3t - 2563049{,}34$	0,95	NO
Government	-	-	-
Higher Education	-	-	-
Private Non Profit	-	-	-

1	2	3	4
Abroad	$\hat{Y} = 0{,}5268t - 1050{,}5$	0,77	YES
EU15			
Business Enterprise	Segment 1: $t = 1\ldots7$ $\hat{Y} = 0{,}6t - 1143{,}8$	0,89	NO
	Segment 2: $t = 8\ldots16$ $\hat{Y} = -0{,}0208t^3 + 125{,}08t^2 - 250839t + 167675862{,}12$	0,73	NO
Government	$\hat{Y} = 0{,}0439t^2 - 175{,}98t + 17651$	0,83	YES
Higher Education	$\hat{Y} = 0{,}0321t - 63{,}498$	0,92	NO
Private Non Profit	$\hat{Y} = -0{,}0037t^2 + 14{,}893t - 14939$	0,85	YES
Abroad	$\hat{Y} = 0{,}1638t - 319{,}96$	0,77	YES
EU28			
Business Enterprise	Segment 1: $t = 1\ldots9$ $\hat{Y} = -0{,}1464t^2 + 585{,}63t - 585490$	0,84	YES
	Segment 2: $t = 10\ldots16$ $\hat{Y} = -0{,}0821t^2 + 329{,}66t - 330689$	0,71	YES
Government	$\hat{Y} = 0{,}043t^2 - 172{,}67t + 173168$	0,82	YES
Higher Education	$\hat{Y} = 0{,}035t - 69{,}363$	0,85	NO
Private Non Profit	$\hat{Y} = -0{,}0039t^2 + 15{,}451t - 15494$	0,88	YES
Abroad	$\hat{Y} = 0{,}1712t - 334{,}72$	0,79	NO

Source: own elaboration on the basis of the Eurostat database.

4. Conclusions

The research presented in this article allowed us to formulate the conclusions which are shown below. The trend estimations of changes of gross expenditure on research and development by sources of funds for Poland, the EU15 and the EU28 in particular sectors were as follows:

– the business enterprise sector: decrease in gross expenditure on R&D in GDP by sources of funds in Poland, the EU15 and the EU28 in the last few years of the researched period;
– the government sector: lack of trend estimation of gross expenditure on R&D in GDP by sources of funds in Poland, growing trend estimation of gross expenditure on R&D in GDP by sources of funds in all member states of the EU15 and the EU28;
– the higher education sector: it was not possible to determine the trend estimation of gross expenditure on R&D in GDP by sources of funds in Poland, decreasing trend estimation in all member states of the EU15 and the EU28;
– the private non-profit sector: lack of trend estimation of gross expenditure on R&D in GDP by sources of funds in Poland, decreasing trend estimation in all member states of the EU15 and the EU28;

– the abroad sector: growing trend estimation of gross expenditure on R&D in GDP by sources of funds in Poland and all member states of the EU15 and the EU28 – which is the only thing in common;
– for Poland there was irregular diversification for government, higher education and the private non-profit sector – the EU15 and the EU28 government sector had a descending-ascending trend, higher education – ascending trend and private non-profit – ascending-descending trend.

Analysis of the trend estimation changes of gross expenditure on research and development in gross domestic product by sources of funds can be the basis for further, more detailed research and differentiation analysis of structures of expenditure on research and development by the sources of funds in European Union countries.

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ZRÓŻNICOWANIE UDZIAŁU WYDATKÓW NA B+R W PKB W POLSCE WEDŁUG ŹRÓDEŁ FINANSOWANIA NA TLE KRAJÓW UNII EUROPEJSKIEJ

Streszczenie: Celem opracowania jest analiza tendencji rozwojowych udziału wydatków na badania i rozwój w produkcie krajowym brutto według następujących źródeł finansowania: sektor przedsiębiorstw prywatnych, sektor rządowy, sektor szkolnictwa wyższego, sektor prywatny *non-profit* i sektor zagraniczny. Badaniami objęto Polskę oraz grupy państw UE15 i UE28 w latach 1995-2010.

Słowa kluczowe: wskaźnik GERD, sektory finansowania nakładów na B+R, państwa członkowskie UE.