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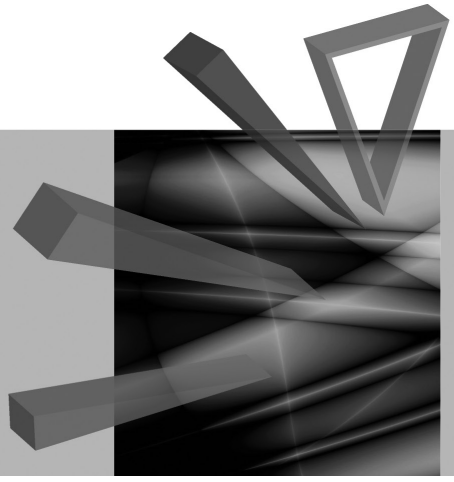

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GROSS DOMESTIC EXPENDITURE ON RESEARCH AND DEVELOPMENT IN GDP OF EUROPEAN UNION COUNTRIES – CHANGES IN TRENDS

Summary: Since the establishment of the Lisbon Strategy, the European Union has been trying to achieve the target of 3% of expenditure on research and development in GDP in the whole EU. According to the Strategy Europe 2020, this should be reached in 2020, which will result in the competitiveness of the member states' economies with regard to such countries as the USA or Japan. The purpose of this article is to identify and analyse the trends in changes of expenditure on research and development in GDP of European Union member states, as well as an assessment of the deviations of expenditure on R&D in 2010 from the targets set in the Strategy Europe 2020.

Keywords: research and development, GERD indicator, Strategy Europe 2020.

1. Introduction

New technologies are more often developed by their users [von Hippel 1988, p. 3], who are able to define the ways for their improvement while using them so they can become more efficient. But, they are inventors – outstanding individuals who discover completely new solutions. However, nowadays new products are usually created gradually, by conducting observations as well as research, which require the creative effort of many specialists from many different scientific fields [Czupiał (ed.) 1994, p. 7]. Such teams develop innovative solutions which will be implemented in the country's enterprises – they will be useful for the whole of society. Financial funds are necessary to establish the team of specialists and gain crucial tools for effective work. Successful companies are able to invest in innovation from their own resources. Whereas enterprises struggling with financial problems, the public sector and higher education undoubtedly require government support. The European Union recognized this problem long time ago, therefore in 2010 the Strategy Europe 2020 described the target for the whole EU as spending 3% of GDP on investments in research and development.

The purpose of the following article is to identify and analyse changes in trends in the share of expenditure on research and development in the GDP of EU member states as well as an assessment of the deviations of expenditure on R&D in 2010 from the targets set in the Strategy Europe 2020.

2. Research and development in the Strategy Europe 2020

Research and development (R&D) and innovation activity (both are related [*Oslo Manual*... 2005, §457]) cover consistent creative work undertaken in order to increase knowledge resources. Also, knowledge about people, culture and society as well as the use of these knowledge resources contributes in elaborating modern technologies [*Frascati Manual*... 2002, §63]. Therefore, we should be aware of the need for systematic, creative work so innovations (new technologies) can come into common use [Schumacher 2011, p. 127]. European Union treaties were developing fields which were supposed to be included into an innovation-oriented policy. However, only the Lisbon Strategy strengthened the innovation issue as one of the most important directions of EU policy. Its plan included diametrical changes, very high development and rapid transformations in the economic policy. The basic output for those transformations was supposed to be strongly developed and extensive research, used by the economies of European countries. A major role was assigned to innovations, modern knowledge fields, which are the source of development. The Lisbon Strategy targets were defined for 2000–2010. They focused mainly on discussable investments in scientific research and development, which were about to increase GDP expenses on R&D by up to 3% [*Lisbon Strategy* 2000]. The implementations of the Lisbon Strategy assumptions fell apart because of the lack of priorities, despite establishing many initial goals. Therefore, efforts to improve the situation in the European Union were ineffective and did not bring the expected results.

In 2010, the European Commission presented the Strategy Europe 2020, which is the successor of the Lisbon Strategy. Expenditure on research and development activity include current expenditure incurred for basic and applied research as well as development works and investment expenditure on fixed assets connected with R&D activities, independently from the funds' sources. The measure used to determine their value is the GERD indicator – gross domestic expenditure on research and development, which is commonly used in order to illustrate the intensity of research in the national economy, and so its ability to create new products and services' development [Walwyn 2010, p. 183].

The Strategy Europe 2020 includes three interrelated priorities:

- smart growth: development of the economy based on knowledge and innovation;
- sustainable growth: support the economy which effectively uses resources, which are more environment-friendly and more competitive;
- inclusive growth: supporting the economy with a high employment level, ensuring social and territorial cohesion.

The most important thing for the European Union is defining in which place and on what position it wants to be in 2020. From this reason the European Commission proposed to establish five measurable EU targets:

1) the employment rate of people aged 20–64 years should be 75%;

2) 3% of EU GDP should be designated for investment in research and development;

3) to achieve the goals "20/20/20" within climate and energy (including carbon dioxide emissions);

4) the amount of people finishing education too early should be limited to 10%, and a minimum 40% of people from young generations should have a higher education;

5) the amount of people at risk of poverty should be decreased by 20 million.

The targets above are interrelated and their achievement will indicate the success of the Strategy Europe 2020. However, taking into account the differences in the development of the countries which belong to the European Union, the above measurable targets were changed into targets and the activity method for each of the 27 EU member states because of their differences in innovation level. As a result, every member state is able to fit the Strategy Europe 2020 to its specific economic situation. The current EU target in the area of investment in R&D activities is 3% of GDP. This allowed to pay attention to how important are both public and private investment in research and development. The most important thing is to improve the condition of private research and development activity in the EU countries, therefore, the Strategy Europe 2020 described the necessary actions. By creating a uniform attitude to research and development activity as well as to innovation, it would be possible to use more funds, which would result in business activity development and an increase in productivity stimulants [*Strategy Europe 2020*... 2010].

3. Statistical information and research methods

The study subject in this article is the GERD indicator as a GDP percentage. The analysis included the European Union as a whole as well as 27 member states separately. The time range of research covers the period of 1995–2010. The statistical information used in the research was taken from the Eurostat internet databases.

The GERD indicator data were incomplete in the case of Estonia (lack of data: 19%), Greece (lacking 44%), Cyprus (lacking 19%), Luxembourg (lacking 44%) and Sweden (lacking 25%). Missing statistical information were completed on the basis of trend estimation models with the use of inter and extrapolation. In the situation of Malta, the statistic data covers the period from 2002 to 2010 because it was impossible to fill in data by the use of extrapolation (negative values of GERD in GDP).

Econometric trend estimation models were used in research. For a selection of analytical trend function, the author used the heuristic method and the visual

assessment method with its specific variant as well as segment approximation method in cases when the distribution of empirical points was complicated.

4. Trend estimation models and forecast of expenditure on R&D in GDP

On the basis of the GERD indicator value (in 27 countries of the European Union 1995–2010) trends estimation models were built, marking trend lines on them; in mostcountries it is a linear trend estimation, for some of them, polynomial function was applied. In the case of France and Sweden, segment approximation was made. Because of the high data diversification in the case of Latvia, Luxembourg and Great Britain, there was no possibility to match the trend function, for this reason scatter plots are presented. All trend estimation models were chosen so the coefficient of determination R^2 (the basis measure of model fit) is not lower than 0.7 (see Table 1). This means that more than 70% of expediture changes on research and development were explained by the trend function. After construction of the forecast, the indicator deviation in year 2010 from the goal for 2020 and deviations of the target from the forecast for 2020 were also shown.

Figure 1 presents (in 13 EU countries) linear trend estimations of expenditure changes on R&D in GDP. In 12 countries it is an ascending trend – it increases the value of a variable in time. Expenditure on R&D in the GDP of countries like Austria, Cyprus, Spain or Poland are growing systematically. This proves that governments of those countries are aware of the importance of investment in research and development. In the Netherlands the trend is descending – it decreases the value of a variable in time. This is a worrying situation when taking into account the target of this country. In 2020, expenditure on R&D in GDP is supposed to be 2.5%, but the value decreased in 2010 to the level of 1.83% from 1.97% in 1995.

Figure 2 shows polynomial trend changes of expenditure on R&D in GDP. They were fitted for data from nine EU countries (Ireland, Slovakia, Greece, Malta, Slovenia, Romania, Poland, Belgium, Bulgaria) but also for all of the EU27 together. In six countries (Ireland, Slovakia, Greece, Malta, Slovenia and Romania) there are polynomial trends estimations of the second grade. In the cases of Ireland, Slovakia, Slovenia and Romania, those are descending-ascending trends, which means that expenses on R&D in GDP of the mentioned countries were decreasing to a certain moment, after which they started to increase. This indicates that the governments of these countries realized the need to invest in innovation, which is the source of economic development.

For Malta and Greece this tendency is ascending-descending. Attention should be paid to those countries in whose economies tourism is the most important sector.

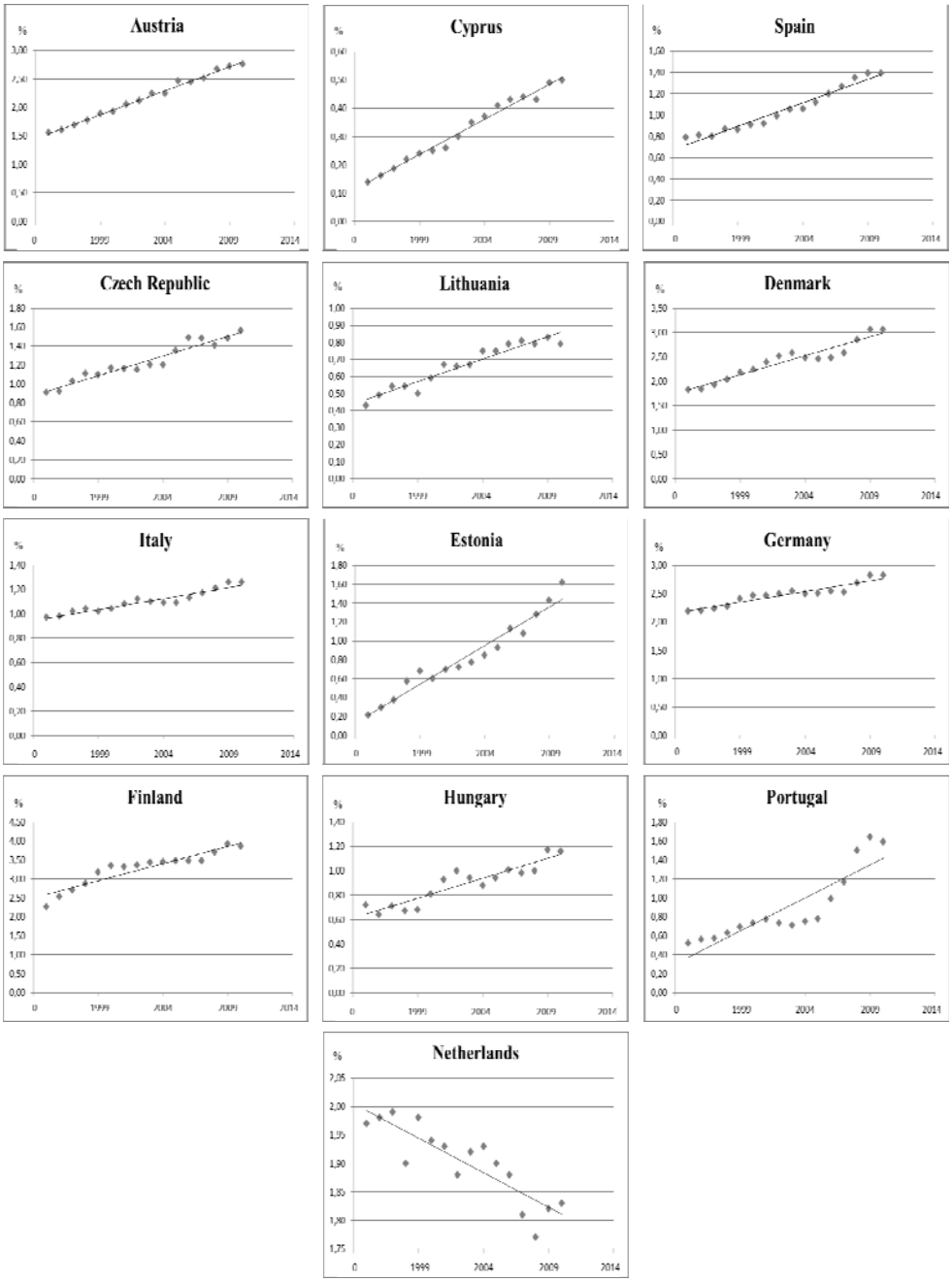

Figure 1. Linear trend functions of expenditure on R&D in GDP of EU countries 1995–2010

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

For this reason, investment in research and development is not so crucial as for countries in Central Europe. For Poland, Belgium, Bulgaria (descending-ascending tendency) and the EU generally (ascending tendency), polynomial trend estimations of the third grade were matched. Poland and Bulgaria, though with a descending-ascending tendency, spend a small percentage of GDP on research and development, whereas in Belgium there is much higher expenditure.

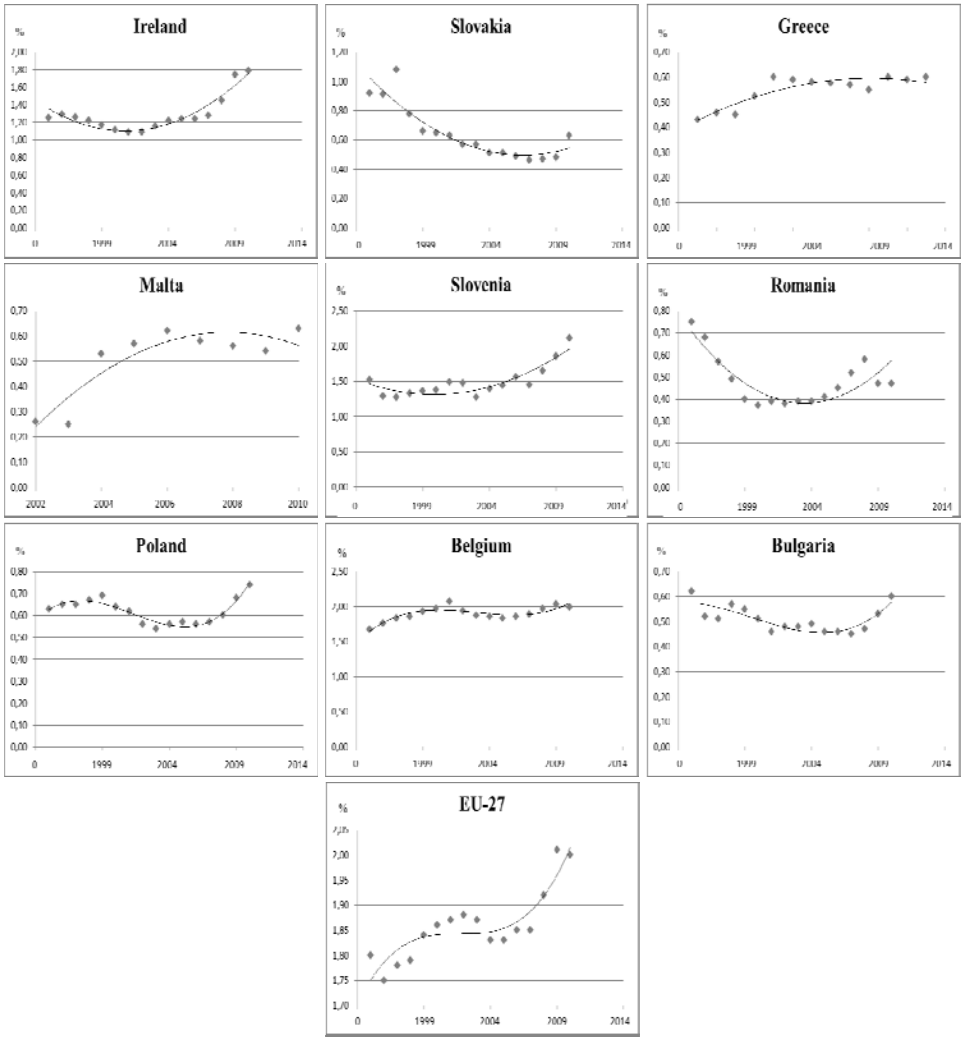

Figure 2. Models of polynomial trend functions of expenditures on R&D in GDP of EU countries 1995–2010

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

Figure 3 presents segment approximants of the expenditure on R&D in GDP. To define the analytical form of trend estimation segment approximation for France and Sweden was applied. In the case of France, the first segment (polynomial trend estimation of the second grade) covers 1995–2002, and the second (polynomial trend estimation of the second grade) 2003–2010. For Sweden, 1995–2001 (the first segment) linear trend estimation was used, and for 2002–2010 (the second segment) polynomial trend estimation of the third grade. In France, the expenditure on R&D in GDP was very different in each of the studied years (1995 – 2.28%, 1998 – 2.14%, 2002 – 2.24%, 2007 – 2.08% and 2010 – 2.26%). In Sweden, up to 2001 that expenditure was systematically increasing (from 3.26% in 1995 to 4.13% in 2001), and from 2002 started to decrease (2002 – 3.97%, 2010 – 3.42%). There also started to occur a huge dispersion between the subsequent years. Although Sweden is the country which, besides Finland, allocates the highest GDP percentage on R&D.

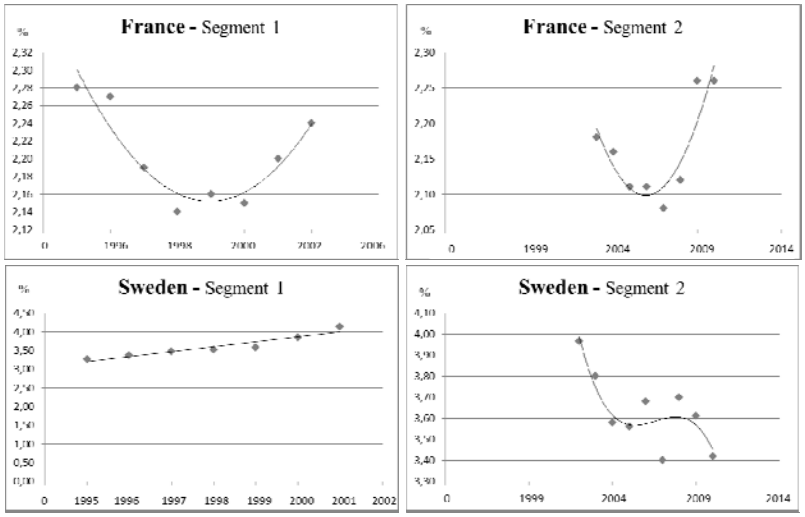

Figure 3. Segmentation models of expenditure on R&D in GDP of EU countries 1995–2010

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

Figure 4 presents scatter plots for Latvia, Luxembourg and Great Britain. Because of irregular expenses on R&D in GDP of specific years, it was not possible to match the analytical form of trend estimation. Among the mentioned countries, the lowest expenditure on research and development in GDP was in Latvia, the highest in Luxembourg. From the scatter plot for Latvia it can be observed that expenses slightly increased (0.47% in 1995, 0.60% in 2010). In Luxembourg, expenses were on a similar level to 2003 (1.65%). In subsequent

years they started to have different values. The case of Great Britain is very interesting – expenses on R&D from 1995 to 2010 are strongly diversified (i.e. in 1995 –1.91%, 1998 – 1.76%, 2004 – 0.68%, 2009 – 1.86% and 2010 – 1.77%).

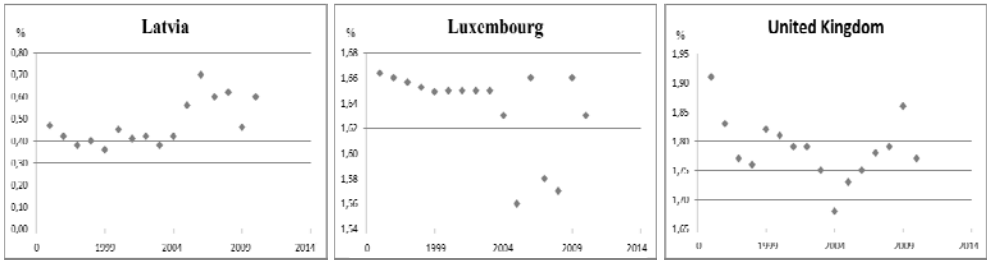

Figure 4. Scatter plots of expenditure on R&D in GDP of EU countries 1995–2010

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

Table 1shows the coefficient of determination: R^2 and trend functions for EU27 as well as for the member states separately. The coefficient of the determination of the trend function for the EU27 is 0.81; the highest R^2 for Austria 0.99, the lowest for Bulgaria (0.70)). Because of the lack of the appropriate trend estimation fit for Latvia, Luxembourg and Great Britain, it was not possible to determine the equation and R^2 coefficient. According to the presented equations the forecast of expenditure on R&D in member states GDP to 2020 was also made. Moreover, the structural parameters significance of trends estimation models was tested. Only for Bulgaria and the second segment of Sweden were these parameters not statisticaly significant.

Table 2 presents the actual values of the GERD indicator for 2010, the forecasted values for 2020 and the target described in the Strategy Europe 2020 for year 2020 for EU member states. Table 2 also presents deviations of the GERD indicator in 2010 from the target in 2020 as well as the deviation of the forecast for 2020 from the target for 2020. Countries included in Table 2 are those for which it was possible to match the trend function. The forecast does not respond to the target in any country, which is the reason for setting the target to which they should strive to, but with additional support from government and the EU. The set targets illustrate the values necessary to achieve, so the member states' economies can be competitive (in comparison with the USA or Japan).

Figure 5 presents the deviation of the GERD indicator in 2010 from the target for 2020. More than a half of the member states have to take action to reach the target set in the Strategy Europe 2020, countries like Spain, Estonia, Portugal, Poland and Romania need to increase to year 2020 significantly their share of R&D in GDP. However, countries such as Sweden and Germany were already in 2010 close to achieve their targets. The GERD indicator from 2010 corresponds to the target in 2020 for Cyprus and Denmark.

Table 1. Models of trends estimation of expenditure on R&D in GDP in chosen EU countries

Countries	Trend functions	R^2	Significance of parameters
EU27	$\hat{Y} = 0.0003t^3 - 0.007t^2 + 0.0542t + 1.703$	0.81	YES
Austria	$\hat{Y} = 0.0843t + 1.4483$	0.99	YES
Cyprus	$\hat{Y} = 0.0248t + 0.113$	0.97	YES
Spain	$\hat{Y} = 0.0443t + 0.6725$	0.96	YES
Czech Republic	$\hat{Y} = 0.0417t + 0.8783$	0.93	YES
Lithuania	$\hat{Y} = 0.0266t + 0.4365$	0.93	YES
Denmark	$\hat{Y} = 0.0781t + 1.742$	0.92	YES
Italy	$\hat{Y} = 0.0181t + 0.9453$	0.91	YES
Estonia	$\hat{Y} = 0.0818t + 0.1326$	0.91	YES
Germany	$\hat{Y} = 0.0382t + 2.1575$	0.90	YES
Finland	$\hat{Y} = 0.0908t + 2.503$	0.87	YES
Hungary	$\hat{Y} = 0.0327t + 0.6123$	0.85	YES
Portugal	$\hat{Y} = 0.0698t + 0.3025$	0.79	YES
Netherlands	$\hat{Y} = -0.0122t + 2.0053$	0.75	YES
Ireland	$\hat{Y} = 0.0077t^2 - 0.1037t + 1.4517$	0.91	YES
Slovakia	$\hat{Y} = 0.004t^2 - 0.0999t + 1.1208$	0.85	YES
Greece	$\hat{Y} = -0.0021t^2 + 0.0421t + 0.3821$	0.80	YES
Malta	$\hat{Y} = -0.0111t^2 + 0.3058t - 1.4985$	0.80	YES
Slovenia	$\hat{Y} = 0.0063t2 - 0.0733t + 1.5262$	0.80	YES
Romania	$\hat{Y} = 0.0045t^2 - 0.0857t + 0.7876$	0.75	YES
Poland	$\hat{Y} = 0.0005t^3 - 0.0113t^2 + 0.0585t + 0.5791$	0.91	YES
Belgium	$\hat{Y} = 0.0008t^3 - 0.0218t^2 + 0.1781t + 1.4915$	0.77	YES
Bulgaria	$\hat{Y} = 0.0002t^3 - 0.0036t^2 + 0.0027t + 0.5745$	0.70	NO
France	$t = 1,\ldots,8$ $\hat{Y} = 0.0095t^2 - 0.0939t + 2.3848$	0.89	YES
	$t = 9,...,16$ $\hat{Y} = 0.0111t^2 - 0.2642t + 3.674$	0.82	YES
Sweden	$t = 1,\ldots,7$ $\hat{Y} = 0.1321t + 3.0693$	0.91	YES
	$t = 8,\ldots,16$ $\hat{Y} = -0.0054t^3 + 0.2037t^2 - 2.5358t + 14.004$	0.74	NO

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

Table 2. Comparison of the actual values of the GERD indicator from 2010 with values set for the EU countries in the Strategy Europe 2020

Country	GERD 2010	Target 2020	GERD 2010 in comparison with target 2020	Country	GERD 2010	Target 2020	GERD 2010 in comparison with target 2020
EU27	2.00	3.00	–1.00	Germany	2.82	3.00	–0.18
Malta	0.63	0.67	–0.04	Slovakia	0.63	1.00	–0.37
Spain	1.39	3.00	–1.61	Bulgaria	0.60	1.50	–0.90
Netherlands	1.83	2.50	–0.67	Cyprus	0.50	0.50	0.00
Lithuania	0.79	1.90	–1.11	Denmark	3.06	3.00	0.06
Estonia	1.62	3.00	–1.38	Finland	3.87	4.00	–0.13
Portugal	1.59	2.70	–1.11	Slovenia	2.11	3.00	–0.89
Romania	0.47	2.00	–1.53	France	2.26	3.00	–0.74
Sweden	3.42	4.00	–0.58	Ireland	1.79	2.50	–0.71
Hungary	1.16	1.80	–0.64	Poland	0.74	1.70	–0.96
Austria	2.76	3.76	–1.00	Belgium	1.99	3.00	–1.01
Italy	1.26	1.53	–0.27				

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

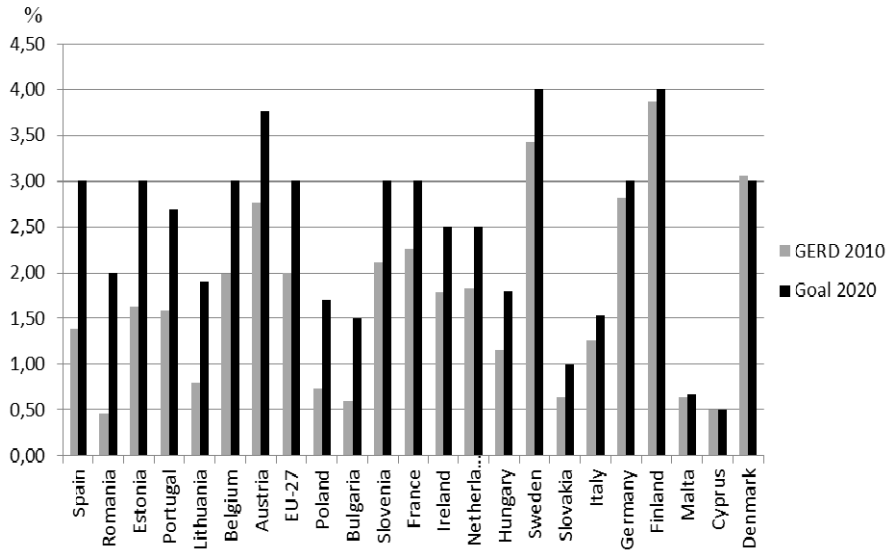

Figure 5. GERD indicator value in 2010 and the goal for expenditure share on R&D in GDP identified by EU on year 2020

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

5. Conclusions

The conducted studies allowed for conclusions resulting from changes in expenditure on research and development in GDP of the EU27 and each member state separately. The most important of them are as follows:

- There is a visible difference between the EU15 countries and the new member states. The countries which belonged to the EU before 2004 spend the highest percentage of their GDP on R&D. The highest value in 2010 was allocated by Finland in the amount of 3.87%, the lowest by Romania: 0.47%. Poland allocated 0.74%, which puts the country at a position which is much below the average. The average for all member states of the EU in 2010 was 1.64%.
- Generally, EU spending did not change a lot during 15 years. In 1995 it was 1.8%, and in 2010 it increased only to 2%. During that period, the most increased expenditure on R&D was in Finland – from 2.26% in 1995 to 3.87% in 2010. In Poland, expenditure increased respectively from 0.63% to 0.74%.
- 12 member states of the EU have an ascending linear trends estimation of expenditure on R&D.
- Many countries (i.e. Poland, Lithuania, Spain, Portugal, Romania) face a great challenge in the near future, because by 2020 they need to increase significantly their share of expenses on R&D in GDP.

On the basis of the performed analysis of expenditure on R&D in GDP of the EU member states, it can be concluded that the financial situation of the research and development activities in the member states is improving. This is a positive signal, which shows that some action in this direction has been taken. However, to achieve the set targets in 2020, the EU will face a lot of work. The data taken from the Eurostat database allowed to present the situation up to 2010.

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UDZIAŁ NAKŁADÓW NA BADANIA I ROZWÓJ W PKB KRAJÓW UNII EUROPEJSKIEJ – TENDENCJE ZMIAN

Streszczenie: Unia Europejska od ustanowienia Strategii Lizbońskiej stara się osiągnąć cel 3% udziału nakładów na badania i rozwój z PKB całej UE. Według najnowszej Strategii Europa 2020 ma być on osiągnięty w 2020 roku, przez co gospodarka państw członkowskich będzie konkurencyjna dla takich potęg jak USA czy Japonia. Celem opracowania jest identyfikacja i analiza tendencji zmian udziału wydatków na badania i rozwój w PKB krajów należących do Unii Europejskiej oraz ocena odchyleń nakładów na B+R w 2010 roku od celów założonych w Strategii Europa 2020.

Słowa kluczowe: badania i rozwój, wskaźnik GERD, Strategia Europa 2020.