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ANALYSIS OF EXPENSES ON RESEARCH AND DEVELOPMENT ACTIVITY AS A STIMULANT OF COMPANY INNOVATIVENESS

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Purpose: The purpose of this paper is to model the expenses on research and development as a factor affecting the company innovativeness.
Design/methodology/approach: This article focuses on the analysis of the most frequently used indicators affecting the expenses on the research and development activity. The attempt to estimate these factors was performed in order to show their influence on R&D expenses. The independent part was decomposed to present the characteristics for a given country. The research was done on the annual data for years 2009-2021 for the European Union member states on the basis of data from the Eurostat base.
Findings: The performed analysis proves that the GBP percentage of expenses on research and development activity is still very low in our country (it is only 1.44% of GDP in Poland), the share of companies financing these expenses is also low. The test results show the less than proportional influence of the wealth of states measured with the GDP and human resources for science and technique on the value of R&D expenses. Although the impact of human resources is much lower, it is really important. The big differentiation of these factors indicates that the cooperation of states is necessary in the scope of innovations, which is consistent with the sustainable growth principles. The level of innovativeness in Poland is low in comparison to Sweden, Finland, Denmark, Belgium, Austria or Germany. Our country receives negative results in comparison to the EU and weakening of the reaction to the R&D expenses is noticed. It makes it possible to conclude that the innovativeness policy in Poland should be improved, in particular in the area of R&D financing, environment investments, cooperation of science and business or education.
Research limitations/implications: The discussed research may constitute the guidelines for further analyses in which it is necessary to use more variables in order to assess the impact of various factors (e.g. environmental, institutional ones) in the short and long-run in individual states. The access and reliability of data are the main limits of the research.
Practical implications: The information obtained from the presented analyses may help decision-makers manage the pro-innovative companies in an efficient way. The increase in R&D expenses generates the research and technological possibilities in the scope of innovations and improves the trustworthy of companies.
Originality/value: The analysis of expenses on research and development is significant in the aspect of creating innovation policy. Due to this fact the comparative analyses seem to be desired as they make it possible to indicate the countries the example of which Poland should follow to achieve the higher level of innovativeness. Thus, it will enable to manage the

innovation processes in Polish companies better and thanks to it contribute to their competitiveness in the European market.

Keywords: innovativeness of companies, human resource management for science and technique, space-time model.

Category of the paper: Research paper.

1. Introduction

The development of science and conducting research on innovative solutions in the state economy as well as in companies plays a significant role in determining the level of economic growth. It is connected with the fact that each company wants to be competitive because it provides it with high profit and recognition in the market (Osieczko, Stec, 2019; Agarwal, 2018). Despite the fact that at first new solutions created in e.g. a company contribute to this aspect, the ability to introduce them is also very important. In the subject literature these both phenomena are often connected as they often present the same information (Hee-Jae, Pucik, 2005). However, they may be also understood in a different way: the first one specified as innovations whereas the other one as innovativeness (Hilami et al., 2010). Nevertheless, it should be remembered that the mentioned ability is strongly stimulated by the state innovation policy (Alam, Arshad, Rajput, 2013), creating general conditions of the company operating in the fast changing surrounding (Yachmeneva, Vol's'ka, 2014). Thus, the appropriate level of funds assigned to the research and development activity is necessary so that the innovations could be created. So the state help is indispensable here as there is the need to "provide" strategic sectors with high technology and the companies are not able to cover all the expenditures connected with creating or introducing innovations. Thus, the governments should be interested in supporting companies in this scope as supporting innovativeness of companies contributes to the development of the whole economy and to the growth of its competitiveness (Wolniak, 2010).

Human resources are also a significant determinant of innovative potential as each new solution is a result of human work. Human capital usually adapts to the challenges of the changing reality being one of the significant conditions of fast economic growth. Thus, it is possible to say that human resources constitute an important part of the paradigm which is knowledge based economy (Wegrzyn, 2016; Pleśniarska, 2013). Taking it into consideration, it is possible to state that research and development institutions the work of which contributes to creativity and patent activity play a key role in the mentioned process. The workers' abilities, their knowledge and experience not only contribute to creating innovations but also, undoubtedly, affect the company market success (Durić, Ristić, Dragičević, 2021). Thus, human capital not only plays the role of innovation determinant but

also has a great impact on the product adaptation. As we can see, the whole R&D staff participates in the innovation process and it is the indication for innovation managers that they should cooperate with both research units and companies (Szajt, 2017).

Taking the above into consideration, it is possible to conclude that the proper "leading" of a new product plays the more and more significant role and the permanent growth of the innovation significance results from their positive influence on the organisational changes and being the important factor of state economic growth (Hammar, Belarbi, 2021). The programmes in the scope of research and innovations initiated by the European Union prove that the innovations are the engine of economies all over the world. There have been 9 such programmes since 1995. The last of them Programme Horizon Europe is assumed for years 2021-2027 and is the update of the programme Horizon 2020 in connection with the changing social, economic or ecological conditions. Among others, the segment for employers was developed in the newest programme, the counteraction of harmful effects of climate changes was emphasised and the instruments were proposed to equalise the chances of member states (European Commission, 2019). The Programme Horizon Europe shall contribute to the scientific development thanks to providing the support for the best scientists and innovators. It shall activate scientific excellence with the intermediary of *European Research Council* to enable the excellent scientists the development of science and knowledge borders as well as support the most talented young scientists in developing their knowledge or skills. Such an approach may help particular countries "enter the higher level of innovativeness" as at present the level of economic growth is impeded by assigning high amounts on R&D. Thus, the improvement of the position in the research and development area may cause that the countries will get more competitive in the European market.

Thus, it is important to perform comparative analyses of Poland and other member states concerning the research and development activity. Moreover, in connection with meeting the objectives of sustainable growth and proposing the ambitious programme of scientific and innovative research by the European Commission, it seems necessary to compare and monitor the factors affecting the innovativeness of individual economies and companies. In this context, it is justified to learn how GDP and human resources affect the expenses on research and development activity in Poland and EU states. Thus, the expenses are one of the determinants of innovation activity. Answering this question will be helpful to verify the hypothesis that the comparative analysis of expenses on research and development activity provides information being the benchmark of creating the pro-innovative activity of companies in each country.

Taking the above into consideration, the article is attempt to model the expenses on research and development depending on the economic growth meter (GDP) and human resources for science and technique.

2. Methods

R&D sector is often organised in a different way in various countries due to e.g. social or historic conditions. However, financial policy plays an important role in R&D in every state, especially now when the relations of this sector with the market is emphasised more and more often (Piekut, 2011).

In order to meet the article objective, it was tested how the determinants affecting the company innovativeness shape and the space-time analysis which makes it possible to comprehend the value how the both factors affect R&D in particular EU states was performed.

Due to the complexity of this issue, the research was performed in two parts. The first one was to monitor the stimulants of the expenses on research and development activity, the second – checking how GDP and resources for science and technique in the EU member states affect the considered expenses.

The intention to analyse the impact of these two determinants induced the author to observe shaping the expenses on research and development activity in the European union member states in the first stage and then to refer these levels to our country. The analysis was started with showing which percentage of GDP the states spent on R&D and presenting the medium-term pace of changes. Then the attention was paid on the structure of innovation financing sources. It was also stated how the human resources for science and technique are distributed in Poland and the EU member states as the element the quality and structure of which affects the level of economy and company innovativeness in a significant way. The second stage consisted in modelling the R&D expenses depending on GDP and human resources for science and technique. It was done to, among others, specify the characteristics for each EU member state.

The model was based on the cross-sectional and time data. In the model European Union member states were objects (i) and time (t) was covered years 2009-2021. The exponent form of the model was proposed after taking the logarithm of which we receive:

$$\ln\mathrm{WBR}_{it} = \alpha_0 + \alpha_1 \ln\mathrm{GDP}_{it} + \alpha_2 \ln\mathrm{ZL}_{it} + \varepsilon_{it} \quad (1)$$

where:

$\ln\mathrm{WBR}_{it}$ – ln of gross expenses on R&D activity per 1,000 people employed in R&D for country *i* in period *t* (according to PPP in fixed prices from 2009),

$\ln\mathrm{PKB}_{it}$ – ln of gross domestic product per 1,000 residents for country *i* in period *t* (according to PPP in fixed prices from 2009),

$\ln\mathrm{ZL}_{it}$ – ln of human resources for science and technique per 1,000 active people for country *i* in period *t*,

α_0, α_1,α_2, – structural parameters,

α_0 – decomposed independent part for individual states,

ε_{it}– random part for country *i* in period *t*.

The differences in the level of decomposed independent parts were presented to show the distance of Poland and other countries to the mean of the EU member states.

The data referring to WBR and GDP were given according to the purchasing power parity (PPP) and in calculation to the fixed prices from 2009 in order to compare them internationally. The necessity to use such a solution arises from the different purchasing power of currencies in individual states and the calculation of nominal values to so called real values. Moreover, it is necessary to show the values as the intensity indicators in which the current values refer to the number of residents employed in R&D or the number of active people.

The model was estimated with the use of the Least Square Method. The data base EUROSTAT was used in the research. Taking into consideration the time series coming from one source in this paper makes it possible to avoid differences in definitions and in the method of collecting information. The research covers the period of 13 years (years 2009-2021) and 27 countries so the research group covered 351 observations. The choice of these years was connected with the availability of data.

3. Results

The expenses on research and development activity presented as the percentage of GDP are the indicator assessing the situation of the R&D sector which is used in the international analyses the most often. Although it is assumed in the EU strategies that the level of expenses on the research and development in the national income should achieve the level of at least 3% of GDP, not all countries achieved such a factor. In fact, only four countries: Belgium, Germany, Austria and Sweden met this postulate to 2019.

Table 1.
GDP percentage spent on R&D activity in years 2009, 2015-2021

Item	2009	2015	2016	2017	2018	2019	2020	2021	Average rate of change
European Union - 27 countries	1.97	2.12	2.12	2.15	2.19	2.22	2.30	2.26	101.15
Average for old EU members	2.00	2.43	2.52	2.67	2.86	3.16	3.35	3.22	100.51
Average for new EU members	0.49	0.95	0.77	0.74	0.75	0.83	0.85	0.77	103.19
Poland	0.66	1.00	0.96	1.03	1.21	1.32	1.39	1.44	106.72

Source: Own study based on EUROSTAT data.

On the basis of the information in table 1 it is possible to talk about the permanent increase in the expenses on R&D in %GDP in the EU in years 2009 – 2021. On average this percentage increased by 1.15% every year but it is impossible to talk about the same direction of changes in all countries. Whereas it is possible to talk about the increase in this factor in 22 states (the biggest change in Greece, Poland, Slovakia or Cyprus – about 7.19%, 6.27%, 5.85%, 5.85%, respectively, the lowest in Portugal (0.41%) or Spain (0.42%)), the opposite direction may be observed in such countries as: Luxembourg, Ireland, Finland, Denmark and Sweden. This result is surprising as the Scandinavian countries have taken the highest positions concerning the innovativeness for years. It is confirmed by the fact that the Scandinavian countries have the highest (Sweden) or one of the highest (Finland, Denmark) levels of the considered factor. Thus, such location of Luxembourg, Ireland and other Scandinavian countries should be considered in the context of the dynamics of financing the expenses on R&D and should not be connected with the level of their innovativeness. Analysing the percentage of expenses on R&D in %of GDP in the EU member states, it is possible to notice quite big differentiation which is mainly connected with the level of economy wealth and the fact that companies use the economic calculations. In 2021 among the "old EU" states the lowest percentage was observed in Luxembourg (1.02%) and the highest in Sweden (3.36%) and among the countries belonging to the EU since 2004, the lowest level was observed in Romania (0.47%) and the highest in Slovenia (2.14%). In 2021 in the group of countries belonging to the old EU member states only three states had lower percentage of the expenses on R&D in GDP in comparison to Poland: Ireland and Luxembourg (since 2018) and in Spain (since 2019). Another situation may be noticed in the second group (new EU member states). Here as many as 8 countries have the indicators lower than in Poland and the analysed percentage is higher in such countries as the Czech Republic, Estonia, Hungary and Slovenia (approximately by 1.89% in 2021). However, taking into consideration the average growth rate in these countries in years 2009 – 2021, it is possible to notice that it is much lower – by about 3.26 percentage points (the Czech Republic, Hungary) and 5.07 percentage points (Estonia, Slovenia). In Poland we observe the increase in the expenses on R&D in % of GDP by on average 6.72% year by year in the whole research period (Table 1). It means that we are at a high position among the "new" countries.

Comparing the dynamics, it is possible to notice the change in the states that joined the EU after 2004 is much faster than in the states of so called old EU (Figure 1). The considered expenses increased on average by 0.51% in EU-14 and by 3.19% in EU-13 year by year in 2009-2021.

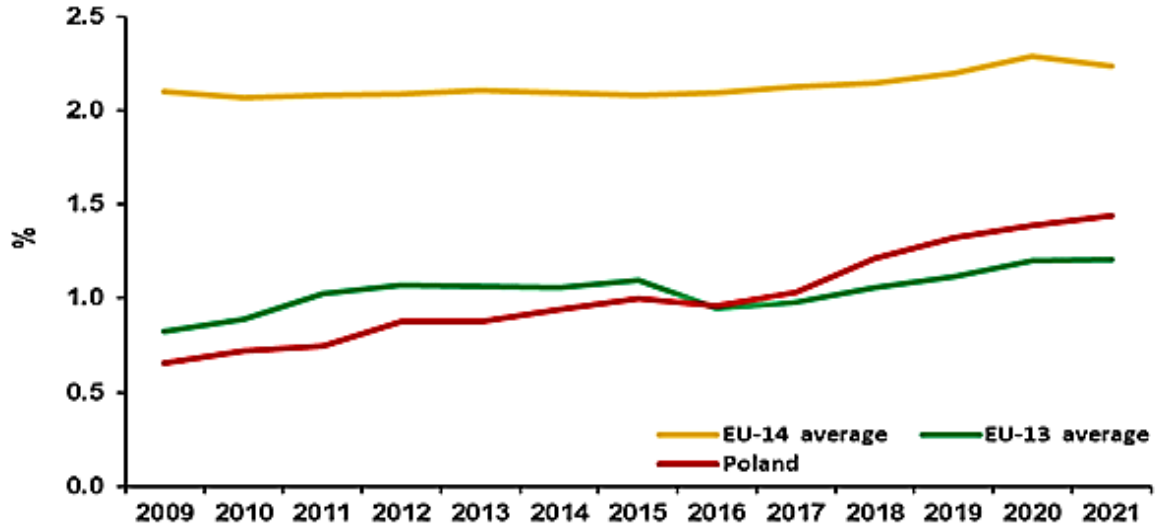

Figure 1. Expenses on R&D in the percentage of GDP in the EU in years 2009-2021.
Source: Own study based on EUROSTAT data.

However, it should be said that the level of the measured value is about twice bigger in the old EU member states than in the new EU member states. Poland is leading in the second group. In our country the % of GDP assigned for R&D was about 3.53 per cent points higher in the last year of research whereas in 2009 this difference amounted to 0.17 per cent points of the benefit of other countries.

The structure of sources of funds on research and development activity should also be considered while doing research on expenses on R&D. These sources include: government, companies, higher education and private non-commercial institutions. This distinction is important as the source of funds origin is also a factor contributing to the actions in the R&D sector. Considering the participation of the company sector in the EU and Poland, it is possible to notice the advantage of the states belonging the EU before 2004 (The exceptions are Portugal in 2019 and Austria in 2020) and the negative value for the majority of EU-13 states. Analysing the penultimate year of the research, the company expenses on R&D in the whole EU amount to about 57.9% and this percentage is lower in Poland (50.6%). In comparison to the EU, only in Germany the companies participate in the R&D financing in the higher rate than in Poland, taking into consideration the countries neighbouring with ours, by about 4.7 per cent point (Table 2).

Table 2.
Expenses on R&D activity according to the sources of financing in years 2019-2020

Item	Business sector		Government sector		Higher education sector		Non-profit institutions sector	
	2019	2020	2019	2020	2019	2020	2019	2020
European Union - 27 countries	59.0	57.9	29.4	30.2	1.2	1.2	1.1	-
	EU-14							
Belgium	64.3	-	17.8	-	2.6	-	0.6	-
Denmark	59.6	-	28.7	-	-	-	6.3	-

cont. table 2.

Germany	64.5	62.6	27.8	29.7	-	-	0.4	0.4
Ireland	62.8	-	22.6	-	0.6	-	0.6	-
Greece	41.4	39.9	41.1	42.7	2.2	2.6	0.6	0.4
Spain	49.1	49.2	37.9	38.5	4.2	3.8	0.7	0.8
France	56.7	56.8	31.4	31.5	2.9	2.9	0.9	1.1
Italy	55.9	52.8	32.3	33.7	0.7	0.8	1.4	1.4
Luxembourg	51.3	-	43.2	-	1.4	-	0.3	-
Netherlands	57.6	56.9	29.4	30.3	0.2	0.2	2.4	2.2
Austria	54.8	49.8	27.0	33.3	0.9	-	0.3	0.3
Portugal	48.3	52.2	40.2	37.3	3.5	2.9	1.2	1.2
Finland	54.3	56.0	27.8	27.7	0.7	0.6	1.7	1.7
Sweden	62.4	-	24.2	-	0.9	-	3.4	-
	EU-13							
Bulgaria	37.6	35.4	23.6	25.3	0.1	0.2	0.3	0.3
Czechia	38.2	35.6	33.7	34.0	1.0	1.2	0.1	0.1
Estonia	49.1	50.1	37.2	37.0	0.2	0.2	0.2	0.3
Croatia	36.6	37.6	39.1	36.9	4.4	4.2	0.1	0.0
Cyprus	36.4	38.0	35.4	35.5	4.1	3.5	1.3	1.9
Latvia	24.3	27.0	35.4	38.1	1.7	1.7	-	-
Lithuania	34,0	37.3	32.3	29.1	3.0	2.4	0.2	0.2
Hungary	52.9	50.2	33.3	32.5	0.2	0.2	0.5	0.4
Malta	58.7	60.2	31.2	30.3	1.0	0.7	0.4	0.5
Poland	50.7	50.6	38.8	39.0	3.0	2.7	0.5	0.5
Romania	54.6	55.6	34.4	32.9	0.4	0.6	0.1	0.0
Slovenia	61.5	49.5	24.7	25.1	0.5	0.7	0.0	0.1
Slovakia	46.8	43.7	40.5	39.6	1.8	2.0	0.3	0.4

Source: Own study based on EUROSTAT data.

In the case of the governmental sector it is: 30.2% (EU) and 39.0% (Poland). In comparison to these two economic sectors the participation of the higher education sector and non-commercial institutions is low. In the EU the participation of the first one is at the level of 1.2% and the second one about 1.1% (2019). The situation is different in Poland. The participation of the higher education is higher and the non-profit organisations is lower in comparison to 27 EU member states.

Apart from economic factors, also human resources should be considered, in particular, that they are the basis of company competitiveness and innovativeness and in a consequence, of the new paradigm of the economic growth.

Comparing the human resources for science and technique in companies internationally, they are usually presented in respect to the active population and are given in full-time equivalent (FTE). In years 2010-2021 this participation increased by 4.30% in the EU year by year and in Poland by 16.94%. It does not prove that the changes occur in the EU more slowly but rather that Poland is "chasing" it. It is probably connected with the change of innovation policy in our country and in the fact that education and training of current and future employees is more and more important. Although the difference between the EU and Poland fell from the level of 0.46 to the level 0.28, the employment was at a much lower level in Poland in the whole tested period (Figure 2). It should be emphasised that this analysis should be considered through the prism of individual EU member states as each state has a different long-term employment policy. Comparing the mean for EU-14 and EU-13 states, it has been possible to notice some

fluctuations in the group EU-13 and much bigger growth in EU-14 since 2020. Despite this fact, the changes in EU-13 were bigger that in EU-14 – by 3.69 per cent point. The participation of employment in R&D in companies in Poland has been higher than the mean for EU-13 states since 2017. It is lower only than in Slovenia, the Czech Republic and Hungary.

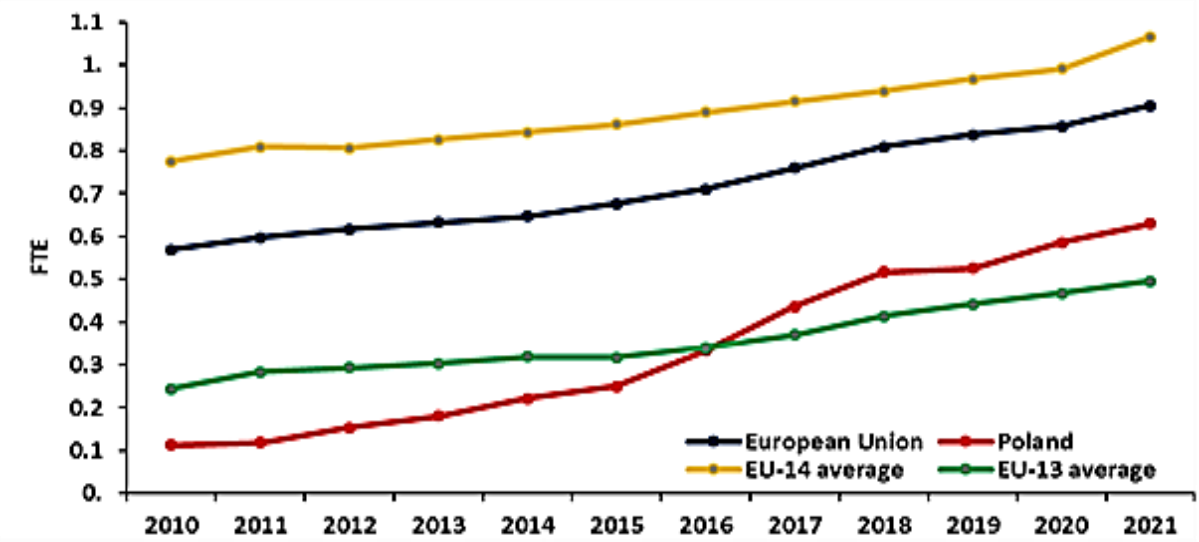

Figure 2. Employment in R&D in companies in respect to active population (in FTE) in years 2010-2021.

Source: Own study based on EUROSTAT data.

On the basis of the figure above it is possible to notice that there was a permanent growth in every case but the "starting point" is higher in the whole EU. What is interesting, whereas the higher level was noticed in all groups in Poland in 2010, in the last year of research only in two (EU and EU-14). The growth was noticed in 22 countries belonging to the European Union in years 2020/2021 and the fall of this indicator in 5 states: Ireland (5.47%), Luxembourg (5.24%), Malta (3.95%), Bulgaria (3.50%) and Denmark (1.80%). Some fluctuations are present in these countries for the whole period of research but they are not big. Thus, these changes may be regarded as the result of human resources instability or rather as the effect of demographic chances (society aging).

In other sectors the total employment measured in the full-time equivalent was at the level lower than 0.50 in the last year. The analysed percentage was higher in the EU (0.18) than in Poland by about 0.15 in the government sector in the last year of research whereas it was just the opposite in the case of higher education – there is 0.41 in the EU and 0.44 in Poland. We have the penultimate rank (only before Malta) in the first sector and the twelfth in second sector (after Austria, Latvia, France, Belgium, Lithuania, Luxembourg, Ireland, Greece, Portugal, Finland and Denmark).

The people directly engaged in creating concepts, new knowledge, products, methods and systems, i.e. the research ones should be considered among the R&D staff. Their participation in the group of all research and development staff in the EU fluctuated around 50% in the whole period of analysis (Figure 3).

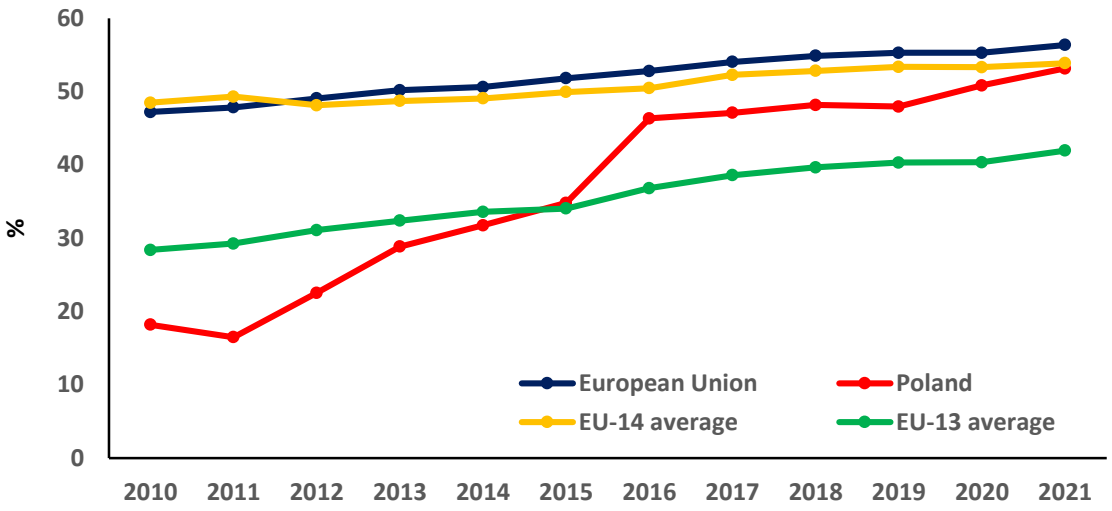

Figure 3. The percentage share of researchers in companies in respect to all people from this employment group in the EU and Poland in years 2010-2021.

Source: Own study based on EUROSTAT data.

On the basis of this figure it is possible to state that a big change in the number of researchers (measured in FTE) occurred in our country contrary to the EU. The advantage of the EU is visible in the whole period of analysis, but the difference between it and Poland decreased significantly. Whereas it amounted to 29.03 percentage points in 2010, it was only 3.20 points eleven years later. However, it must be remembered that the EU consists of 27 states and the number of researchers is differentiated in them. Nevertheless, despite these differences, the considered percentage is getting more and more similar in all the countries and in Poland. It is assumed that the distance will be getting smaller and smaller as a result of among others changes in the employment policy and economic instability of less developed countries. In the last year of the research such countries as: the Netherlands (70.15%), Belgium (64.27%), Austria (63.30%), France (61.76%) and Germany (60.13%) took the leading positions and Latvia (25.52%), Croatia (26.39%), Slovakia (27.16%), Greece (29.76%), Lithuania (30.86%), Luxembourg (31.56%), Romania (33.14%), Cyprus (35.38%) or Spain (39.17%) were at the other end of the ranking.

Considering the percentage share of researchers (measured in FTE) in the EU in the governmental sector, it was stated that it was the highest in Germany (28.42%) and the lowest in Cyprus (0.05%). This share amounts to about 1.61% in Poland. When it comes to higher education sector, Germany has the highest level (18.88%) and the lowest Malta (0.08%).

The next step was an attempt to present the impact of GDP and human resources for science and technique on the expenses on R&D with the use of the econometric model. The independent part was decomposed into part in order to examine the significance of these stimulants in each country. This let to comprehend the characteristics for the given country. Then the value of decomposed independent parts was “de-logarithmed”, which made it possible to interpret the differences between the countries (in the multiplicative approach). The results are presented in the table below:

Table 3.
Estimate of parameters in WBR model

Variable	Parameter estimate	Parameter error	T statistics	p-value	Parameter estimate (elasticity)
lnPKB	0.745	0.023	32.840	<0.0001	0.745
lnZL	0.241	0.065	3.736	0.0002	0.241
Belgium	0.769	0.052	14.910	<0.0001	2.157
Bulgaria	−0.354	0.051	−7.009	<0.0001	0.702
Czechia	0.505	0.050	10.130	<0.0001	1.657
Denmark	0.899	0.051	17.750	<0.0001	2.458
Germany	0.933	0.050	18.520	<0.0001	2.542
Greece	0.233	0.050	4.639	<0.0001	1.262
Spain	0.327	0.050	6.480	<0.0001	1.386
France	0.773	0.050	15.360	<0.0001	2.165
Italy	0.654	0.051	12.750	<0.0001	1.923
Ireland	0.217	0.050	4.302	<0.0001	1.242
Cyprus	−0.793	0.051	−15.600	<0.0001	0.452
Latvia	−0.675	0.052	−13.080	<0.0001	0.509
Lithuania	−0.330	0.053	−6.283	<0.0001	0.719
Luxembourg	0.095	0.051	1.852	0.0649	1.100
Hungary	0.397	0.050	8.006	<0.0001	1.488
Malta	−0.431	0.050	−8.647	<0.0001	0.650
Netherlands	0.465	0.051	9.095	<0.0001	1.591
Austria	1.033	0.050	20.610	<0.0001	2.811
Poland	−0.109	0.052	−2.089	0.0375	0.897
Portugal	0.682	0.053	12.900	<0.0001	1.977
Slovenia	0.599	0.051	11.770	<0.0001	1.821
Slovakia	−0.244	0.050	−4.927	<0.0001	0.783
Finland	0.946	0.051	18.620	<0.0001	2.576
Sweden	0.892	0.051	17.380	<0.0001	2.440

Source: Own study based on EUROSTAT data.

On the basis the information given in Table 3 it is possible to state that all variables turned out to be significant, the significance level is higher for Luxembourg and Poland. Moreover, the value of uncentered correlation coefficient and the F-test proves that the model matching degree is high (R^2_N = 0,999, F(26.235) = 114635.1with p = 0,000).

The research shows that the flexibility coefficients were lower than one for six of the analysed countries, which means that the expenses on R&D increase in these countries but slower than their determinants. The short-term flexibilities turned out significant when it comes to both the employed in R&D sector and the gross domestic product. Similarly, as in the case of GDP, human resources also change in the same direction but this change is much smaller than in the case of economic wealth measured with GDP. The increase in GDP by 1% causes the increase in R&D expenses on average by 0.75% whereas the increase in human resources by 1% caused the considered expenses rise on average by about 0.24%. However, it should be taken into consideration that human resources are a significant determinant of expenses on research and development activity and they should not be omitted in the e.g. quantitative analyses. Much lower HR flexibility coefficient is mainly the result of not well-developed system of education of potential people dealing with creating and wide spreading innovations and in consequence low cooperation of science and companies.

Thus, it is possible to state (using the data included in Table 3) that more funds is designed for research and development activity and human resources for science and technique are more important in the short-term in the states regarded as powers in the area of innovation (Sweden, Finland, Denmark, Austria, Germany). The effect of the impact of GDP and HR on the tested expenses is much higher here.

Considering the level of expenses on research and development activity, we can say that they are below the average level of this value in Poland in comparison to the analysed EU member states (Figure 4). It is mainly affected by the innovation policy but also by the fact that the performance of innovation projects in companies meets a lot of difficulties mainly connected with obtaining funds.

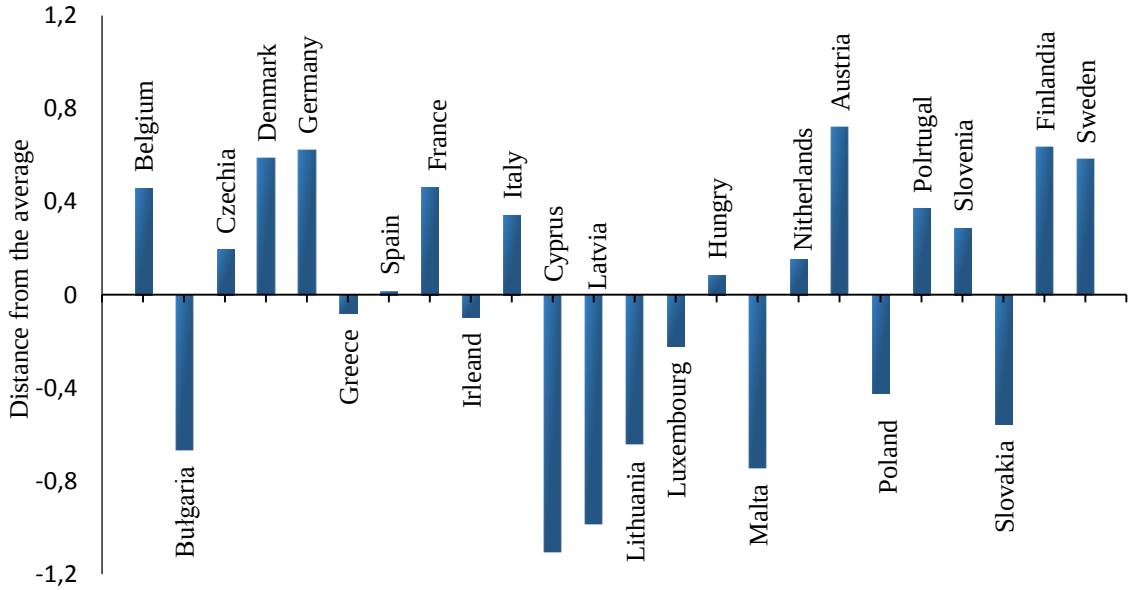

Figure 4. Differences in the levels of decomposed independent parts for WBR model.

Source: Own study.

The decomposed independent parts turned out to be significant in 24 out of 27 countries. Their values over one reinforce the aggregate effect arising from the impact of other variables, below one – weaken this effect. Such countries as Romania, Estonia and Croatia (the p-value was too high for them) do not show any significant impact on tested expenses but it cannot be said that it does not exist. When it comes to Poland, we notice its big difference from the average and it is negative. Although the situation in Poland is not good, we can improve it thanks to e.g. cooperation with Scandinavian companies which invest in new technologies and open research and development centres.

4. Discussion

The interest in the research and development activity increases with the growth of requirements which companies face in the era of open economy. Their willingness to be competitive in the market requires that the companies have to create and introduce newer and newer solutions. Moreover, innovations affect the economic growth or employment significantly and contribute to the improvement of life quality or also make it possible to deal with threats of fast changing surrounding (Atkinson, Ezell, 2014). However, it should be stressed that the opinions concerning the relation of competition and innovations are divided. Some think that companies are competitive because they offer new solutions (Tylżanowski, 2012; Szamrej-Baran, 2012; Stawasz, 2013; Robakiewicz, 2018; Fundeanua, Badele, 2014; Udriyaha, Thama, Azam, 2019), whereas the others claim that innovations are created in companies because there is a lot of competition in the market (Gryczka, 2016; Grossman, Helpman, 1990; Dodgson, Rothwell, 1994; Fagerberg et al. 2006). It is difficult to solve this dispute, especially that there is a feedback. Despite these disputes, it is possible to conclude that the innovation activity plays an important role in functioning of the company the productivity of which grows together with the involvement in the research and development activity (Medda, Piga, 2014).

The index of the synthetic economic growth, i.e. GDP is the most often used in the analyses to compare the company innovativeness (Al-Qudah, Al-Okaily, Alqudah, 2022). However, this index is referred to the number of residents to enable international comparisons. Nevertheless, it should be stressed that it is necessary to include the difference, while comparing Poland with other EU member states, which occurred due to a different starting position as the historical and political conditions not only contribute to the existence of big social and economic differentiation between countries but also decide (indirectly) about the national ability to run innovative activity (Andrijauskiene, Dumciuviene, Stundziene, 2021; Celli, Cerqua, Pellegrini, 2021). Despite these differences, Poland (but also other countries) has to focus on the improvement of its position in R&D activity if it wants to compete with the leading European states. It requires mainly intensified efforts of the companies but also of the state (Ziętek-Kwaśniewska, 2020). It is confirmed by the research on the impact of the political R&D support on the results of the company innovation activity (Grabowski, Staszewska-Bystrova, 2020; Czarnitzki, Hussinger, 2018; Szczygielski et al., 2017; Doh, Kim, 2014). Moreover, it is more and more important that the European Union emphasises the enhancement of the integration of industry and academic surrounding, which favours their mutual complementarity and global challenges (Kim, Yoo, 2019). The strict connection between the economy innovativeness and company innovativeness contributes to the introduction of various strategies both at the national and EU level, which may help to run pro-innovative politics taking into consideration the peculiarity of a given country (Głodek, 2011; Fedirko, O., Fedirko, N., 2021).

The structure of the innovation financing sources comprises another factor indicating the involvement in the development of research activities. Research and development activity is connected with high costs and due to this fact it requires the engagement of not only one economic sector. The companies mainly use their own funds and significantly less foreign capital to finance the innovation activity (Bednarczyk, Zapartowicz, 2019). Whereas the governmental sector, even though it assigns little funds on innovation projects in comparison to companies, is still a significant stimulant of economy and company innovation policy. Thus, it is necessary that the government supports the innovativeness, e.g. by providing appropriate environment for companies which are eager to invest and introduce innovations or by financing public research or encouraging to invest in research and innovations (Maradana et al., 2017; Bircan, Gençler, 2015; Balsalobre-Lorente et al., 2021). Although the percentage on expenses in GDP is growing, it can be said that expenses on R&D are still too small. Their level affects the patent activity indirectly, which is often limited due to the few expenses on e.g. modern equipment or purchase of new technologies. Thus, it is necessary to invest in the research and development activity as it contributes to the increase in work performance e.g. thanks to the facilitation of knowledge exchange between organisations (Audretsch, Belitski, 2020).

It confirms the significance of another sector – higher education sector. Due to the fact that creating and introducing innovations requires a lot of knowledge, the role of research institutions is undisputable in raising the level of innovativeness. The cooperation of business and science is really desired in this respect, especially at the commercialisation of the research results. In other words, the level of R&D expenses or cooperation between companies, companies and universities is important to perceive the company innovation abilities. As Gust-Bardon claims, the cooperation between scientific institutions and companies will make it possible to exchange knowledge and experiences, which may result in the creation of new technological or organisational solutions (Gust-Bardon, 2011). Thus, it is possible to say that human resources take a significant place in all innovation processes. Thanks to highly qualified employees, their motivation and work satisfaction, inventions in the scope of new technologies or a big number of patents may occur (Bircan, Gençler, 2015). As the research shows, the companies take advantage of their workers' knowledge to increase the management efficiency, organisation productivity and survival (Nonaka, von Krogh, 2009, Braunerhjelm et al., 2018; Alnoor, 2020). Due to this fact knowledge may be regarded as the basic strategic resource of companies wanting to develop their activity in the market (Durić, Ristić, Dragičević, 2021; Martínez-Sánchez, Vicente-Oliva, Pérez-Pérez, 2020; Myjak, 2018; Harasim, Dziwulski, Wyrwisz, 2020). Moreover, there is also an argument in favour of using human resources and it says that nowadays it is difficult to base the company development only on the possessed financial resources. Thus, investing in human resources and innovations is very important for the companies concerning their proper functioning and being competitive (Kearney, Meynhardt, 2016; Palos-Sáncheza et al., 2022). However, it should be remembered that the

effects which may be achieved thanks to investing in R&D are visible in the long-term (Kiraci, Celikay, Celikay, 2016). Thus, the companies are obliged to raise the quality of human resources and to introduce new management methods and techniques. It is especially important in the situation when the companies want to consider the rules of sustainable growth. Many entities see the necessity to connect their actions with the creative and participative use of human resources in the context of innovations and sustainable growth (Mroczko, 2020; Lenihan, McGuirk, Murphy, 2019).

Nevertheless, it is impossible to compare the countries uncritically and make conclusions from it. Analysing the company innovativeness, both the potential of a given country and its size and population should be remembered. It is much easier to manage the economy in the countries that have a small population than the ones in which the population is a few millions (Szajt, 2010). However, the level of innovativeness in a given country should not be explained with these issues. As it was mentioned before, the cooperation of states and regions and companies and research institutions are ones of the most important factors that affect the innovation and innovativeness. It is confirmed by the high innovation rates in such countries as: Austria, Sweden, Finland and Denmark in which the system of entrepreneurship and innovation support is well developed (Majkut, 2021; Miłek, Mistachowicz, 2019; Borrás, Schwaag Serger, 2022). In these countries the percentage of R&D expenses in GDP is one of the highest and the organisation of the educational system and institutional solutions facilitate functioning in the complex and variable conditions of the surrounding. The structure of innovation support consists of various organisations and measures supporting the development of innovations and business ideas from the concept stage to the introduction to the market. In other words, the suggested and used solutions contribute to the integration of scientific environment with entrepreneurs in a high rate. According to the European Innovation Scoreboard 2022 (EIS) the innovativeness level is not good in Poland. Our country is in the group of so called raising innovators and takes the fourth rank from the bottom in this scoreboard. With the result of 60.5% of the EU mean, we are only better than Latvia, Bulgaria and Romania (European Innovation Scoreboard, 2022). Although the difference between our country and the EU is getting smaller and smaller, the situation is still not good. Almost all factors considered in EIS worsened (among others investments in environmental technologies, expenses on research and development work, support of academic workers). Thus, the countries should mainly focus on the efficiency of investments in R&D sector as the conclusions from the assessment of the economic efficiency may indicate whether creating and introducing the innovative solutions is justified economically for the company or whether it does not bring any measurable profits.

5. Summary

The presented comparative analysis referring to the company innovativeness showed that there is a growing tendency in assigning public funds on research and development activity in the European Union member states (on average by 1.15%). However, due to the existence of vast differentiation in the economic level, the difference in the percentage of expenses on R&D in GDP in the "old" and "new" EU member states is clearly visible. This advantage is significant which is not a beneficial situation especially when it comes to the sustainable growth.

On the basis of the performed research it is possible to notice that % of GDP assigned on the innovation activity in Poland is not high in comparison to 15 EU member states (it is only 1.44% of GDP in Poland whereas in some UE member states almost 1.5-2 times bigger) and the achievement of 3% assumed by the UE is quite far. Of course, comparing the results of Poland and other states, their starting points and historic conditions should be remembered. However, if Poland wants to get the same level as the leading states in Europe in the area of innovations, it has to take steps to improve its position in the area of R&D activity. It is necessary to increase innovation financing, enhance the cooperation of business and science as well as increase the governmental efforts in order to meet this aim.

Although the permanent increase of employment in this sector is visible in the whole period of analysis, the lack of significant optimisation in workers' management is a big obstacle to improve the level of innovativeness and company productivity (especially in Romania, Croatia or Bulgaria). Thus, if it came to the change in human resources management and the employment tendency remained the same and funds increased significantly, the situation would be optimistic as it would be possible to expect the increase in patent activity. Monitoring these indexes strongly affects the creation and introduction of innovations in companies. Although the difference between the EU and Poland decreased, it does not provide changes in the education of the society in a visible way. Moreover, the systems of trainings are insufficient. The employers do not often finance these courses, which causes that the workers are not interested in them. It is not the case that the workers do not want to educate themselves and raise their competences but that they are not able to cover the costs.

Considering the structure of expenses on research and development activity, it is possible to notice that mainly the sector of companies affects the R&D expenses. Their high percentage in R&D financing may be noticed in the most industrialised countries such as: Belgium, Germany, Ireland, France or Sweden. However, regardless of the country, each company has to "learn" various types of innovations, efficient human and tangible resource management, to introduce and widespread new solutions as it is the basis of leading the efficient innovation policy in which the fast adaptation and widespread of new technologies is emphasised.

On the basis of the information from the model (the value of flexibility coefficients) it is possible to state that the economic wealth (measured in GDP) has greater influence on expenses on R&D than HR. It may be a sign of high sensitivity of analysed expenses on the current economic situation of the country. On the other hand, the lower impact of human resources may be connected with the instability or the shortage of staff including the technicians and research staff.

Contrary to the Scandinavian countries the situation referring to the international patents and cooperation of science and business is quite negative in Poland. It is consistent with the results of the European Innovation Scoreboard in which our country takes one of the last positions and it shows its low positions in the area of innovativeness. It is not good information for Poland. Thus, it is possible to say when it comes to it (but also to the states of South and East Europe) that it is necessary to verify innovation policy and structure of sources of innovation financing. It will be a long-term process and its results will surely depend on the level of economic growth and changes in the approach to human management. Although there was the increase in investments in our country including the transfer of new technologies, these changes are insufficient, especially when it comes to education or the participation in R&D financing by company and government sector.

The general conclusion from the analysis of the presented indicators is that the situation in so called new EU member states in not satisfying. Thus, it seems to be necessary to increase the funds on R&D and to intensify the actions so that the science and business could cooperate more strictly, which will contribute to the commercialisation of the results of the research and development work. It is important especially because a lot of companies finished their activity in the pandemic or limited it so the funds on research and development decreased. Thus, the cooperation between countries (especially with Scandinavian companies), proper human resource management and spending more money on innovations may affect the existence and innovativeness of companies in a positive way and at the same time may affect their competitiveness.

Summing up, it should be emphasised that the attention was paid on the influence of GDP and human resources for science and technique on the expenses on R&D in the article. The performed analyses can be the starting point for further research in the area of innovativeness which would include demographic changes, technological or organisational progress and the assessment of company innovative activity e.g. in the time of crisis.

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