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EXPENDITURE ON RESEARCH AND DEVELOPMENT AS A FACTOR STIMULATING INNOVATIVENESS OF EUROPEAN UNION ECONOMY

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Purpose: The aim of the study is to search for relationships between expenditure on research and development activities and the development of innovation in EU countries.
Design/methodology/approach: For the purposes of the study, the dependence of the selected results of innovative activities in the European Union states on GERD and its individual components was assessed. For this purpose, the simple linear regression method was used. By calculating the values of Pearson's linear correlation coefficients, it was determined whether there was a dependence between the analyzed variables. Cluster analysis was also conducted and, using the Ward's method, the EU member states were grouped by similar innovation indicators and polices regarding expenditures on R&D.
Findings: The study showed the usefulness of the regression analysis in the assessment of the effectiveness of the selected components of the EU and domestic innovation policies and financial instruments used as part of those policies. It can be seen that higher expenditures on R&D result in increasing the indicators, although the most effective are the expenditures regarding SMEs introducing product and process innovations.
Research limitations/implications: The fact that some countries achieve better results, despite similar investments, requires further research.
Practical implications: The findings can be used to shape national innovation policies and to assess the effectiveness and efficiency of the financial interest.
Originality/value: The research covered the latest available data on R&D expenditure and innovation indicators, the analysis of which may be important for innovation policy makers.

Keywords: R&D expenditure, innovation indicators, innovativeness.

Category of the paper: Research paper.

1. Introduction

Innovations are of great importance in shaping the development policy of many states. Many authors believe that the states that base their development on the creation of innovations or the implementation of already existing solutions can achieve higher incomes and, above all, build a competitive advantage, resulting, among other things, in an increase in the living level of the society (Siwek, 2021). Entrepreneurs, thanks to the introduction of innovations, create an advantage over their competitors. It is possible mainly due to the fact that they offer cutting-edge products that can enjoy increased interest from customers, which can translate into profit. The use of modern solutions also makes it possible to increase productivity and reduce costs of doing business. The more innovative enterprises there are in a given economy, the more competitive it may be internationally. This is argued, among others, by M.E. Porter, according to whom the competitiveness of a state depends on the ability of enterprises to innovate and modernise (Porter, 1990).

2. Innovation and innovativeness

The innovativeness is considered mainly in technical and economic terms, however according to J. Baruk, it is primarily a social phenomenon, and not only a technical process or an economic mechanism, since it enables members of society to express and satisfy their needs and to develop and manifest their creativity (Baruk, 2004).

Both the concepts of innovation and innovativeness do not have a single definition. The literature also writes about innovations much more often than about innovativeness, because the former seem easier to define. The authors also point to the close relationship between innovations and innovativeness.

One of the first authors credited with laying the foundations of modern innovation theory is J. Schumpeter. He was the first to use the concept of innovation, which he understood as new combinations of factors of production, among which he highlighted knowledge, resources, equipment, etc. Thus, innovation did not always have to mean something that was created. He noted above all that innovativeness should be distinguished from invention. Schumpeter emphasised this difference because he perceived innovation as a specific social activity carried out in the economic sphere, the purpose of which is to be commercial, while inventions, identified by him with inventiveness, can occur anywhere and without any intention of their commercialisation. For him, therefore, innovations are innovative combinations of knowledge and resources that are subject to commercialisation attempts, so they should be practically implemented. According to Schumpeter, they could take various forms of activity, which could

consist in introducing a new product to the market or offering products with new properties, introducing a new production method or implementing a new technological process, opening up a new market, gaining new sources of organising for an industry or introducing a new organisation for a given industry (Schumpeter, 1934).

A similar interpretation is recommended by the Oslo Manual, according to which an innovation is a new or significantly improved product or process for a specific company. They do not have to be new for the economy, society or a particular market. It is sufficient that the products or processes will be used in other geographic or product markets. The requirement of implementation is also a characteristic feature of innovations, distinguishing them from inventions, prototypes, new ideas, etc. (OECD, 2028).

In their study, W. Nasierowski and F.J. Arcelus consider that innovations can be defined as an economic decision taken in order to carry out tasks related to either taking advantage of emerging market opportunities or preventing the materialisation of potential threats. According to them, such decisions are very often of a strategic nature, i.e. they are taken considering a long time horizon in relation to the expected benefits, which are most often increased profits (Nasierowski, Arcelus, 2012).

An organisational innovativeness, on the other hand, is most often perceived in the literature of the subject as a desirable aspect of a given organisation. However, the authors often emphasise that the lack of a clear distinction between these two concepts, and thus erroneous theoretical and measurement assumptions, may lead to mutually contradictory results and conclusions. It consists of five elements (creativity, openness, future orientation, risk-taking, and proactiveness) that mutually characterise the climate in an organisation that determines its ability to generate new ideas and develop innovations (Ruvio et al., 2014).

Innovativeness is also defined as the development and implementation of new ideas. This definition focuses on the results of innovative activity (Van de Ven, 1986). However, some authors emphasise that innovativeness precedes innovation, so it is a condition for the development of new ideas. According to some, innovativeness is the process by which innovations are created (Younis, Nor'Aini, 2010). A similar view is shared by L. Hill, G. Brandeau, E. Truelove and K. Lineback, who consider organisational innovativeness as the ability to create something new and useful (Hill et al., 2014), and also by M.F. Hilami, T. Ramayah, Y. Mustapha, S. Pawanchik (Hilami et al., 2010). This group also includes A. Pomykalski, who believes that innovativeness is the organisation's ability to constantly seek, implement and disseminate innovations (Pomykalski, 2001).

A slightly different approach is proposed by L. Kozioł, A. Wojtowicz and R. Pyrek, whose view is that innovativeness is a function of innovation potential and its innovative activity determined by innovation ability (Kozioł et al., 2014). In turn, I. Bielski points out that innovativeness is the ability to effectively allocate resources to shape the optimal configuration of competitive advantages (Bielski, 2000). The effect of innovativeness is pointed out by E. Danneels and E.J. Kleinschmidt stating that innovativeness is the ability to introduce new

products to the market, to open a new market through a combination of strategic orientation and innovative behaviour and processes.

An interesting summary of the various approaches to the concept of innovativeness that can be found in the literature was made by T. Bal-Woźniak, who divided it into several groups: the ability to generate and implement innovations that gain recognition among recipients thanks to a high level of modernity and global competitiveness, the ability to continuously seek, introduce and disseminate innovations, the ability to create and introduce changes in various aspects of socio-economic life, and the ability to create innovations (Bal-Woźniak, 2012).

The innovativeness depends on many factors. It is certainly influenced by creativity, which, according to R. Wolniak and M.E. Grebski, should be constantly fostered. According to them, creativity, and the resulting innovativeness, are not only the main assets of an organisation, but are also important attributes in any profession (Wolniak, Grebski, 2018).

The factors influencing the innovativeness are different. They are also often used to construct a variety of indirect indicators to measure the innovative activity of an economy. In this case, it is often based on the amount of expenditure and effects related to research and development (R&D) activity. Gross domestic expenditures on R&D (GERD) consists of business enterprise expenditure on R&D (BERD), government expenditure on R&D (GOVERD), higher education expenditure on R&D (HERD) and private non-profit expenditure on R&D (PNPERD). GOVERD and HERD are one of the indicators used to assess innovativeness in the European Innovation Scoreboard reports as R&D expenditure in the public sector. The second indicator is the business enterprise expenditure on R&D (BERD) (R&D expenditure in the business sector) (Hollanders, Es-Sadki, 2022). The R&D activity is also the first of the activities that can be undertaken by enterprises in their pursuit of innovations, also indicated in the Oslo Manual, which confirms that expenditure on it is an important factor in the development of innovativeness.

According to Eurostat, R&D expenditure and intensity are key indicators used to monitor resources devoted to science and technology worldwide (Eurostat, 2021).

3. Methods

For the purposes of the study, the dependence of the selected results of innovative activities in the European Union states on GERD and its individual components was assessed. For this purpose, the simple linear regression method was used. By calculating the values of Pearson's linear correlation coefficients, it was determined whether there was a dependence between the analysed variables. The regression coefficients were also examined in order to find dependencies linking R&D expenditure with its results, which may be important for creating elements of the national innovation system.

Cluster analysis was also conducted and, using the Ward's method, the EU member states were grouped by similar innovation implementation indicators and polices regarding expenditures on R&D.

4. Results

Gross domestic expenditures on R&D comprise four components related to the economy sectors in which the expenditures are made: BERD, GOVERD, HERD, PNPERD. In the 27 European Union member states as a whole BERD has the greatest share out of the four components, amounting to 60.6% in 2020. BERD had the lowest share (31%) in Latvia, while the highest (76.4%) - in Hungary. Higher Education expenditure on R&D ranked second with 25.8% share in the EU. HERD had the lowest share in Bulgaria (5.9%) and Romania (8.5%), and the highest (49.3%) in Latvia. Government expenditure on R&D (GOVERD) in the EU amounted to 12.6%, with the lowest share recorded in Poland (2.2%) and the highest in Romania (31.2%). Private non-profit expenditure on R&D (PNPERD) accounted for only a fraction of a percent of GERD in the EU. Therefore, it was omitted. Detailed data are presented in the table (Table 1).

Table 1.
Gross domestic expenditure on research and development in the EU

Country	BERD (Percentage of GDP)	GOVERD (Percentage of GDP)	HERD (Percentage of GDP)
Belgium	72,7%	8,9%	17,5%
Bulgaria	68,2%	25,9%	5,9%
Czechia	60,8%	17,1%	21,6%
Denmark	60,7%	3,0%	36,0%
Germany	67,2%	14,6%	18,2%
Estonia	54,7%	10,1%	33,5%
Ireland	74,0%	3,3%	22,8%
Greece	46,0%	21,3%	31,3%
Spain	55,3%	17,7%	26,2%
France	66,4%	11,9%	20,4%
Croatia	48,0%	20,0%	32,0%
Italy	60,8%	13,1%	23,5%
Cyprus	45,1%	7,3%	36,6%
Latvia	31,0%	18,3%	49,3%
Lithuania	47,4%	15,5%	36,2%
Luxembourg	54,0%	23,9%	22,1%
Hungary	76,4%	9,9%	13,0%
Malta	64,2%	1,5%	34,3%
Netherlands	67,2%	5,7%	27,1%
Austria	69,4%	7,2%	22,8%
Poland	63,3%	2,2%	35,3%
Portugal	56,8%	4,9%	35,8%
Romania	59,6%	31,9%	8,5%

Cont. table 1.

Slovenia	73,0%	14,0%	12,1%
Slovakia	53,8%	19,8%	26,4%
Finland	67,0%	7,5%	24,5%
Sweden	72,2%	4,5%	23,2%
EU 27	60,6%	12,6%	25,8%

Source: own study based on Eurostat data.

During the study of the relations between the expenditures on R&D and innovativeness, the direct indicators of the implementation of innovative solutions were taken into account. Those indicators were from 2020 and were made available by EUROSTAT. The year 2020 was selected due to the availability of data and because it was the final year before the crisis caused by the COVID-19 pandemic, which affected numerous sectors worldwide. PCT patent applications per billion GDP were not taken into account, because the latest data were from 2018. The data taken into account are presented in the table (Table 2).

Table 2.
Expenditures on R&D and innovation indicators in the EU member states in 2020

Country	**BERD***	**GOVERD***	**HERD***	**GERD***	**1**	**2**	**3**	**4**	**5**
Belgium	2,53	0,31	0,61	3,48	34,7	63,4	53,1	73,6	15,1
Bulgaria	0,58	0,22	0,05	0,85	22,2	24,5	36,4	57,5	7,4
Czechia	1,21	0,34	0,43	1,99	35,2	52,2	68,0	51,7	14,4
Denmark	1,84	0,09	1,09	3,03	31,5	45,5	53,2	81,0	15,0
Germany	2,11	0,46	0,57	3,14	34,1	54,8	67,0	77,9	14,0
Estonia	0,98	0,18	0,6	1,79	25,2	41,1	40,4	61,4	9,0
Ireland	0,91	0,04	0,28	1,23	28,7	47,7	61,1	93,8	36,9
Greece	0,69	0,32	0,47	1,5	48,0	66,3	28,9	74,5	20,3
Spain	0,78	0,25	0,37	1,41	17,9	26,1	45,8	53,1	21,7
France	1,56	0,28	0,48	2,35	26,7	44,1	57,0	69,9	5,9
Croatia	0,6	0,25	0,4	1,25	34,6	47,2	39,4	31,0	12,9
Italy	0,93	0,2	0,36	1,53	29,7	46,4	51,8	62,5	13,5
Cyprus	0,37	0,06	0,3	0,82	38,8	64,9	57,6	93,3	13,8
Latvia	0,22	0,13	0,35	0,71	13,7	24,9	33,9	55,8	6,4
Lithuania	0,55	0,18	0,42	1,16	30,5	44,8	39,9	22,8	11,5
Luxembourg	0,61	0,27	0,25	1,13	28,7	39,3	42,6	92,6	6,3
Hungary	1,23	0,16	0,21	1,61	19,9	23,5	69,4	55,3	7,8
Malta	0,43	0,01	0,23	0,67	17,4	34,5	60,0	52,2	6,1
Netherlands	1,54	0,13	0,62	2,29	27,7	43,1	54,2	81,2	8,2
Austria	2,22	0,23	0,73	3,2	30,4	50,2	57,6	50,9	13,0
Poland	0,88	0,03	0,49	1,39	14,2	25,5	49,3	48,7	7,5
Portugal	0,92	0,08	0,58	1,62	24,9	43,4	42,6	47,8	14,5
Romania	0,28	0,15	0,04	0,47	6,7	5,3	58,9	54,3	5,2
Slovenia	1,57	0,3	0,26	2,15	34,8	41,6	62,8	41,7	12,3
Slovakia	0,49	0,18	0,24	0,91	14,1	26,1	70,8	45,8	14,9
Finland	1,97	0,22	0,72	2,94	37,8	54,2	46,3	82,9	19,3
Sweden	2,55	0,16	0,82	3,53	38,1	51,4	56,3	84,0	12,9

Note: 1. SMEs introducing product (percentage of SMEs) innovations
2. SMEs introducing business process innovations (percentage of SMEs)
3. Exports of medium and high technology products as a share of total product exports
4. Knowledgeintensive services exports as percentage of total services exports
5. Sales of newto-market and newto-firm innovations as percentage of turnover

Source: own study based on Eurostat data.

The results of the cluster analysis using Ward's method indicate a significant similarity of the innovation policies and the results regarding the introduction of innovations in enterprises in several groups of countries shown in the dendrogram. The first group comprises Belgium, Denmark, Netherlands, the Scandinavian countries, and Cyprus in which, however, the expenditures on R&D are significantly lower. There is also a significant similarity between Croatia and Lithuania. There are relatively low expenditures on R&D in those countries, which translates into lower results regarding commercial activity of enterprises in the area of innovation. Bulgaria and Latvia are characterised by similar, very low expenditures on R&D and unfavourable innovation indicators. Spain and Poland are characterised by similar expenditures on R&D in relation to the GDP. However, it may come as a surprise that this group includes also Malta which invests less but achieves similar results in terms of innovation activity of enterprises. Irrespective of the differing expenditure structures in Hungary (higher than in Spain and Poland) and Slovakia (expenditures lower than in Spain and Poland), the indicators studied are slightly more favourable. It is not surprising that Portugal, France, Italy and Estonia are in the same group. They achieve similar results in terms of innovation of enterprises, but France features significantly higher expenditures on R&D. Czechia, Austria and Slovenia, which fell into the same group, feature large differences in terms of expenditures, but similar results in terms of activity. The results of the analysis are presented in the chart (Figure 1).

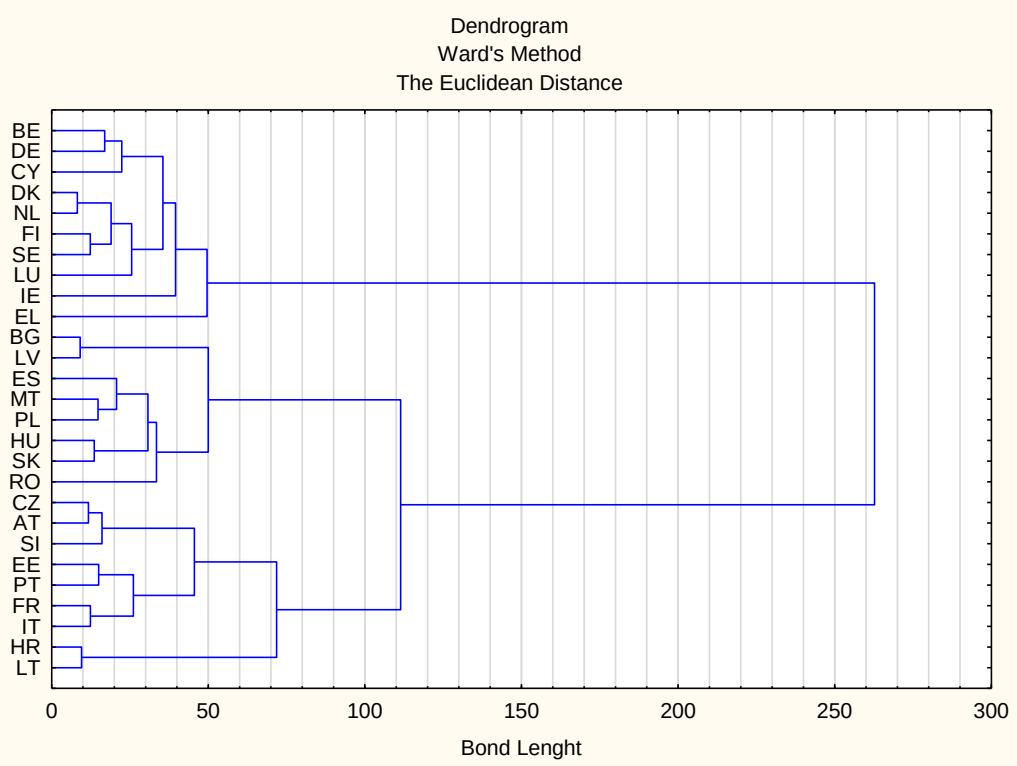

Figure 1. Grouping of EU member states using the Ward's method.
Source: own study.

The Pearson correlation coefficient analysis was performed for the indicators studied. This analysis made it possible to examine what interrelations occur between the individual components of GERD.

In the case of the GERD components, a very high correlation (0.9841) of BERD was observed. BERD is the component with a very high share in total expenditures. Its level in individual EU member states changes in a similar way. The HERD and GERD correlation coefficient is lower (0.8045). GOVERD does not exhibit strong correlation with GERD or with other components.

The analysis of correlations shows surprising results according to which such indicators as exports of medium and high technology products as a share of total product exports, knowledge-intensive services exports as percentage of total services exports and sales of new-to-market and new-to-firm innovations as percentage of turnover indicate a very weak or no correlation with expenditures. SMEs introducing product innovations and SMEs introducing business process innovations indicate a moderate positive correlation with the expenditures on R&D. In case of these indicators, the charts show the relationship according to which the increase in expenditures on R&D result in the increase in the percentage of SMEs introducing product and business process innovations. In case of the other three indicators, increase in expenditures has a weaker effect. The results of the regression analysis are presented in the graphs (Figure 2).

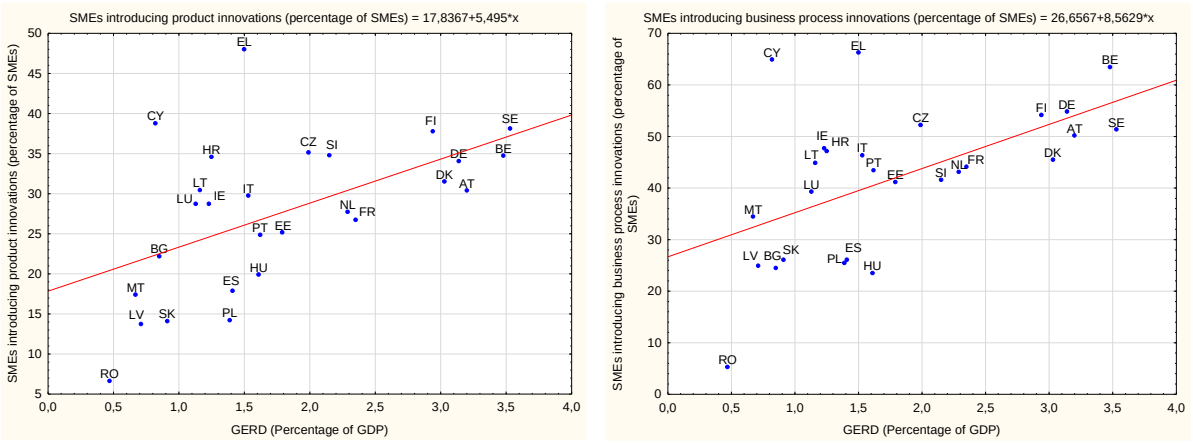

Figure 2. SMEs introducing product and business process innovations as a function of GERD.
Source: own study.

The results for Cyprus and Greece may be surprising as those countries achieved better results than other countries with similar levels of expenditures on R&D in relation to the GDP.

5. Summary

The study showed the usefulness of the regression analysis in the assessment of the effectiveness of the selected components of the EU and domestic innovation policies and financial instruments used as part of those policies. It can be seen that higher expenditures on R&D result in increasing the indicators, although the most effective are the expenditures regarding SMEs introducing product and process innovations. This has a weaker effect on the market performance in terms of export of innovations and share of new-to-market products in company sales. This can be influenced by various factors. One of them may be the fact that a significant share of innovation projects is EU-funded. The implementation of such projects entails the demonstration of the introduction of innovation, but some of those innovations may fail commercially and fall short of achieving good sales results. Regarding the research conducted, it can be concluded that a delay is also possible between the moment the investment is made and the moment of actual market launch and achievement of significant sales results. However, taking into account that the level of expenditures in individual countries is similar over longer periods, this is of negligible significance for achieved results.

In 2020 and before, most of the expenditures on R&D were borne by enterprises, except for in Latvia. Enterprises make efforts to introduce innovations as they are aware of their importance for their competitiveness. In some countries the involvement of enterprises accounts for up to circa 75% of the total expenditures incurred for this purpose.

The fact that some countries, such as Greece, Cyprus or Croatia, achieve better results requires further research. In their case, relatively low expenditures on R&D yield better results than in case of e.g., Poland, Hungary or Portugal. It may be conditioned by the purchasing power, readiness of enterprises for innovation activities or by the ability to use means of stimulating innovation other than just through expenditures (e.g., through the use of open innovations).

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