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Article

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Comparative Analysis of R&D in the Visegrad Group Countries in the Years 2004–2018

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Abstract

The purpose of this paper is to present a comparative analysis of basic measures that demonstrate the development of R&D in the Visegrad Group countries (Poland, the Czech Republic, Hungary, and Slovakia) in the years 2004–2018. The preliminary analysis of the problem allowed for the formulation of a research hypothesis, which reads: Since becoming a member of the EU, the innovation of the economies of the Visegrad Group countries has improved. The analysis shows that the structure and dynamics of R&D expenditure in these countries are diverse, although the innovation potential of the regions of the Visegrad Group countries is still low compared to the average EU level.

Keywords: innovativeness, R&D, Visegrad Group, economy

JEL: G30, G10, O16, K40

Introduction

An integral part of research and development is innovation, which is one of the most important instruments of competition. Innovations play a significant role in the processes of socio-economic development, and they are an indicator of the transformation processes and development of each country. They are also seen as a priority source of competitiveness, economic growth, and employment. Innovations allow companies to compete, which is why the literature on the subject qualifies innovations to a narrow group of factors that determine the sustainable economic and social development of regions.

The purpose of this paper is to present a comparative analysis of basic measures demonstrating the development of R&D in the Visegrad Group countries (Poland, the Czech Republic, Hungary, and Slovakia) in the years 2004–2018. The preliminary analysis of the problem allowed for the formulation of the research hypothesis, which reads: Since becoming a member of the EU, the innovation of the economies of the Visegrad Group countries has improved positively. The Visegrad Group countries are located in Central and Eastern Europe. All of them joined the European Union on 1 May 2004, thus becoming beneficiaries of assistance from the Structural Funds and the EU Cohesion Fund, which favored the development of innovativeness at many levels. The regional presentation of data used in the study is also justified by the fact that these countries have a similar history of the transformation of their economies, the same specifics, as well as similar economic and social conditions.

The study is based on an analysis of the available literature on the subject in the context of European integration and contemporary challenges in the development of the innovativeness of the economies. It is also based on an analysis of data collected by Eurostat across the Visegrad Group countries in the period 2004–2018.

Innovativeness and development. A theoretical approach

The integral elements of innovativeness are innovative solutions, which are of key importance for gaining a competitive advantage. Leadership in terms of competitiveness is not only about obtaining higher income, resulting from, e.g., the increased demand, but also gaining an advantage in the area of research, technology, and organization. Accumulating all these advantages results in the implementation of new or qualitatively improved products and processes (Jabłońska 2011, p. 124).

Activity in the area of research and development (R&D) is aimed at continuously improving the business activity of enterprises, as well as determining the opportunities and threats hidden in the environment of business units. R&D is understood as systematic creative work undertaken to increase the knowledge base, including knowledge about man, culture, and society, as well as to find new applications for this knowledge. Research and development includes three types of research:

- *basic research* understood as experimental or theoretical work, undertaken to acquire new knowledge about the foundations of phenomena and observable facts, without focusing on practical applications or use,
- *industrial research*, which is research aimed at acquiring new knowledge and skills to develop new products, processes, and services,
- *development work*, which includes the acquisition, combination, shaping, and use of currently available knowledge and expertise in the field of science for production planning and the creation and design of new, changed, or improved products, processes, or services (https://stat.gov.pl/cps/rde/xbcr/wroc/ASSETS_Dzialalnosc_badawcza_i_rozwojowa.pdf).

The innovativeness of the economy is, therefore, associated with an increase in the competitiveness of enterprises, and this directly translates into the development of the economy. Conducting a properly targeted innovation policy increases GDP and reduces the unemployment rate, thus creating favorable conditions for the development of entrepreneurship, which is the foundation of the country's economic growth (Dziuba 2014, p. 225). According to the literature on the subject, innovativeness is impacted by:

- entrepreneurship,
- ease of doing business,
- financial resources,
- the relationship between the user and the product or service provider (Mikołajczyk 2013, p. 265).

Modern enterprises treat innovations as a key to market success (Walas and Trębacz 2010, p. 289). They perceive innovations as ground-breaking ideas (Mikołajczyk 2013, p. 95). Therefore, the key factor of competitiveness is the ability to introduce innovations, which is a condition for achieving the sustainable competitiveness of the economy in the global market (Wysokińska 2011, p. 124).

Innovativeness is one of the phenomena that give rise to much doubt in the research and cognitive spheres. The most problematic issue here is the selection of measures that would be suitable to describe the state, level, and direction of changes in the area of innovativeness. The most commonly used measures of innovativeness include the following:

- expenditures of enterprises on innovative activities, the structure of financing innovative activities, and the structure of expenditures by type of innovative activity,
- the number of inventions filed in patent offices in a given country by its citizens, the number of foreign inventions filed in a given country by foreigners, the number of patent applications filed by domestic inventors per 10,000 inhabitants,
- the number and value of research projects, the share of private and public expenditures on R&D in GDP, internal and external expenditures on research and development activities, and employment in scientific and research and development units (Czupich 2013, p. 75).

The presented division of measures of the innovativeness of the economy covers the three most important areas: general innovation, inventiveness, and research and development. In the context of this study, the R&D area, which determines the level of innovativeness and competitiveness of each economy, deserves special attention.

The importance of innovativeness for the economic development of the Visegrad Group countries

The Visegrad Group (V4) is an alliance established in 1991 between the Czech Republic, Hungary, Poland, and Slovakia. The basis of the cooperation between these economies is the similar nature of the economic changes they underwent, as well as the established socio-cultural system (Dziuba 2013, pp. 64–65). Thanks to accession to the European Union, the V4 countries experienced rapid economic growth, accompanied by restructuring and modernization. Thus, the EU accession significantly improved the international competitive position of these economies (Molendowski and Folfas 2019, p. 65).

The V4 countries present a similar level of economic development, geographical location, history, and values. These economies have convergent interests in the area of policies and decisions taken in the European Union. The advantages of the V4 economies are low labor costs and a high level of professional qualifications of employees, which makes them an attractive place to locate foreign investments (Czupich 2018, p. 17). The table below summarizes the basic characteristics of the economies of the V4 countries.

Table 1. Basic data on the economies of the V4 countries. Comparative analysis of 2004 and 2018

Country / NUTS 2	Area (km ²)	Population density 2004	Population density 2018	GDP per capita 2004 in euro	GDP per capita 2018 in euro	Dynamics of GDP of per capita
Poland	312,685	122	123	6,109	12,200	200%
dolnośląskie	19,948	145	145	6,181	13,400	217%
kujawsko-pomorskie	17,970	115	116	5,379	9,800	182%
lubelskie	25,121	87	84	4,325	8,400	194%
lubuskie	13,989	72	73	5,416	10,100	186%
łódzkie	18,219	142	135	5,615	11,400	203%
małopolskie	15,190	215	224	5,412	11,100	205%
mazowieckie	35,559	145	152	9,237	10,400 ^a 26,600 ^b	
opolskie	9,412	112	105	5,217	9,700	186%
podkarpackie	17,844	118	119	4,439	8,500	191%
podlaskie	20,187	60	59	4,504	8,700	193%
pomorskie	18,293	120	127	5,998	11,800	197%
śląskie	12,331	381	368	6,812	12,600	185%
świętokrzyskie	11,708	110	106	4,861	8,700	179%
warmińsko-mazurskie	24,192	59	59	4,622	8,600	186%
wielkopolskie	29,826	113	117	6,538	13,300	203%
zachodniopomorskie	22,896	74	74	5,509	10,100	183%

Country / NUTS 2	Area (km ²)	Population density 2004	Population density 2018	GDP per capita 2004 in euro	GDP per capita 2018 in euro	Dynamics of GDP of per capita
Slovakia	49,034.7	109.6	111.7	6,400	15,600	244%
Bratislavský kraj	2,052.6	289.2	319.8	14,600	36,700	251%
Stredné Slovensko	16,263.2	83.2	82.9	5,300	12,400	234%
Východné Slovensko	15,726.4	99.8	103.6	4,800	11,100	231%
Západné Slovensko	14,992.5	123.8	123.3	6,100	14,400	236%
Hungary	93,029	108.6	107.3	8,300	12,700	153%
Dél-Alföld	18,337.8	74.0	68.9	5,800	9,000	155%
Dél-Dunántúl	14,168.7	69.2	64.7	5,800	8,400	145%
Észak-Alföld	17,728.8	87.1	84.1	5,400	8,100	150%
Észak-Magyarország	13,431	95.0	85.7	5,400	8,500	157%
Közép-Magyarország	6,918.3	409.8	442.6	13,300	19,400	146%
Közép-Dunántúl	11,116.2	100.0	98.8	7,800	11,700	150%
Nyugat-Dunántúl	11,328.2	88.4	88.0	8,500	13,400	158%
Czech Republic	78,866.7	132.0	137.2	9,400	18,100	193%
Jihovýchod	13,991.3	119.6	123.3	8,200	16,400	200%
Jihozápad	17,618	68.8	71.1	8,700	15,700	180%
Moravskoslezsko	5,427	230.8	227.3	7,600	14,900	196%
Praha	496.1	2,391.3	2,654.7	19,800	37,900	191%
Severovýchod	12,440.1	120.6	123.2	7,900	15,200	192%
Severozápad	8,649	132.3	131.9	7,600	12,800	168%
Střední Čechy	11,014.8	105.5	125.6	9,100	16,900	186%
Střední Morava	9,230.4	136.4	133.4	7,400	14,800	200%

^a Eurostat data for the region excluding capital city.

^b Eurostat data for capital city.

Source: own elaboration based on Eurostat and Local Data Bank.

The Visegrad countries constitute a significant part of the European Union. The population concentrated in these four countries is 12% of the EU population. Slovakia and Poland recorded the highest dynamics of GDP per capita (244% and 200%, respectively). However, none of the economies exceeded the EU average in any of the analyzed periods. Above-average values were recorded only in individual NUTS 2 regions that are the economic centers of the countries. In Poland it is Mazovia (26,600 EUR/person), in Slovakia – Bratislavský Kraj (36,700 EUR/person), in the Czech Republic – Praha (37,900 EUR/person) and in Hungary – Közép-Magyarország (19,400 EUR/person).

From the point of view of the potential of the V4 regions, these countries are becoming particularly interesting in terms of the development of regional innovativeness, which can significantly affect the competitiveness of the entire European Union. Therefore, to support the development of R&D, innovation, and entrepreneurship in this part of Europe, the Warsaw Declaration was signed in 2017. The main premise of the Declaration was to strengthen cooperation in research, digitization, and innovation (Dworak and Grzelak 2018, p. 515). The subjects of interest for cooperation between the V4 countries were:

- strengthening and expanding the regional cooperation of clusters and start-ups;
- promoting the V4 region and sharing best practices in R&D&I and digitization;
- cooperation in the area of patents, activities for the European Digital Single Market;
- increasing the number of transnational research and development projects implemented by research institutions and enterprises from the Visegrad countries – including joint projects implemented under the Horizon 2020 program;
- ensuring free data flow and cybersecurity;
- cooperation in the field of next-generation mobile services (5G) (<https://www.gov.pl/web/gospodarkamorska/premierzy-panstw-grupy-wyszehradzkiej-pod-pisali-deklaracje-warszawska>).

The increase in innovativeness and competitiveness of the V4 economies is associated with the need to adapt to rapid changes in the global economy, as well as to eliminate the technological gap that exists between the V4 and the countries of the old Union (Adamczyk 2018, p. 156). Therefore, using the potential of this region is an opportunity to develop R&D in the European Union, while the region itself has the chance to become the center of European innovation (Dziuba, Jabłońska, Sulak and Ławińska 2018, p. 24).

Analysis of the changes and development directions of R&D potential in the Visegrad Group countries against the background of the European Union after 2004

The innovativeness of the economy occurs in the literature on the subject as the ability of enterprises to put into practice the results of scientific research and R&D, as well as the effective use of newly created concepts and ideas. Innovations play an important role in the socio-economic development of countries and regions. The innovation performance of regions can be assessed in a variety of ways using several indicators (Ivanova and Masarova 2018, p. 28). Selected indicators will be discussed in the next parts of the paper.

Employment structure indicators, which include the employment of people involved in research and development activities (both knowledge employees and supporting personnel), are used to determine the innovative position.

Table 2. Employment in the R&D sector in 2004 and 2018

EU countries	Total employment in R&D in 2004	Total employment in R&D in 2018	Average employment in R&D in enterprises	Average employment in R&D in the public sector	Average employment in R&D in universities
European Union	100%	100%	100%	100%	100%
Czech Republic	1%	2%	2%	3%	2%
Hungary	1%	1%	1%	2%	1%
Poland	4%	5%	2%	1%	6%
Slovakia	1%	1%	0%	1%	1%

Source: own elaboration based on Eurostat.

There were no evident changes in the dynamics and structure of employment in the R&D sector in the V4 countries in the analyzed period. The employment rate remains one of the lowest in the EU. The highest number of people employed in R&D was reported in Poland, which in recent years has recorded the fastest growth in this respect among the EU and OECD countries. The rapid increase in the number of employees in the R&D sector in Poland should be associated with the introduction of tax breaks, which also include the cost of remuneration for employees involved in R&D.

The indicators presenting R&D expenditures are the primary determinants of innovativeness on a micro and macroeconomic scale.

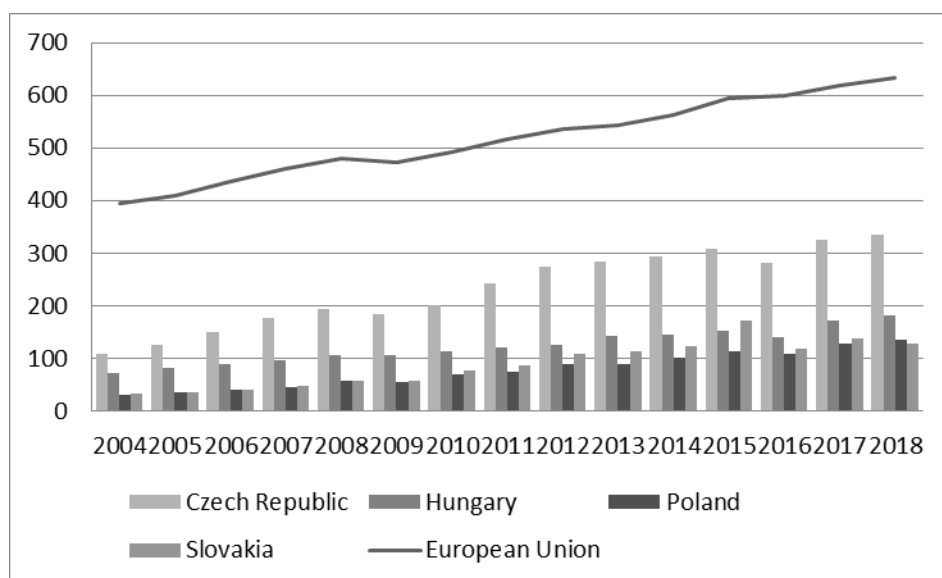


Figure 1. Total R&D expenditures [EUR/person]

Source: own elaboration based on Eurostat.

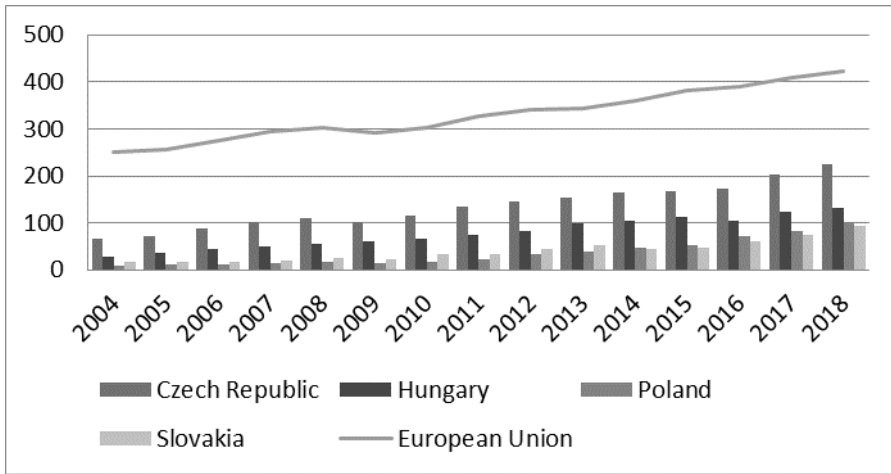


Figure 2. R&D expenditures in the enterprise sector [EUR/person]
Source: own elaboration based on Eurostat.

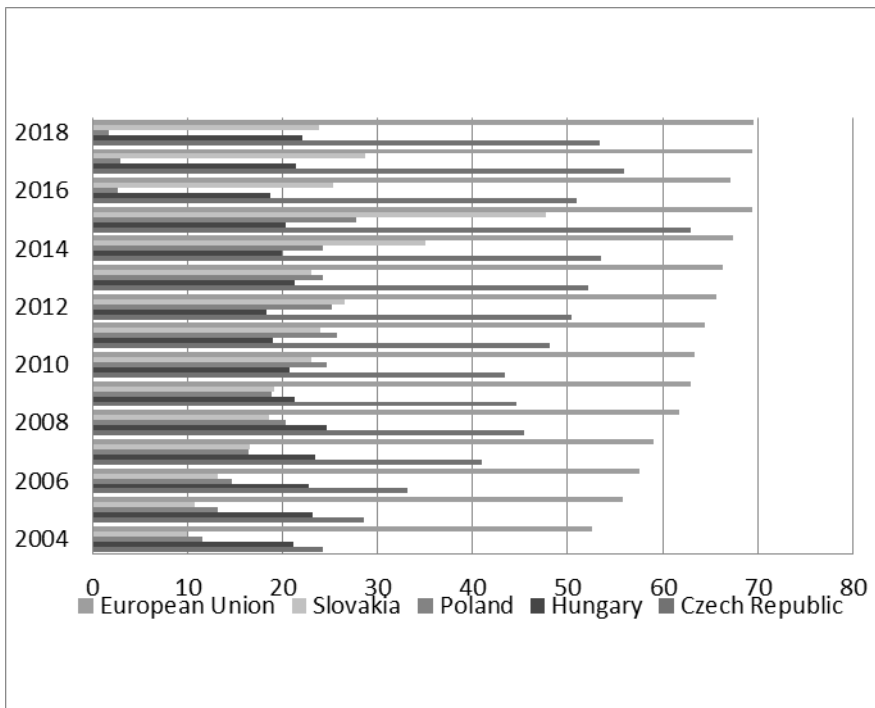


Figure 3. Government expenditures on R&D [EUR/person]
Source: own elaboration based on Eurostat.

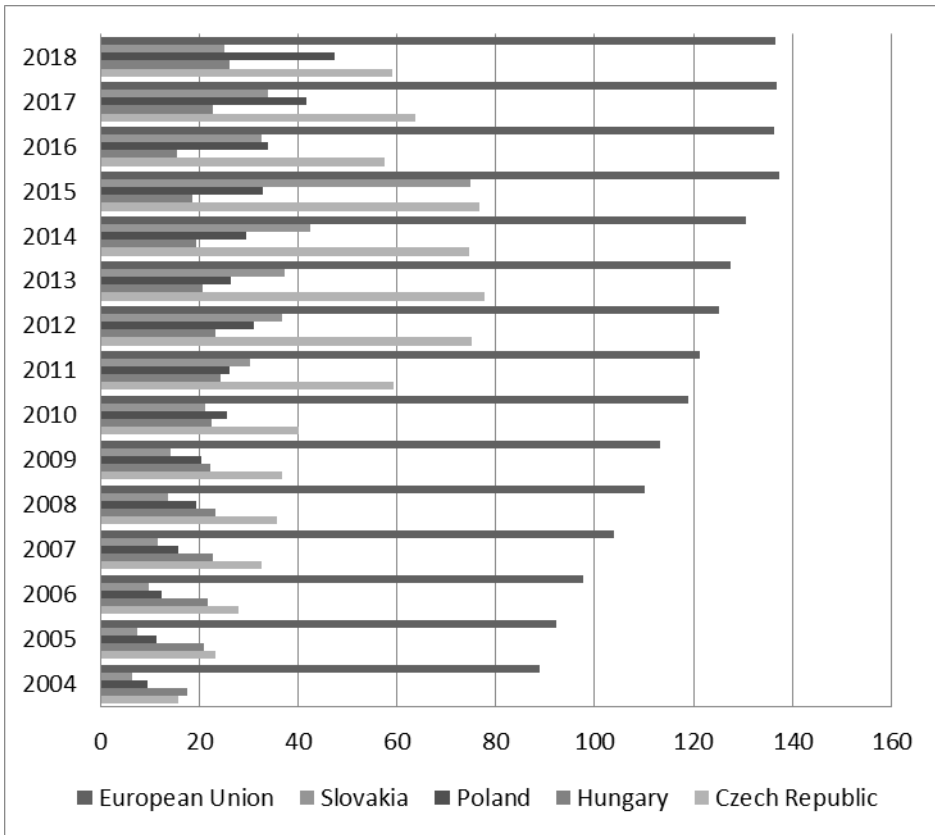


Figure 4. University expenditures on R&D [EUR/person]

Source: own elaboration based on Eurostat.

The above data show that none of the Visegrad Group countries recorded expenditures higher than the EU 28 average (the charts illustrate the expenditures in the period 2004–2018). Only the Czech Republic neared the average values for the EU in the period, standing out from the other V4 countries.

R&D expenditures in the enterprise sector were very low and far from the average in the analyzed years. Too little involvement of business in R&D is a serious barrier in the processes of commercializing created knowledge. The expenditures of enterprises on R&D may concern the investment activities of enterprises, for example, and they are important from the point of view of improving the availability or quality of R&D infrastructure in the enterprise sector. Therefore, their growth is essential and desirable from the point of view of increasing the competitiveness of enterprises.

Analyzing the data for the period 2004–2018 shows that government funds dominated the structure of R&D expenditures. This is especially visible in the Czech Republic, where the level was slightly lower than the average for all EU countries. The share of government expenditures on R&D in Poland was significant until 2015, af-

ter which, as the chart shows, their value significantly decreased. It can be concluded that Poland has become a leader of the changes in R&D financing in the V4 countries. The data present the phenomenon of increasing the expenditures of the enterprise sector on R&D with a simultaneous reduction in government expenditures. This change is taking place in the direction of the most innovative economies in which the share of R&D financing by the enterprise sector is the highest (e.g., 80% in Korea). In the case of the most innovative countries, a small share of public funds in financing the total R&D activity is noticeable. In the age of the knowledge-based economy, universities play a significant role in innovation. The recognition of the importance of universities in the development of R&D was reflected in financing, as there has been a significant increase in funds that universities spend on R&D since 2010.

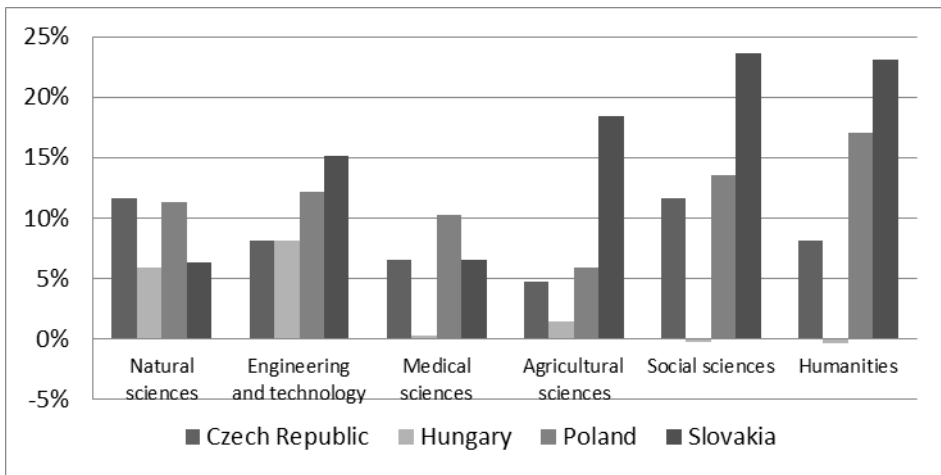


Figure 5. Average growth rate of total R&D expenditures in 2004–2018 by field of science
Source: own elaboration based on Eurostat.

The chart above shows how diverse the V4 economies are in terms of financing individual fields of science. During the analyzed period, most funds for innovation in the Czech Republic were allocated to natural and social sciences. Hungary allocated most resources to financing innovation in natural sciences as well as engineering and technology. This country stands out from the rest due to the low rate of change in expenditures in the field of medical sciences. In Poland, on the other hand, the pace of change in expenditures in individual fields of science is comparable because progress was observed in each of the fields in the analyzed period. Noteworthy, however, is the fact that Poland stands out from the other V4 economies in terms of increased expenditures on innovation in medicine. Slovakia recorded the highest rate of change in expenditures in the humanities, social, and agricultural sciences.

Comparative Analysis of R&D in the Visegrad Group Countries in the Years 2004–2018

Table 3. R&D expenditures in the Visegrad Group countries by sector of the economy. Average values in 2004–2018 [EUR/person]

Sector	Czech Republic	Hungary	Poland	Slovakia
Agriculture, forestry and fishing	0.49	1.34	0.15	0.21
Manufacturing	77.80	43.51	12.26	20.50
Manufacture of food products; beverages and tobacco products	10.48	10.77	30.18	0.94
Manufacture of textiles, wearing apparel, leather and related products	1.07	0.05	0.17	0.09
Manufacture of wood, paper, printing and reproduction	2.35	5.33	13.09	0.00
Manufacture of chemicals and chemical products	3.49	1.09	0.71	0.56
Manufacture of basic pharmaceutical products and pharmaceutical preparations	3.84	19.13	1.31	1.34
Manufacture of rubber and plastic products	2.96	0.68	0.52	2.05
Manufacture of other non-metallic mineral products	1.84	0.25	0.24	0.26
Manufacture of basic metals	1.07	0.31	0.30	0.66
Manufacture of fabricated metal products, except machinery and equipment	3.17	0.77	1.07	0.91
Manufacture of fabricated metal products, computer, electronic and optical products, electrical equipment, machinery, motor vehicles and other transport equipment	55.95	20.36	9.24	17.70
Manufacture of computer, electronic and optical products	6.42	4.64	0.78	0.71
Manufacture of electronic components and boards	0.54	0.51	0.08	0.17
Manufacture of communication equipment	1.64	5.04	0.30	0.43
Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks	3.04	0.70	0.27	0.29
Manufacture of electrical equipment	7.76	2.20	1.53	2.36
Manufacture of machinery and equipment n.e.c.	11.65	3.83	1.29	2.27
Manufacture of motor vehicles, trailers and semi-trailers	21.49	9.51	2.44	13.26
Manufacture of other transport equipment	5.56	0.25	1.19	1.35
Manufacture of medical and dental instruments and supplies	1.02	0.92	0.20	0.27
Repair and installation of machinery and equipment	4.90	0.57	0.37	1.39
Construction	1.68	0.42	0.25	0.15
Services of the business economy	59.16	27.96	22.60	13.91
Wholesale and retail trade; repair of motor vehicles and motorcycles	3.12	8.86	1.89	0.71
Wholesale of information and communication equipment	0.33	0.24	0.18	0.05
Information and communication	21.84	7.55	4.89	2.89
Computer programming, consultancy and related activities	15.42	6.03	5.97	5.28

Table 3. (continued)

Sector	Czech Republic	Hungary	Poland	Slovakia
Professional, scientific and technical activities; administrative and support service activities	30.86	13.60	8.49	7.60
Professional, scientific and technical activities	30.59	13.30	9.13	7.69
Scientific research and development	23.15	9.91	7.31	5.83
Administrative and support service activities	0.34	0.42	0.26	0.29
Human health and social work activities	0.79	0.82	0.14	0.14
Other service activities; activities of households as employers and extraterritorial organizations and bodies	0.23	0.21	0.07	0.00

Note: n.e.c. – not elsewhere classified

Source: own elaboration based on Eurostat.

The growing share of enterprises in financing innovation somehow forces a more detailed analysis of the role of this sector in financing R&D. The presented structure of enterprises makes it possible to determine which units play a crucial role in creating and developing innovations in the economies of the V4 countries. The most significant expenditures on R&D in the Czech Republic are incurred by enterprises manufacturing fabricated metal products, electronic products, other machinery and equipment, motor vehicles, those providing services of the business economy, information services, as well as information and communication services, computer services, and those conducting scientific activities and statutory research, and development activities. It can be concluded that some of these sectors are the key sectors for the development of the Czech economy, which is famous for the production of machinery, equipment, and means of transport (as evidenced by the highest export of these products). In all of these areas, Czech enterprises spend above the average for the V4 economies. In Hungary, the enterprises that invest most in R&D represent the pharmaceutical sector, wholesale and retail trade, the repair of motor vehicles and motorcycles, and R&D. In Poland, on the other hand, investments mainly concern the manufacture of food products and the manufacture of wood and paper products. The dominant sectors in Slovakia are the manufacture of motor vehicles and the manufacture of plastic products. The data presented in the table above regarding expenditures on R&D by sector illustrate significant differences between the V4 countries.

Conclusions

Innovations are closely related to science and research, and they express the practical implementation of an idea into economic reality. Investing in R&D directly affects the level of innovativeness and competitiveness of the country. The priority of research and development is the development and successive implementation of technological innovations in the area of products and processes. The level of innovativeness of the economy is, next to technical infrastructure, the fundamental factor that determines

the possibility of achieving and maintaining the high dynamics of socio-economic development of regions.

Strengthening research and innovation capacity at the level of the Visegrad Group countries, and increasing the facilitation of inclusion in the European Research Area, may contribute to the economic development of these countries. The level of investment should be increased, in particular by investing in the business environment, and by stimulating public and private investment in research. Thanks to such investments, the level of the innovative capacity of the Visegrad Group countries should expand.

The innovation potential of the regions of the Visegrad Group countries is still low compared to the average EU level, although an increase in the share of expenditures on R&D is evident. However, the scale of this increase is different, as confirmed by the analysis of the structure and dynamics of innovation measures in individual V4 countries. Indicators related to capital city regions differed significantly from those related to other regions. This is primarily due to the higher level of entrepreneurship, education, or financial resources that enable the implementation of an innovative idea into a business. It is also worth noting that the Czech Republic achieved the highest values of indicators of innovation potential among the V4 countries (this concerned the level of R&D expenditures, among others, which was close to the EU average). The Czech Republic is still an evident leader in the region in terms of both the share of R&D expenditures and its growth dynamics. A lower share than in the Czech Republic, but similar dynamics, can be observed in Hungary and Poland.

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Streszczenie

Analiza porównawcza działalności B+R w krajach Grupy Wyszehradzkiej w latach 2004–2018

Celem niniejszej pracy jest analiza porównawcza podstawowych mierników świadczących o rozwoju B+R w krajach Grupy Wyszehradzkiej (Polska, Czechy, Węgry i Słowacja) w latach 2004–2018. Wstępna analiza problemu pozwoliła na postawienie hipotezy badawczej, która brzmi: członkostwo w UE gospodarek krajów Grupy Wyszehradzkiej wpłynęło pozytywnie na ich innowacyjność. Przeprowadzone analizy pokazały, że struktura i dynamika wydatków na B+R w badanych krajach jest zróżnicowana a potencjał innowacyjny regionów krajów Grupy Wyszehradzkiej jest nadal niski, w porównaniu ze średnim poziomem UE.

Słowa kluczowe: innowacyjność, badania i rozwój, Grupa Wyszehradzka, ekonomia