

Innovativeness as Well as Research and Development in Selected Countries of Central Europe

Sławomir STEC *, Kornelia OSIECZKO and Michał KOŚCIÓŁEK

Ignacy Łukasiewicz Rzeszów University of Technology, Rzeszow, Poland; s.stec@prz.edu.pl;
k.osieczko@prz.edu.pl; mkos@prz.edu.pl

* Correspondence: s.stec@prz.edu.pl

Abstract: The article contains synthetic characteristics of activities related to the implementation of innovation, and the basic research problem was to present the dynamics of changes in the area of research and development activities, with particular emphasis on the expenditure and expenses for the above-mentioned activities in the Czech Republic, Poland and Slovakia. The situation in these countries was related to the conditions in the European Union. In addition, the state of R&D staff and the number of obtained intellectual property rights were analyzed. This allowed us to identify the strengths and weaknesses of national innovation systems and to identify areas to which attention should be paid to improving the innovation indicators of individual countries. Research shows that the most innovative country among the three analyzed is the Czech Republic. Subsequently, Slovakia and Poland proved to be the least innovative country. However, in all countries in the last decade there has been a dynamic growth of individual indicators that are significant when measuring the innovativeness of a given country. Although the Czech Republic is leading the way in innovation, in most cases they differ from the EU average indicators.

Keywords: innovation; innovativeness; innovative processes; research and development activities; research staff

JEL Classification: O30; O31; O34

1. Introduction

Science, technology and innovation play a key role in implementing the development of the economy and society in order to maintain and increase the country's competitiveness, and development is one of the EU's main tasks. Innovations are the driving force of the modern economy, transforming ideas and knowledge into products and services (Robinson 2004). They help solve many critical problems, including social threats, and increase society's ability to act. The consequence of innovation is economic growth, improvement of well-being and communication, access to education and environmental sustainability. Practically, innovations are implemented in every branch and area of life. This happens in IT, medicine, agriculture, electrical engineering, energy, mechanics or logistics. Modern technologies are also used in the everyday functioning of cities and villages.

However, for innovations to be implemented, they must be created. And innovative technologies and solutions arise as a result of research and development activity, cooperation between enterprises and public administration, business environment institutions and research units. All developed economies are shifting their structures towards knowledge-based industries and services. This, in turn, involves spending huge amounts of money and economic and social maturity. Therefore, the development of technology, new products and services in individual countries is not even. Innovations in developing countries will grow much faster and more intensively. In turn, in less prosperous countries, the speed of implementing innovations will be lower. Despite this, each country should strive to create conditions aimed at implementing a pro-innovation policy. This was also noticed by the European Union, which in one of the five main goals of the Europe 2020 strategy adopted the improvement of research and development conditions, and in particular the raising of the general level of public and private investment in this sector to 3% of EU GDP (European Commission 2010). This is followed by all

Community countries, which try to pursue their policies to varying degrees, in order to gradually increase their country's position in innovative as well as research and development activities.

The article contains synthetic characteristics of activities related to the implementation of innovation, and the basic research problem was to present the dynamics of changes in the area of research and development activities, with particular emphasis on the expenditure and expenses for the above-mentioned activities in the Czech Republic, Poland and Slovakia. The situation in these countries was referred to the conditions in the European Union. In addition, the state of R&D staff and the number of obtained intellectual property rights were analyzed. This allowed to identify the strengths and weaknesses of national innovation systems and indicate areas that should be noted to improve the innovation indicators of individual countries.

2. Methodology

The wide scope of research covers three countries of Central Europe: the Czech Republic, Poland and Slovakia, i.e. countries which in many scientific studies are analysed in terms of socio-economic indicators. These are Slavic states, belonging to the Visegrad Group since 1991, and since 2004 to the European Union. Despite significant similarities in location, level of development and economic history, these countries present significant differences in many respects. Poland has the largest population of around 38 million. Four times less people live in the Czech Republic and eight times in Slovakia. But only Slovakia joined the eurozone in 2009. Each of these countries differs in macroeconomic indicators, however, most economic indicators are still below average factors for the entire European Union. The time range of the research covers the last decade and applies to the years 2008 - 2018. The analyzes were conducted based on the literature studies of the subject, analysis of previous studies and mass statistics data made available by the national statistical offices, national patent offices and EUROSTAT, OECD and the European Commission. The methodology of research in the field of innovation was based on the textbooks of international organizations (Frascati Manual for R&D Statistics, Oslo Innovation Statistics Manual). In the case of the analysis of the ratio of gross domestic expenditure on R&D to GDP, analysis of the share of budget funds for research and development (GBAORD) and the number of patents and protection rights granted to domestic entities for utility models per one employed in R&D, the forecast of the trend for the to 2025 was made year to determine further lines of action in the field of innovation for the countries concerned.

The work uses methods for processing and interpreting optional knowledge using the descriptive method, the method of tabular-descriptive analysis and graphic presentation, as well as literature studies. The analyzes used numerical data for business entities conducting innovative activities, the involved research and development personnel, the number of intellectual property rights obtained and the involvement of financial capital for research and development. The comparative interpretation also uses the methodology developed by the European Commission for assessing the innovativeness of countries on the basis of an innovation indicator allowing the development of the European Innovation Scoreboard, which has been published since 2011. To determine such an indicator, an assessment of 27 elements from the following groups is used: involvement of human resources in innovative activities, functioning research systems, R&D environment, financial support, investments, connections between entities, investors, intellectual property (European Commission 2019). Trend forecasts for selected indicators were made using the linear function method, taking into account historical data based on time, assuming a 95% confidence level.

3. Results

3.1. Innovativeness as well as research and development in the light of theoretical considerations

The term 'innovation' comes from the Latin "innovatis", meaning renewal, creating something new. Innovation, also known as change, means the introduction of new products, processes or management models, more effective and cheaper than those previously used (Janasz and Kozioł 2007). The term "innovation" was introduced by Joseph A. Schumpeter in 1911. He said that innovation is the commercial or industrial use of something new: a product, a process, a production method, a new

market or supply sources, a new form of doing business (Schumpeter 1960). It is a broad frame of the concept of innovation, including the introduction of a new production method, a new good, opening a new market, discovery of a new source of raw materials, and introduction of a new industry organization. In the second half of the 20th century, many definitions appeared in the literature on the subject representing a narrow or broad approach to conceptualizing the term "innovation". And so in 1980 to the concept of innovation M.E. Porter includes technological improvements, better methods and ways of doing a given thing or product. This can be done by changing the product, process, new marketing approaches, new forms of distribution (Porter 1992). Innovations in its definition are treated as a series of technical and organizational changes, including ordinary modifications to existing ones, as well as the development of completely new products and processes. Creating and implementing innovations involves a whole range of scientific, technological, organizational, financial and commercial activities. In turn, P. Drucker in 1992 presented his view on innovation in the context of the organization's activities, because he stated that innovation is: "a special tool of entrepreneurs, through which changes make an opportunity to start a new business or provide new services. Innovation is a specific entrepreneurial tool - an activity that gives resources new opportunities for creating wealth" (Drucker 1991). Another point of looking at innovation was presented by P. Kotler (1994), who pointed out that innovations are ideas that have already existed for a long time, but for a given person it is new (Kotler 1994). Currently, the most popular and commonly used definition is the one specified in the Oslo Manual (2005), where innovation means the implementation of a new or significantly improved product (good or service) or process, a new marketing method or a new business organization or external relations. Innovative activities are of a scientific, technological, organizational, financial or commercial nature and are intended to lead or lead to the implementation of innovations (OECD 2018). Therefore, product, process, organizational and marketing innovations can be specified. Often functional and ecological innovations are also identified in the literature (Penc 1999). Product innovation, often referred to as subject innovation, is the placing on the market of a product or service that is new or significantly improved in terms of its characteristics or applications. In turn, process (technological) innovations point to the implementation of new or significantly improved existing methods of production, distribution and support of activities in the field of products and services. Technological changes often condition the emergence of functional innovations that meet new, previously undisclosed social needs. As a result of the occurrence of process innovations, there is a desire among the society to use new technologies. In the case of organizational innovations, a new organizational method is implemented in the operating principles adopted by the entity, in the organization of the workplace or in relations with the environment, which has not been used in the unit before. However, we will meet with marketing innovation when a new concept or marketing strategy is implemented that is significantly different from the marketing methods previously used in the unit (OECD 2018). Ecological innovation contributes to reducing or eliminating the negative effects of economic entities on the environment (Krzepicka and Tarapata 2012).

Beside the innovation term, there exist also innovativeness term. Innovativeness occurs when a process that takes place in a determined or undetermined time, which is not an event but a set of activities that begins from a concept and ends with practical application, which in turn leads to an increase in of value of the entity. Therefore, it is a specific way of operating of entities, based on innovations, i.e. making innovative decisions and implementing them into business activity (Poznańska 1998).

Entities involved in implementing innovations, called innovators, conduct innovative activities, i.e. a process constituting all scientific, technical, organizational, financial and commercial activities that leads to the implementation of innovations (OECD 2018). Innovative activity includes research and development (R&D) activity, characterized by creative work, carried out in a methodical way, undertaken to increase knowledge resources and to create new applications for existing knowledge that leads to the implementation of innovation (Bukowski et al. 2012). In addition, as part of the innovation activity of a given entity, there can be distinguished activities related to the purchase of knowledge from external sources, the purchase of software or fixed assets, staff training, marketing and other (Stępiak-Kucharska 2012).

Conducting R&D activity allows measuring the innovation and innovativeness of the economy of country, region, industry, sector or given entity.

The following groups of indicators are used for the most frequently performed measurements of innovation [GUS 2019b]:

1. cash expenditure on research and development,
2. the number of people employed in the R&D sphere,
3. the number of patents and rights granted for utility models,
4. number of innovation active entities.

The above indicators inform about how intensively innovative activity is conducted. On an economic scale, the Frascati Methodology is most often used to measure innovation in financial expenditure on R&D, and the measure used is GERD - gross expenditures on research and development, i.e. the sum of internal expenditure incurred in a given year on R&D by all units conducting this activity in a given country. The Frascati methodology enables multidimensional analyses and comparisons. Frascati expenditure on R&D is classified according to the distance for the economic application of the conducted research, divided into basic research, applied research and development works, as well as into other classes (according to the criteria: sector in which research is conducted - business, government, higher education, private non-profit; by source of funds: domestic and foreign; according to socio-economic goals; according to research areas, etc.) (Bağ 2016). In turn, people employed in the R&D sphere play a key role, because they constitute the greatest intellectual value and through a creative commitment to creating innovation significantly affect the overall result of measuring innovation. The following three groups of employees can be distinguished in R&D: research and development employees, technicians and equivalent employees as well as other auxiliary staff connected with R&D. These groups of employees differ in their level of education, scope and content of activities (OECD 2015).

A key measure of innovation results are patents and rights for utility models. Patent indicators reflect the inventive results of countries, regions, technologies, enterprises and scientific institutions. They are also used to observe the level of spreading of knowledge in various areas of technology, country, industry, field, etc. An important role in measuring innovation are innovation active entities, i.e. enterprises that have implemented at least one product or process innovation or have conducted discontinued or unfinished innovation activities (including research and development activity that is not directly related to the creation of a specific innovation). The measurement of this indicator shows what percentage of units conduct innovation activity in a given year (GUS 2019a). In recent years, the fourth industrial revolution (Industry 4.0) has become widespread in the world. However, numerous studies show that entrepreneurs approach the implementation of the Industry 4.0 concept with caution. Changes in this area are being introduced slowly, as financial factors are a barrier for many entrepreneurs. Therefore, the concept of industry 4.0 has a relatively small impact on improving the innovation indicators in individual countries (MPiT 2018).

In order to encourage entrepreneurs to increase innovation activity, governments of individual countries introduce the possibility of applying tax reliefs on R&D activities. For comparative purposes between countries, indicators of suggested rates of R&D tax relief determined by OECD are used. The tax subsidy rate is defined as 1 minus the B-index, a measure of the before-tax income needed by a "representative" firm to break even on USD 1 of R&D outlays. As tax component of the user cost of R&D, the B-Index is directly linked to measures of effective marginal tax rates (OECD 2019).

3.2. Innovativeness as well as research and development in the Czech Republic, Poland and Slovakia

Innovation and innovativeness in the enterprise is one of the elements of competitive advantage in the daily activities of business entities. According to data from 2016, it appears that about 80% of enterprises in EU countries introduced innovations or have conducted innovative activities (fig. 1). In the analyzed countries, the most innovative enterprises were in the Czech Republic - over 72%, and the least in Poland - about 59%. This is less than average across the EU. A similar situation occurred in the case of implementing product and / or process innovations as well as organizational and / or

marketing innovations. In the EU, several innovations use more than 54% in total, and in the subject countries from 37% in Poland to 49% in the Czech Republic. A similar trend is noticeable in the case of enterprises producing innovative products or using only organizational or marketing innovations. Here the leader is again the Czech Republic, followed by Slovakia and finally Poland. The situation is the opposite if the entities implement process or product innovations. It was Poland where the most enterprises implemented this type of innovation (16.7%) and it was 3% more than on average in the entire EU. It can be seen from all statistical analyzes that not all economic entities implement innovations. The largest number of enterprises that cannot be innovative was in Poland - 41.2%, and the least in the Czech Republic - 27.6%. These data indicate that these countries diverge from the EU average, in which the number of enterprises without implementing innovation is 20.3%.

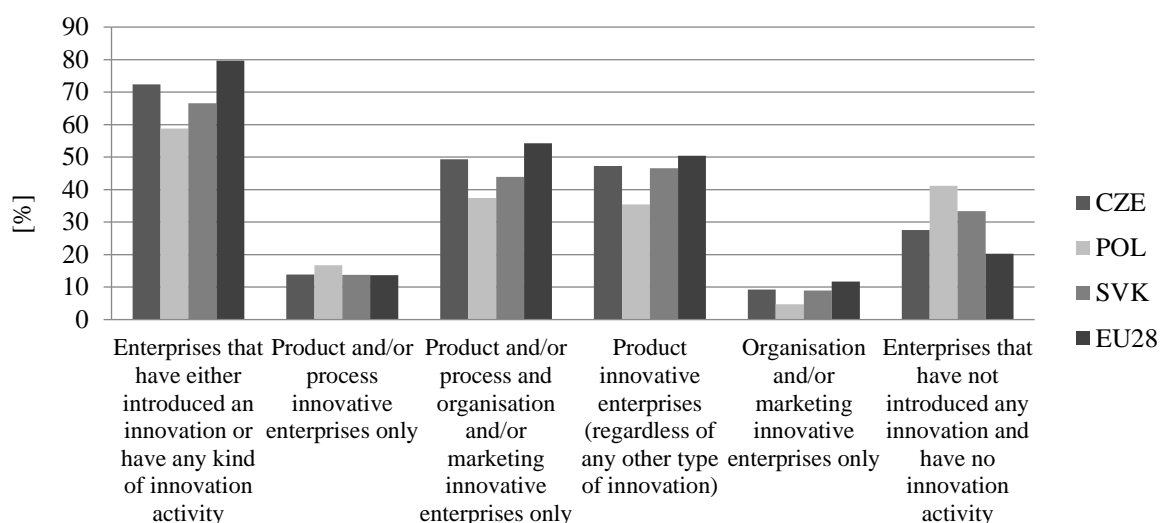


Figure 1. Share of innovation-active enterprises by implemented types of innovations.

The last decade has shown a systematic increase in staff involved in research and development (fig. 2). The largest share of researchers and creators is in the Czech Republic. In 2017, they accounted for 1.33% of the total labor force and it was more by 0.03% than in the EU. A much smaller share of scientists among the total workforce was recorded in Poland and Slovakia - 0.85% and 0.7% respectively. It is worth noting, however, that until 2014 the share of R&D staff in the total workforce was higher in Slovakia than in Poland, and in 2015-2016 was the same. Despite this, both Poland and Slovakia must definitely intensify their activities in the field of increasing R&D staff to match the EU average and the Czech Republic. Therefore, a challenge awaits the governments of these countries to create conditions for acquiring new staff, as well as to open development opportunities for young scientists.

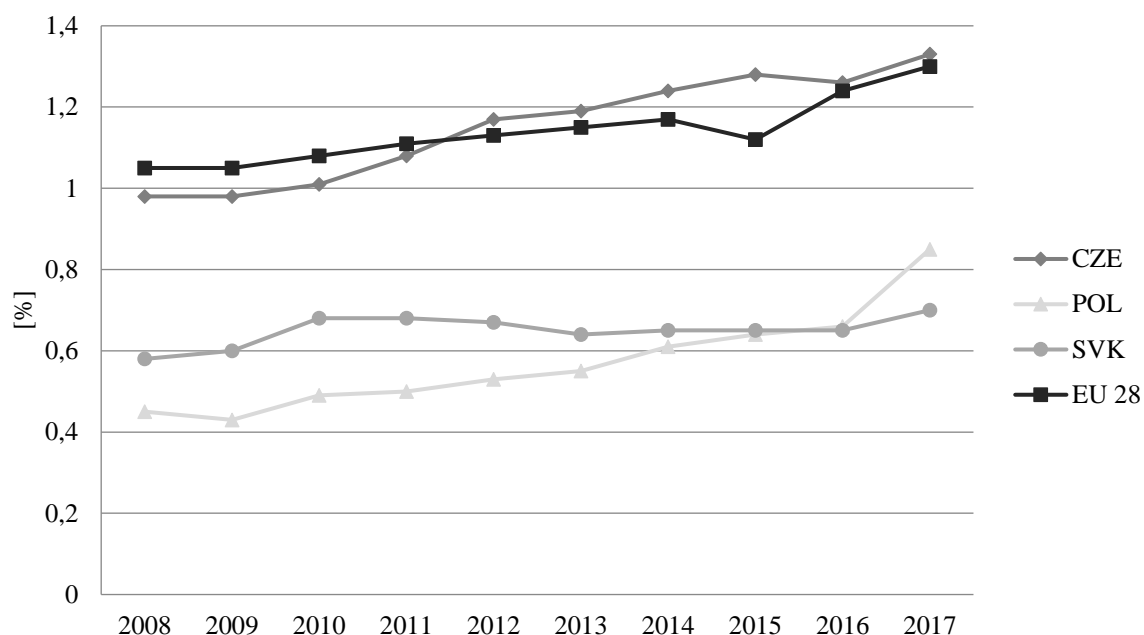


Figure 2. Total R&D staff as a% of total workforce and total employment.

As indicated in the previous chapter, one way to measure the innovation of a given country is by researching expenditure on research and development. The graphical analysis below (fig. 3) shows the relation of gross domestic expenditure on R&D, which is distributed similarly to the structure of innovation-active enterprises, as well as the number of employed R&D personnel. In the period 2008 - 2018, these expenditures are steadily increasing, and the highest are in the Czech Republic. In 2008, 1.24% of GDP was allocated to R&D. After a decade, these expenses increased to 1.93% of GDP. In the case of the Czech Republic, there was a slight decrease in these expenses in 2015-2017. In Poland, these expenses have doubled over the decade from 0.6 to 1.21% of GDP and are 0.4% higher than in Slovakia. However, since 2015 quite significant fluctuations of these expenses have been noticed by about 0.4%. Despite this, expenses in the countries surveyed are lower than the EU average, which in 2018 was 2.09% of GDP. Based on the results to date, a forecast has been made of the ratio of gross domestic expenditure on R&D (GERD) to GDP by 2025. As can be seen from the chart below, in these countries these expenses will increase successively. However, only in the Czech Republic these expenses will exceed the average of 28 EU countries. Despite this, in both the countries surveyed and the EU, forecasts until 2025 do not predict that R&D expenditure will reach at least 3% of GDP. Therefore, further actions of all interested parties (enterprises, scientific units, government and EU) are needed to achieve the planned minimum expenditure on R&D.

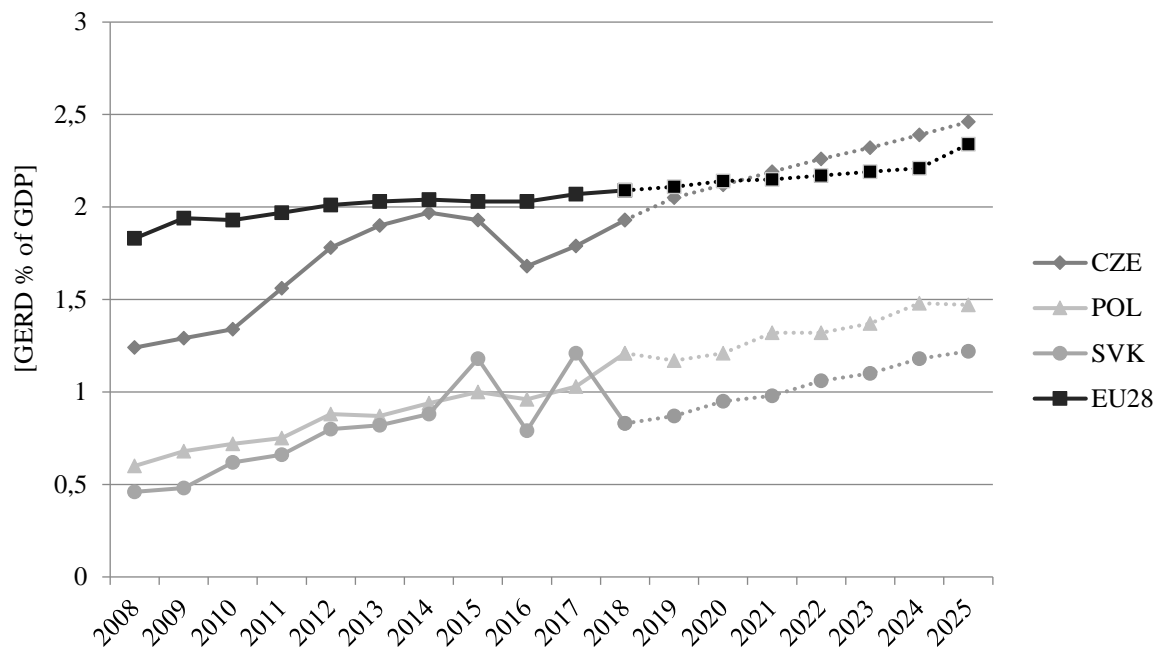


Figure 3. Relation of gross domestic expenditure on R&D (GERD) to GDP in% in 2008-2018 together with the forecast for 2019-2025.

To increase the country's innovativeness, governments of individual countries allocate budgetary resources to R&D activities (fig. 4). The most funds for innovative activities are transferred by the Czech government, as in 2018 1.8% of the budget was allocated to research and development. This result was better of over 0.4% than the EU average and as much as twice higher than the share of budget funds for this activity in Poland. The least amount was allocated to financing innovative activities in Slovakia - 0.69%. It is worth noting that in the Czech Republic and Poland the share of budget funds for R&D has been systematically increasing in the last decade. In Slovakia, by contrast, it increased until 2013, and has been steadily decreasing since 2014. On the other hand, averaging the data for all EU countries, a systematic decrease of budget expenditure for this type of activity is noted. It caused that the Czech authorities spend more funds on R&D than on average 28 EU countries. On the basis of the presented data, expenditure forecasts in individual countries until 2025 have been made. According to the forecast, expenditure on R&D in the Czech Republic will systematically increase, and thus will be significantly higher than the average expenditure in the EU, as it will systematically decrease. Similarly, R&D expenditure is forecast to increase at least until 2025 in Poland and Slovakia, which will bring the indicator closer to the EU average.

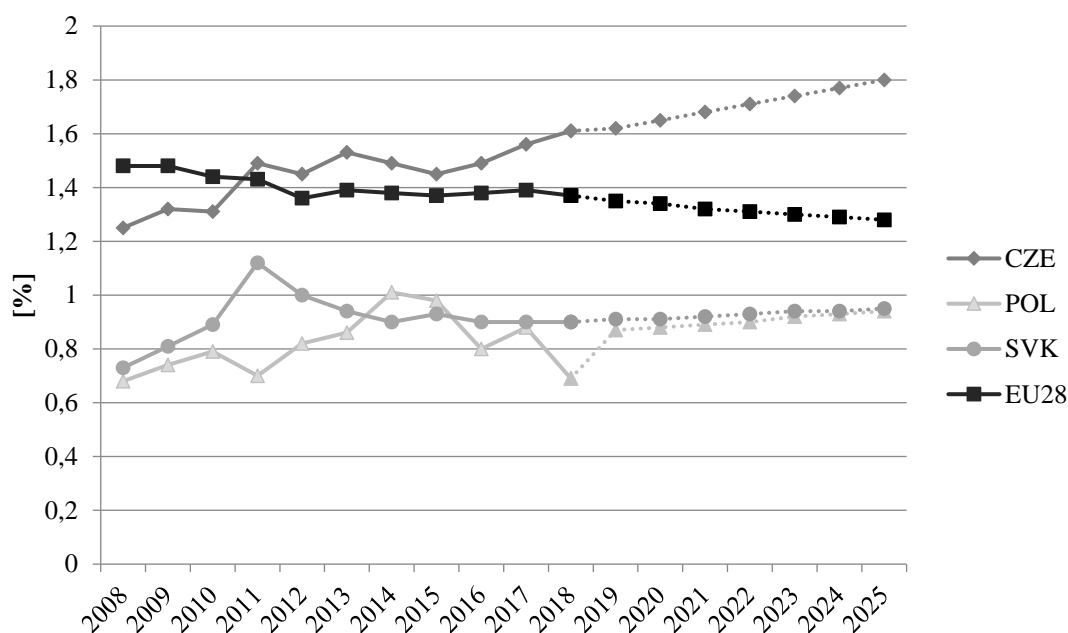


Figure 4. Share of budget funds for research and development (GBAORD) in the years 2008 - 2018 together with the forecast for the years 2019 – 2025.

In order to increase innovation as quickly as possible, the governments of individual countries use incentives for entrepreneurs to increase expenditure on innovation activities. Entrepreneurs can apply tax reliefs in the form of deductions for R&D expenses, employment of research staff, purchase of modern technologies, patents, computer programs, etc. It was the Czech government which has provided entrepreneurs with the opportunity to apply tax reliefs as a first one and for the longest time. In this country, the alleged tax relief rate is between 0.20 and 0.23 (table 1). In Poland, on the other hand, the possibility of applying tax breaks on expenditure on innovation exists only since 2017. Initially, the supposed relief rate was at level of 0.10, and in 2018 it increased to 0.22. In Slovakia, in turn, entrepreneurs can apply R&D tax reliefs from 2015. At that time, the supposed relief rate was at the level of 0.11. In 2018, a discount of 0.28 was allowed. The authorities of all countries declare that similar concessions in this respect will be maintained in the following years, thanks to which it will be possible to accelerate the growth of innovativeness of a given country and get closer to the most developed EU countries.

Table 1. Alleged rates of tax relief on R&D expenses.

State	Company size	2008	2010	2015	2017	2018
Czechia	MŚP	0,23	0,20	0,21	0,21	0,21
	DP	0,23	0,20	0,21	0,21	0,21
Poland	MŚP	-	-	-	0,10	0,22
	DP	-	-	-	0,10	0,22
Slovakia	MŚP	-	-	0,11	0,10	0,28
	DP	-	-	0,11	0,10	0,28

By analyzing the number of ownership rights granted for patents and utility models, we can determine the dynamics of growth or decrease in innovation in a given country. In case of the Czech Republic and Poland, the number of granted rights has increased in the last decade (table 2). In case of Slovakia, only the number of allocated rights for utility models increased. In case of patents, in 2018, five times less rights were granted than in 2008. It is also worth noting that in the Czech Republic there

are definitely more rights granted for utility models than patents. A similar phenomenon began to occur in 2011 in Slovakia. In Poland, the number of patents granted invariably exceeds the number of granted utility models.

Table 2. Patents and protection rights granted for utility models.

State/ year	Czechia		Poland		Slovakia	
	/a/	/b/	/a/	/b/	/a/	/b/
2008	249	1046	1451	616	566	102
2009	387	1178	1536	431	554	250
2010	295	1194	1385	484	376	283
2011	339	1545	1989	498	317	377
2012	423	1609	1848	514	161	358
2013	435	1552	2339	621	115	287
2014	493	1388	2497	586	94	364
2015	605	1356	2404	562	82	322
2016	676	1187	3370	638	122	363
2017	606	1107	2795	776	82	307
2018	507	1130	2906	769	109	337

a - patents

b - protection rights for utility models

In order to compare the level of innovation between given countries on the basis of the number of ownership rights granted, we should refer to the selected variable, which will allow to illustrate these relationships. Figure 5 shows the number of patents and utility models granted per employee employed in R&D. In the context of patents, the largest decrease was recorded in Slovakia. In 2008, 2.4 patents were granted for one employed in R&D. At the time, it was the highest number of rights granted per researcher in the examined countries. During the decade, the number of patents granted per researcher fell to 0.25, which put Slovakia in last place. However, in the case of utility models, the statistics look slightly better, because in ten years the number of utility models granted has been doubled from 0.43 to 0.92 per researcher. In the Czech Republic, the number of patents obtained per employee employed in R&D in the last decade has increased from 0.33 to 0.56. Although the number of utility models obtained exceeds the number of patents obtained, a slow decrease of the number of utility models obtained per person has been recorded since 2008. This is probably due to the increase in the number of employees in research. In turn, in Poland, in the case of patents, the upward trend continued in the years 2008 - 2016. The number of patents granted per person increased from 1.21 to 2. Unfortunately, in 2017 there was a significant decrease of this indicator to the level from the beginning of the analysis. A smaller number of obtained patents contributed to this, as well as an increased number of employees in R&D. In the case of rights obtained for utility models, a downward trend can be observed. Therefore, comparing the examined countries, the most patents were granted per person in Poland, followed by the Czech Republic and the least in Slovakia. In the case of utility models, the Czech Republic is the leader, followed by Slovakia and Poland.

Based on the above data, forecasts of the trend of obtained patents and utility models in the analysed countries were created. The best forecast is in terms of obtaining patents by R&D staff in Poland and the Czech Republic. Despite the annual fluctuations, in Poland in 2024-2025 one scientist should be granted about 2 patents a year, while in the Czech Republic less than one. It will be different in Slovakia, as the number of patents granted will be systematically decreasing. However, the number of utility models will grow steadily, and in 2025 one scientist can be expected to average 1.2 designs a year.

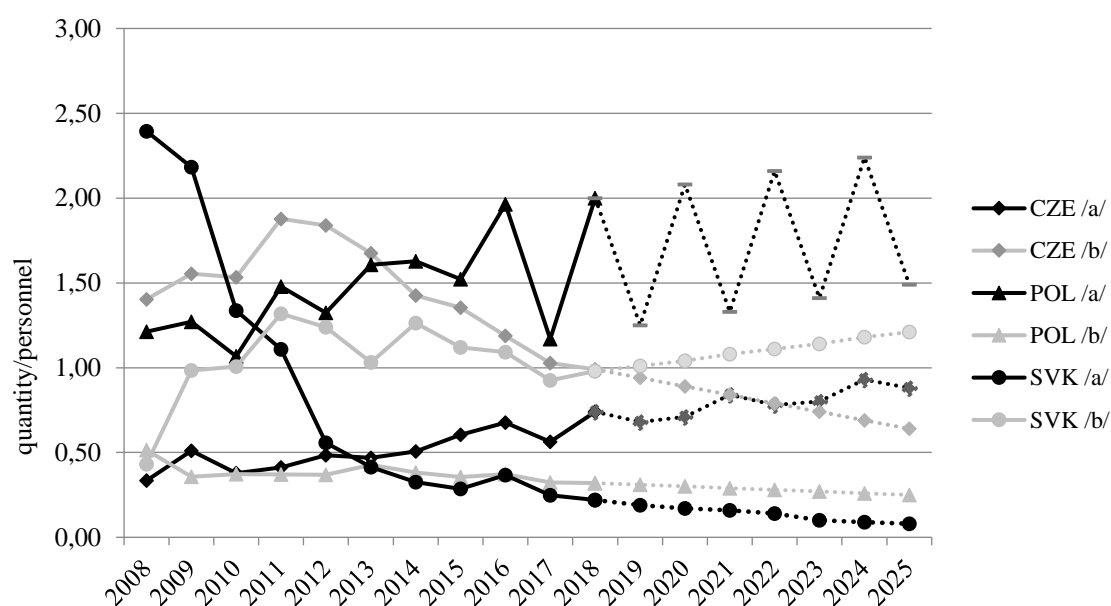


Figure 5. The number of patents and protection rights granted to domestic entities for utility models per one employed in R&D in the years 2008 - 2018, together with the forecast for 2019 - 2025.

a - patents

b - protection rights for utility models

Based on the methodology for assessing the innovativeness of countries developed by the European Commission, it is possible to compare innovation indicators presented in the European Innovation Scoreboard (fig. 6). The highest innovation rate in the analyzed period was recorded in the Czech Republic. An upward trend in the overall ratio can also be seen from 85.9 in 2008 to 89.4 in 2018. Slovakia is second in terms of innovation, which also has an upward trend. In 2008 this indicator was at the level of 63.3 and increased over the decade to the level of 69.1. Poland is the least innovative country. Despite the upward trend, Poland failed to achieve even the lowest innovation rate of Slovakia in earlier years. In 2018, this ratio was 61.1. All three countries have significantly lower indicators than those specified for the EU average. In EU countries, this indicator also has an upward trend and in 2018 amounted to 108.8. This state of affairs is probably due to the fact that the vast majority of the EU are countries with longer membership years, and thus more economically developed. In these countries, the authorities allocated much more funds to innovation than in the Czech Republic, Poland and Slovakia. However, the decisive inflow of EU funds, which is, among other things, to support entities to increase R&D activities will contribute to reducing disparities between the surveyed countries and the entire EU. In addition, further reforms in higher education, research and development, as well as maintaining a favorable innovation policy should be made. Poland faces a special challenge, which stands out not only from the EU average indicators, but also from the countries studied in the publication.

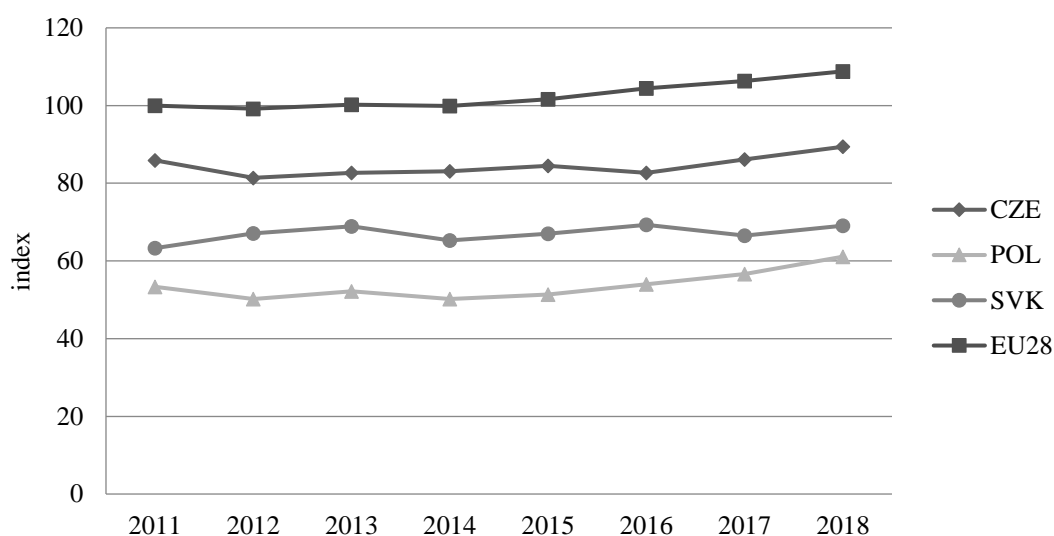


Figure 6. Innovation indicators of the European Innovation Scoreboard of the surveyed countries against the background of the EU.

5. Conclusions

In the last decade, the R&D sphere in the Czech Republic, Poland and Slovakia as well as the entire European Union has undergone significant transformations. The presented data indicate an increase of the level of innovation of individual countries. The number of employed R&D staff is systematically increasing. The biggest number of these people are in the Czech Republic and the least in Slovakia. Financial expenses on research and development is rising similarly. An analysis of financial expenditure on R&D per GDP has shown that the most is spent in the Czech Republic, and it is not much less than average expenditure in the entire EU. Nearly half the expenditure is spent on research in Poland and Slovakia. As EU expenses are above 2% of GDP, many more steps still need to be taken to achieve the planned minimum R&D expenditure of 3% of GDP. One of such activities is the possibility of applying reliefs on innovative activities. The Czech government introduced the relief at the earliest, and the Polish government the latest. The number of acquired property rights for patents and utility models is increasing successively. However, the dynamics of this growth is definitely too low, because the increasing number of R&D personnel means that the number of patents and utility models obtained per one employed in R&D slowly decreases. Based on the European Innovation Scoreboard, the average innovation indicator calculated on the basis of 27 components indicates that the Czech Republic is the most innovative country. Next, Slovakia and Poland were the worst, which can be said to be the least innovative country. Despite the fact that the Czech Republic exceeds Poland and Slovakia in practically all innovation indicators, this country is still less innovative than the European Union.

Forecasts made regarding the ratio of gross domestic expenditure on R&D to GDP, the share of budget funds for research and development (GBAORD) and the number of patents and protection rights granted to domestic entities for utility models per one employed in R&D showed that the indicators in most cases they will have an upward trend. However, these increases will be so small that by 2025 the assumed indicators will not be achieved at a satisfactory level. The 4.0 industry concept is also important, as it has a significant impact on the use of modern technologies. However, entrepreneurs approach this topic with great caution, changes in this area are implemented slowly, which is why the concept of industry 4.0 has a relatively small impact on improving the indicators of innovation in individual countries.

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