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CONTENTS

PATENT ACTIVITY IN CENTRAL AND EASTERN EUROPE FOR THE PERIOD 2014-2024

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Abstract: This paper uses patent statistics as an indicator of the technological development of individual economic sectors. The aim of the study is to identify the priority sectors for development in each of the countries in Central and Eastern Europe (CEE), using the data on the number of patents applied for and granted through the EPO in the period 2014-2024. The object of research is the development of technological areas and directions, and patent activity has been chosen as a subject of research, as an indicator of technological development. Using empirical research methods, the technological areas, and technological fields with the highest concentration of patent rights and their development in the period 2014-2024 are deduced. In conclusion, we recognize a growing need to promote research and increase investment in R&D in CEE countries to achieve a higher level of technological development, following the example of leading countries.

Keywords: patents; patent activity; technological area; technological fields; economic development.

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* * *

The technological development of individual regions, countries, enterprises, and society depends on the management of intellectual property. The category of "intellectual property" includes the results of human creativity, which are divided into two main groups: objects of industrial property, protected under the Paris Convention, including patents for inventions,

utility models, industrial design, trademarks, geographical indications, etc. (Paris Convention for the Protection of Industrial Property, 1883) and objects of artistic property protected under the Berne Convention, such as: works in the fields of science, literature, and art (Berne Convention for the Protection of Literary and Artistic Works, 1886). As a result of the unceasing development of human ingenuity, the so-called group "New Intellectual Property", which covers the latest achievements of human innovation. To ensure comprehensive protection of all these intellectual products, the number of international, regional, and national normative documents through which intellectual property objects are administered is constantly increasing.

Accepting the idea that inventions are the source and prerequisite for human progress, the main place in this study is occupied by the process of securing their legal protection by patent. Patents are protective documents providing exclusive rights to the patent owner and guaranteeing his right to dispose of the patented invention for a certain and limited period (most often 20 years) in the territory where the patent was granted. The provision of this legal protection through a specific patent office or international organization is accompanied by the relevant documentation, the data for which fall within the scope of patent statistics.

Patent statistics is an information resource that acquires a strategic role for the modern socio-economic and technological development of society. Due to its complex nature and reliability, patent data are used both to monitor innovation activity and technological development (De Rassenfosse, Dernis, Guellec, Picci, de la Potterie, 2013; Petralia, Balland and Morrison, 2017; Ponta, Pulgia, and Manzini, 2021), and in combination with other indicators – to obtain a more in-depth assessment of the innovative development of individual countries' economies (Adak, 2015; Georgieva, 2011; Molhova, 2021; Pavlov, 2020; Pece, Simona, Salisteanu, 2015; Prokop, Stejskal, Klimova, Zitek, 2021).

The significant place that patent statistics find in modern research is due to the role of patents in technological development. They stimulate the creation of innovative technologies, attract investors and are the basis for the development of innovation in economies (De Rassenfosse, Dernis, Guellec, Picci, de la Potterie, 2013; Haščič, Silva, Johnstone, 2015; Nikolova-Minkova, 2023).

In this work, following the example of the authors cited above, we try to analyze the innovativeness of the economies of the countries in Central and Eastern Europe (CEE countries). In this way, it will be established the extent to which the policy of individual countries meets the pronounced need for modern development of science and innovation and their transformation into a powerful factor for economic growth.

The object of research in this paper is the technological development of selected CEE countries.

The subject of the study is the patent activity of the CEE countries for the period 2014-2024.

Therefore, the purpose of the research is to study and assess the state of patent activity in the countries of Central and Eastern Europe, to analyze and reveal the trends in the development of technological areas and directions through the use of patent-based indicators of the patent application activity carried out through the EPO in the period 2014-2024. This focus of research will enrich the existing literature in the field and will contribute to revealing the inventive potential of individual countries and their capacity to transform the accumulated knowledge into economic benefits.

The study focuses on the following more important tasks:

- To establish the structure and dynamics of the total patent application activity for the period 2014-2024.
- To analyze patent statistics reflecting the development of selected areas for the period 2014-2024.
- To highlight the areas with the highest relative share of patent activity.
- To outline the role of individual countries in achieving technological development.
- To identify and highlight the ongoing trends of technological development during the period of research.

The performance of the tasks falling within the focus of research helps to prove the following working *hypotheses*:

Hypothesis 1: CEE countries are still lagging in absorbing and transforming innovative knowledge into economic benefits.

Hypothesis 2: The specialization of patent activity of the CEE countries is influenced by the trends of technological development that are taking place among the world leaders but lags their level.

The limitation in the development is limited to the number of studied countries from Central and Eastern Europe – Bulgaria (BG), Czech Republic (CZ), Estonia (EE), Croatia (HR), Hungary (HU), Latvia (LV), Lithuania (LT), Poland (PL), Romania (RO), Slovenia (SL) and Slovakia (SK) and the data on which the study is based, sourced by the European Patent Office (EPO). When relying on the data in the IPC, it is necessary to consider the possibility of assigning several classes of the IPC to one invention, which predetermines that a patent application is counted in more than one technological area or area.

The significance of the study lies in the use of patent statistics to establish the technological specialization of countries, and the activity of patent holders in technological areas is a predictor of the expected technological changes in the economy.

To achieve the purpose and objectives of the study, it is structured in the following sequence. First, a brief overview of existing research in the field of patent statistics is prepared, with a focus on research in CEE countries. Secondly, the data on which the study is built and the methods of analysis used are presented. Thirdly, the data on the patent activity of the selected countries are analyzed and the trends in the development of technological areas and directions are outlined. Then conclusions were drawn.

Literature Review

For years, patent information has been a source of knowledge about the most significant and innovative developments of the human mind. Its role as an engine of the development of society is possible thanks to the full disclosure of the essence of inventions in patent documents. This has contributed signify-cantly since the 1960s to a number of scholars (Muller, 1966; Scherer, 1965a, 1965b; Schmookler, 1966; Solow, 1956) to take into account the importance of patent information, and to make the use of patent activity an economic indicator in the coming years the subject of in-depth theoretical and empirical research (Dernis, Guellec & van Pottelsberghe, 2001; Faust, 1990; Faust & Schedl, 1983; Grilitches, 1990, 1992; Scherer, 1992).

Since then, the number of studies in the field of the use of patent indicators and patent statistics has been growing steadily, with the interests of researchers acquiring different strands of analysis, which Nikolova-Minkova (2023) groups in general 5 areas: measuring the degree of innovation of an economy; identifying the source of inventive activity; tracking technological changes in the economy; eco-innovation, circular economy, and sustainable development; company performance.

In recent decades, the application of patent statistics has been constantly expanding due to the complex and multifaceted nature of patent data, and patent-based indicators are also applied by international organizations when measuring the innovative development of individual countries: Global Innovation Index (WIPO, 2023); Clean Energy Innovation Index (European commission); Global Competitiveness Index (Schwab, 2018).

The ongoing digitization processes, which also cover patent databases, provide free access to publicly available online patent databases for interested parties, which predetermines the claim of Ponta, Pulga & Manzini, according to which *"The availability of online patent databases means that patents are a simple and immediate source to measure innovation performance both for academic and industrial researchers."* (Ponta, Pulga & Manzini, 2020, p.74). This facilitates the ability to review hundreds of thousands of patents of

inventors from all over the world and allows researchers to verify the validity of theories developed over the years about the suitability of patent statistics as an indicator for conducting economic research.

Table 1.

A review of selected studies with a focus on patents as an indicator of development in CEE countries.

Source	Aim of the study	Used indicator
Prodan (2005)	The study focuses on the relationship between expenditure in R&D and the number of patent applications and examines if the business sector is the most important institutional sector for patent applications. The analysis includes Hungary, Czech Republic, Slovenia, Finland, OECD	*number of patent applications*, R&D expenditure in business sector, gross domestic expenditure on R&D
Petrariu, Bumbac, Ciobanu, (2013).	Investigate the link between innovation and economic growth in the Central and Eastern European countries (CEE). The analysis includes Estonia, Latvia, Lithuania, Poland, Germany, Czech Republic, Slovakia, Hungary, Romania, Moldova, Bulgaria, Croatia, Macedonia, and Serbia	*number of patents*, R&D spending, percent of R&D expenditure in GDP, GDP per capita, GDP growth from year to year, number of researchers, etc.
Pece, Simona, Salisteanu (2015)	Examine the connection between economic growth and innovation. The analysis includes CEE countries, namely Poland, Czech Republic, and Hungary	*number of patents*, number of trademarks, R&D expenditures
Lacasa, Giebler, & Radošević (2017)	Studies the technological capabilities of Central and Eastern European. The analysis includes Slovenia, Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Hungary, Romania, Bulgaria, Croatia, former Yugoslavia, and former Czechoslovakia.	*Patent applications, patent applications per one mil inhabitants per period*
Mengxuan, Khan, Cifuentes-Faura, & Sukumaran, 2024	Evaluates the causal nexus between technological innovation and Energy efficiency in Central and Eastern Europe (CEE) countries. The analysis includes Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia, Estonia, and Latvia	total primary energy supply divided by the gross domestic product (GDP); *annual count of patent applications* related to climate change mitigation technologies.

***Source: compiled** by the author from various sources*

The application of patent information is also used with particular interest by researchers in analyzing the current trends in economic development of lagging and developing countries and regions, to track the impact of innovation activity on economic growth (Adak, 2015; Ferrazzi, Schanz, & Wolski, 2025; Gyedu, Heng, Ntarmah, He, & Frimppong, 2021; Prodan, 2005; Rodriguez-Pose & Wilkie, 2019; Vlajčić, 2025; Vlajčić, Keđo & Filipović, 2025; Willoughby and Mullina, 2021; Zastempowski, 2025).

In this study, we use the data on patent activity of the countries of Central and Eastern Europe to identify the directions in their innovation development. The development of CEE countries has been the focus of a number of researchers (see Table 1), due to the complex economic processes taking place since 1989 and the desire for an accelerated transformation of the economic environment to integrate into the European community.

The information summarised in Table 1 does not claim to be exhaustive regarding the surveys conducted among CEE countries. It presents a limited part of them and is used as an example of the application of patent statistics in this type of analysis. Following the objective of this study – to establish the technological specialization of selected CEE countries, we limit ourselves to using data on the number of patents applied for and granted in the period 2014-2024, as well as their distribution by technological areas and technological fields. The relationship between countries' patent activity and their economic development, measured by the example of the developments cited above, is the subject of future research.

Method

Our sample includes annual data for selected CEE countries – Bulgaria, Czech Republic, Estonia, Croatia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia, and Slovakia. The study is based on data for the period 2014-2024.

The patent application activity carried out by CEE countries is presented through data from the European Patent Office, which includes: firstly, applications filed directly with the EPO; secondly, applications filed through the Patent Cooperation Treaty (PCT), in which the EPO is designated as the territory in which protection is sought. Like patent applications, data on patents granted by the EPO for the period under study were also used.

To analyse the patent activity of CEE countries and to track the technological orientation of this activity, we use the Schmoch (2008) technology classification, which defines the presence of five technological areas and thirty-five technological areas, as follows:

- Electrical engineering (Electrical machinery, apparatus, energy; Audio-visual technology; Telecommunications; Digital communication; Basic communication processes; Computer technology; IT methods for management; Semiconductors).
- Instruments (Optics, Measurement; Analysis of biological materials; Control; Medical technology).
- Chemistry (Organic fine chemistry; Biotechnology; Pharmaceuticals; Macromolecular chemistry, polymers; Food chemistry; Basic materials chemistry; Materials, metallurgy; Surface technology, coating; Micro-structure and nano-technology; Chemical engineering; Environmental technology).
- Mechanical engineering (Handling; Machine tools; Engines, pumps, turbines; Textile and paper machines; Other special machines; Thermal processes and apparatus; Mechanical elements; Transport).
- Other fields (Furniture, games; Other consumer goods; Civil engineering).

Each of these areas may include a number of classes under the IPC, which applicants indicate in patent applications, and which define the scope of action and the possibilities for application of the invention for which legal protection is sought. The number of applied and defended technological innovations in each class under the IPC illustrates the patent activity in technological areas and fields for a certain period. Data on this activity obtained by the EPO were used in this study to analyse technological development trends in CEE countries for the period 2014-2024.

The results of the analysis are presented through:

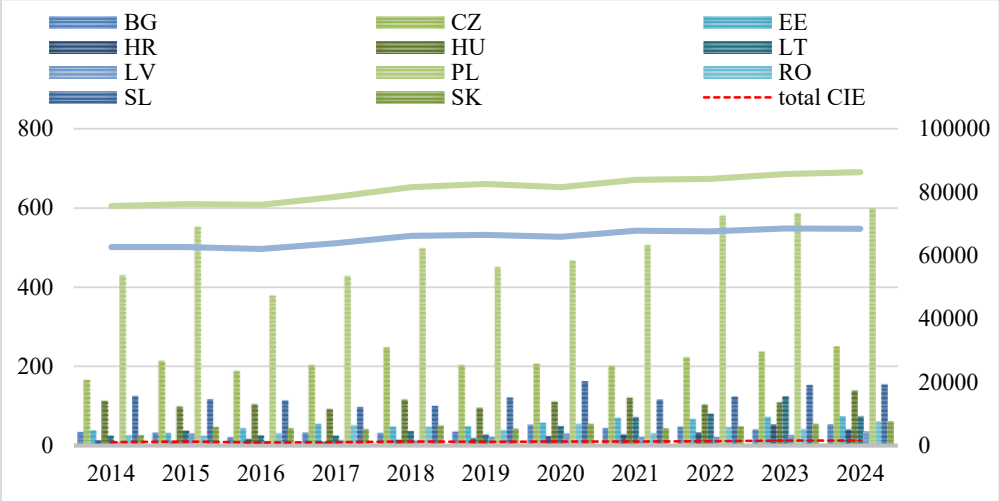
- *Graphical method* – allows for easier perception of the results of the analysis by illustrating the studied indicators, as well as graphical representation of the dynamics and trends in their development for easier orientation in the nature of the studied proportions.
- *Comparative method* – suitable for comparing the patent activity of individual CEE countries in terms of quantitative data, as well as for identifying the proportions of the individual technological directions. This allows us to identify the technologically leading countries where the concentration of patent rights is highest and at the same time to compare their development with those of other countries.

Results

Patent application activity of CEE countries

Patent application activity expresses the number of patent applications filed for patenting an invention. According to data from the European Patent

Office for the period 2014-2024, a total of 13,381 inventions has been filed by CEE countries. This turnout (see Figure 1) represents only 1.85% of the activity of EU applicants and 1.5% of the activity of all Member States in the EEA.



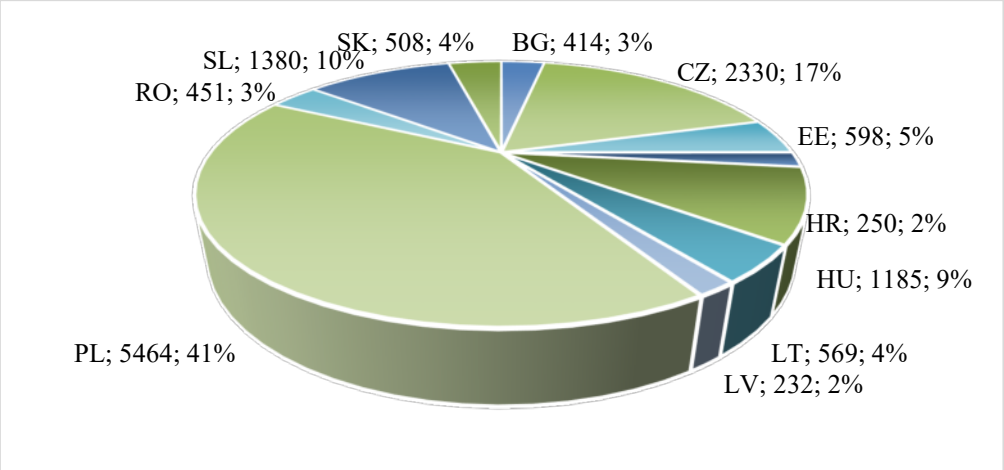
Source: *compiled by the author based on data from the EPO Statistics & Trends Centre*

Figure 1. ***Application activity of CEE countries for the period 2014-2024***

The data in Figure 1 are also indicative of the dynamics of the patent activity of the CEE countries for the period 2014-2024. The largest increase in the number of applications submitted was observed in 2015 compared to 2014 – by 19.2% and in 2020 compared to 2019 – by 14.8%. The lowest activity was in 2016 (971 applications), 18.3% less than in 2015.

The structure of patent activity (see Figure 2) shows the contribution of each of the CEE countries to the total number of inventions applied for protection during the study period.

We find that Poland has the highest number of patents filed, accounting for 40.8% of the application activity of the CEE countries. The Czech Republic is the second country in terms of application activity with a total of 2,330 patents applied for in the period 2014-2023 (17.4%), Slovenia is third with 1,380 patents. (10.3%), and fourth – Hungary with 1,185 applications and a total contribution of 8.86%. The top four positions account for 77.36% of the total application activity of CEE countries. This determines that the changes in the number of applications submitted by applicants from each of them have a decisive impact on the dynamics of the total application activity.



***Source**: compiled by the author based on data from the EPO Statistics & Trends Centre*

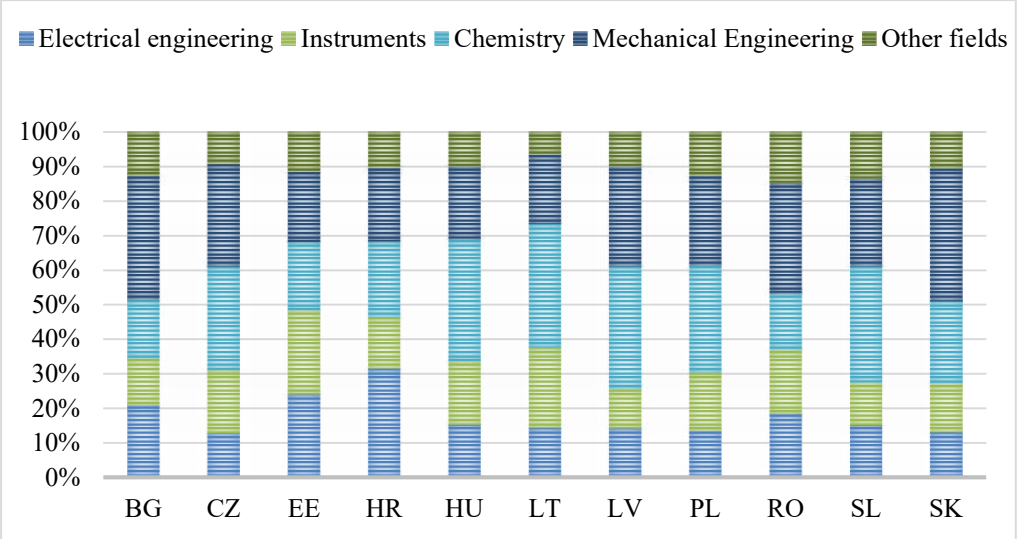
Figure 2. ***Structure of the total application activity of CEE countries for the period 2014-2024***

The illustrated structure of the patent activity of the CEE countries (see Figure 2) considers only the applications filed in the relevant year of the study period. Considering other factors such as the number of applications per capita and the number of people employed in R&D, the innovation activity of countries acquires other dimensions that remain outside the scope of the current survey and are subject to future developments.

In addition to the analyzed structure and dynamics of the total patent filing activity of the CEE countries, the technological specialization of this activity is also of interest to this study (see Figure 3).

The data from Figure 3 indicate the high interest in the technological areas *of Chemistry* (29.9%) and *Mechanical Engineering* (26.5%). After them, researchers apply for patenting an invention in the areas of *Instruments* (17.1%), *Electrical Engineering* (15%), *and Other Fields* (11.4%).

For the entire period of study, the area of *Chemistry* is first in interest to inventors from Poland (1,696 patent applications), the Czech Republic (699), Slovenia (465), Hungary (419), Lithuania (204), and Latvia (82). The area ranks second in terms of patent applications filed for Slovakia (121) and Croatia (55), and third among patent applicants from Estonia (119), Romania (74), and Bulgaria (71).



Source: *compiled by the author based on data from the EPO Statistics & Trends Centre*

Figure 3. ***Structure of the application activity of CEE countries by technology area (2014-2024)***

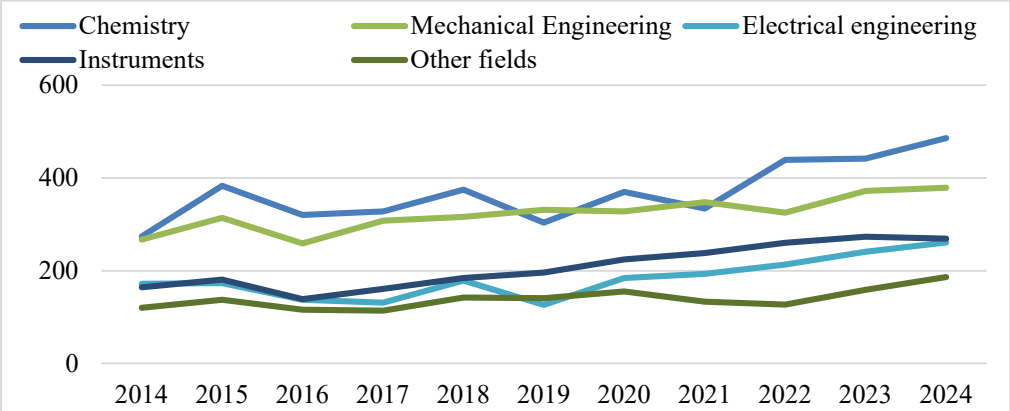
The area of *Mechanical Engineering* has the priority for development among applicants from the Czech Republic (689 applications filed), Slovakia (195), Bulgaria (148), and Romania (144). The second most interesting area is the area for inventors from Poland (1418), Slovenia (349), Hungary (249), and Latvia (67), while Estonia (121), Lithuania (114) and Croatia (53) remain third in terms of patent application.

The third area of interest among applicants Instruments is a priority only for Estonia (145 applications), where the difference in patent application activity between the different technological areas is negligible. The *Instruments* area is second in favors among applicants from Lithuania (132), while for Poland (923), Czechia (425), Hungary (218), and Slovakia (72) the area is third.

In the technological field *of Electrical Engineering, the* inventive potential of applicants from Croatia is concentrated (79), with the district ranking second among inventors from Estonia (144), Bulgaria (87), and Romania (84). Third in terms of the number of applications submitted is the area for inventors from Slovenia (209) and Latvia (33).

In the *Other fields* area, there was no priority backlog of applications from any of the CEE countries, although applicants from Poland (684), Czechia (217), Slovenia (186) and Hungary (117) had a significant volume (against the background of the activity of the other countries) filed patent applications for inventions.

The change in the application activity by areas of technological development for the period 2014-2024 is presented in Figure 4.



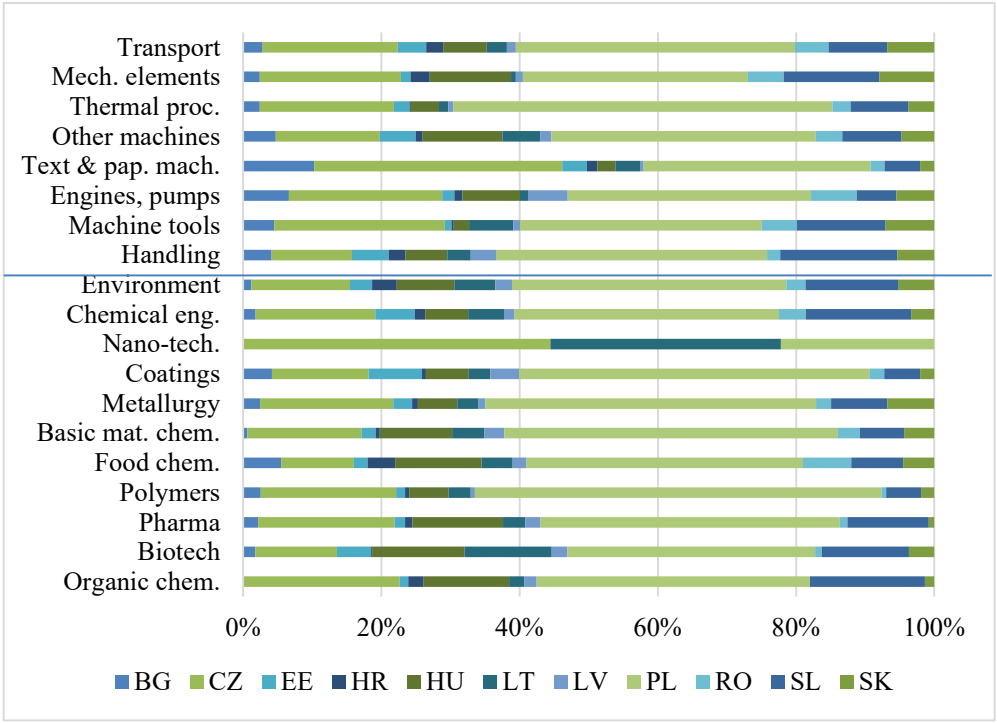
Source: *compiled by the author based on data from the EPO Statistics & Trends Centre*

Figure 4. ***Dynamics of the application activity of CEE countries by technology areas for the period 2014-2024***

Despite the reported dynamic environment of development of application activity during the period of the study, in each technological area there is a general positive trend of growth in activity. On average, the annual increase in the number of applications submitted by districts is as follows: for *the district of Chemistry* the change is by 7.5%, for the *district of Mechanical Engineering* is 4.1%, for the district *of Electrical Engineering* is 6.32%, for *the Instruments area* was 5.7%, and *Other areas* grew by 5.4%.

The strong concentration of applications for obtaining patent rights in the two areas of technological development – *Chemistry* and *Mechanical Engineering*, necessitates illustrating the distribution of applications between technological areas (Figure 5).

The highest concentration of patent rights in *Chemistry* is distinguished by the technological fields *Organic Chemistry* (728 applications), *Pharmaceuticals* (739), and *Biotechnology* (627), which form a total share of 52.3% of the activity in the area. Less than 10% is the activity in the other technological fields, such as *Chemical Engineering* (387 applications; 9.7%), Metallurgy (368; 9.2%) and *Chemistry of basic materials* (344; 8.6%) are among the preferred for the development and protection of innovative technologies. With the lowest interest in the technological field of *Nanotechnology,* in which for the entire period from 2014 to 2024 the CEE countries have filed only nine patent applications.



Source: *compiled by the author based on data from the EPO Statistics & Trends Centre*

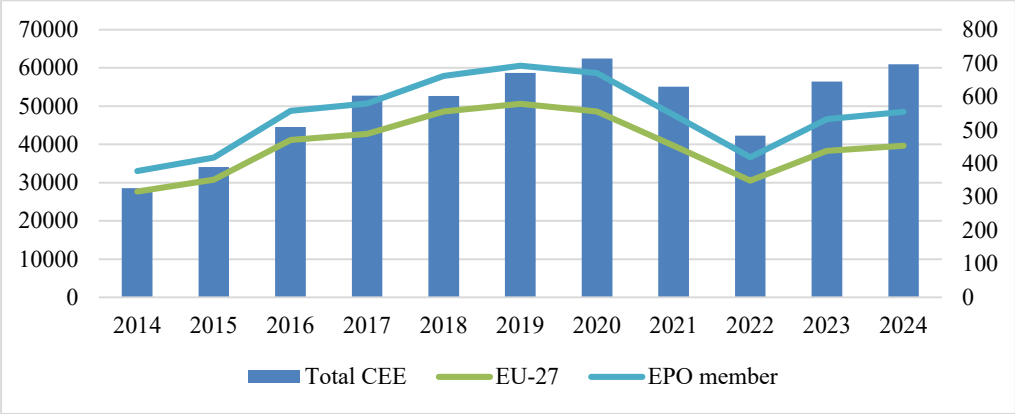
Figure 5. ***Distribution of application activity of CEE countries for the period 2014-2024 by technological areas of Chemistry and Mechanical Engineering***

In the technological area of *Mechanical Engineering*, the highest concentration of patent rights are Transport (778 applications), *Other Machinery* (677), *Thermal Processes* (536), and *Machining* (413) with a total share of 67.8%. Below 10% share remains the *Engines and Pumps* (347 applications; 9.8%), *Machine Elements* (312; 8.8%), *Mechanical Elements* (289; 8.1%) and *Textile and paper processing machinery* (195; 5.5%).

Outside the technological areas *of Chemistry* and *Mechanical Engineering*, the fields with the highest concentration of patent rights among all CEE applicants remain – *Medical technology* (1,062 applications) in the *Instruments* area and Civil Engineering (809) in the *Other fields area*.

Patents granted to CEE countries

To identify the current trends in the patent activity of patent holders from CEE countries, Figure 6 visualizes the dynamics of patents granted for the period 2014-2024.



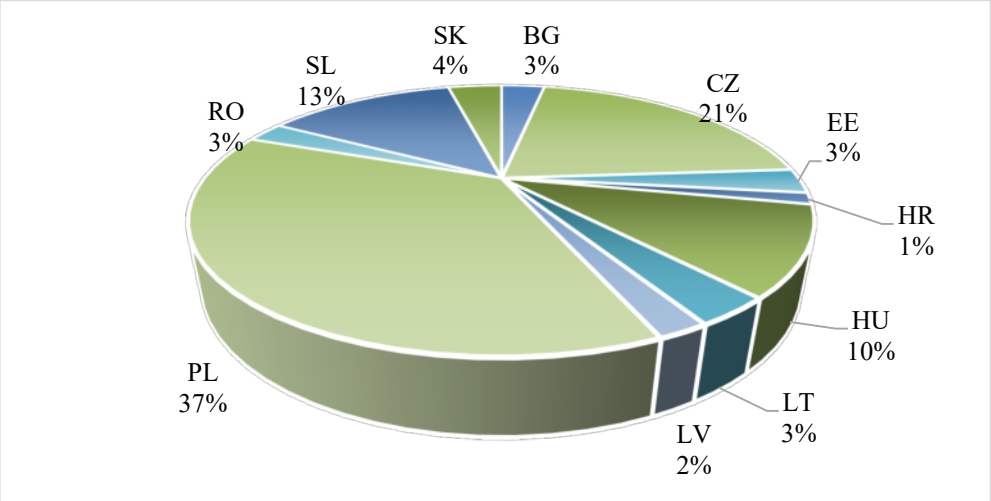
Source: *compiled by the author based on data from the EPO Statistics & Trends Centre*

Figure 6. ***Dynamics of the granted patents of the CEE countries for the period 2014-2024***

We find that similar processes are taking place, influencing the number of patents granted by CEE countries and EU Member States, as well as other Member States in the European Patent Office. In the CEE countries, the period under study was characterised by an increase in the number of patents granted for the period from 2014 to 2020, an average annual increase of 14.4%, followed by a decline, most pronounced in 2022 (23.2%). By the end of the period, we again report an increase in the granted patents, on average by 20.7% per year.

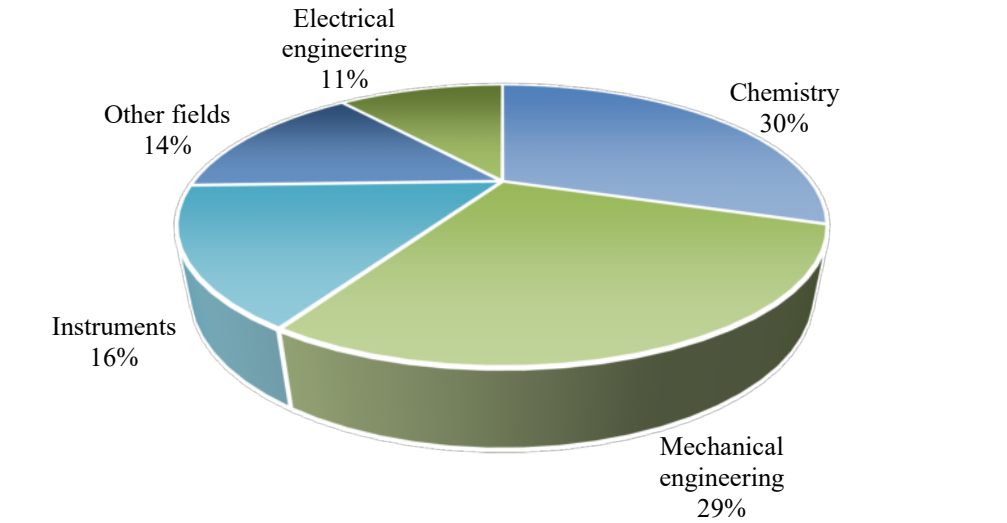
From the structure of patents granted by CEE country is (see Figure 7) we find that the largest share of patent rights is protected by patent holders from Poland (37%), followed by the Czech Republic (21%), Slovenia (13%), and Hungary (10%). The remaining CEE countries contribute between 1% and 4% to the patent activity carried out in the period 2014-2024.

Analyzing the areas of technological development to which patent activity is directed (see Figure 8), we found that there is a two times stronger concentration of patent rights in the areas of *Chemistry* (1,876 patents granted) and *Mechanical engineering* (1,813) compared to the other areas of technological development.



Source: *compiled by the author based on data from the EPO Statistics & Trends Centre*

Figure 7. ***Structure of the granted patents of the CEE countries for the period 2014-2024***

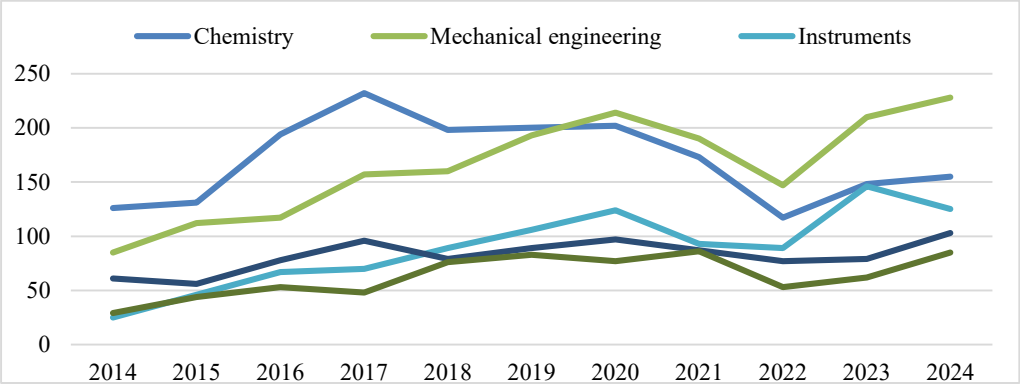


Source: *compiled by the author based on data from the EPO Statistics & Trends Centre*

Figure 8. ***Structure of CEE countries' patents grants by technology areas (2014-2024)***

Next are the areas of *Instruments* (980 patents), *Other fields* (902), and *Electrical engineering* (696). We can say that the structure of the patent activity of the applicants corresponds to the structure of the granted patents, with one exception – the applicant's interest in *Electrical engineering* is higher than that in inventions in *Other fields,* while the rights obtained in *Other fields* exceed those in *Electrical engineering.*

The visualized dynamics of the patents granted during the 2014-2024 study period (see Figure 9) show an upward trend in the five technological areas. Although the highest concentration of patent rights is observed in the *Chemistry* and *Mechanical engineering* areas, the measured growth in the granted patents is weaker – on average by 4.35% annually for the *Chemistry* and 12.1% for the *Mechanical engineering.*



Source: *compiled by the author based on data from the EPO Statistics & Trends Centre*

Figure 9. ***Dynamics of the granted patents by technological areas for the period 2014-2024***

After the reported average annual growth (23.9%) of the granted patents in *Chemistry* from 2014 to 2017, (see Figure 8), there is a decrease until 2022, an average annual decline of 11.9%. In 2023, a new growth of 26.5% compared to 2022 is reported, which contributes to the positive change in the issued patents for the entire period 2014-2024.

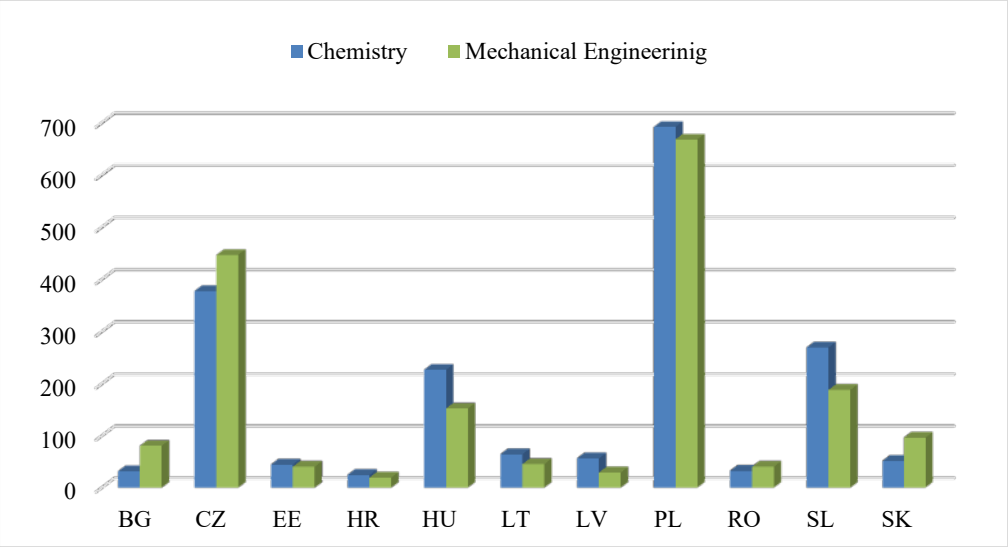
For *Mechanical engineering,* the period 2014-2020 is characterized by a consistent and continuous increase in the number of patents granted, by an average of 17.3% per year. Two years of reduced activity followed and again an increase in 2023 of 42.9%.

It is important to note that from 2019 to the end of the study period, there was a higher patent activity in *Mechanical engineering,* and in 2024 it was 1.5 times higher than the reported in the technological area of *Chemistry.*

The highest growth for the period studied, on average by 21.8% per year, was measured in the Instruments area, which in 2023 is equal to the *Chemistry* area in terms of the number of patents granted. The average annual change in the number of patents granted from 2014 to 2020 is an increase of 32.9%, followed by a decrease in the number of patents granted for 2021 and 2022 and again an increase of 64% in 2023.

In the area *of Electrical engineering*, the change is on average by 12.6%, and in *Other fields* an increase of 6.9% on average per year.

Considering the activity of patent holders thus outlined, the contribution of each of the countries studied to the formation of the two preferred technological areas is presented in Figure 10.



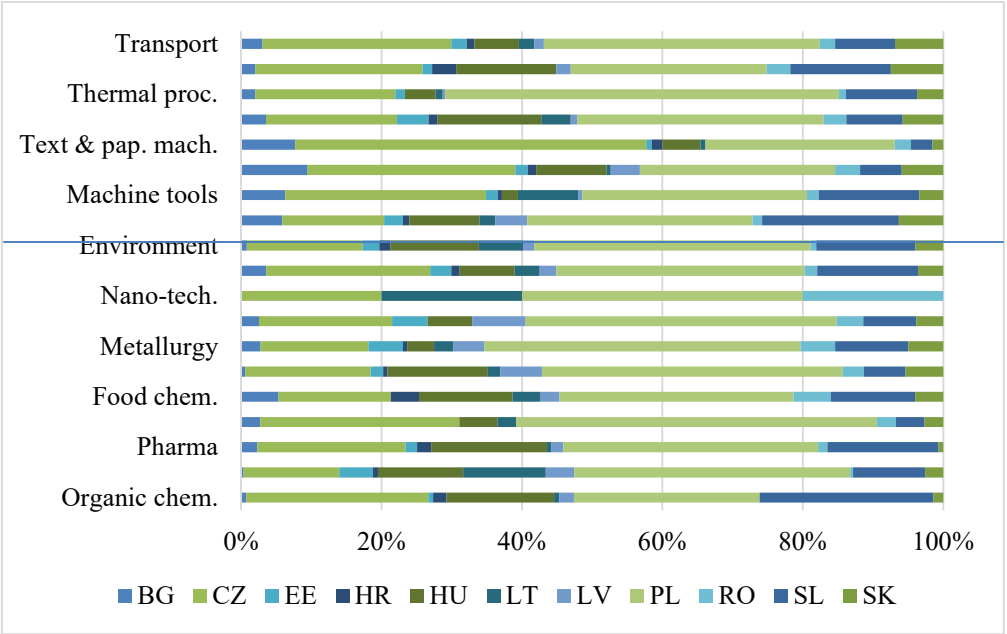
Source: *compiled by the author based on data from the EPO Statistics & Trends Centre*

Figure 10. ***Structure of the issued patents in the fields of Chemistry and Mechanical Engineering for the period 2014-2024***

Patent holders from Poland (692), Slovenia (270), Hungary (227), Latvia (65), Lithuania (57), Estonia (45), Croatia (25) prioritize their innovative developments in *Chemistry*, while Czech Republic (447), Slovakia (97), Bulgaria (81), and Romania (41) report a higher share of granted patents in *Mechanical engineering*. An interesting fact is that patent holders from some of these countries, although following the reported trends for high activity in *Chemistry* and *Mechanical engineering*, have directed their inventive capacity in a different direction, such as: for Bulgaria the second most interesting is the area of *Electrical engineering* (38 patents); for Estonia, the second position is

in the area of *Instruments* (44 patents), which also corresponds to the high applicant interest in the same area; for Romania, second in terms of patent activity, similar to Estonia, is the area of *Instruments* (43 patents).

To establish the specialization of the studied countries and the orientation of the granted patents in the priority areas, we present the information on the distribution of patent activity by technological fields (see Figure 11).



Source: *compiled by the author based on data from the EPO Statistics & Trends Centre*

Figure 11. ***Distribution of granted patents by technological fields in Chemistry and Mechanical engineering (2014-2024)***

The highest concentration of patent rights in *Chemistry* is the field of *Organic chemistry* (424 patents), followed by *Pharmacy* (303 patents) and *Biotechnology* (272 patents). In the area of *Mechanical engineering*, the technological field with the largest number of protected rights is *Transport* (364 patents), followed by *Other machinery* (311 patents) and *Thermal processes* (296 patents). The least interesting of the two areas is Nanotechnology (*Chemistry* area) with only five inventions patented for the period 2014-2024.

Like the application activity, the technological fields in which the most protected rights are reported remain outside the two preferred technological areas. Among all thirty-five technological fields in which inventors can receive legal protection for their developments, the largest number of protected

innovations are reported in the *Civil Engineering* field (510 patents) in the *Other fields* area, followed by *Medical technology* (438 patents) in the field of *Instruments.*

Discussion

The contribution of this research can be revealed in the following directions:

First, the place of CEE countries among applicants and patent holders in the EPO and EU-27 is outlined. Data on the structure and dynamics of patent application activity and granted patents are presented, paying attention to the contribution of each of the countries in achieving this activity.

Secondly, the technological specialization of the CEE countries is reflected. The fields of Chemistry and Mechanical Engineering have the highest concentration of patent applications, which expresses the development trends imposed over the years by European countries. A study by Lacasa, Giebler, & Radošević (2017) on the technological specialization of the CEE countries in different periods since 1980 testifies to the priority development of the fields of Chemistry and Mechanical Engineering in Europe, which highlights the continuing development of the trends already established. The tendencies revealed by Lakasa et al (2017) and the results of the present study allow us to confirm the derived working *Hypothesis 2*, according to which *The specialization of patent activity of the CEE countries is influenced by the trends of technological development taking place among global leaders but lags their level.*

Thirdly, the analysis of the patent activity of the CEE countries focuses on the former socialist countries and reveals the lack of adequate policy and management measures in the period after 1989 to transform the knowledge of inventors into economic benefits. The results of this study confirm the conclusions established by Lacasa, Giebler, & Radošević (2017), according to which the innovation capacity of the CEE countries is drastically decreasing after 1989, compared to the pre-socialist levels. They prove that the cumulative patent intensity of the CEE countries in the socialist period was equal to that of the United States and was ahead of that of Korea and Taiwan, although it lagged that of Germany and Great Britain. Since 1990, CEE countries have been rapidly surpassed by Korea, and between 2000 and 2009, patent intensity decreased dramatically (Lacasa, Giebler, & Radošević, 2017).

Conclusion

As a result of the analysis of the patent activity carried out by applicants from CEE countries in the period 2014-2024, we found the following:

- The aggregate patent application activity of the surveyed CEE countries was only 1.85% of the activity of EU applicants and 1.5% of the activity of all Member States in the EEA. Comparing the activity of each individual country in the scope of CEE, we again find significant differences and imbalances in their innovative performance.
- The total number of patents granted to holders of CEE countries is 1.4% of the granted patents of EU countries and 1.2% of all patents granted in the EPO. This reflects the insignificant role of the eleven countries studied in the process of creating and disseminating innovations and proves the working *Hypothesis 1* derived in this study, according to which: *"CEE countries are still lagging behind in the absorption and transformation of innovative knowledge into economic benefits".*
- The structure of patent activity expresses a high concentration of patent rights in the areas of *Chemistry* and *Mechanical engineering.* Although the number of patent applications filed still shows a higher activity in *Chemistry,* there is a predominance of rights in *Mechanical engineering* over the area of *Chemistry* in the number of patents granted after 2019. For 2024, the granted patents in *Mechanical Engineering* are 1.5 times more than those in *Chemistry.*

The prerequisites for these trends in patent activity in CEE countries were revealed at the end of the last century, when Jones & Williams (1998) concluded that there is a significant underinvestment in R&D: *"… optimal R&D spending as a share of GDP is more than four times larger than actual spending"* (Jones & Williams, 1998, p. 1121). This is particularly true for CEE countries, which are lagging in technological development compared to Western European countries and for which it can be argued that low R&D expenditure does not have the expected effect on economic development (Samimi and Alerasoul, 2009). Reasons for this phenomenon can also be sought in the very nature of R&D investments – they are high-risk, costly and to a large extent depend on the qualities of the R&D personnel (Paunov, 2012), which is why enterprises are not ready to direct a large amount of financial resources to innovative developments, especially in a period of transformation of the economy which for CEE countries is proceeding at a slow pace. This, and given that in the post-1989 period the focus on R&D and innovation development has been left in the background, and competition in Western European markets is high, CEE countries face additional difficulties in stepping up their innovation activity. The lack of a targeted and environmental policy in the field of

innovation, lack or insufficient investment in R&D, as well as ongoing economic processes are a prerequisite for CEE countries to lag in their development and fail to deploy their full innovation capacity. Vlajčić, Kađo & Filipović (2025) note that the poor adaptability of innovation policy and the inability to read market signals in a timely manner led to the development of low-value-added innovations, which makes CEE countries a less attractive region for high-value-added investments.

We must bear in mind that the innovation lag affects not only economic and technological development, but also the social development of society in the CEE countries. Seen through the prism of innovations applied in the social sphere and their primary areas *„... public health, education, the environment and regional development, the development of new technologies, the cultural and creative development of communities, quality of life, etc."* (Tsoneva, 2022, p. 53), the slowdown in innovative development leads to negative trends related to the quality of life of people.

A direction for accelerating the innovative development of the analyzed countries and eliminating the consequences of the insufficient use of their own research capacity and the lack of powerful research centers is the purchase of licensing rights for the use of foreign inventions. Obtaining a license for the latest achievements of the human mind in a certain area helps to stimulate the development of the same, which allows you to catch up with other countries. But this is not enough to achieve sustainable development over time. We accept that it is necessary to use the object of the license as a lever for intensification – the achieved technological level to be upgraded and improved through investments in our own research and development and the implementation of an effective innovation policy to create innovative and significant inventive results. This is also confirmed by a study by Prokop, Stejskal, Klimova & Zitek (2021), which proves that internal research and development activities are a more important factor for the development of CEE countries than the acquisition of external knowledge through the purchase of licenses for patented inventions, know-how, etc.

Increasing the intensity of development of countries requires changes in the approach to the formation and implementation of national policies in the field of innovation and scientific development, so that they are adequate to global trends in technological development.

Considering the statement of Ponta, Pulgia, and Manzini (2021), according to which *„... the number of patents does not seem to be fully representative of the innovation performance and the use of other indicators provides a better understanding of innovation performance"* (Ponta, Pulgia, and Manzini, 2021, p.91), the current study presents a limited look at the capacity of CEE countries to innovate. The proposed analysis outlines the possibilities and direction for a

further in-depth study of the performance of CEE countries through combining patent statistics with other indicators showing the relationship between innovation activity and economic development of CEE countries.

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