

THE EFFECT OF THE COVID-19 PANDEMIC ON ECONOMIC GROWTH AND R&D SPENDING IN CZECHIA, GERMANY, AND POLAND

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Abstract

The article investigates the impact of the COVID-19 pandemic on economic growth, specifically focusing on research and development (R&D) expenditures in the Czech Republic, Germany, and Poland. The analysis spans the periods preceding, during, and following the pandemic. The central objective of the article is to examine whether the pandemic, considering the implemented restrictions and associated financial aid, influenced the economic growth trajectory and the allocation of resources to research and development in the aforementioned Central European countries. The research utilizes time series data from 2011 to 2022, sourced from Eurostat, to track the evolution of Gross Domestic Product (GDP) and Gross Expenditure on Research and Development (GERD). Key indicators under scrutiny included GDP, GERD, and R&D intensity – GERD as a percentage of GDP. A chain index was constructed to facilitate not only cross-country comparisons of these indicators but also an examination of year-to-year changes and an analysis of the growth rate of the GERD indicator. The research findings reveal that that COVID-19 really affected not only the development of the monitored economies but also the R&D area; however, it was not the same in all the monitored countries. The impact of the pandemic can be seen in the decline in GDP in all three countries in 2020, but GERD decreased in only two of them – the Czech Republic and Germany. Poland experienced a significant increase in research and development funding in real terms. Both indicators (GDP and GERD) immediately resumed their growth in 2021 in all analyzed countries. From that it can be concluded that the impact of the COVID-19 pandemic on the GDP and GERD of the Czech Republic, Germany and Poland was not of a long-term nature.

Keywords

GDP; GERD; R&D; Innovation; COVID-19.

Introduction

After completing an extensive research article titled "The Effect of the COVID-19 Pandemic on Economic Growth and R&D Spending in the EU Countries" (see [1]) for LEF 2023, the

authors are now focusing their attention to the national level, applying the same analytical approach on three particular Central European countries: Czechia, Germany, and Poland. The rationale behind this decision is multifaceted and aims to further refine our understanding of how the pandemic has affected economic growth and R&D spending. This involves assessing the impact on both the entire EU and specific member states individually.

Geographic and Economic Diversity: These three countries were selected due to their diverse economic characteristics within the EU. Germany represents one of the EU's largest and most robust economies, serving as a benchmark for economic performance [2]. Poland, on the other hand, has been experiencing significant economic growth in recent years, making it an interesting case for examining the pandemic's effects on emerging economies [3]. Czechia, with its dynamic economy, provides an additional perspective on Central European dynamics [4]. Studying these countries can capture a more comprehensive view of the pandemic's repercussions across different economic landscapes within Europe.

Variability in Pandemic Response: Each of these countries adopted distinct strategies and policies to combat the COVID-19 pandemic [5]. These strategies included restrictive measures and tools such as lockdowns, travel restrictions, and stimulus packages that had varying impacts on economic activity and R&D spending. Analysing these differences in responses will shed light on the role of government policies in shaping economic and innovation outcomes during crises.

R&D Investment Patterns: These three countries also exhibit diverse patterns in R&D investment, with Germany being a renowned global leader in innovation, Czechia having a growing R&D sector, and Poland seeking to bolster its innovation capabilities [6]. Examining how the pandemic influenced R&D investments in these countries will provide insights into the resilience and adaptability of their innovation ecosystems [7].

Regional Implications: Czechia, Germany, and Poland are located in Central Europe, sharing geographic proximity and close economic ties [8]. Understanding the impact of the pandemic in this regional context can be valuable not only for these particular countries and their individual regions but also for their neighbouring nations and the broader EU [9].

By focusing the research on these three Central European countries, the authors aim to deepen their analysis and draw more nuanced conclusions regarding the pandemic's impact on economic growth and R&D spending. This investigation will encompass detailed case studies of each country to discern the intricate relationships between government policies, economic resilience, and innovation in the face of adversity.

The COVID-19 pandemic has wrought profound alterations in our daily lives and the operational paradigms of businesses worldwide [10]. Governments across the globe have enforced an array of measures, including lockdowns, remote learning, travel constraints, and social distancing protocols, to curtail the virus's spread [11]. These measures have engendered considerable disruption across various industry sectors, significantly affecting their functioning. In tandem with these operational hurdles, businesses have been compelled to navigate an inherently uncertain economic terrain [12].

The pandemic has led to substantial economic upheaval, compelling businesses to quickly adjust to shifts in demand and supply chain dynamics. Despite the challenges, many enterprises have demonstrated resilience and a willingness to innovate in response to the crisis. The innovative approaches taken by these businesses have been truly remarkable. Businesses have had to swiftly embrace novel modes of operation, sales, and service delivery [13]. This transformation has ushered in the rapid adoption of cutting-edge technologies and digital platforms, such as e-commerce, contactless payments, and remote work tools [14],

[15]. Moreover, several businesses have realigned their operations to address the distinctive exigencies arising from the pandemic. In sum, the COVID-19 pandemic has introduced profound alterations and challenges for businesses while providing an opportunity for innovative adaptation to novel circumstances [16].

Amidst the pandemic, numerous countries introduced substantial bailout packages to buttress various businesses. These packages have furnished financial sustenance to companies spanning a spectrum of sectors. Innovations, knowledge, and R&D are widely regarded as quintessential drivers of economic growth, elevating standards of living and economic performance [17], [18]. The affirmative impact of R&D on innovation output and productivity has been substantiated by a wealth of studies (e.g. [19]–[22]). Technology is the linchpin that empowers businesses to secure a competitive edge in the market [23], [24]. Consequently, businesses invest in R&D to amplify their productivity and profitability.

Roper and Turner [25] posit that the impact of COVID-19 is particularly pronounced in the case of Small and Medium-sized Enterprises (SMEs), whose financial robustness tends to be more fragile, rendering their capacity to invest in R&D vulnerable to disruption [26]. However, enterprises that can sustain such investments stand a better chance of survival, heightened economic growth and enhanced profitability. Biswas [27] likewise substantiates that R&D investments can mitigate the negative repercussions of a pandemic on a company. Guan, Tienan, and Tang [28] add that the ability to embrace digital technology plays a pivotal role in bolstering resilience to a pandemic; higher R&D investment correlates with a higher level of digital technology adoption, ultimately enhancing resistance to external crises.

1 Aim of the Research

The authors have expounded upon the role of innovations in the developmental process in numerous research articles (e.g. [26], [29], [30]). In this article, the focus is on exploring the innovations within the ongoing context of the COVID-19 pandemic. The objective of this article is to scrutinize its ramifications not only on R&D funding but also on the broader economic performance of nations.

As mentioned above, the selection of Czechia, Germany, and Poland as focal points for further study is motivated by their economic diversity, divergent pandemic responses, R&D investment patterns, and regional significance. Through this focused analysis, the authors aspire to contribute valuable insights to the ongoing discussion of the pandemic's repercussions on European economies and innovation ecosystems.

2 Methodology

The data for the analytical part of the article is drawn from Eurostat [31]; it is mainly about the intensity of research and development, both at the macroeconomic and microeconomic levels. In the first case, research and development intensity is derived as the share of GERD on the monitored countries' GDP. In the second case, intensity represents the percentage of companies' revenues reinvested in their research and development. The article deals with a macroeconomic point of view, so the first of the abovementioned approaches will be introduced in formula (1)

$$R\&D\ intensity = \frac{GERD}{GDP} \quad (1)$$

where

GERD = gross domestic expenditure on research and development

GDP = gross domestic product.

Tab. 1 provides an overview of indicators and data sources used, as well as the time series under review within the conducted research.

Tab. 1: *Data used in the research*

Indicator		Source	Time series
GDP	Gross domestic product	Eurostat [32]	2011–2021
GERD	Gross domestic expenditure on R&D	Eurostat [33]	
R&D intensity	GERD as % of GDP		

Source: *Own*

The first cases of Coronavirus disease were reported towards the end of 2019, and in 2020, the 27 member countries of the European Union (EU-27) implemented restrictive measures in response. For the purpose of this research, the period from 2011 to 2019 is considered the “pre-covid” era, while the year **2020** is referred to as the “covid” year (in the figures, this year has been underlined), and 2021 is denoted as the first “post-covid” year.

The research works with data related to three EU member countries – Czechia, Germany, and Poland. Additionally, data covering EU-27 have been used to compare the development of some indicators (R&D intensity and chain index constructed for this variable) with the EU benchmark. Even though the research covers the period of 2011–2021, the United Kingdom (UK) was excluded from the analysis, and its data were not taken into account for the entire period covered by the research due to Brexit.

Firstly, GDP, GERD and R&D intensity development were separately analysed and compared among the countries (see Fig. 1, 2, 3 in section 2). Further, to compare the development of R&D intensity, the chain index (2) of the time series was calculated. This index compares two immediately consecutive values – year-on-year changes – and thus, it enables to analyse the growth rate of the indicator.

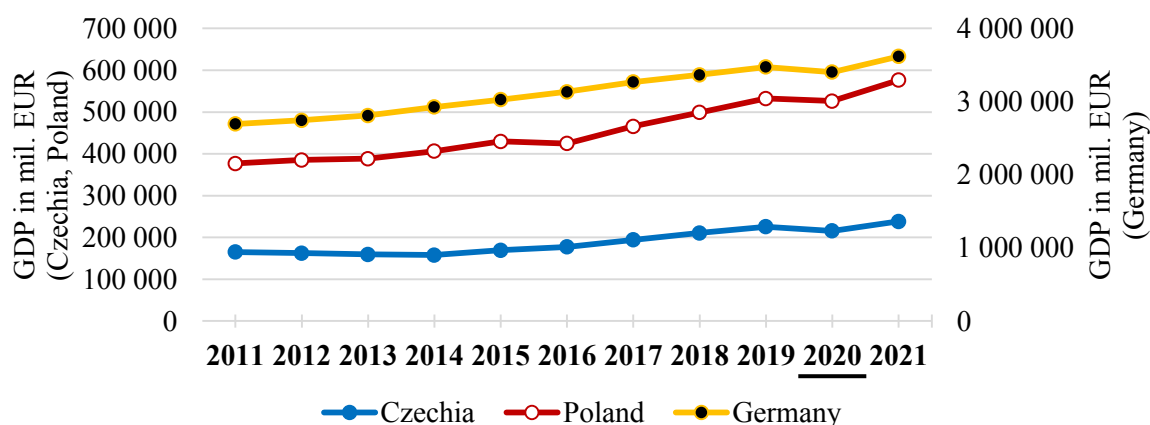
$$Ti = \frac{x_{i+1}}{x_i} \quad (2)$$

where Ti is the chain index in the year i , and x is the value of the analyzed indicator.

3 Results of Research

In this part of the article, the research results are presented. The research findings are summarized in four figures (Fig. 1–Fig. 4) on the development of gross domestic product (GDP), gross domestic expenditure on R&D (GERD), R&D intensity (GERD as a percentage of GDP), and the chain index development in the analyzed period (2011–2021).

Fig. 1 presents the development of GDP in Czechia, Germany, and Poland over the examined period (2011–2021). The values are measured in current market prices.

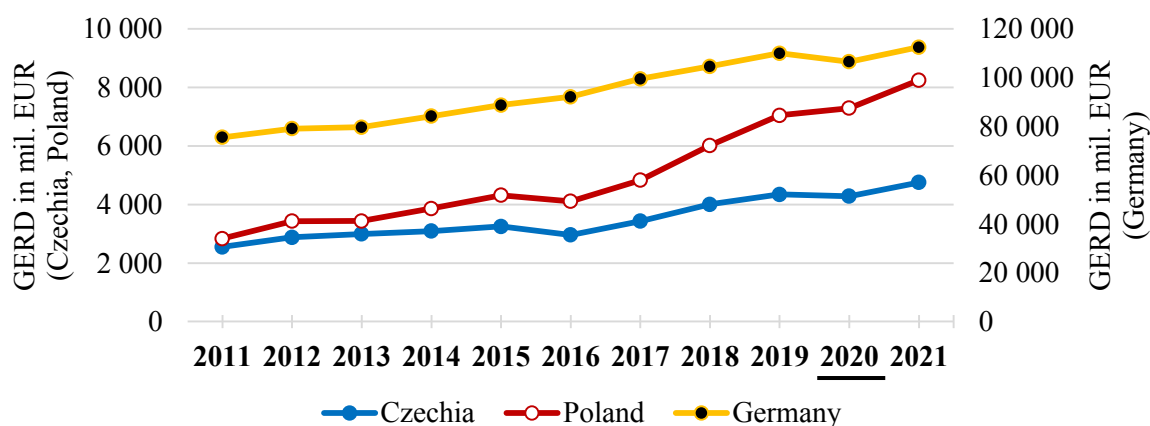


Source: Authors' own processing of data from Eurostat [32]

Fig. 1: GDP in Czechia, Germany, and Poland (2011–2021; mil. EUR)

The countries' GDP grew slowly during the analyzed period, with a 3.9% average growth rate for Czechia, 4.4% for Poland, and 3.0% for Germany. However, all three countries reported a significant decline in the pandemic year 2020. The year-on-year change was -4.4% in Czechia, -1.2% in Poland, and -2.0% in Germany. Even though these noticeable declines, the GDP growth was revived right away in 2021, with the strongest growth in the case of Czechia (a 10.4% year-on-year change compared to the previous year), a 9.6% change in the case of Poland and a 6.3% change in the case of Germany.

Fig. 2 captures the development of GERD in Czechia, Germany, and Poland over the examined period (2011–2021).

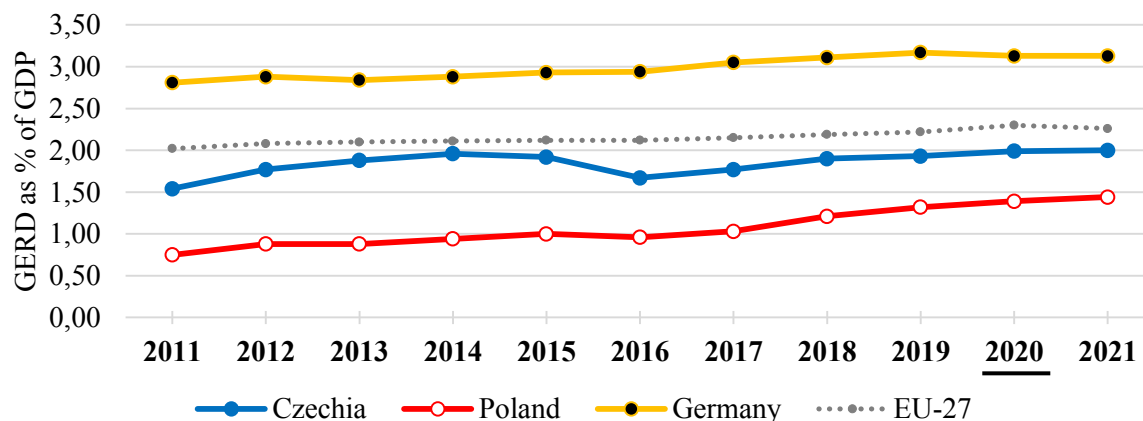


Source: Authors' own processing of data from Eurostat [33]

Fig. 2: GERD in Czechia, Germany, and Poland (2011–2021; mil. EUR)

The development of GERD largely follows changes in GDP. The development of GERD in the case of Czechia reported a slight decline in 2020 (-1.4% year-on-year) and a more noticeable slump in Germany (-3.1%). However, a significant year-on-year increase of 3.5% was reported in Poland. In all three cases, the average growth rate (long-term year-on-year development) in GERD was higher than GDP (6.7% vs. 3.9% for Czechia, 11.6% vs. 4.4% for Poland, and 4.1% vs. 3.0% for Germany). A strong positive development for Poland continued in 2021 (+13.2% compared to 2020), and a noticeable recovery came in the two remaining countries (+11.0% in Czechia and +5.6% in Germany compared to the 2020 values).

The data presented in the previous two figures are further used in Fig. 3, where GERD as a percentage of GDP is expressed using the formula 1 presented in section 1. Moreover, Fig. 3 provides a comparison of the analyzed three countries with the EU-27 values.

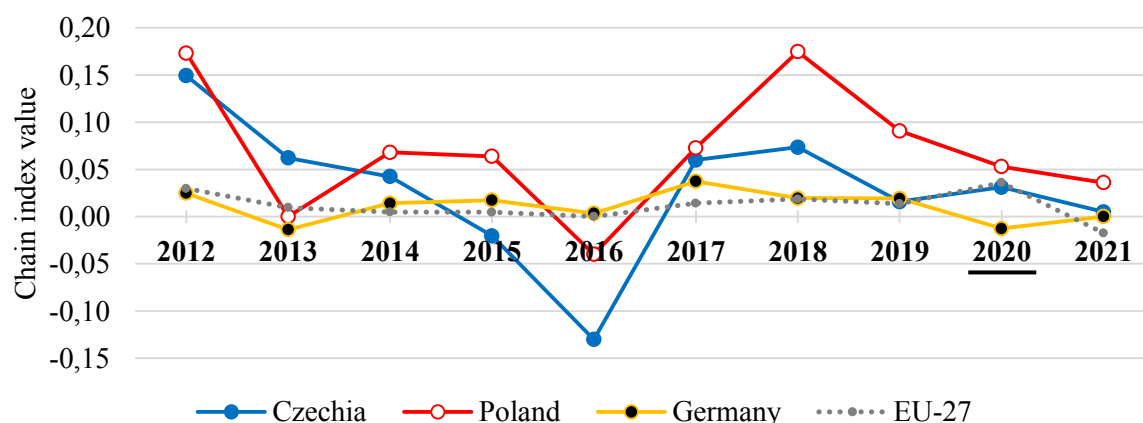


Source: Authors' own processing of data from Eurostat [33]

Fig. 3: R&D intensity in Czechia, Germany, and Poland (2011–2021 in % of GDP)

As depicted in Fig. 3, the share of GERD in GDP increased slowly over the period under review. The highest increase can be seen in Poland, where the share of GERD in GDP increased from 0.75% in 2011 to 1.44% in 2021 (+0.69%). In Czechia, the share changed by +0.46%, and in Germany, it was only 0.32% over the analyzed period. The most significant drop appeared in Czechia in 2016. In the given year, GDP grew by 4.7% compared to the previous year 2015, while the support of R&D was reduced by -8.8% in the same period. This is the reason behind the substantial decrease in the share of GERD in GDP, thus the fall of R&D intensity in Czechia. The figure shows that only Germany reported a small reduction in R&D intensity in 2020 due to the COVID-19 pandemic.

Fig. 4 compares the evolution of the chain index (i.e. the annual growth rate) of the R&D intensity (GERD as % of GDP). In addition, here, the comparison of the analyzed countries with the EU-27 countries has been made.



Source: Authors' own processing of data from Eurostat [26], [31]

Fig. 4: Chain index – R&D intensity in Czechia, Germany, and Poland (2012–2021)

The comparison made in Fig. 4 confirms the aforementioned findings. Regarding the development of R&D intensity, the most significant year-on-year decrease can be seen in the case of Czechia (-0.13) and Poland (-0.04) in 2016, while the greatest year-on-year increase

was reported in Poland in 2018 (0.17). Regarding the pandemic year of 2020, Germany is the only country where the year-on-year development of GERD was negative (-0.01).

Since the aim of this article is to examine the effect of COVID-19 on R&D funding, the authors have not provided detailed information about the chain index deviations during the pre-covid period (2011–2019). To analyze the year-on-year changes more precisely, it would be necessary to closely examine the individual years' development of both GDP and GERD.

4 Discussion

The OECD [34] points to the pro-cyclicality of investment in research and development and, thus, logically, their susceptibility to a sharp decline in crisis periods and, conversely, an increase in recovery periods. The functioning of innovation systems deviates from the normal course in these situations. The impact of the pandemic is certainly a new element; it is not an ordinary crisis. Therefore, its effects may differ from already known standards, e.g. by sector - during COVID-19, some companies expanded their research and development activities (digital and pharmaceutical sectors), while others, on the contrary, reduced their investments in research and development (automotive industry, aerospace industry, defense) [1], [5], [35], [36].

What is clear, however, is that the pandemic has revealed and confirmed the importance of digital technologies. Massive investments in areas such as e-commerce, remote work and online education were quickly targeted and intensively implemented [37]. COVID-19 also confirmed the importance of the cooperation of the business sphere with universities towards joint research activities in EU countries, the development of new knowledge and technologies to support the growth of industry and the education of highly qualified workers [38]. Intensive cooperation between universities, businesses and essentially the whole society is essential for the further growth and development of the EU economy, whether in normal economic conditions or special deviations from the standard, as was the case with COVID-19 [39].

Conclusion

The presented article focused on the issue of R&D funding in EU countries. To analyze the topic, the authors studied the evolution of GDP, GERD, and R&D intensity indicators and examined the impact of the COVID-19 pandemic on them. The issue was examined in the environment of three selected neighboring Central European countries – Czechia, Germany, and Poland.

As the COVID-19 pandemic spread across Europe in the early part of 2020 and various countries started implementing various restrictive measures throughout that year, the authors considered 2020 as the pivotal pandemic year for their analysis. The findings obtained in this research confirm that the COVID-19 pandemic affected both GDP and GERD of the selected countries. Both GDP and GERD grew slowly throughout the period under review (2011–2021). As the growth rate was a bit higher in the case of GERD, R&D intensity (the share of GERD on GDP) also increased.

In the pandemic year of 2020, there was a notable decrease in GDP when compared to the levels recorded in 2019 (by 4.4% in Czechia, 2.0% in Germany, and 1.2% in Poland). The same year, GERD decreased (by 1.4% in Czechia and 3.1% in Germany). However, there was a sharp year-on-year increase of 3.5% in Poland. Moreover, in 2021, both GDP and GERD recovered again in all three countries.

Based on the research findings, it can be concluded that the COVID-19 pandemic did not have a significant and lasting impact on the economic growth of the analyzed countries

(measured by GDP) and R&D funding (measured by GERD). This is confirmed by the analysis of the development of both indicators. Despite the declines in the pandemic year of 2020, there was a significant and immediate increase of both GDP and GERD in 2021.

This article should be seen as an initial step towards analyzing the relationship between the COVID-19 pandemic and economic development of the analyzed economies along with its impact on R&D funding.

The trends in both analyzed variables, GDP and GERD, indicate that R&D spending is closely tied to the economic development of a country. However, it may take some time before the impact of the restrictive measures on R&D funding becomes apparent. To get a more comprehensive understanding, further analytical analysis is required, and it is necessary to extend the time series used in the current period.

It is also important to note that COVID-19 is not the only challenge companies have had to face. There are other factors (such as the ongoing war in Ukraine and rising inflation) that need to be taken into account.

This research was performed using EU-wide data across economic sectors and analyzed three EU member countries – Czechia, Germany, and Poland. However, as Eurostat [33] tracks the data used in this research separately for each sector, it will be possible to conduct further research examining the impact of the pandemic on R&D funding not only in other countries but also in different sectors of the national economy – sectoral perspective (business, government, higher education, private non-profit entities).

The R&D activities of businesses and institutions in EU countries have been notably impacted by the COVID-19 pandemic. While certain entities have persisted in their commitment to R&D investments, others have encountered financial challenges, leading them to scale back or defer their expenditures on R&D.

The pandemic has had a significant economic impact on R&D intensity in the EU. The economic decline triggered by the pandemic led to budget cuts and reduced R&D spending for certain businesses and institutions. Moreover, the pandemic caused disruptions in the supply chain and alterations in consumer behavior, potentially influencing the orientation and emphasis of R&D activities. However, it is also necessary to note that other destabilizing factors such as the war in Ukraine, global inflationary waves, and natural catastrophes can also negatively affect the flow of R&D funding.

Overall, the COVID-19 pandemic affected R&D in different ways across selected EU countries. Some areas saw more intense R&D activity, while others faced challenges due to money issues and disruptions in the economy. The long-term impact on R&D will depend on factors such as how long the pandemic lasts, how quickly the economy recovers, and the priorities of businesses, governments, and other entities.

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EFEKT PANDEMIE COVID-19 NA HOSPODÁŘSKÝ RŮST A VÝDAJE NA VÝZKUM A VÝVOJ V ČESKU, NĚMECKU A POLSKU

Článek se zabývá problematikou hospodářského růstu a výdajů na výzkum a vývoj (VaV) ve třech sousedících středoevropských zemích – Česku, Německu a Polsku – před pandemií COVID-19, během pandemie a po ní. Článek využívá analýzu časových řad ke zjištění, zda pandemie a s ní spojená přijatá restriktivní opatření a poskytnuté záchranné balíčky ovlivnily hospodářský růst a financování výzkumu a vývoje ve vybraných zemích. Pro zodpovězení této výzkumné otázky byla využita data Eurostatu týkající se vývoje HDP a GERD a analyzováno období 2011-2021. Kromě vývoje sledovaných ukazatelů (HDP, GERD, intenzita VaV – GERD jako procento HDP) byl zkonstruován řetězový index, který slouží nejen k porovnání vývoje těchto ukazatelů mezi jednotlivými zeměmi, ale také k porovnání meziročních změn a k další analýze tempa růstu ukazatele GERD. Z výzkumu vyplývá, že COVID-19 ovlivnil HDP i oblast výzkumu a vývoje, což ilustruje vývoj analýz časových řad daných ukazatelů. Hovoříme-li v absolutních číslech, dopad pandemie lze spatřovat v poklesu HDP ve všech třech zemích v roce 2020, zatímco GERD se snížil pouze ve dvou z nich – v Česku a Německu, zatímco Polsko vykázalo výrazný nárůst financování VaV. Oba ukazatele (HDP i GERD) se však ve všech analyzovaných zemích okamžitě vrátily k růstu v roce 2021. Na základě provedené analýzy lze konstatovat, že dopad pandemie COVID-19 na HDP a GERD Česka, Německa a Polska nebyl významný ani neměl dlouhodobý charakter.

DIE AUSWIRKUNGEN DER COVID-19-PANDEMIE AUF WIRTSCHAFTSWACHSTUM UND FORSCHUNG UND ENTWICKLUNG AUSGABEN IN TSCHECHIEN, DEUTSCHLAND UND POLEN

Der Artikel befasst sich mit der Frage des Wirtschaftswachstums und der Forschung und Entwicklung (F&E) Ausgaben in den drei benachbarten mitteleuropäischen Ländern – Tschechien, Deutschland und Polen – vor, während und nach der COVID-19-Pandemie. Anhand einer Zeitreihenanalyse wird untersucht, ob sich die Pandemie und die damit verbundenen restriktiven Maßnahmen und Rettungspakete auf das Wirtschaftswachstum und die F&E-Finanzierung in den ausgewählten Ländern ausgewirkt haben. Zur Beantwortung dieser Forschungsfrage wurde die Entwicklung des BIP und der BAFE auf der Grundlage von Eurostat-Daten für den Zeitraum 2011-2021 analysiert. Neben der Entwicklung der überwachten Indikatoren (BIP, BAFE, FuE-Intensität - BAFE als Prozentsatz des BIP) wurde der Kettenindex erstellt, um nicht nur die Entwicklung dieser Indikatoren zwischen den Ländern gegenüberzustellen, sondern auch um die jährlichen Veränderungen zu vergleichen und die Wachstumsrate des BAFE-Indikators weiter zu analysieren. Die Untersuchung zeigt, dass sich COVID-19 sowohl auf das BIP als auch auf den Bereich F&E ausgewirkt hat, wie die Entwicklung der Zeitreihenanalysen der genannten Indikatoren zeigt. In absoluten Zahlen ausgedrückt zeigt sich die Auswirkung der Pandemie im Rückgang des BIP in allen drei Ländern im Jahr 2020, während die BAFE nur in zwei von ihnen – Tschechien und Deutschland – zurückgingen, wohingegen Polen einen deutlichen Anstieg seiner F&E-Mittel meldete. Beide Indikatoren (BIP und BAFE) stiegen jedoch in allen untersuchten Ländern im Jahr 2021 sofort wieder an. Auf der Grundlage der durchgeführten Analyse kann der Schluss gezogen werden, dass die Auswirkungen der COVID-19-Pandemie auf das BIP und die BAFE der Tschechischen Republik, Deutschlands und Polens weder signifikant noch von langfristiger Natur waren.

WPLYW PANDEMII COVID-19 NA WZROST GOSPODARCZY I WYDATKI NA BADANIA I ROZWÓJ W CZECHACH, NIEMCZECH I POLSCE

Artykuł dotyczy kwestii wzrostu gospodarczego i wydatków na badania i rozwój w trzech sąsiadujących ze sobą krajach Europy Środkowej - Czechach, Niemczech i Polsce – przed, w trakcie i po pandemii COVID-19. W artykule wykorzystano analizę szeregów czasowych w celu zbadania, czy pandemia i związane z nią podjęte środki ograniczające oraz przyznane pakiety ratunkowe wpłynęły na wzrost gospodarczy i finansowanie badań i rozwoju w wybranych krajach. Aby odpowiedzieć na to pytanie badawcze, wykorzystano dane Eurostatu dotyczące PKB i GERD oraz przeanalizowano okres 2011-2021. Oprócz rozwoju monitorowanych wskaźników (PKB, GERD, intensywność nakładów na B+R - GERD jako procent PKB), skonstruowano indeks łańcuchowy, aby porównać nie tylko rozwój tych wskaźników między poszczególnymi krajami, ale także porównać zmiany rok do roku i dalej analizować tempo wzrostu wskaźnika GERD. Z badań wynika, że COVID-19 wpłynął na PKB, a także na obszar badań i rozwoju, co ilustruje ewolucja analiz szeregów czasowych danych wskaźników. Mówiąc w liczbach bezwzględnych, wpływ pandemii można dostrzec w spadku PKB we wszystkich trzech krajach w 2020 r., podczas gdy GERD zmniejszył się tylko w dwóch z nich – w Czechach i Niemczech, natomiast Polska odnotowała znaczny wzrost finansowania badań i rozwoju. Jednak oba wskaźniki (PKB i GERD) natychmiast powróciły do wzrostu w 2021 r. we wszystkich analizowanych krajach. Na podstawie przeprowadzonej analizy można stwierdzić, że wpływ pandemii COVID-19 na PKB i GERD Czech, Niemiec i Polski nie był znaczący ani nie miał charakteru długoterminowego.