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ARTYKUŁY

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THE IMPACT OF CRISES IN THE 21ST CENTURY ON THE RAILWAY TRANSPORT SECTOR IN POLAND IN TERMS OF ECONOMIC SECURITY

Abstract

The article presents research on the impact of the financial crisis between 2007-2009 and the COVID-19 pandemic in 2020 on the freight and passenger rail transport sector. Multidimensional comparative analyses were used in the study. The data obtained for the research were grouped. They were, then, compiled on categorized line and bar charts. The research shows that during the financial crisis between 2007-2009, a decrease in the number of transported goods by 48 488 thousand tons was observed. During the COVID-19 pandemic between 2019 and 2020, a decrease in the number of goods was also visible - by 15,363 tones. However, when considering the number of passengers transported, during the financial crisis between 2007-2009 in Poland there was an increase by 1,928 people and in the period of impact of COVID-19 in 2020 compared to 2019 a decrease by 130,270 passengers. When examining the rail passenger transport sector in Poland, a decrease in the number of employees by 385 was observed in the years 2003-2021. During the financial crisis between 2007-2009, the number of employees increased by 5,745 people, while during the COVID-19 pandemic in 2020, compared to 2019, it decreased by 109. In the case of the rail passenger transport sector in Poland, the number of employees oscillated around the arithmetic mean of 23,914 employees. Between 2003-2007, a downward trend can be observed, followed by a visible increase in 2008 and a downward trend in subsequent years.

Keywords: transport, rail transport, COVID-19, financial crisis, multidimensional data analysis

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Introduction

The article focuses on the following research problem: to what extent have the crises of the 21st century affected the functioning of the rail transport sector in Poland and what changes have they caused? This made it possible to outline the purpose of the work: to conduct a multidimensional comparative analysis of the number of transported goods, passengers and workers employed in the freight and passenger rail sector dynamically.

For the research problem and the purpose of the work, a research thesis was presented: the financial crisis and the COVID-19 pandemic led to fluctuations in the number of transported goods and passengers and influenced the change in the number of employees in both considered sectors.

Multidimensional data analyses were used in the study - the considered dependent variables were outlined on categorized line and bar charts dynamically. This, as a result, made it possible to observe trends, detect similarities and differences in fluctuations of the considered dependent variables in the identical time slots adopted for the study.

Analysis of the literature on the research subject

In the literature, transport is related to activities attributable to supply chain management and paid provision of services in the following fields: movement, storage, packaging[1]. One of the types of transport is rail, considered a safe way to transport loads which include both passengers and goods. It is the second most important branch of transport in Poland after road transport[2]. It includes rolling stock: locomotives, traction vehicles and wagons, as well as: railway lines, platforms, ramps, bridges, culverts, tunnels, railway crossings, railway surface, safety, signaling and communication devices, access roads, pedestrian tracks, lighting, energy processing devices, as well as buildings and structures[3].

There are many parameters by which transport networks can be compared, including the length of railway lines and the density of railway lines per 100 km^2. In 2021, in the Republic of Poland, there were 19,326 electrified railway lines, about 9,000 double-track and 12,000 railway crossings. The length of railway lines in 2021 compared to 2020

[1] M. Stajniak [et.al.], *Transport i spedycja*, Poznań 2008, p. 8.

[2] *Transport kolejowy w Polsce – charakterystyka, wady i zalety. – Geografia*, portal eSzkoła, https://eszkola.pl (21.01.2023).

[3] *Transport kolejowy*, Zintegrowana Platforma Edukacyjna, https://zpe.gov.pl (21.01.2023).

decreased by 135 km. On the other hand, the length of electrified lines increased by 108 km[4]. Of the approximately 12,000 km of electrified lines, one-third was single-track and the other two-thirds were double-track. Single-track lines in Poland account for 53.8% of all operating lines. This is significant in terms of rail capacity and accessibility for passengers and freight operators. The lack of a second track hinders modernization works which most often result in a complete closure of the line for train traffic. The average density of the railway network in Poland is 6.2 km per 100 km^2 and on 46% of railway lines it is possible to travel at a maximum speed of up to 120 km/h, and on 15% of lines up to 160 km/h[5].

Poland is the second largest European country in terms of freight transport by weight[6]. Undoubtedly, rail transport in the 21st century in Poland was influenced by two crisis situations: the financial crisis between 2007-2009 and the COVID-19 pandemic in 2020. The financial crisis between 2007-2009 was triggered in the United States by granting mortgage loans of the lowest subprime standard[7]. Eventually, the real estate market collapsed, leading to the rapid growth of the mortgage bubble. This was the beginning of a huge financial crisis that affected most countries in the world, including Poland[8].

On the other hand, the COVID-19 pandemic was announced on March 11, 2020 by the World Health Organization[9]. It caused an increase in the number of human deaths in the world[10] and stopped the air transport sector around the world, including Poland. It also led to the largest ever increase in the unemployment rate in the world economy leader, the United States, in April 2020[11]. It also caused large

[4] *Linie kolejowe w Polsce – podstawowe parametry*, Urząd Transportu Kolejowego, https://utk.gov.pl (21.01.2023).

[5] *Linie kolejowe w Polsce – podstawowe parametry*, Urząd Transportu Kolejowego, https://utk.gov.pl (21.01.2023).

[6] *Polski transport kolejowy*, SHIPHUB. https://www.shiphub.pl (21.01.2023).

[7] S. Owsiak, *Finanse*, Warszawa 2015, p. 372.

[8] B. Kozicki, *Model planowania potrzeb Sił Zbrojnych RP wobec aktualnych wyzwań bezpieczeństwa narodowego XXI wieku*, Warszawa 2022, pp. 30-31.

[9] E. Satomi [et.al.], *Alocação justa de recuros de saúde escassos diante da pandemia de COVID-19 Considerações éticas*, „Einstein", 2020, no 18(2), pp. 1-5, DOI: 10.31744 /Einstein_Journal/ 2020AE5775.

[10] B. Kozicki, S. Mitkow, *Analysis of Human Deaths in Regard to Covid-19 Pandemic in European Countries*, „European Research Studies Journal", 2020, vol. XXIII, pp. 213-227, DOI: 10.35808/ersj/1878.

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fluctuations in exchange rates, including the dollar, euro, franc, pound, zloty[12].

The repercussions of the crises had an influence on the level of economic security of many sectors of the economy, including freight and passenger rail transport[13]. Security in the literature is interpreted in a variety of ways. According to Pokruszyński, it is a state and process of striving, survival and development[14]. It is also considered a theory and practice to ensure the existence (survival) of a given entity in an uncertain environment while maintaining the freedom to pursue its own interests[15]. According to Kitler, it is the primary, existential need of individuals, social groups, and finally states[16]. It is considered one of the basic needs, such as health, freedom or dignity, it has also become one of the universal goods, such as truth or justice, a kind of universal law, a universal human value.

One of the types of security is the economic security[17]. According to Nurzyńska, it is the lack of threats, including access to the market, financial resources, natural resources that ensure the economic development of countries and their appropriate position on the international arena[18]. The impact of the financial crisis between 2007-2009 and the COVID-19 pandemic affected the level of economic security through strong fluctuations in the number of transported loads, an increase in inflation and unemployment.

In the article, with the use of multidimensional data analyses, the authors decided to present[19] fluctuations of dependent variables such as the number of goods transported by rail in Poland, passengers or employees

[12] M. Jurgilewicz [et.al.], *Contemporary challenges for the economic security of enterprises in Poland*, "Journal of Security and Sustainability", 2022, Issues 12, pp. 71-80, https://doi.org/10.47459/jssi.2022.12.6

[13] *Wpływ pandemii na rynek kolejowy w Polsce i w Europie*, Urząd Transportu Kolejowego, https://utk.gov.pl (21.01.2023).

[14] W. Pokruszyński, *Bezpieczeństwo. Teoria i praktyka*, Józefów 2012, p. 57.

[15] S. Koziej, *Podstawy bezpieczeństwa*, Warszawa 2009, p. 6.

[16] W. Kitler, *Bezpieczeństwo narodowe RP. Podstawowe kategorie. Uwarunkowania. System*, Warszawa 2011, p. 23.

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[19] M. Łuniewska, W. Tarczyński, *Metody wielowymiarowej analizy porównawczej na rynku kapitałowym*, Warszawa 2006, pp. 9-10; K. Nermend, *Metody analizy wielokryterialnej i wielowymiarowej we wspomaganiu decyzji*, Warszawa 2017, pp. 55-56.

in dynamically during the impact of crises in the 21st century. The following indices were used: dynamic indices with a fixed base, arithmetic mean or median[20].

Multidimensional comparative analysis of the rail transport sector in Poland between 2004-2021

The research began with the presentation in Figure 1 of the number of goods transported by rail in thousands of tons in six European countries between 2003-2021. The observed large disparity between the obtained results as the sum of the transported goods became a premise for the selection of three scale values.

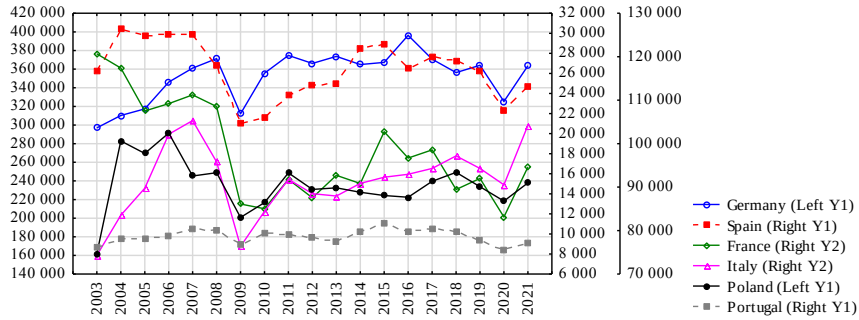

Fig. 1. Categorized line chart of the number of goods transported by rail in thousands of tons in six European countries between 2003-2021 (scale values: Germany - left Y axis; Spain, Poland, Portugal - right first Y axis; France, Italy - second right axis Y axis)

Source: own study based on data obtained from the website: https://ec.europa.eu/ (21.01.2023).

Observation of the data in Figure 1 shows that most goods were transported in Germany: 6,330,516 tons. Poland was in the second place: 4,245,064 tons of transported goods. The following places were taken by: France (1,771,226 tons); Italy (1,632,313 tons); Spain (476,778 tons) and Portugal (176,737 tons). This made it possible to observe the fluctuations of respective dependent variables dynamically. These fluctuations are visible during the impact of two global crises: the financial crisis between 2007-2009 and the COVID-19 infectious disease pandemic in 2020.

[20] J. Górniak, J. Wachnicki, *Pierwsze kroki w analizie danych*, Kraków 2013, pp. 99-113.

Analyzing the financial crisis from the beginning of the 21st century, decreases in the number of goods transported by rail were observed in each of the six European countries under consideration between 2007 and 2009. The decrease ranking from highest to lowest is as follows:

1. Germany (decrease by 49,029 tons, i.e. by 13.916% of the arithmetic mean of goods transported between 2003-2021);
2. Poland (decrease by 44,488 tons, i.e. 18.855% of the arithmetic mean of goods transported between 2003-2021);
3. Italy (decrease by 28,978 tons, i.e. 31.706% of the arithmetic mean of goods transported between 2003-2021);
4. France (decrease by 25,088 tons, i.e. 25.547% of the arithmetic mean of goods transported between 2003-2021);
5. Spain (decrease by 8,831 tons, i.e. 33.458% of the arithmetic mean of goods transported between 2003-2021);
6. Portugal (decrease by 1,609 tons, i.e. 16.454% of the arithmetic mean of goods transported between 2003-2021).

In the case of the COVID-19 pandemic in 2020, compared to 2019, a decrease in the number of goods transported by rail was also recorded in selected European countries. The decrease ranking is shown below:

1. Germany (decrease by 38,817 tons, i.e. 11.017% of the arithmetic mean of goods transported between 2003-2021);
2. Poland (decrease by 15,363 tons, i.e. 6.511% of the arithmetic mean of goods transported between 2003-2021);
3. France (decrease by 8,854 tons, i.e. 9.016% of the arithmetic mean of goods transported between 2003-2021);
4. Spain (decrease by 4,014 tons, i.e. 15.208% of the arithmetic mean of goods transported between 2003-2021);
5. Italy (decrease by 3,766 tons, i.e. 4.121% of the arithmetic mean of goods transported between 2003-2021);
6. Portugal (decrease by 939 tons, i.e. 9.603% of the arithmetic mean of goods transported between 2003-2021).

The data shows that the leaders in the study of decreases in the number of transported goods are in both cases Germany, followed by Poland. The subsequent places in the ranking from third to fifth change when we compare two periods: 2007-2009 and 2020. In both cases, the ranking is closed by Portugal with the lowest recorded decrease in the number of transported goods dynamically.

The next stage of the research was the analysis of the number of passengers transported by rail in four European countries between 2004-2021.

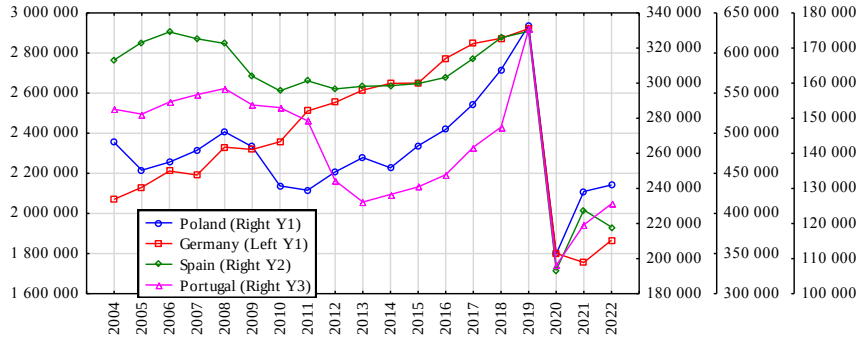

Fig. 2. Categorized line chart of the number of passengers transported by rail in four European countries between 2004-2021 (scale values: Germany - left Y axis; Poland - right first Y axis; Spain - right second Y axis; Portugal - right third Y axis)

Source: own study based on data obtained from the website: https://ec.europa.eu (21.01.2023)

The data in Figure 2 shows that during the financial crisis between 2007-2009 there was a decrease in the number of passengers in two of the four countries considered:

1. Spain (decrease by 46,593, or 8.422% of the arithmetic mean of the number of passengers transported between 2004-2022);
2. Portugal (decrease by 2,923, i.e. 2.058% of the arithmetic mean of the number of passengers transported between 2004-2022).

The other two countries recorded an increase in the number of passengers transported. The leader in the increase ranking was Germany. Between 2007-2009, there was an increase by 127,236 passengers, i.e. by 5.321% of the arithmetic mean of the number of passengers transported between 2004-2022. In the period under consideration, Poland recorded an increase of 1928 passengers, i.e. 0.739% of the arithmetic mean of the number of passengers transported between 2004-2022.

Comparing 2020 to 2019, it was observed that, as in the case of the freight rail transport sector, there was a decrease in the number of transported loads - in this case, passengers. It should be emphasized that the number of passengers during the COVID-19 pandemic was much higher than in the case of goods. The arithmetic mean of the decreases in the four countries under consideration from 2019 to 2020 is about 49%.

The ranking of decreases in the number of passengers transported between 2019 and 2020 was as follows:

1. Germany - decrease by 1,120,519 passengers, i.e. by 47% of the arithmetic mean of passengers transported between 2004-2022;

2. Spain - decrease by 297,629 passengers, i.e. by 54% of the arithmetic mean of passengers transported between 2004-2022;
3. Poland - decrease by 130,270 passengers, i.e. by 50% of the arithmetic mean of passengers transported between 2004-2022;
4. Portugal - decrease by 67,294 passengers, i.e. by 47% of the arithmetic mean of passengers transported between 2004-2022.

The next stage of the research was the analysis of the number of workers employed in the rail transport sectors (passenger and freight) between 2003-2021.

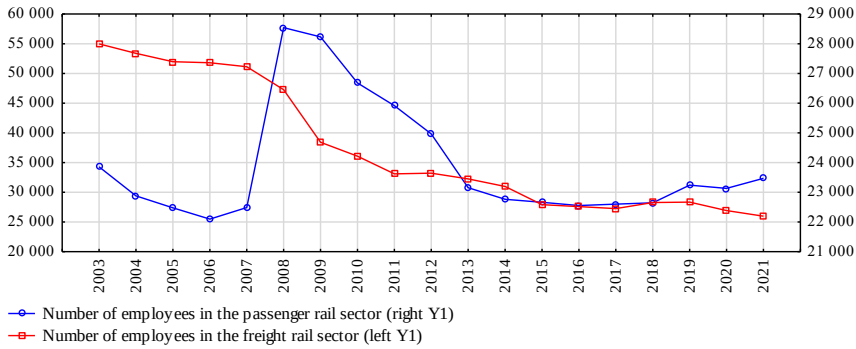

Fig. 3. Categorized line chart of the number of employees in the rail transport sector (passenger and freight) between 2003-2021 (scale values: number of employees in the freight transport sector - left Y axis; number of employees in the passenger transport sector - right Y axis)

Source: own study based on data obtained from the websites: *Zatrudnienie w sektorze pasażerskim*, Urząd Transportu Kolejowego, https://utk.gov.pl (21.01.2023).

The data in Figure 3 indicate that in the rail freight transport sector between 2003-2021 there is a visible decreasing trend in the number of employees. From 2003 to 2021, the number of employees decreased by 29,000 people. The biggest decreases were between 2007 and 2009: 12,713 employees. On the other hand, during the impact of the COVID-19 pandemic, a decrease of 1,411 employees was recorded.

Considering the rail passenger transport sector, a decrease in the number of employees by 385 was observed between 2003-2021. During the financial crisis of 2007-2009, the number of employees increased by 5,745 people, while during the COVID-19 pandemic in 2020, the number decreased by 109.

Next, for illustrative purposes, Figure 4 presents data on dynamics indices with a constant base of employees in the rail transport sectors: passenger and freight between 2003-2021.

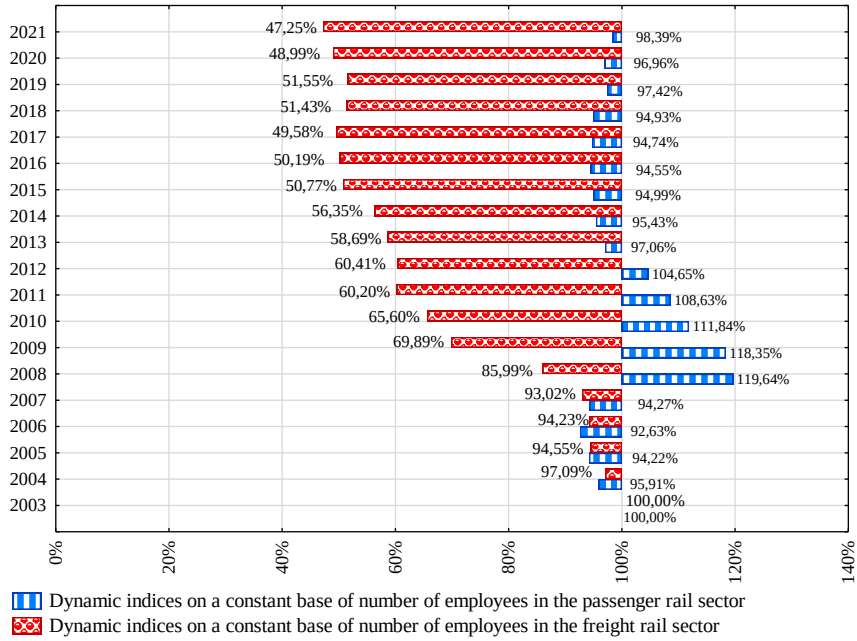

Fig. 4. Categorized bar chart of dynamics indices on a constant base of the number of workers employed in the rail transport sectors (passenger and freight) between 2003-2021 (constant value - the number of employees in the individual railway transport sectors under consideration in 2003)

Source: own study based on data obtained from the websites: *Zatrudnienie w sektorze pasażerskim*, Urząd Transportu Kolejowego, https://utk.gov.pl (21.01.2023).

Observation of the information presented in Figure 4 confirms the strong downward trend in the number of employees in the rail freight transport sector between 2003-2021 and the largest decrease in the number of employees between 2007-2009. Then, the decline was 23.13%.

In the case of the rail passenger transport sector, the number of employees oscillated around the arithmetic mean of 23,914 employees. Between 2003-2007, a downward trend can be observed. Then, in 2008 an increase, and between 2008-2014 – a decrease. The period of 2014-2021 marks a similar level of the number of employees with a slight upward trend, broken by a slight decrease in 2020 caused by the COVID-19 pandemic.

For illustrative and research purposes, Figure 5 presents a comparative analysis of the number of employees in respective positions in both sectors in 2021.

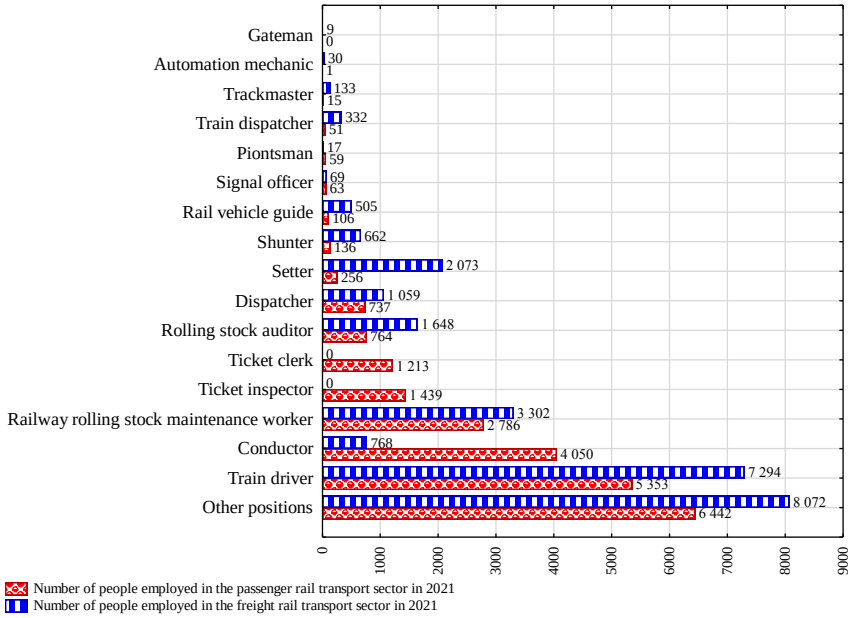

Fig. 5. Categorized bar chart of the number of workers employed in positions in respective sectors of rail transport (passenger and freight) in 2021.

Source: own study based on data obtained from the websites: *Zatrudnienie w sektorze pasażerskim*, Urząd Transportu Kolejowego, https://utk.gov.pl (21.01.2023).

The largest number of employees in both sectors is in the group of positions including other positions: 8,072 people in the freight rail sector and 6,442 in the passenger rail sector. In the second place in the ranking is the train driver position with 7,294 people employed in the freight sector and 5,353 in the passenger sector. On the other hand, in the third place in the case of the rail freight transport sector is the position called railway rolling stock maintenance worker with the number of employees in 2021 amounting to 3,302 people and, in the case of the passenger sector, the conductor with the number of employees 4,050.

There are two jobs in passenger rail transport that are not found in the freight sector: ticket inspector (1,439 employees) and ticket clerk (1,213 employees). On the other hand, in the passenger sector, there were no records of people employed in the position of a gateman. In the freight rail sector, 9 workers were employed in this position in 2021.

The arithmetic mean of the difference in the number of employees in respective positions in the two analyzed sectors is 850 while the median is 516.

Conclusions

Between 2003-2021, the largest number of goods from the six analyzed European countries was transported by rail in Germany: 6,330,516 tons. The second place was taken by Poland: 4,245,064 tons. The third place - France: 1,771,226 tons. Portugal was ranked last: 176,737,000 tons of transported goods.

The conducted research shows that in the ranking of decreases in the number of transported goods during the financial crisis between 2007-2009, Germany ranks first with a score of 49,029 tons. The second one is Poland with a decrease of 48,488 tons of goods and the third place is Italy. There was a decrease here by 28,978 tons. The smallest decrease in the number of transported goods during the financial crisis was recorded in Portugal (a decrease of 1,609 tons).

The COVID-19 pandemic also caused decreases in the number of transported goods in four European countries under consideration. The leader in the classification of the largest decreases during the pandemic (between 2019 and 2020) is Germany: 38,817 tons. The second place was taken by Poland: a decrease of 15,363 tons On the other hand, France was in the third place where a decrease of 8,854 tons was recorded. The slightest decreases were recorded in Portugal - 939 tons.

Analyzes show that the leaders in the decrease in the number of transported goods in both analyzed crises are Germany followed by Poland. The subsequent places in the ranking from the third to the fifth position change when we compare the periods: 2007-2009 and 2020.

During the impact of the financial crisis between 2007-2009, there was a decrease in the number of passengers transported in two of the four countries considered. The largest decreases were recorded in Spain and Portugal. The leader in the passenger increase ranking was Germany. The second place was taken by Poland.

However, the leader in the ranking of decreases in the number of passengers transported between 2019 and 2020 was Germany. The second place was taken by Spain and the third one by Poland.

The analyzes show that in the freight rail transport sector in Poland between 2003-2021, a decreasing trend in the number of employees is visible. From 2003 to 2021, the number of employees decreased by 29,000 people. The largest decreases (12,713 employees) were between 2007-2009. On the other hand, during the impact of the COVID-19 pandemic, a decrease in employment was recorded at the level of 1,411 employees.

Considering the passenger rail transport sector in Poland, a decrease in the number of employees by 385 was observed between 2003-2021.

During the financial crisis of 2007-2009, the number of employees increased by 5,745 people whereas, during the COVID-19 pandemic in 2020, the number decreased by 109 employees.

This was also confirmed by the dynamics indices with the constant base outlined in the categorized bar chart, where a strong downward trend in the number of employees between 2003-2021 was observed in the freight rail transport sector in Poland, as well as a strong decrease in the number of employees between 2007-2009 amounting to 23.13%. In the case of the passenger rail transport sector in Poland, the number of employees oscillated around the arithmetic mean of 23,914 employees. Between 2003-2007, a downward trend can be observed. Then, in 2008 an increase and from 2009 a decreasing trend in the number of employees. The most employees in both sectors are in the group of positions called other positions: 8,072 in the freight rail sector and 6,442 in the passenger rail sector. The second place in the ranking was the train driver position: 7,294 employed in the freight sector and 5,353 in the passenger sector. On the other hand, the third place in the case of the freight rail transport sector was the position called railway rolling stock maintenance worker with the number of employees in 2021 amounting to 3,302 people and, in the case of the passenger sector, the conductor with the number of 4,050 employees.

The above analyzes confirmed the research thesis adopted at the beginning that the financial crisis and the COVID-19 pandemic led to fluctuations in the number of transported goods and passengers and influenced changes in the number of employees in both considered sectors of rail transport in Poland. The decrease in the number of transported loads in Poland led to a decrease in the revenues of respective rolling stock management companies and forced changes in the rail freight transport sector related to the dismissal of employees, especially between 2007-2009. One of the ways of handling crises was the introduction of numerous regulations at the level of the European Union and within respective countries concerning, among other things, the payment of partial financial compensation related to the losses incurred.

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Wpływ kryzysów w XXI wieku na sektor transportu kolejowego w Polsce w aspekcie zachowania bezpieczeństwa ekonomicznego

Streszczenie

W artykule przeprowadzono badania dotyczące wpływu kryzysu finansowego w latach 2007-2009 oraz pandemii COVID-19 w 2020 roku na sektor transportu kolejowego towarowego i pasażerskiego. W opracowaniu zastosowano wielowymiarowe analizy porównawcze. Pozyskane do badań dane poddano grupowaniu. Następnie zestawiano je na skategoryzowanych wykresach liniowych i słupkowych. Z przeprowadzonych badań wynika, że w czasie kryzysu finansowego pomiędzy 2007 a 2009 rokiem zaobserwowano spadek liczby przewiezionych towarów o 48 488 tys. ton. W okresie pandemii CO-

VID-19 pomiędzy 2019 i 2020 rokiem również widoczny był spadek liczby towarów – o 15 363 tys. ton. Natomiast rozpatrując liczbę przewiezionych pasażerów, w czasie kryzysu finansowego pomiędzy 2007 a 2009 rokiem w Polsce nastąpił wzrost o 1928 osób, a w okresie oddziaływania COVID-19 w 2020 w porównaniu do 2019 roku spadek o 130 270 pasażerów. Badając sektor pasażerskiego transportu kolejowego w Polsce, zaobserwowano w latach 2003-2021 spadek liczby zatrudnionych o 385 pracowników. W czasie kryzysu finansowego pomiędzy 2007 a 2009 rokiem odnotowano wzrost liczby zatrudnionych o 5745 osób, natomiast w czasie pandemii COVID-19 w 2020 roku w porównaniu do 2019 roku spadek o 109. W przypadku sektora pasażerskiego transportu kolejowego w Polsce liczba zatrudnionych oscylowała wokół średniej arytmetycznej 23 914 pracowników. W latach 2003-2007 zaobserwować można trend malejący, a następnie w 2008 roku silny wzrost i w kolejnych latach tendencję malejącą.

Słowa kluczowe: transport, transport kolejowy, COVID-19, kryzys finansowy, wielowymiarowa analiza danych