Changes in Cargo Transport in the European Union in the Face of the COVID-19 Pandemic

MONIKA CISZEWSKA, BEATA SLUSARCZYK, DALIA STREIMIKIENE

Abstract

A major shift has been observed recently in the transport industry due in no small part to the COVID-19 pandemic. The purpose of this paper was to determine the changes that occurred on the cargo transport market during that period. In order to examine these changes, an analysis of which mode of transport was most popular in the European Union during 2019-2021 was conducted. For this purpose, a comparative analysis of secondary data which demonstrated whether the proportions of specific modes of transport in the overall volume of cargo shipments were similar before the declaration of the COVID-19 pandemic and during the time when the pandemic unfolded was carried out. The results of the study confirmed the prevalence of road transport, and the market position of that mode of transport was further strengthened during the pandemic. The review further covered the shifts in the proportions of the specific modes of transport in the EU member states during the study period. The review established that these shifts were comparable across all the member states, even though the most dramatic change occurred with regard to road transport. Finally, a linear regression model was developed to investigate whether a linear relationship exists between the volume of cargo shipments undertaken by means of road transport and the external and internal factors defined in the literature on the subject as having had the greatest impact on the transport services market.

Key words

transport, cargo transport in the European Union, COVID-19 pandemic.

DOI: 10.23762/FSO_VOL11_NO3_2

Monika Ciszewska
e-mail: monika.ciszewska@pcz.pl
Czestochowa University of Technology,
Faculty of Management

Beata Slusarczyk[1]
e-mail: beata.slusarczyk@pcz.pl
Czestochowa University of Technology,
Faculty of Management
North-West University,
Trade and Development;
Potchefstroom Campus

Dalia Streimikiene
e-mail: Dalia.streimikiene@lei.lt
Institute of Sport Science and Innovations,
Lithuanian Sports University
Kaunas, Lithuania

[1] Corresponding author

Introduction

The paper takes up the subject of cargo transport in the European Union immediately after the declaration of the COVID-19 pandemic and during the

Paper received: 15 May 2023 • Paper revised: 20 August 2023 • Paper accepted: 22 September 2023

subsequent period of that pandemic. The majority of the existing body of research published during that period and relating to the subject matter of this study focused on the presentation of the situation in air and sea transport in Asian countries. The authors of this paper, on the other hand, intended to present the changes that occurred in all modes of cargo transport in specific European Union member states. Not only did the study demonstrate the restructuring of cargo transport in the European Union, but it also identified the mode of transport which underwent the most rapid transformation. In addition, the authors decided to examine whether a statistically significant linear relationship existed between the external and internal factors defined in the literature as having had the greatest impact on cargo transport before the pandemic. These statistics were developed for one of the most popular European modes of transport, namely road transport.

1. Literature review

Transport means the movement of people or cargo from a starting point to a destination using adequate means of transport for the specific modes of transport. In light of the subject matter of this article, special attention is paid further in the paper to one type of transport, specifically cargo transport, which plays an important part in the economy (Pawlak, 2015; Sośniak and Szkutnik, 2020) as it stimulates economic growth. At the same time, it should be noted that economic growth strongly affects cargo transport as well (Kulpa, 2009). What can be inferred from the above is that any changes affecting the economy are also relevant to transport, while any disruptions to transport processes determine the economic situation. Hence, it should be noted at this point that the relationship between transport and economic growth is multifaceted, complex, and dynamic, shifting along with the changes that take place in the more or less distant environment (Bernacki, 2010). Demand for transport services is therefore not only formed on the national level but also on the European (Suproń, 2016) and global levels.

In addition to the prevailing economic situation, there are other factors influencing the demand for transport services as well. Among all the determinants of transport services, external, internal and institutional factors are mentioned (Pawłowska, 2009; Pawłowska, 2015). External factors obviously include factors originating from outside the transport sector. In this case, one should primarily mention the fuel and energy market (Kozłowski et al., 2016; Dieaconescu et al., 2022), the aforementioned condition of the economy, demographic changes, technological changes and social changes (Kulińska et al., 2018; Grondys et al., 2021). The factors from inside the transport sector include the changes occurring within the infrastructure (Banerjee et al., 2020; Gnap et al., 2021; Daroń, 2022) as well as the changes in the technologies employed in transport (e.g. in vehicles, fuels, infrastructure facilities, etc.). Institutional factors, on the other hand, are the drivers of transport business decisions as well as the development of the transport sector stemming from the policies pursued (Pawłowska, 2015; Berg, 2017).

The empirical part of the article focuses on the external and internal growth factors applicable to transport. Taking the aforementioned areas of influence into account, secondary EUROSTAT data were reviewed. This was followed by the selection of quantitative data which best represent the studied area of influence. Consequently, a list was produced which is presented in Table 1.

Table 1. Groups of external and internal factors determining the market for transport services with corresponding quantitative variables defining the specific areas of influence

Specification of factors	Area of influence of the specific group of factors	Numerical data representing the area of influence of the specific group of factors
External factors	Fuel and energy market	• Oil and oil products supplied to the domestic market; • Petrol stocks; • Diesel stocks.
	State of the economy	• Gross Domestic Product (GDP); • GDP per capita; • Harmonised Index of Consumer Prices (HICP);
	Demographic changes	• Total fertility rate; • Crude death rate.
	Technology changes	• Research and development expenditure, in million €; • Research and development expenditure, in € per capita; • Internet access in households.
	Social changes	• Population; • Unemployment rate.
Internal factors	Transport infrastructures (differ by mode of transport)	• Length of railway lines; • Length of motorways.
	Volume of shipments (differs by mode of transport)	• Cargo transport by rail; • Road transport of cargo; • Inland waterway cargo transport; • Cargo transport by sea; • Cargo and mail transport by air.

Source: own research

The data presented in Table 1 were used to estimate the linear regression model. 13 different data types were allocated to external transport determinants, while seven types of quantitative data were distinguished among the internal drivers. The areas of influence identified could be described with a higher volume of numerical data. However, the authors of the article placed emphasis on the completeness of the selected data and on the data referring to the 2013-2021 perspective.

Two events had the greatest impact on the cargo transport sector during the last two decades. The first of these was the global economic crisis on the financial and banking markets, which peaked during 2008-2009 (Kłos, 2009) and which greatly affected the global economy, thus having an impact on the condition of the transport industry. The other occurrence that had a significant impact on cargo transport service providers was the COVID-19 pandemic (Nundy et al., 2021; Zhang et al., 2021; Mofijur et al., 2021), declared by the World Health Organization (WHO) on 11 March 2020. For a certain time, the pandemic led to a partial shutdown of the economies of

many countries (Gomes and Lopes, 2022; Ahmed et al., 2020), disrupting mobility and transport (Rovňák et al., 2022) and bringing about significant changes on the freight transport market (Łącka and Suproń, 2021).

Since 2020, research papers have begun to mention the impact the pandemic has had on transport. Initially, researchers from various parts of the world would focused on analysing the effect of COVID-19 on air transport (e.g. Nižetić, 2020; Li, 2020; Yong-feng et al., 2020; Rahman et al., 2020; Robinson et al., 2020; Forsyth et al., 2020; Serrano and Kazda, 2020). Besides that, a large volume of articles studied the effect of the pandemic on the transport preferences and behaviours of the general population (Labonté-LeMoyne et al., 2020; Chan et al., 2020; Barbieri et al., 2020; Song and Choi, 2020; Wielechowski et al., 2020; Navickas et al., 2022), while cargo transport matters were only rarely mentioned (Choi and Park, 2020). More papers on cargo transport were published in 2021. Again, the emphasis in these papers was primarily on air transport (Shaban et al., 2021; Bartle et al., 2021; Bierwirth et al., 2021), followed by sea transport (Narasimha et al., 2021; Rahmawan Destyanto et al., 2021; Delibasic, 2022). However, research on the impact of the pandemic on road transport has recently been published (Fang, 2021; Gabedavaa and Khvedelidzeb, 2021). During the following years (2022-2023), research papers were published on cargo transport in Europe as well (Zaharia et al., 2022, Settembri and Kumar, 2023; Elbert et al., 2023). What was clearly missing was a publication describing the changes that occurred in cargo transport in the European Union, which would cover the changes of their structure during the crucial period after the declaration of the COVID pandemic. This article was developed by the authors focusing on an examination of that particular period.

2. Methodology

The research for this paper covered cargo transport in the European Union. The purpose of the research was to present the changes that occurred in cargo transport during the period of the COVID-19 pandemic and to determine whether a statistically significant relationship exists between the external and internal factors relevant to this mode of transport.

The main research problems have been stated as follows:

- What were the changes in the proportions of specific modes of transport in cargo shipments in 2020 compared to 2019?
- Does a statistically significant dependence exist between the volume of shipments carried in cargo transport and the external and internal factors affecting the transport services market?

Certain research hypotheses have been developed on the basis of the research problems.

The first primary hypothesis was as follows:

H1: The utilisation of specific modes of transport as percentages of the entire volume of cargo shipments in the European Union in 2020 (the year in which the COVID-19 pandemic was declared) did not change significantly in comparison to 2019 (the year preceding the pandemic).

This hypothesis was extended with a secondary hypothesis, as follows:

H1.1: The changes in the proportions of specific modes of transport within the entire volume of cargo shipments were similar across the European Union member states.

Another research hypothesis is also defined in the article, as follows:

H2: A linear relationship exists between the volume of shipments carried within the territory of the European Union

and the quantitative data representing the external and internal drivers of the transport service market.

The following secondary hypotheses were defined on the basis of the second primary hypothesis:

H2.1: A linear relationship exists between the dependent variable, i.e. the volume of shipments carried by road, and the predictors, i.e. the quantitative data representing the external factors affecting cargo transport in the European Union;

H2.2: A linear relationship exists between the dependent variable, i.e. the volume of shipments carried by road, and the predictors, i.e. the quantitative data representing the internal factors affecting cargo transport in the European Union;

One of the quantitative research methods, i.e. document analysis, was used in the course of verifying the first research hypothesis. Among the documents covered by the analysis were data published on the official Web pages of the Statistical Office of the European Union (EUROSTAT) and the Central Statistical Office of the Republic of Poland (GUS). The use of secondary data originating from the aforementioned sources and the application of the linear regression model facilitated the verification of the second research claim.

3. Research results

3.1. Analysis of secondary data

The research was divided into two stages. Stage one covered the analysis of secondary data, including the volume of cargo shipments in the European Union member states measured in thousands of tonnes. In the course of the analysis, the structure of cargo shipments in 2019 and 2020 (the year before and immediately after the declaration of the COVID-19 pandemic by the WHO) was determined; the results are presented in Table 2.

Table 2. Structure of cargo shipments in the EU member states by mode of transport during 2019-2020

Mode of transport	2019	2020	Change in 2020 vs. 2019 [pp.]
Road	52.0%	53.3%	1.30
Rail	12.0%	11.5%	-0.50
Pipeline	3.0%	2.8%	-0.20
Inland waterway	4.1%	4.0%	-0.10
Sea	28.8%	28.2%	-0.60
Air	0.1%	0.1%	0.00

Source: own research based on Żegluga śródlądowa w Polsce w latach 2020 i 2021 [Inland shipping in Poland in 2020 and 2021] (2022), Główny Urząd Statystyczny, Urząd Statystyczny w Szczecinie [Central Statistical Office of the Republic of Poland, Statistical Office in Szczecin], Warszawa, Szczecin, 2022, Ośrodek Statystyki Morskiej [Maritime Statistics Centre], p. 81

Considering the data presented in Table 2, it is reasonable to draw the conclusion that, across all modes of cargo transport, road transport accounted for the highest proportion of total transport in both the years covered by the analysis, followed by sea, rail,

inland navigation, pipeline, and air transport. By comparing the structure of cargo shipping across all modes of transport during the two years of analysis, a relative increase was noticed only in the case of road transport, in this case by 1.3 percentage points. Decreases were recorded for sea transport (-0.6 pp.), rail transport (-0.5 pp.), pipeline transport (-0.2 pp.) and inland water transport (-0.1 pp.). Only for air transport did the situation remain unchanged. The results of the study have brought about the positive verification of the first research hypothesis, namely that the percentages of specific modes of transport across the entire volume of cargo shipments in the European Union in 2020 (the year in which the COVID-19 pandemic was declared) did not change significantly in comparison to 2019 (the year preceding the pandemic).

The next stage of research aimed to verify whether the change in proportions of specific modes of transport in terms of the overall cargo shipping volume, defined in percentage points, was similar across all the member states of the European Union. This task involved gathering the available data on cargo shipments for the particular modes of transport, measured in thousands of tonnes. The structure of shipments was determined in the 27 EU member states on this basis. Afterwards, the estimated percentages were compared, taking the years 2019, 2020 and 2021 into account. The assumption was that a minor difference between the values would be present when the gap is lower or equal to 10 percentage points. The gap was determined on the basis of the following formula:

$$R = x_{max} - x_{min}$$

where x is the difference between the studied variables, given in percentage points.

Shipments of cargo by road were reviewed first (Table 3). The list comprises 26 member states as the volumes of cargo shipped by road were not available for Malta for the period of analysis.

Table 3. Cargo shipments by road transport as percentages of total cargo shipments in the European Union member states and the difference in percentages during the period of analysis

EU Member State	2019	2020	2021	2020-2019 percentage difference [pp.]	2021-2020 percentage difference [pp.]
Belgium	39.50%	39.06%	37.80%	-0.44	-1.26
Bulgaria	59.78%	66.30%	69.47%	6.52	3.17
Czechia	81.58%	81.99%	81.87%	0.41	-0.12
Denmark	61.09%	63.35%	62.21%	2.26	-1.14
Germany	77.09%	78.09%	76.92%	1.00	-1.17
Estonia	32.43%	30.30%	31.53%	-2.13	1.23
Ireland	74.67%	72.91%	73.76%	-1.76	0.85
Greece	64.47%	61.85%	60.31%	-2.62	-1.54

EU Member State	2019	2020	2021	2020-2019 percentage difference [pp.]	2021-2020 percentage difference [pp.]
Spain	73.45%	74.46%	75.46%	1.01	1.00
France	76.09%	76.77%	77.75%	0.68	0.98
Croatia	63.07%	61.60%	62.87%	-1.47	1.27
Italy	57.70%	58.54%	58.11%	0.84	-0.43
Cyprus	79.74%	77.65%	79.79%	-2.09	2.14
Latvia	41.66%	52.78%	56.77%	11.12	3.99
Lithuania	45.71%	48.35%	50.88%	2.64	2.53
Luxembourg	82.55%	81.37%	81.40%	-1.18	0.03
Hungary	73.23%	71.96%	75.57%	-1.27	3.61
Netherlands	40.57%	41.92%	41.17%	1.35	-0.75
Austria	72.83%	72.51%	73.27%	-0.32	0.76
Poland	79.73%	80.60%	80.41%	0.87	-0.19
Portugal	61.41%	59.29%	60.86%	-2.12	1.57
Romania	62.79%	66.57%	67.30%	3.78	0.73
Slovenia	67.58%	70.67%	70.99%	3.09	0.32
Slovakia	75.16%	74.99%	73.45%	-0.17	-1.54
Finland	62.87%	63.85%	64.36%	0.98	0.51
Sweden	65.23%	66.46%	66.76%	1.23	0.30
			R	13.74	5.53

Source: own research based on EUROSTAT data

Compared to 2019, the largest negative difference for the percentage of road transport in all cargo shipping volume in 2020 was observed for Greece, at a level of -2.62 pp. The most significant decrease during 2020-2021, on the other hand, was recorded for Slovakia, at -1.54 pp. The largest growth in percentage terms in both the first and the second period of analysis occurred in Latvia, initially 11.12 pp., and subsequently 3.99 pp. It should be noted that in 2019 and 2020, the gap for all the established values was at 13.74, whereas it was 5.53 for 2020 and 2021. It may therefore be concluded that the change in proportions of the particular modes of transport in cargo shipments in the member states was diverse in the first period of analysis, whereas this diversity was only slight in the second period.

Subsequently, rail transport data were analysed, the results of which are presented in Table 4.

Table 4. Cargo shipments by rail transport as percentages of total cargo shipments in the European Union member states and the difference in percentages during the period of analysis

EU Member State	2019	2020	2021	2020-2019 percentage difference [pp.]	2021-2020 percentage difference [pp.]
Bulgaria	7.80%	7.97%	7.97%	0.17	0.00
Czechia	15.99%	16.21%	16.29%	0.22	0.08
Denmark	3.10%	3.06%	2.52%	-0.04	-0.54
Germany	8.75%	8.14%	9.00%	-0.61	0.86
Estonia	24.39%	20.57%	25.43%	-3.82	4.86
Ireland	0.16%	0.23%	0.20%	0.07	-0.03
Spain	1.25%	1.13%	1.15%	-0.12	0.02
France	4.28%	4.23%	4.46%	-0.05	0.23
Croatia	11.23%	11.44%	11.23%	0.21	-0.21
Italy	5.56%	5.68%	6.13%	0.12	0.45
Latvia	23.44%	16.78%	15.16%	-6.66	-1.62
Lithuania	25.03%	24.13%	22.97%	-0.90	-1.16
Luxembourg	6.58%	6.57%	6.27%	-0.01	-0.30
Hungary	18.89%	19.85%	17.53%	0.96	-2.32
Netherlands	2.51%	2.45%	2.50%	-0.06	0.05
Austria	18.58%	18.95%	18.84%	0.37	-0.11
Poland	12.37%	11.73%	12.10%	-0.64	0.37
Portugal	3.69%	3.81%	3.75%	0.12	-0.06
Romania	14.39%	12.40%	12.60%	-1.99	0.20
Slovenia	16.13%	15.08%	14.60%	-1.05	-0.48
Slovakia	18.64%	18.48%	23.69%	-0.16	5.21
Finland	8.94%	9.36%	9.98%	0.42	0.62
Sweden	9.90%	9.76%	9.82%	-0.14	0.06
			R	7.62	7.53

Source: own research based on EUROSTAT data

Four member states were not included in the analysis of statistical data in this case. Malta and Cyprus do not have railway systems, whilst data was unavailable for Belgium and Greece. The most significant negative shift in the proportion of rail transport within cargo shipments during 2019-2020 was observed in Latvia, while the largest positive shift occurred in Hungary. In as many as 15 cases, the negative or positive shift did not exceed 0.5 percentage points. Moreover, based on the research assumptions, the gap of 7.62 between the analysed values provides grounds for inferring that the changes in the

proportions of specific modes of transport in the overall volume of cargo shipments in the member states were insignificant during 2019-2020. The difference for 2020-2021 was 7.53, which is another indication of minor shifts in the proportion of rail transport in the total volume of cargo shipments in the EU member states. Interestingly, following the initial increase of the share of such shipments in 2019-2020 in Hungary, this proportion recorded the largest decrease in the subsequent period of analysis, by 2.32 percentage points. On the other hand, following a minor decline in the significance of rail transport in Slovakia during the first period of analysis, the change in this area was highest in the subsequent interval, at 5.21.

Another mode of transport studied was inland waterway transport, for which data from 17 EU member states were available for analysis. The results of the analysis are presented in Table 5.

Table 5. Cargo shipments by inland water transport as percentages of total cargo shipments in the European Union member states and the difference in percentages during the period of analysis

EU Member State	2019	2020	2021	2020-2019 percentage difference [pp.]	2021-2020 percentage difference [pp.]
Belgium	21.66%	22.32%	22.61%	0.66	0.29
Bulgaria	9.63%	9.21%	7.99%	-0.42	-1.22
Czechia	0.13%	0.07%	0.06%	-0.06	-0.01
Germany	4.93%	4.71%	4.83%	-0.22	0.12
France	2.99%	2.85%	2.67%	-0.14	-0.18
Croatia	5.05%	5.40%	4.84%	0.35	-0.56
Italy	0.02%	0.05%	0.06%	0.03	0.01
Lithuania	0.01%	0.00%	0.07%	-0.01	0.07
Luxembourg	9.60%	10.42%	10.50%	0.82	0.08
Hungary	3.11%	3.37%	2.76%	0.26	-0.61
Netherlands	21.03%	21.38%	21.65%	0.35	0.27
Austria	1.54%	1.60%	1.50%	0.06	-0.1
Poland	0.15%	0.14%	0.11%	-0.01	-0.03
Romania	8.14%	7.62%	7.05%	-0.52	-0.57
Slovakia	2.58%	2.67%	2.85%	0.09	0.18
Finland	0.12%	0.12%	0.14%	0.00	0.02
Sweden	0.09%	0.13%	0.28%	0.04	0.15
			R	1.34	1.51

Source: own research based on EUROSTAT data

Upon consideration of the changes in the proportions of inland waterway transport to overall cargo shipping in the European Union during 2019-2020, the largest negative shift occurred in Romania, while the largest positive shift was in Luxembourg.

During 2020-2021 Belgium had the most significant positive change and Bulgaria had the greatest negative shift. For the first period of analysis, the gap between the analysed values was at 1.34, followed by 1.51 for the second period. Hence, we may infer that, as in the case of rail transport, the change in inland waterway shipments as a proportion of the total volume of cargo transport was insignificant as well.

Another mode of transport reviewed was transport by sea (Table 6).

Table 6. Cargo shipments by maritime transport as percentages of total cargo shipments in the European Union member states and the difference in percentages during the period of analysis

EU Member State	2019	2020	2021	2020-2019 percentage difference [pp.]	2021-2020 percentage difference [pp.]
Belgium	38.64%	38.40%	39.30%	-0.24	0.90
Bulgaria	16.17%	12.29%	11.29%	-3.88	-1.00
Denmark	34.13%	32.50%	34.18%	-1.63	1.68
Germany	7.08%	6.90%	7.16%	-0.18	0.25
Estonia	43.16%	49.12%	43.03%	5.96	-6.09
Ireland	25.10%	26.78%	25.97%	1.68	-0.82
Greece	35.41%	38.13%	39.66%	2.73	1.53
Spain	23.67%	23.11%	22.13%	-0.56	-0.97
France	14.07%	13.97%	13.09%	-0.09	-0.88
Croatia	16.00%	16.34%	16.01%	0.34	-0.33
Italy	29.95%	29.45%	29.53%	-0.50	0.08
Cyprus	20.17%	22.28%	20.14%	2.11	-2.14
Latvia	33.35%	29.37%	27.64%	-3.99	-1.73
Lithuania	23.69%	23.27%	22.21%	-0.42	-1.06
Malta	99.77%	99.77%	99.53%	0.00	-0.24
Netherlands	35.78%	34.15%	34.58%	-1.63	0.43
Poland	4.97%	4.76%	4.92%	-0.21	0.16
Portugal	33.62%	35.89%	34.38%	2.28	-1.51
Romania	12.99%	11.79%	11.65%	-1.20	-0.14
Slovenia	16.28%	14.24%	14.40%	-2.04	0.16
Finland	28.01%	26.62%	25.47%	-1.39	-1.15
Sweden	24.76%	23.63%	23.13%	-1.13	-0.50
			R	9.94	7.77

Source: own research based on EUROSTAT data

Minor changes in the proportions of sea transport were recorded in the first and second study intervals. The gap of the values was 9.94 percentage points and at 7.77 pp., respectively. This proportion grew most significantly during 2019-2020 in Estonia, to reach 5.96 pp. However, in the same member state, the growth in the relative use of this type of transport fell by as much as 6.09 pp. during 2020-2021, to ultimately reach a lower value than before the WHO declaration of the pandemic. A 3.98 pp. decrease was recorded for Latvia in the first period of analysis, while the largest growth in the second period of analysis occurred in Denmark. However, this growth was offset by a decrease in the relative proportion during 2019-2020.

The least significant percentage shifts occurred for air transport. The gaps defined for this mode of transport would equal 0.40 and 0.24 in the first and second period of analysis, respectively (Table 7).

Table 7. Cargo shipments by air transport as percentages of total cargo shipments in the European Union member states and the difference in percentages during the period of analysis

EU Member State	2019	2020	2021	2020-2019 percentage difference [pp.]	2021-2020 percentage difference [pp.]
Belgium	0.19%	0.23%	0.28%	0.04	0.05
Bulgaria	0.02%	0.01%	0.01%	-0.01	0.00
Czechia	0.02%	0.01%	0.02%	-0.01	0.01
Denmark	0.09%	0.06%	0.09%	-0.03	0.03
Germany	0.11%	0.11%	0.13%	0.00	0.02
Estonia	0.01%	0.01%	0.01%	0.00	0.00
Ireland	0.07%	0.07%	0.07%	0.00	0.00
Greece	0.02%	0.02%	0.02%	0.00	0.00
Spain	0.04%	0.03%	0.04%	-0.01	0.01
France	0.11%	0.10%	0.11%	-0.01	0.01
Croatia	0.01%	0.01%	0.01%	0.00	0.00
Italy	0.06%	0.05%	0.06%	-0.01	0.01
Cyprus	0.09%	0.07%	0.07%	-0.02	0.00
Latvia	0.01%	0.01%	0.02%	0.00	0.01
Lithuania	0.01%	0.01%	0.01%	0.00	0.00
Luxembourg	1.27%	1.64%	1.84%	0.37	0.20
Hungary	0.03%	0.03%	0.04%	0.00	0.01
Malta	0.23%	0.23%	0.47%	0.00	0.24
Netherlands	0.10%	0.10%	0.11%	0.00	0.01
Austria	0.04%	0.03%	0.04%	-0.01	0.01

EU Member State	2019	2020	2021	2020-2019 percentage difference [pp.]	2021-2020 percentage difference [pp.]
Poland	0.01%	0.01%	0.01%	0.00	0.00
Portugal	0.08%	0.06%	0.07%	-0.02	0.01
Romania	0.01%	0.01%	0.01%	0.00	0.00
Slovenia	0.01%	0.01%	0.01%	0.00	0.00
Slovakia	0.01%	0.01%	0.01%	0.00	0.00
Finland	0.05%	0.04%	0.04%	-0.01	0.00
Sweden	0.02%	0.02%	0.02%	0.00	0.00
			R	0.40	0.24

Source: own research based on EUROSTAT data

Upon reviewing the data presented in Table 7, it may be concluded that air transport was least susceptible to changes in the use of this mode of transport as a proportion of the overall cargo shipped across the European Union during 2019-2021. Moreover, no decrease in this percentage was recorded in any of the Member States in the second period of analysis. In the first period of study, the most significant drop occurred in Denmark, but this change in proportion was balanced by a subsequent increase in the following period. The highest increase in 2019-2020 occurred in Luxembourg (0.37 pp.) and in 2020-2021 in Malta (0.24 pp.).

The official EUROSTAT Web pages present the data illustrating the volumes of cargo shipments in transport via pipelines for seventeen member states. On the basis of such data, the use of this mode of transport as a percentage of the overall volume of cargo transport was determined (Table 8).

Table 8. Cargo shipments by pipeline as percentages of total cargo shipments in the European Union member states and the difference in percentages during the period of analysis

EU Member State	2019	2020	2021	2020-2019 percentage difference [pp.]	2021-2020 percentage difference [pp.]
Bulgaria	6.60%	4.22%	3.27%	-2.38	-0.95
Czechia	2.29%	1.72%	1.77%	-0.57	0.05
Denmark	1.59%	1.02%	1.00%	-0.57	-0.02
Germany	2.05%	2.05%	1.97%	0.00	-0.08
Greece	0.11%	0.00%	0.00%	-0.11	0.00
Spain	1.59%	1.28%	1.22%	-0.31	-0.06
France	2.47%	2.08%	1.92%	-0.39	-0.16
Croatia	4.64%	5.21%	5.04%	0.57	-0.17

EU Member State	2019	2020	2021	2020-2019 percentage difference [pp.]	2021-2020 percentage difference [pp.]
Italy	6.72%	6.23%	6.11%	-0.49	-0.12
Latvia	1.53%	1.06%	0.41%	-0.47	-0.65
Lithuania	5.56%	4.23%	3.86%	-1.33	-0.37
Hungary	4.74%	4.79%	4.10%	0.05	-0.69
Austria	7.01%	6.90%	6.35%	-0.11	-0.55
Poland	2.77%	2.77%	2.46%	0.00	-0.31
Portugal	1.21%	0.95%	0.93%	-0.26	-0.02
Romania	1.68%	1.60%	1.40%	-0.08	-0.20
Slovakia	3.61%	3.85%	0.00%	0.24	-3.85
			R	2.95	3.90

Source: own research based on EUROSTAT data

For transport via pipelines, the gap determined for the two periods of analysis was insignificant as well, at 2.95 percentage points and 3.9 pp., respectively. During 2019-2020, the largest positive shift of 0.57 pp. occurred in Croatia. In 2020 and 2021, on the other hand, this growth rate was at 0.05 pp. in the Czech Republic. The most significant decreases were recorded for Bulgaria during the first period (-2.39 pp.) and for Slovakia during the second period (-3.85 pp.).

The results of the study provided grounds for the positive verification of one of the specific hypotheses, stating that the changes in proportions of specific transport modes within the entire volume of cargo shipments were similar across the European Union member states. For all specific cases, there was a minor shift in the proportions of specific modes of transport in the overall cargo shipping volume, at less than 10 percentage points. However, it should be emphasised that as we analyse the gap defined for the difference in percentages during the specific periods for the EU member states, the most prominent changes occurred in 2020 in the case of road transport. It may therefore be concluded that this mode of transport was most susceptible to the impact of the COVID-19 pandemic.

3.2. Linear regression model

The second stage of research aimed to produce an answer to the second research question of whether a statistically significant dependence between the volume of cargo transport shipments and the external and internal factors affecting the market of transport services exists. In order to arrive at an answer to that research question, a second research hypothesis was stated as follows: a linear relationship exists between the volume of shipments carried within the territory of the European Union and the quantitative data representing the external and internal drivers of the transport service market. Whereas road transport played an essential role in shipping cargo in the European Union during the study periods, this mode of transport was taken into account in the process of gathering data and building a linear regression model.

External factors, i.e. 13 types of quantitative data representing five areas of influence, were analysed first. A linear regression

model was used to investigate the existence of a linear relationship between variables. The general form of the model can be shown in the following formula:

$$Y_t = \alpha_0 + \alpha_1 X_1 + \varepsilon_1$$

In this model, the value of α_1 tells us how many units the response variable Y will change by if the explanatory variable X increases by one unit.

At first, an explanation of variable Y was attempted, i.e. the volume of cargo shipments by road transport in particular European Union member states (measured in thousands of tonnes) during the period of 2013-2021, depending on predictors such as:

X1 – oil and oil products supplied to the domestic market;
X2 – petrol stocks;
X3 – diesel stocks;
X4 – Gross Domestic Product (GDP);
X5 – GDP per capita;
X6 – Harmonised Index of Consumer Prices (HICP);
X7 – total fertility rate;
X8 – crude death rate.
X9 – research and development expenditure, in million €;
X10 – research and development expenditure, in € per capita;
X11 – Internet access in households;
X12 – population;
X13 – unemployment rate.

For the specified explanatory variables, coefficients of variation were calculated on the basis of the following formula:

$$V = \frac{s}{\bar{x}} \cdot 100\%$$

where:
V – coefficient of variation
s – standard deviation
$\bar{x}$ – arithmetic mean of the variable value

The calculations for the variables under consideration are shown in Table 9.

Table 9. Linear regression model explanatory variables for external factors – selected descriptive statistics

Variable X	Arithmetic mean	Standard deviation	Coefficient of variation
X_1	481,207.88	21,379.81	4.44%
X_2	14,610.00	417.73	2.86%
X_3	49,677.64	3,172.45	6.39%
X_4	29,078.89	2,174.38	7.48%
X_5	100.00	0.00	0.00%
X_6	102.72	3.28	3.19%
X_7	1.54	0.02	1.42%
X_8	4,715,158.44	318,710.72	6.76%
X_9	282,427.81	30,765.35	10.89%
X_{10}	634.37	66.37	10.46%
X_{11}	85.49	5.32	6.22%
X_{12}	445,036,453.00	2,073,053.53	0.47%
X_{13}	8.77	1.82	20.78%

Key: Explanatory variables which were included in the estimated form of the linear regression model.

Source: own research findings

Following the analysis of the coefficients of variation, it has been determined that only three explanatory variables could be included in the modelling process in this case. The assumption was that in order for the explanatory variables to be included in the model, the coefficient of variation had to be equal to or higher than 10%. These variables included research and development expenditures (measured in € per capita) and the variable rate of unemployment. At this point, the linear regression model was presented as follows:

$$Y_t = \alpha_0 + \alpha_1 X_{9t} + \alpha_2 X_{10t} + \alpha_3 X_{13t} + \varepsilon$$

Regression statistics were determined for these variables (Table 10) as well as a summary of statistics (Table 11).

Table 10. Regression statistics for the analysed variables: volume of shipments and external factors

Regression statistics	
R-multiple	0.941804
R-squared	0.886995
Adjusted R-squared	0.819192
Standard error	179956.9
Observations	9

Source: own research findings

Table 11. Summar of statistics for the analysed variables: volume of shipments and external factors

	Coeffi-cients	Standard error	t Stat	p-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intersection	11044229	3115705	3.544697	0.01648	3035056	19053403	3035056	19053403
X_9	-292.397	242.7051	-1.20474	0.28221	-916.291	331.4959	-916.291	331.4959
X_{10}	136087.1	109812.8	1.239265	0.270243	-146196	418369.8	-146196	418369.8
X_{13}	-202292	159003.1	-1.27225	0.259239	-611022	206438.6	-611022	206438.6

Source: own research findings

Considering the general form of the model and the determined coefficients, Table 11 presents the estimated form of the model:

$$\widehat{Y}_t = 1\ 1044\ 229 - 292{,}397\ X_{9t} + 136\ 087{,}1\ X_{10t} - 202\ 292\ X_{13t}$$

The coefficient of determination R^2 was estimated at 0.886995 in this case, which means that the regression line estimated on the basis of the variables was well adjusted to the data. Further steps were intended to verify whether the explanatory variables were statistically significant, i.e. whether $p < 0.05$. As it transpired from the study results presented in Table 11, none of the explanatory variables (X9, X10, X13) met this criterion.

Therefore, the secondary hypothesis that a linear relationship exists between the dependent variable, i.e. the volume of shipments carried by road, and the predictors, i.e. the quantitative data representing the external factors affecting cargo transport in the European Union, has not been verified.

Verification of the subsequent secondary hypothesis required the collection of secondary data representing the areas of influence of the internal factors on the cargo transport in the European Union during 2013-2021. As in the preceding case, an explanation of variable Y was attempted, i.e. the volume of cargo shipments by road transport in the particular European Union Member States (measured in thousands of tonnes). The following variables were included among the predictors (explanatory variables) in this case:

X1 – length of railway lines
X2 – length of motorways
X3 – cargo transport by rail
X4 – inland waterway cargo transport
X5 – gross weight of goods transported at all ports
X6 – cargo and mail transport by air

Here, coefficients of variation were again calculated for the specified explanatory variables (Table 12).

Table 12. Linear regression model explanatory variables for internal factors – coefficient of variation

Variable X	Arithmetic mean	Standard deviation	Coefficient of variation
X_1	197,973.58	7,876.08	3.98%
X_2	69,158.77	1,490.72	2.16%
X_3	1,500,704.00	46,355.46	3.09%
X_4	533,121.67	18,802.17	3.53%
X_5	3,406,627.89	129,553.17	3.80%
X_6	13,001.56	1,151.80	8.86%

Source: own research findings

Whereas only those explanatory variables were to be included in the linear regression model for which the coefficient of variation was at least 10%, none of the values presented in Table 12 met this criterion. Hence, it is not possible to build a linear regression model that would verify the existence of a linear relationship between the dependent variable, i.e. the volume of shipments carried by road, and the predictors, i.e. the quantitative data representing the internal factors affecting cargo transport in the European Union. As a consequence, the latter secondary research hypothesis could not be verified. In summary, the study has demonstrated that the second research hypothesis, according to which a linear relationship exists between the volume of shipments carried within the territory of the European Union and the quantitative data representing the external and internal drivers of the transport service market, could not be verified.

4. Discussion

In the course of the research procedures, it has been concluded that the COVID-19 pandemic certainly had an impact on the transport sector. These changes were noticeable among the European Union member states as well. The essential conclusion of the study is that the situation strengthened the position of road transport in terms of the overall volume of cargo shipping. Moreover,

the proportions of such shipments in the EU member states during the study period changed most dynamically. It was further found that the least significant percentage shifts were recorded for air transport. Other conclusions were as follows:

1. 2020, i.e. the year in which the COVID-19 pandemic was declared, was a period of significant changes on the transport services market. This outcome is consistent with the results of K. Jureczka's (2022) research, which noted that the transport, shipping and logistics sector was most disrupted by the COVID-19 pandemic in March and April 2020. Moreover, as A. Pomykała (2020) noted, the economic slowdown period in spring stressed the importance of well-functioning supply chains in many countries, as well as the need to respond quickly to the variability of the environment.
2. In 2021, which was the subsequent study period, the situation on the cargo transport market was less dynamic than in the first period of study. In addition, K. Jureczka (2022) noted that the COVID-19 pandemic forced transport companies to implement new solutions in their operations in order to be able to survive. Among these new developments, there was an intense growth of digitalisation in transport. As emphasised by T. Rokicki and K. Wojtczuk (2021), the solutions developed at that time may come useful in the event of another crisis (not only a subsequent pandemic).
3. During the pandemic, the proportion of road transport in the European Union increased. If we compare 2019 and 2020, the growth rate was at 1.3 percentage points. Conversely, decreases were recorded for the other modes of transport. This conclusion is consistent with the results obtained by M. Menes (2022), who stated that the extensive use of road transport for cargo shipments is still characteristic of developed economies, notwithstanding the high costs involved in this type of transport. Moreover, K. Jureczka (2022) observed that the number of shipments carried by road vehicles increased in 2020 (compared to 2019), which could have led to an increase in the proportion of this mode of transport in overall cargo shipping.
4. A minor change in the proportions of specific modes of transport within the overall cargo shipping volumes was observed during 2019-2021 in the European Union member states. The most significant differences (determined by means of the calculation of the gap for the studied values) occurred for road transport, albeit only for 2020. In addition, the gap determined for maritime transport in the same year was nearly 10 percentage points.
5. The following transport modes were least susceptible to the shifts in proportions, in the order below: air transport, inland waterway transport, and transport by pipelines. The reason may be the fact that such shipments are generally a low proportion of the entire volume of shipments, and the economic situation during the pandemic has only affected them to a negligible extent.
6. Three predictors could be used to build a linear regression model for the volume of cargo shipping in road transport in the European Union and the external factors for modelling: research and development expenditures in million €; research and development expenditures in € per capita; and the unemployment rate. However, the conclusion drawn from the modelling process was that the distinguished variables were not statistically significant.
7. A linear regression model could not be defined for the internal factors affecting the volume of cargo shipments by road in the European Union because of the low variability of the studied variables.

Conclusions

Apart from the economic situation, other factors that determine the demand for transport services exist. These factors can generally be divided into external, internal and institutional ones. The situation in the more or less distant environment is also relevant to the volume of cargo shipped. This was recently noticeable during the COVID-19 pandemic, when the transport sector experienced certain interim difficulties related to shipment planning and organisation, which was emphasised in research by Xiang et al. (2021), Lu et al. (2021), Perkumienė et al. (2021), and Dominiak (2022). In many cases, a change of approach was necessary for business operations, particularly the need for a more flexible approach to the services provided, or placing less emphasis on the costs of operations. The role of these measures was to survive the period of hardship. After a certain period of time (approximately one year), the situation on the transport market stabilised, as emphasised by researchers such as K. Jureczka (2022). Tzvetkova (2021) noted that the transport sector in the European Union was still required to face a great deal of difficulty in order to overcome the negative consequences of the COVID-19 pandemic. A certain stabilisation in cargo transport after 2021 was verified by the relevant research. A change in proportions of shipped cargo was observed in almost all modes of transport, albeit air transport was an exception, with the lowest differences in percentages during the study periods. The changes during the pandemic were most dynamic in road transport. In this case, the change in the volume of this mode of transport as a percentage of the overall cargo shipping volume determined for the period of 2019-2020 was the highest, whereas it was no longer so significant in the subsequent period of study, i.e. 2020-2021. Obviously, there were certain limitations to the studies. Specifically, data availability was an issue. For some member states, no official data were available for specific modes of cargo transport. Moreover, examining the transport market conditions in 2022 was not feasible because EUROSTAT had not published the complete data for that period as at the date of submission of this paper. Therefore, it will be more feasible to verify the cargo transport situation in the European Union after 2022 by means of subsequent research.

References

Ahmed, R. R., Streimikiene, D., Rolle, J-A, & Duc, P. A. (2020), The COVID-19 Pandemic and the Antecedents for the Impulse Buying Behavior of US Citizens. Journal of Competitiveness, 12(3), 5–27. DOI: 10.7441/joc.2020.03.01

Banerjee, A., Duflo, E., Qian, N. (2020), On the road: Access to transportation infrastructure and economic growth in China, Journal of Development Economics, 145, 102442. DOI: 10.1016/j.jdeveco.2020.102442.

Barbieri D.M., Lou B., Passavanti M., Hui C., Lessa D.A., Maharaj B. Banerjee A., Wang F., Chang K., Naik B., Yu L., Liu Z., Sikka G., Tucker A., Foroutan Mirhosseini A., Naseri S., Qiao Y., Gupta A., Abbas M., Fang K., Ghasemi N., Peprah P., Goswami S., Hessami A., Agarwal N., Lam L., Adomako S. (2020), A survey dataset to evaluate the changes in mobility and transportation due to COVID-19 travel restrictions in Australia, Brazil, China, Ghana, India, Iran, Italy, Norway, South Africa, United States. Data in Brief. 2020 Dec; 33:106459. DOI: 10.1016/j.dib.2020.106459.

Bartle, J. R., Lutte, R. K., Leuenberger, D. Z. (2021), Sustainability and air freight transportation: Lessons from the global pandemic, Sustainability, 13(7), 3738. DOI: 10.3390/su13073738.

Berg, C. N., Deichmann, U., Liu, Y., Selod, H. (2017), Transport policies and development, The Journal of Development Studies, 53(4), 465-480. DOI: 10.1080/00220388.2016.1199857.

Bernacki, D. (2010), Wzrost gospodarczy a popyt na przewozy towarowe w Polsce, Zeszyty Naukowe Uniwersytetu Szczecińskiego, 603, 17-36.

Bierwirth, B., Brylka, R., Schwanecke, U. (2021), Business process transformation in air cargo Logistics, Global Challenges of Digital Transformation of Markets, 77-92.

Chan, H. F., Skali, A., Savage, D. A., Stadelmann, D., Torgler, B. (2020), Risk attitudes and human mobility during the COVID-19 pandemic, Scientific reports, 10(1), 19931. DOI: 10.1038/s41598-020-76763-2.

Choi, J. H., Park, Y. H. (2020), Investigating paradigm shift from price to value in the air cargo market, Sustainability, 12(23), 10202. DOI: 10.3390/su122310202.

Daroń, M. (2022), Planning of International Transport in the Context of the Condition of Transport Infrastructure in Selected EU Countries, in: K.S. Soliman (Eds.), Business Excellence and Innovation Management: a 2025 Vision to Sustain Economic Development in the Era of Pandemic (pp. 2973-2982), International Business Information Management Association (IBIMA), April 1-2, 2020, Seville, Spain.

Delibasic, M. (2022), Institutional Imbalance of Interests in Maritime Transport and Sustainable Development, Transformations in Business & Economics, 21(1), 263-273.

Dieaconescu, R. I., Belu, M. G., Gheorghe, M. (2022), Impact of Oil Price Evolution on Logistics Industry, Romanian Economic Journal, 25(84), 3-18, DOI: 10.24818/REJ/2022/84/01.

Dominiak, J. (2022), Wpływ pandemii COVID-19 na zmiany w sektorze usług w Polsce, Prace Komisji Geografii Przemysłu Polskiego Towarzystwa Geograficznego, 36(2), 126-136. DOI: 10.24917/20801653.362.8

Elbert, R., Roeper, F., Vanelslander, T., Cavallaro, F. (2023), Freight operations in the European Union during the COVID-19 pandemic: A multicountry comparison, Transportation Amid Pandemics, 143-152. DOI: 10.1016/B978-0-323-99770-6.00021-1.

Fang, T. (2021, February), Research on one belt one road international road transport development strategies under regular epidemic prevention situation, International Conference on Public Management and Intelligent Society (PMIS), Shanghai, China, 2021, s. 337-340. DOI: 10.1109/PMIS52742.2021.00082.

Forsyth, P., Guiomard, C., Niemeier, H. M. (2020), Covid-19, the collapse in passenger demand and airport charges, Journal of air transport management, 89, 101932. DOI: 10.1016/j.jairtraman.2020.101932.

Gabedavaa, G., Khvedelidzeb, P. (2021), Impact of COVID19 on Ports and Maritime Transport (Georgian Ports Response to COVID19), 21st Annual General Assembly of the International Association of Maritime Universities Conference, IAMU AGA 2021, 46-54.

Gnap, J., Senko, Š., Kostrzewski, M., Brídziková, M., Cződörová, R., Říha, Z. (2021), Research on the relationship between transport infrastructure and performance in rail and road freight transport – A case study of Japan and selected European countries, Sustainability, 13(12), 6654. DOI: 10.3390/su13126654.

Gomes, S., Lopes, J. M. (2022), Consequences of the pandemic constraints on the supply chain of companies: an exploratory approach, Polish Journal of Management Studies, Vol. 26, No.2. DOI: 10.17512/pjms.2022.26.2.10.

Grondys, K., Urbański, M., Sudyka, J. (2021), Expert evaluation of road infrastructure management, Roads and Bridges-Drogi i Mosty, 20(4), 465-492. DOI: 10.7409/rabdim.021.028.

https://ec.europa.eu/eurostat.

Jarocka, M. (2016), Innovative pricing policy for transport services. Studia Ekonomiczne, Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach, nr 306, 59-69.

Jureczka, K. (2022), Branża TSL w obliczu pandemii Covid-19, Zeszyty Naukowe Wyższej Szkoły Zarządzania Ochroną Pracy w Katowicach, nr 1(18), 7-13.

Kłos, Z. (2010), Wpływ kryzysu gospodarczego na funkcjonowanie rynku usług transportowych w Polsce, Zeszyty Naukowe Uniwersytetu Szczecińskiego. Ekonomiczne Problemy Usług, nr 46.

Kozłowski, R., Gajewski, R., Pilichowska, K. (2016), Wpływ ceny ropy naftowej na eksport usług transportowych w Europie, in: B. Glinkowska (Eds.), Internacjonalizacja przedsiębiorstw. Uwarunkowania – procesy – wyniki badań (pp. 215-229), Łódź: Wydawnictwo Uniwersytetu Łódzkiego. DOI: 10.18778/8088-492-2.17.

Kulinska, E., Wojtynek, L., Dendera-Gruszka, M. (2018), Sytuacja polskich przedsiębiorstw na rynku usług transportowych, Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie. Ekonomika i Organizacja Logistyki, 3 (1), 83-95. DOI: 10.22630/EIOL.2018.3.1.8.

Kulpa, T. (2009), Transport ładunków – klasyfikacja i przegląd modeli podróży, Zeszyty Naukowo-Techniczne Stowarzyszenia Inżynierów i Techników Komunikacji w Krakowie. Seria: Materiały Konferencyjne, 90, z. 148, 155-176.

Labonté-LeMoyne, É., Chen, S. L., Coursaris, C. K., Sénécal, S., Léger, P. M. (2020), The unintended consequences of COVID-19 mitigation measures on mass transit and car use, Sustainability, 12(23), 9892. DOI: 10.3390/su12239892.

Li, T. (2020), A SWOT analysis of China's air cargo sector in the context of COVID-19 pandemic, Journal of air transport management, 88, 101875. DOI: 10.1016/j.jairtraman.2020.101875.

Lu, L., Peng, J., Wu, J., Lu, Y. (2021), Perceived impact of the Covid-19 crisis on SMEs in different industry sectors: Evidence from Sichuan, China, International Journal of Disaster Risk Reduction, 55(24), 1-9.DOI: 10.1016/j.ijdrr.2021.102085.

Łącka, I., Suproń, B. (2021), The impact of COVID-19 on road freight transport: evidence from Poland, European Research Studies Journal, volume XXIV, special Issue 3, 319-333.

Menes, M. (2022), Miejsce i rola transportu towarowego w gospodarce polskiej na tle Unii Europejskiej, Transport Samochodowy, 66(2), 10-16. DOI: 10.5604/01.3001.0016.2051.

Mofijur, M., Fattah, I. R., Alam, M. A., Islam, A. S., Ong, H. C., Rahman, S. A., Najafi G., Ahmed S.F., Uddin Md. A, Mahlia, T. M. I. (2021), Impact of COVID-19 on the social, economic, environmental and energy domains: Lessons learnt from a global pandemic, Sustainable production and consumption, 26, 343-359. DOI: 10.1016/j.spc.2020.10.016.

Narasimha, P. T., Jena, P. R., Majhi, R. (2021), Impact of COVID-19 on the Indian seaport transportation and maritime supply chain, Transport Policy, 110, 191-203. DOI: 10.1016/j.tranpol.2021.05.011.

Navickas, V., Grencikova, A., Kordos, M., Sramka, M. (2022), The Information and Communications Technologies Usage within the Covid-19 Pandemic Issue", Transformations in Business & Economics, 21, (1), 101-113.

Nižetić, S. (2020), Impact of coronavirus (COVID-19) pandemic on air transport mobility, energy, and environment: A case study, International Journal of Energy Research, 44(13), 10953-10961. DOI: 10.1002/er.5706.

Nundy, S., Ghosh, A., Mesloub, A., Albaqawy, G. A., Alnaim, M. M. (2021), Impact of COVID-19 pandemic on socio-economic, energy-environment and transport sector globally and sustainable development goal (SDG), Journal of Cleaner Production, 312, 127705. DOI: 10.1016/j.jclepro.2021.127705.

Pawlak, P. (2015), Badania popytu przedsiębiorstw na usługi transportowe w Polsce Wschodniej, TTS Technika Transportu Szynowego, 22.

Pawłowska, B. (2009), Challenges for implementation of sustainable transport development in global economy, in: Globalizácia a jej sociálno-ekonomickié dôsledky '09, Elektronický zborník príspevkov z Medzinárodnej Vedeckej Konferencie: 29.09–1.10.2009, Rajecké Teplice, Slovenská Republika.

Pawłowska, B. (2015), Analiza czynników kształtujących popyt na usługi transportowe Unii Europejskiej, Zeszyty Naukowe. Problemy Transportu i Logistyki/Uniwersytet Szczeciński, 30, 87-104. DOI: 10.18276/ptl.2015.30-07.

Perkumienė, D., Osamede, A., Andriukaitienė, R., Beriozovas, O. (2021), The impact of COVID-19 on the transportation and logistics industry, Problems and perspectives in management, 19(4), 458-469. DOI: 10.21511/ppm.19(4).2021.37.

Pomykała, A. (2020), Sektor towarowy w okresie walki ze skutkami Covid-19, TTS Technika Transportu Szynowego, nr 10.

Rahman, N. A. A., Rahim, S. A., Ahmad, M. F., Hafizuddin-Syah, B. A. M. (2020), Exploring COVID-19 pandemic: Its impact to global aviation industry and the key strategy, International Journal of Advanced Science and Technology, 1829-1836.

Rahmawan Destyanto, A., Huang, Y., Verbraeck, A. (2021, May), Examining the spatiotemporal changing pattern of freight maritime transport networks in Indonesia during COVID-19 outbreaks, in Proceedings of the 4th Asia Pacific Conference on Research in Industrial and Systems Engineering, 590-597.

Robinson, J. (2020), Thoughts on the post-pandemic new normal in air travel, Journal of Airport Management, 15(1), 6-19.

Rokicki, T., Wojtczuk, K. (2021), Operation of a transport company during the COVID-19 pandemic, in: T. Rokicki (Eds.), Społeczno-ekonomiczne skutki pandemii COVID-19 (pp. 44-53), Warszawa: Wydawnictwo SGGW.

Rovňák, M., Kalistová, A., Štofejová, L., Benko, M., Salabura, D. (2022), Management of sustainable mobility and the perception of the concept of electric vehicle deployment, Polish Journal of Management Studies, Vol. 25, No .2. DOI: 10.17512/pjms.2022.25.2.17.

Serrano, F., Kazda, A. (2020), The future of airports post COVID-19, Journal of Air Transport Management, 89, 101900. DOI: 10.1016/j.jairtraman.2020.101900.

Settembri, P., Kumar, R. (2023), The Good, the Bad and the Rest: How the European Union Responded to the COVID-19 Pandemic in the Transport Sector, European Journal of Risk Regulation, 1-17. DOI: 10.1017/err.2023.7.

Shaban, I. A., Chan, F. T. S., Chung, S. H. (2021), A novel model to manage air cargo disruptions caused by global catastrophes such as Covid-19, Journal of Air Transport Management, 95, 102086. DOI: 10.1016/j.jairtraman.2021.102086.

Song, K. H., Choi, S. (2020), A study on the behavioral change of passengers on sustainable air transport after COVID-19, Sustainability, 12(21), 9207. DOI: 10.3390/su12219207.

Sośniak, S., Szkutnik, J. (2020), Development and innovation of polish land transport, International Interdisciplinary Scientific Journal (CZ-WNS), issue 3, 1-16.

Suproń, B. (2016), Uwarunkowania i perspektywy rozwoju polskiego sektora transportu drogowego w aspekcie zmian strukturalnych zachodzących w Unii Europejskiej, Europa Regionum, 27, 205-221.

Tzvetkova, S. (2021), The Effect of COVID-19 on Land Transport Within the European Union and Guidelines for its Stable Development, European Journal of Sustainable Development, 10(4). DOI: 10.14207/ejsd.2021.v10n4p20.

Wielechowski, M., Czech, K., Grzęda, Ł. (2020), Decline in Mobility: Public Transport in Poland in the time of the COVID-19 Pandemic, Economies, 8(4). DOI: 10.3390/economies8040078.

Xiang, S., Rasool, S., Hang, Y., Javid, K., Javed, T., Artene, A. E. (2021), The effect of COVID-19 pandemic on service sector sustainability and growth, Frontiers in psychology, 12, 1178. DOI: 10.3389/fpsyg.2021.633597.

Zaharia, S. E., Pietreanu, C. V., Flăminzeanu, M. C. (2022, June), Air Cargo Transport development in Central and Eastern Europe and Baltic countries, 2022 IEEE 6th International Conference on Logistics Operations Management (GOL), 1-10.

Zhang, J., Hayashi, Y., Frank, L. D. (2021), COVID-19 and transport: Findings from a world-wide expert survey, Transport policy, 103, 68-85. DOI: 10.1016/j.tranpol.2021.01.011.

Żegluga śródlądowa w Polsce w latach 2020 i 2021 (2022), Główny Urząd Statystyczny, Urząd Statystyczny w Szczecinie, Warszawa, Szczecin, 2022, Ośrodek Statystyki Morskiej.

Monika Ciszewska PhD. is an assistant professor at the Faculty of Management of the Czestochowa University of Technology. She is the author of more than 40 scientific publications and her scientific interests are: changes in passenger and freight transport, problems related to the strategic management of the urban transport system, the impact of transport on the natural environment. ORCID no.: 0000-0002-8066-2869.

Beata Slusarczyk, Eng., Ph.D. has been the associated professor at Czestochowa University of Technology at the Management Faculty. She also works at Trade and Development at the Potchefstroom Campus of the North-West University as an extraordinary professor. Prof. Beata Ślusarczyk has over 25 years of teaching, research and managerial experience in higher education. Her research interests are in the areas of Industry 4.0, industrial policy, costs aspects of logistic performance, women and family entrepreneurship. Prof. Ślusarczyk has published widely (over 220 publications), and her publications include books, book chapters, refereed journals' papers as well as conference proceedings or books reviews. Reviewer and scientifically boards member in many international journal and conferences. ORCID no. 0000-0002-7276-8372.

Prof. dr. Dalia Streimikiene is full professor at Vilnius University and Leading Researcher at Institute of Sport Science and Innovations of Lithuanian Sports University. D. Streimikiene is regularly being invited to work in the European Commission, the United Nations Economic Commission for Europe, the United Nations Development Programme, the UNFCCC Secretariat, the World Energy Council, the IAEA, the Nordic Council of Ministers and other international institutions as expert on sustainable development and low carbon transition. She has published over 300 papers in WoS referred journals with high IF. She is a co-author of 15 monographs and presented many papers at many international conferences and forums around the world. ORCID no. 0000-0002-7276-8372.