Elżbieta MACIOSZEK[1], Agata KUREK[2]

INTERNATIONAL ROAD CARGO TRANSPORT IN POLAND AND OTHER EU COUNTRIES

Summary. In the modern world, transport as an integral part of social life is important. The development of all modes of transport requires continuous efficient management of the transport process, as well as the use of tools to optimise this process. This article aims to analyse international road cargo transport in EU countries and Poland from 2008-2018. The first part of this article analyses the number of employees and the trade of transport companies in EU countries. Then, the share of individual modes of transport in the transport of cargo in Poland from 2008 and 2018 is presented. The next section presents the results of the forecast of the volume of cargo transported by road in Poland from 2019-2021. The forecast values of the volume of cargo transport in Poland for 2019-2021, which were determined from the additive and multiplicative model, are at a similar level to the values for 2008-2018.

Keywords: cargo transport, cargo transportation, transport company

[1] Faculty of Transport and Aviation Engineering, The Silesian University of Technology, Krasińskiego 8 Street, 40-019 Katowice, Poland. Email: elzbieta.macioszek@polsl.pl. ORCID: https://orcid.org/0000-0002-1345-0022
[2] Faculty of Transport and Aviation Engineering, The Silesian University of Technology, Krasińskiego 8 Street, 40-019 Katowice, Poland. Email: agata.kurek@polsl.pl. ORCID: https://orcid.org/0000-0002-0648-1680

1. INTRODUCTION

In the modern world, transport as an integral part of social life is important [1]. The development of civilisation, mass consumption, specialisation of labour, and the distant location of places of production of products necessary for human existence causes a territorial gap between the producer, seller, and buyer [9]. As distances extend, supply chains also lengthen, resulting in increased demand for transportation services [6]. Road transport is one of the most popular modes of transport in the world [2, 3]. The increase in the share of road cargo transport contributes to the increase in road traffic. On the other hand, the increasing traffic intensity on the roads affects the deterioration of road conditions, lowering the level of safety, and harms the natural environment [4, 5, 8]. In addition to the impact of transport on social life, it is equally important in the economy of any country [7, 11, 14].

A well-developed transport network is a key element for the development of an economy, both domestic and global. In addition, it enables the migration of people and is a link that allows the development of tourism. In the case of many countries in the world, it is strongly related to the real economic growth of the state, that is, the increase in real gross domestic product. Connections of regions in the transport network make it possible to transport cargo between suppliers and recipients. An important aspect is that due to the extensive and dense transport network, the possibility of transporting cargo between countries is ensured [10].

The development of all modes of transport requires the continuous development of transport process management, managing people working in this industry, as well as the use of tools to optimise this process. Appropriate management of any type of enterprise, be it service or production, requires forecasting activities in subsequent periods.

This article aims to analyse international road cargo transport in EU countries and Poland from 2008-2018. It consists of four sections. After the introduction, section two presents an analysis of international road cargo transport in EU countries from 2008-2015. The next section of the article presents the results of the forecast of the number of cargo transportation by road in Poland. Finally, the article ends with a summary.

2. ANALYSIS OF THE INTERNATIONAL ROAD CARGO TRANSPORT IN EU COUNTRIES AND POLAND FROM 2008-2015

Figure 1 shows the number of people employed in transport companies in 2008 and 2015 in individual EU countries. Among all EU countries, Germany had the largest number of employees in transport companies in 2008 (690 700 people). In France, registered people working in transport companies were 651 700, while in Spain - 611 700 people. In 2008, Great Britain and Italy employed over 500 000 people (526 500 and 514 900, respectively). Poland was in fifth place (436 600 people), followed by the Netherlands with 25 000 people. Less than 200 000 employees are registered in Romania (183 500), the Czech Republic (159 100), Sweden (137 900), Hungary (121 600), Greece (114 300), Austria (112, 00), and Portugal (104 100). In 2008, below 2% percentage share was recorded by Belgium, Bulgaria, Denmark, Finland, Lithuania, Latvia, Ireland, Slovakia, Slovenia, Estonia, Luxembourg, Cyprus, and Malta.

In 2015, as in 2008, Germany employed the largest number of employees in transport companies among all EU countries (427 100 people). France was second with 332 400 people. 327 900 people were registered in Poland, which puts Poland in third place among all EU countries that employed the largest number of people in transport companies. Spain, Italy, and the United Kingdom were fourth, fifth and sixth, respectively, with 313 100, 31 000 and

259 700 employees. Romania, the Czech Republic, and the Netherlands had less than 200 000 employees; 133 000, 121 100 and 115 000, respectively. The following countries employed less than 100,000 people in transport companies: Sweden (78 300), Hungary (70 900), Portugal (63 200), Bulgaria (63 100), Austria (59 600), Belgium (58 000), Lithuania (57 400), Finland (45 000), Slovakia (44 500), Denmark (36 100), Greece (30 200), Latvia (25 600), Ireland (22 800), Slovenia (22 400), Croatia (22 100), Estonia (16 000), Luxembourg (7 400), Cyprus (1 900) and Malta (1 200). It can be concluded that the number of employees in transport companies in the EU countries from 2008-2015 decreased by about 40% based on the data presented in Figure 1.
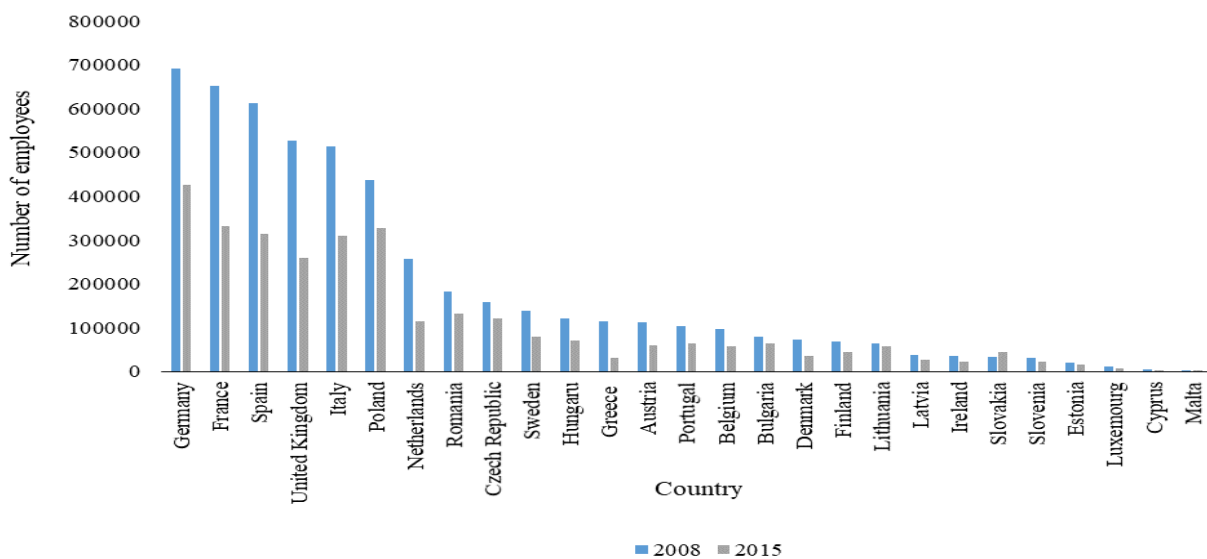

Fig. 1. The number of people employed in transport companies in
individual EU countries in 2008 and 2015
Source: Authors' research based on data presented in [12]

Figure 2 shows the trade of transport companies in EU countries in 2008 and 2015. In 2018, the trade of transport companies in EU countries amounted to EUR 323 106 million. In 2015, however, the trade in total amounted to almost EUR 11 million more than in 2008.

Figures 3 and 4 present the shares of individual EU countries in the export and import of cargo in 2018. Based on the data presented in Figures 3 and 4, it can be concluded that the largest share in the EU countries, both in exports and imports of cargo, is held by Germany and the Czech Republic (around 40 and 10%, respectively). The share of other EU countries in exports and imports ranges from approximately 12 to 2%. Slovakia, which is the third country in the ranking of the largest transport of exported cargo (5.3%), recorded a result of 3.8% in imports in 2018, which gives it the seventh place among EU countries. Italy, with 4.9% of exports, is also fourth in terms of imports (6.4%). A similar situation can be observed in the case of France, which ranks fifth in both exports and imports, with the results of 4.5 and 4.2%, respectively. The Netherlands, with a 4.5% share in exports, ranks fifth, like France, while being in the top three importers of cargo in the EU in 2018 (6.8%). The United Kingdom ranked sixth in exports (4.0%), has a small share in the imports of cargo in the EU (1.7%). The seventh-largest transport of exported cargo is occupied by Hungary (3.5%), reaching 3.9% in imports. Lithuania, which obtained 3.4% in exports, recorded one percentage point less in the share of imports in the EU in 2018. Belgium was ninth in exports and eighth in imports, reaching 3.2 and 3.8%, respectively.
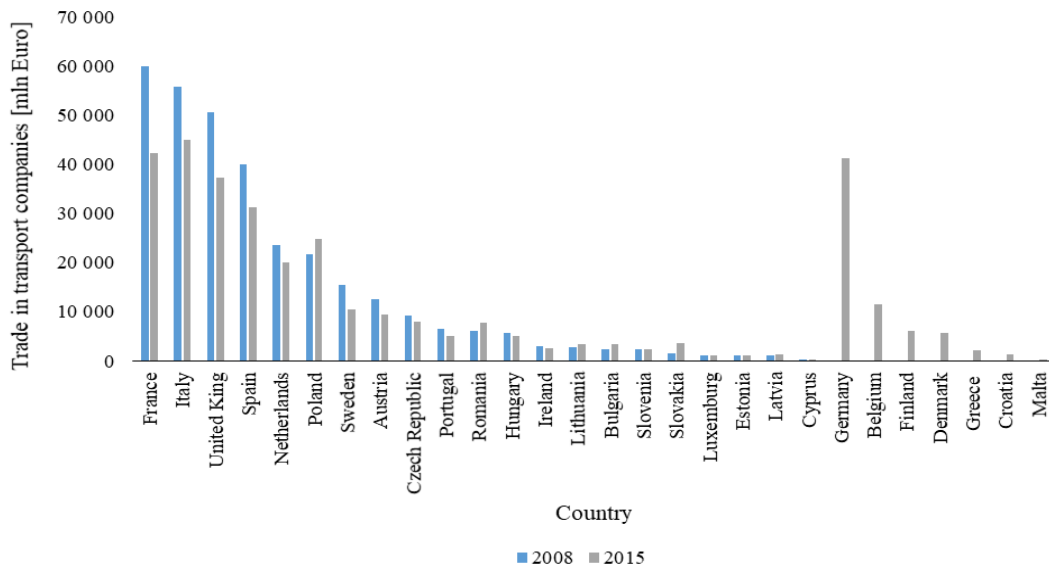
Fig. 2. Trade in cargo in transport companies in
individual EU countries in 2008 and 2015
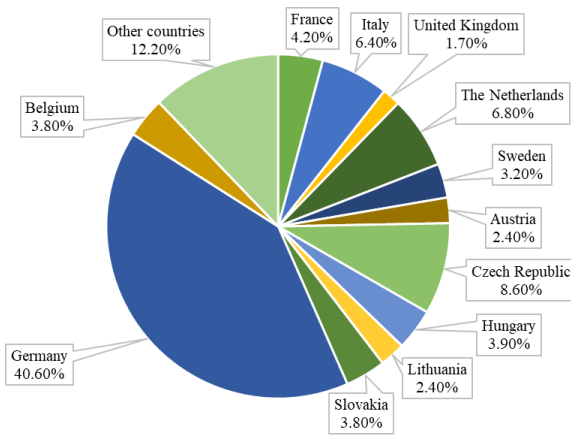Source: Authors' research based on data presented in [12]

Fig. 3. The structure of transport of cargo
imported in individual EU countries in 2018
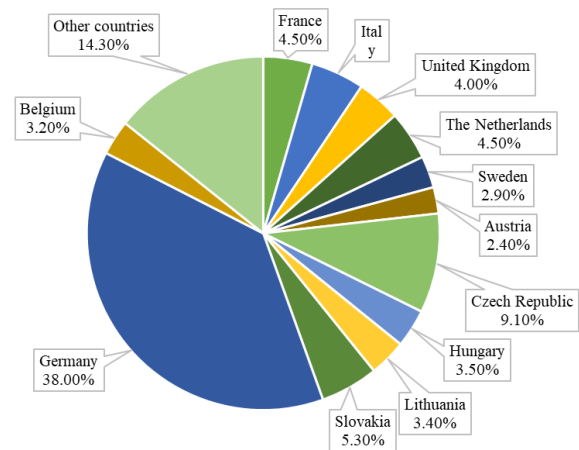Source: Authors' research based on [12]

Fig. 4. The structure of transport of cargo
exported in individual EU countries in 2018
Source: Authors' research based on [12]

Figures 5 and 6 show the share of individual modes of transport in intermodal cargo transport in 2008 and 2018. It can be noted that in 2008, road transport had the largest share in cargo transport in Poland (80.89%) compared to other means of transport. The second most popular means of transporting cargo in 2008 was rail transport (15.03%). Then, the shares of individual forms of transport were successive: pipeline transport − 1.92%, inland shipping − 0.63%, sea shipping − 2.96%. In 2018, there was an increase in the transport of cargo by road (up to 85.50%), in favour of a decrease in the share of cargo transported by other means of transport: rail, inland, and sea transport, which in 2018 amounted to (11.40, 0.20, and 0.40%). It can therefore be concluded that there was a significant increase in the share of cargo transport by road in Poland from 2008-2018, which indicates a significant development of this mode of transport.
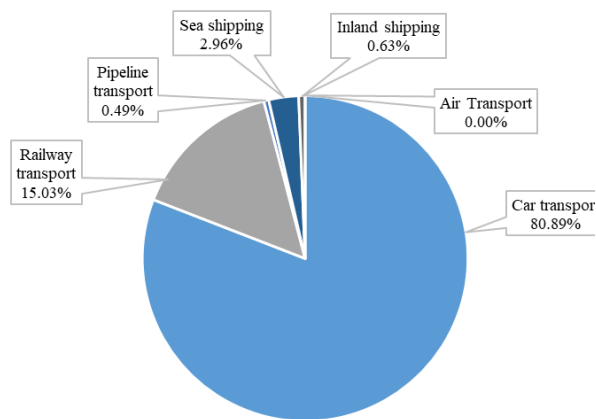
Fig. 5. The share of individual modes of transport in international cargo transport in Poland in 2008
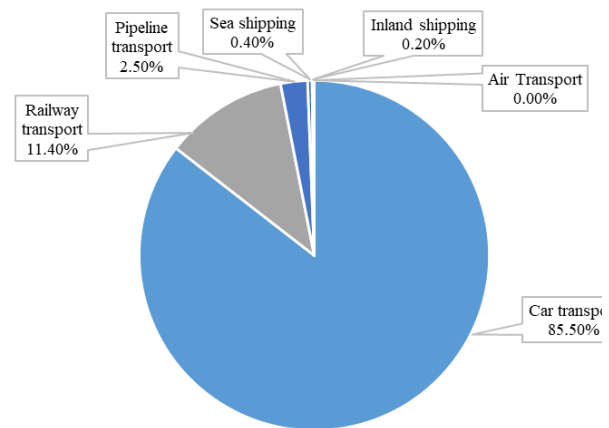Source: Authors' research based on [12]

Fig. 6. The share of individual modes of transport in international cargo transport in Poland in 2018
Source: Authors' research based on [12]

3. FORECAST OF THE NUMBER OF CARGO TRANSPORT IN POLAND

The method of seasonality indicators was used to forecast the volume of cargo transported by road in Poland from 2019-2021. The analysis presented in this paper is based on data for 2008-2018 obtained from the Central Statistical Office database [12]. Additionally, the forecast values for 2019 and 2020 were compared with the real values for 2019 and 2020. In determining the forecasts, an additive model (1) and a multiplicative model (2), were used. In the case of data that are distinguished by constant fluctuations in the time series, that is, those whose fluctuation amplitude is more or less constant, it was an additive model of absolute seasonal fluctuations. On the other hand, if the data are characterised by relatively constant fluctuations in the time series, that is, those whose fluctuation amplitude changes more or less in the same ratio, it is a multiplicative model of seasonal fluctuations [13]:

$$y_T = \alpha_1 \cdot T + \alpha_0 + g_j \tag{1}$$

$$y_T = (\alpha_1 \cdot T + \alpha_0) \cdot w_j \tag{2}$$

where:
α_0 - constant coefficient;
α_1 - model parameter;
T - time variable;
g_j - seasonal fluctuations in the additive model;
w_j - seasonal fluctuations in the multiplicative model.

Table 1 presents the volume of cargo transported by road in Poland in particular quarters from 2008-2018. Afterwards, a regression analysis of the ordered data presented in Table 1 was performed. The value of the coefficient of determination $R^2 = 0.92$, while the p-values for the coefficients in the model are less than 0.05. Therefore, it can be concluded that the choice of the seasonality method was correct as the models were well adjusted to the statistical data.

Tab. 1

The number of cargo transported by road in Poland in the individual quarters of 2008-2018
Source: Authors' research based on [12]

Year	Quarter	Number of transported cargo [million in tonne kilometres]	t
2008	I	41 390	1
	II	44 034	2
	III	42 254	3
	IV	37 252	4
2009	I	42 755	5
	II	45 400	6
	III	48 087	7
	IV	44 500	8
2010	I	45 790	9
	II	51 590	10
	III	55 201	11
	IV	55 201	12
2011	I	50 581	13
	II	52 864	14
	III	51 794	15
	IV	52 412	16
2012	I	53 061	17
	II	57 147	18
	III	57 652	19
	IV	54 472	20
2013	I	57 036	21
	II	65 340	22
	III	64 602	23
	IV	60 616	24
2014	I	61 362	25
	II	62 808	26
	III	63 343	27
	IV	63 417	28
2015	I	63 257	29
	II	67 680	30
	III	65 129	31
	IV	64 647	32
2016	I	71 195	33
	II	77 300	34
	III	71 533	35
	IV	70 721	36

2017	I	76 809	37
	II	84 916	38
	III	86 055	39
	IV	87 440	40
2018	I	77 946	41
	II	83 132	42
	III	77 624	43
	IV	77 172	44

The next stage of the analysis was the determination of raw absolute seasonal fluctuations for individual quarters. Then the seasonal component was adjusted by determining pure absolute seasonal fluctuations. Table 2 shows obtained forecasting models.

Tab. 2

The obtained forecasting models based on the years 2008-2018

Quarter	Additive model	Multiplicative model
I	$y_T = 995.14 \cdot T + 38\,620.99 + 2\,548.78$	$y_T = (995.14 \cdot T + 38\,620.99) \cdot 1.03$
II	$y_T = 995.14 \cdot T + 38\,620.99 + 5\,913.89$	$y_T = (995.14 \cdot T + 38\,620.99) \cdot 1.08$
III	$y_T = 995.14 \cdot T + 38\,620.99 - 3\,091.09$	$y_T = (995.14 \cdot T + 38\,620.99) \cdot 0.97$
IV	$y_T = 995.14 \cdot T + 38\,620.99 - 5\,371.57$	$y_T = (995.14 \cdot T + 38\,620.99) \cdot 0.93$

The results of the forecast of the number of cargo transported by road in the particular quarters of 2019, 2020, and 2021 along with the values of the real number of cargo transported by road in 2019 and 2020 are presented in Table 3.

Tab. 3

The forecast results for 2019, 2020, and 2021 with the real data for 2019

Year	Quarter	Number of transported cargo [million in tonne kilometres]			T
		Additive model	Multiplicative model	Real data	
2019	I	85 951	85 904	85 395	45
	II	90 311	91 149	86 666	46
	III	82 301	82 831	90 867	47
	IV	81 016	80 341	86 026	48
2020	I	89 932	90 004	95 753	49
	II	94 292	95 448	79 710	50
	III	86 282	86 692	-	51
	IV	84 997	84 042	-	52

2021	I	93 912	94 104	-	53
	II	98 272	99 747	-	54
	III	90 263	90 553	-	55
	IV	88 977	87 744	-	56

Figure 7 shows the number of cargo transported by road, real and forecast values for 2019-2021 using the additive and multiplicative model. Based on the presented data, it can be observed that the forecasted values obtained from the additive model are at a similar level to the values for 2008-2018. However, the forecasted values using the multiplicative model are linear, which is not consistent with the real values for 2019. Comparing the forecasted values with the real values, it can be seen that in the case of the first two quarters of 2019 and the first quarter of 2020, the forecast may be accurate. However, in the case of the third and fourth quarters of 2019, the values already differ significantly. The lack of data for 2020 in the databases available in Poland (Central Statistical Office) does not allow concluding on whether the model is well suited. Such a comparison will be possible only after the Central Statistical Office publishes the statistical data for 2020. In the case of the second quarter of 2020, a much higher value of the forecast than the real data may result from the occurrence of the COVID-19 pandemic.
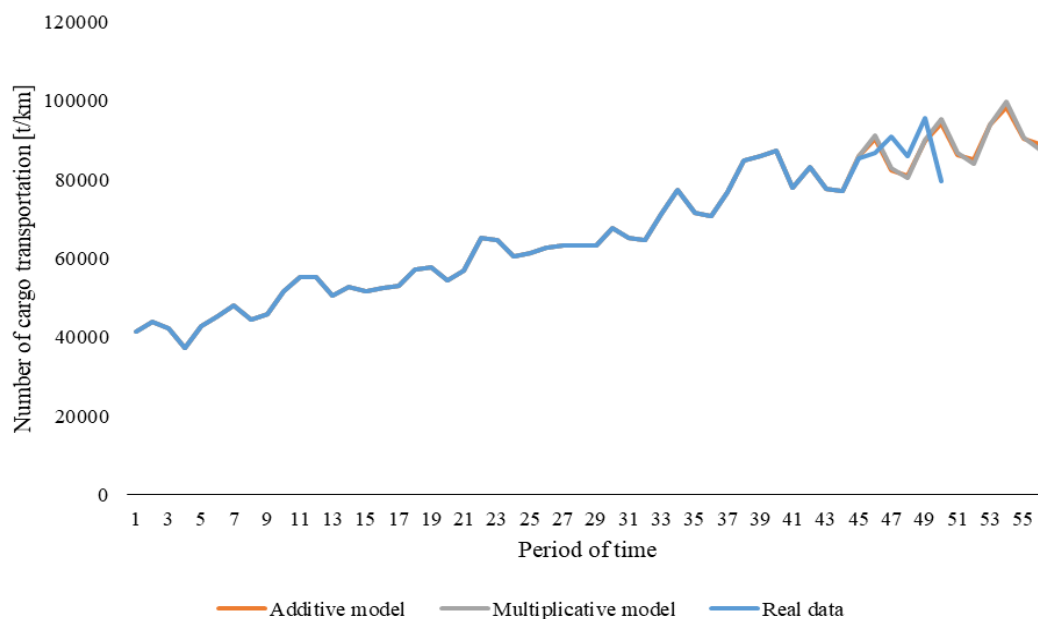

Fig. 7. The number of cargo transported by road in
particular periods from 2008-2018 in EU countries
Source: Authors' research based on data presented in [12]

4. CONCLUSION

This article aimed to analyse international road cargo transport in Poland and EU countries from 2008-2018. Based on the analysis, the following conclusions can be drawn:

- The number of employees employed in transport companies in EU countries decreased by about 40% during the analysed period. The reason for the decline in the number of employees may be the technological development that took place in these countries over the last dozen years, which contributed to the elimination of a certain part of the employees;
- In Poland, there was a significant increase in the share of road cargo transport from 2008-2018, indicating a significant development of road cargo transport;
- The forecasted values of the volume of cargo transport in Poland for 2019-2021, which were determined from the additive and multiplicative model, are at a similar level to the values for 2008-2018;
- A comparison of the forecasted values with the real values for 2019 shows that the forecast for the first two quarters is correct. To confirm the correctness of the forecast for the third and fourth quarters, it would be necessary to compare the data for the following years, which will be possible only after the Central Statistical Office provides data for the years 2020 and 2021. However, the COVID-19 pandemic situation that occurred in 2020 probably largely influenced the volume of road cargo transport.

References

1. Chmielewski Jacek, Paulina Olenkowicz-Trempała. 2018. "Analysis of Selected Types of Transport Behaviour of Urban and Rural Population in the Light of Surveys". In: *Recent Advances in Traffic Engineering for Transport Networks and Systems*. Edited by Elżbieta Macioszek, Grzegorz Sierpiński. P. 27-36. Switzerland: Springer International Publishing. ISBN: 978-3-319-64083-9.
2. Chmielewski Jacek. 2019. „Transport Demand Model Management System". In: *IOP Conference Series: Materials Science and Engineering*. P. 1-10.
3. Cieśla Maria, Aleksander Sobota, Marianna Jacyna. 2020. „Multi-Criteria Decision Making Process in Metropolitan Transport Means Selection Based on the Sharing Mobility Idea". *Sustainability* 12(17): 1-21. DOI: https://doi.org/10.3390/su12177231.
4. Fernandes Paulo, Margarida Coelho. 2019. "Making Compact Two-Lane Roundabouts Effective for Vulnerable Road Users: An Assessment of Transport-Related Externalities". In: *Roundabouts as Safe and Modern Solutions in Transport Networks and Systems*. Edited by Elżbieta Macioszek, Rahmi Akçelik, Grzegorz Sierpiński. P. 99-111. Switzerland: Springer International Publishing. ISBN: 978-3-319-98617-3.
5. Giuffre Orazio, Anna Grana, Maria Luisa Tumminello, Tullio Giuffre, Salvatore Trubia. 2019. "Surrogate Measures of Safety at Roundabouts in AIMSUN and VISSIM Environment". In: *Roundabouts as Safe and Modern Solutions in Transport Networks and Systems*. Edited by Elżbieta Macioszek, Rahmi Akçelik, Grzegorz Sierpiński. P. 53-64. Switzerland: Springer International Publishing. ISBN: 978-3-319-98617-3.
6. Jacyna Marianna, Roland Jachimowski, Emilian Szczepański, Mariusz Izdebski. 2020. „Road vehicle sequencing problem in a railroad intermodal terminal–simulation research". *Bulletin of the Polish Academy of Sciences. Technical Sciences* 68(5): 1135-1148. DOI: https://doi.org/10.24425/bpasts.2020.134643.

7.   Jacyna Marianna, Jolanta Żak, Ilona Jacyna-Gołda, Jerzy Merkisz, Agnieszka Merkisz-Guranowska, Jacek Pielucha. 2013. „Selected aspects of the model of proecological transport system". *Journal of KONES, Powertrain and Transport* 20(3): 193-202.
8.   Małecki Krzysztof. 2017. "The use of heterogeneous cellular automata to study the capacity of the roundabout". In: *Artificial Intelligence and Soft Computing*. Edited by Leszek Rutkowski, Marcin Korytkowski, Rafał Scherer, Ryszard Tadeusiewicz, Lotfi A. Zadech, Jacek M. Zurada. P. 308-317. ISBN: 978-3-319-59059-2.
9.   Mrowczynska Bogna, Maria Ciesla, Aleksander Krol, Aleksander Sladkowski. 2017. „Application of artificial intelligence in prediction of road freight transportation". *Promet-Traffic&Transportation* 29(4): 363-370.
     DOI: https://doi.org/10.7307/ptt.v29i4.2227.
10. Sładkowski Aleksander, Maria Cieśla. 2018. "Analysis and development perspective scenarios of transport corridors supporting eurasian trade". In: *Transport Systems and Delivery of Cargo on East-West Routes. Studies in Systems, Decision, and Control*. Edited by Aleksander Sładkowski. P. 71-119. Switzerland: Springer International Publishing. ISBN: 978-3-319-78294-2.
11. Takele Tesfaye B., Arnt S. Buvik. 2019. "The role of national trade logistics in the export trade of African countries". *Journal of Transport and Supply Chain Management* 13(a464): 1-11. ISSN: 2310-8789.
12. Website of StatSoft – Eectronic Statistic Textbook. Available at: https://www.statsoft.pl/textbook/stathome.html.
13. Website of Central Statistical Office. Available at: https://stat.gov.pl/.
14. Wiśnicki Bogusz, Dariusz Milewski, Leszek Chybowski, Igor Hełczyński. 2017. "The Concept of the Development of Intermodal Transport Network Illustrated by Polish Market". *Nase More* 64(1): 33-37.