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ANALYSIS OF TRANSPORT EFFICIENCY IN POLAND ON THE EXAMPLE OF CARGO TRANSPORT

Anita FAJCZAK-KOWALSKA[1], Daniel TOKARSKI[2*]

[1] Lodz University of Technology; anita.fajczak.kowalska@p.lodz.pl, ORCID: 0000-0002-5347-9735
[2] University of Lodz; daniel.tokarski@uni.lodz.pl, ORCID: 0000-0002-3475-1115
* Correspondence author

Purpose: The aim of the analysis was to demonstrate the level of transport efficiency in Poland on the example of various modes of transport in selected years.
Methodology: Analysis of data from the library of the Central Statistical Office.
Findings: The evaluation results obtained from the analysis showed that changes in transport work were much more influenced by changes in transport distance than in cargo weight.
Originality/value: The publication discussed the topic transport efficiency in Poland on the example of cargo transport in the years 1995-2022. Combining interdisciplinary research in the areas of management and quality sciences with economics and finance.

Keywords: cargo transport, transport efficiency.

Category of the paper: Research paper.

1. Introduction

Transport is an important element of the economic activity of every company. It is a fundamental supply chain process that determines a company's level of profitability and customer satisfaction. Transport processes determine the flow of raw materials, semi-finished products and finished products, and thus determine the effectiveness of the entire supply chain management and, consequently, the level of customer satisfaction of the company. Transport is therefore an important element of the supply chain of every enterprise, responsible for the flow of goods and services between the producer and the consumer. It determines the business success or profit and loss balance of the company, and also affects its image in the eyes of contractors (Berg et al., 2017).

Transport has been the most important element of the flow of goods for hundreds of years. It allows goods to move from place to place, but also people who willingly use its possibilities. The phenomenon of transport is very common, but it still stimulates the desire to develop. New strategies and technologies implemented there make the flow of goods fast and convenient. However, this requires a lot of effort and the use of many modes of transport and extensive road, rail and air infrastructure. The time and quality of transport are influenced by many factors, which most often have their source in good organization of logistics and forwarding (Plawsky, 2020).

Nowadays, a person can transport almost anything. The transformation of the Polish economy, covering the last three decades, began in 1988 with the entry into force of the Economic Freedom Act. The mentioned time frames can be divided into periods such as (Divall, Hine, 2017):

- spontaneous political changes dating back to 1988-1991, when the command-distribution system was dismantled in Poland and close connections with the economies of the countries included in Comecon (Council for Mutual Economic Assistance) were eliminated, with particular emphasis on the Soviet Union;
- preparing the Polish economy to meet the accession conditions set by the European Union (deadline – December 16, 1991, i.e. signing the European Agreement – April 30, 2004);
- Poland's participation in the structures of the European Union (from May 1, 2004).

Transport data collected using various instruments, both traditional and IT, are a valuable source of knowledge about the state of the economy, which has a direct impact on conducting various analyzes and developing action strategies. The source of this data are usually institutions dealing with statistics (Dz.U. 2023, poz. 773).

2. Motivation and purpose

The important role of transport in the processes of socio-economic development and its special place in social life and economy is obvious. However, the second decade of the 21st century brings widespread globalization of the world economy and advanced integration processes in many regions of the globe, which makes transport a key factor in the development of modern societies. Developmental progressivity is the result of both expansive human activity in the social and economic sphere, as well as the modernization and expansion of transport infrastructure. In addition, there is constant progress in the technical development of means of transport (Motowidlak, Tokarski, 2022).

3. Methodology

To confirm changes taking place in various modes of transport, it is necessary to conduct an analysis based on statistical data. In the presented study, they cover the period from 1995 to 2022 (Główny Urząd Statystyczny, 2022). This is a period in which very significant changes took place in individual modes of transport (rail transport, road transport, air transport, pipeline transport, transport using inland navigation, transport using sea navigation). Due to the systematic increase in the volume of transported cargo, total transport, i.e. transport carried out by all the above-mentioned modes of transport, was also taken into account (Di Ciommo, Shiftan, 2017). For this purpose, transport data was used, mainly from the publications of the Central Statistical Office, regarding the volume of loads transported (exported) in the years 1995-2022.

4. Results

4.1. Cargo transport in tons

Thanks to statistical data on cargo transport in tons, it is possible to assess changes in transport services over the years. The above data arranged by type of transport in tonnes in the years 1995-2022 are presented in Table 1, which shows that during the period under study, the total volume of transported cargo (in tonnes) systematically increased until 2020. In 2021, it decreased by 360,439 thousand tons, while in 2022 a slight increase of 23,715 thousand tons can be observed. tone. tons compared to 2021. Referring to individual periods, it is worth noting that in the years 2005-2010, i.e. in the time horizon in which the global economic crisis began, the number of transport by rail, sea and inland navigation increased. An upward trend was observed in road transport of cargo. In the years 2010-2020, road transport of goods increased. However, in 2015 there was a noticeable decline in transport compared to 2010. Perhaps it was the result of a delayed reaction to the global recession. In 2021 and 2022, there will be a decline in road transport, which may be caused by the armed conflict in Ukraine. The decline in the number of sea transport continued, while the amount of cargo transported by rail increased. This is largely the result of improving the railway infrastructure.

Table 2 shows that road transport played the dominant role. Their share ranged from 75.8% (in 2005) to 87.2% (in 2020). Rail transport came in second place. The share of this transport ranged from 9.9% in 2020 to 18.9% in 2005. The next place was taken by pipeline transport, whose share ranged from 2.2% (in 2021) to 3.8% (in 2005), and maritime transport from 0.4% (in 2010-2022). to 1.8% (in 1995). Air transport occupied the last place in transport throughout the period. The share of this transport was the most stable and ranged from 0.0% to 0.1%.

Important information is provided by single-base indicators based on the volume of transport occurring in the first (1995) year of the period covered by the analysis. The calculated indicators are presented in Table 3. As Table 3 shows, since 2005 the total transport began to increase (the increase was 3.1%). The largest increase in total transport, amounting to 89.4%, occurred in 2020. In the following years, 2021 and 2022, a reduction in total transport can be observed to 63.3% and 65%, respectively. The relative changes in size in individual modes of transport were different. Table 3 also shows that in rail transport in the years 1995-2000 there was a decrease in the volume of transport, while the years 2000-2005 were a period of a significant increase in the level of transport. This was influenced by, among others, Poland's entry into the European Union. Special development concerned freight transport. The years 2005-2016 saw another decline in transport. Over the next six years, the level of transport stabilized, which was due to, among others, from: the growing level of transport using road transport (Więcek, Fajczak-Kowalska, 2011).

In road transport in the years 1995-2005 the volume of transport was almost the same. In the years 2005-2010 there was a dynamic increase in the level of transport. These included, among others: a consequence of the fact that in the period in question there was a significant increase in the number of vehicles and the number of transport companies using this type of transport. The increase in the number of vehicles was over 100%, and the increase in the number of enterprises was almost 100% (Kraśniewski, 2012). The years 2010-2015 were characterized by a slight decline in the level of transport, but still reaching a significant level. This was achieved, among others, by: creation of new expressways and highways, which were built, among others, with EURO 2012 taking place in Poland and Ukraine in mind. Since 2020, there has been an increase in transport using this mode of transport by 114.6%. Since 1995, air transport has seen a significant increase in transport. The upward trend was stopped only in 2010-2015, which was undoubtedly influenced by the effects of the global economic crisis that had its roots in 2008-2009. Since 2016, there has been a noticeable increase in transport (compared to 2015) by 86.4%, in 2017 by 141%, in 2018 by 186.3%, in 2019 by 250%, in 2020 by 186%, 4%, in 2021 by 313.6% and in 2022 by 440.9%. It should be added that air transport is one of the most expensive types of transport, so it is not surprising that the level of transport in this area has decreased. It is also worth mentioning an unusual event related to volcanic activity in April 2010, which also limited air traffic. This does not change the fact that it is still an extremely promising branch of transport, especially since numerous works are underway in Poland, resulting in the expansion of existing airports, which results in, among others, creation of modern cargo terminals. Such investments take place, among others: in Warsaw, Katowice and Rzeszów (Dz.U. 2001, nr 5, poz. 43). It is obvious that in the face of infrastructure improvement, new opportunities will appear related to air transport services, especially since their undeniable advantage is the speed of transport (Fajczak-Kowalska, 2012a).

Between 1995 and 2010, there was an increase in pipeline transport. There was some decline between 2010 and 2017. It is highly probable that, as in the case of air transport, the decline in transport dynamics in this area was the result of the far-reaching consequences of the global economic crisis, which translated into a reduction in the amount of purchased raw materials and materials transported by pipelines. This mainly applies to crude oil, liquid gases and heavy petroleum products. Taking a closer look at this branch of transport, it is worth emphasizing its low operating costs and high level of reliability, which makes the transport of the above-mentioned. transporting raw materials via pipelines is extremely profitable from an economic point of view. A separate issue is the strategic importance of gas supplies, a clear example of which is the controversy surrounding the construction of the Nord Stream 2 gas pipeline. Its construction would have a negative impact on Polish interests, including: due to the possibility of limiting gas transmission through the existing Yamal-Europe gas pipeline running through the countries: Belarusian and Polish. According to experts, this would be an argument in the negotiations between Russia and Poland regarding the prices of this raw material. The Russians, citing economic reasons, could declare the need to raise gas prices to make using the Yamal gas pipeline profitable (Wiśnicki, 2011). There is no doubt, therefore, that this type of transport is a key element of the strategic policy of many countries. Inland water transport is subject to large fluctuations. The years 1995-2000 and 2015-2022 were a period of some growth, in the years 2000-2005 there was a decline in transport dynamics, which deepened in the years 2005-2022. In turn, the years 2010-2015 brought a dynamic increase in transport dynamics. This proves the huge potential of this branch of transport, despite the lack of necessary investment activities. It should be emphasized that in Poland, apart from short sections of the lower Oder, the parameters of native routes do not correspond to the minimum international navigation conditions specified in the AGN Convention. This convention imposes on the Polish authorities the obligation to adapt the main waterways so that they have at least class IV navigability. Lower classes do not allow the use of EU funds related to trans-European transport corridors. The possibility of using these funds depends on achieving the parameters of navigability class IV, which involves achieving a transit depth of at least 2.5 m on the route. However, these conditions have not yet been met.

If the Oder were adapted, the industry would make huge profits, because thanks to the connection with the waterways systematized in Germany, it would be possible to send goods by barge to many European countries. However, decisions are needed at the government level, otherwise transport paradoxes may continue to arise, such as the transport of coal from domestic mines to Berlin's power plants. Currently, the situation is that it is transported by rail to Szczecin, then transferred to barges and transported to Berlin. The years 1995-2022 are a time of constant reduction in the dynamics of cargo transport by sea. This tendency can be explained by the decapitalization of the rolling stock previously used in this type of transport. Other reasons for this state of affairs include: growing competition from other branches of transport, a decline in the number of orders from foreign contractors and an insufficient level

of investment activity in this transport industry. This is due to the lack of a coherent strategy for the development of the maritime economy and conflicting ideas on how to improve the current state of affairs. For example, numerous road investments are being carried out to facilitate the transport of cargo to ports, but according to experts, local road routes are not able to handle such a flow of cargo. Rail transport would be more useful in this respect. However, no binding arrangements have been made for wider use of the railway sector (Porter, 2006).

In order to check whether the transport of goods in thousands of tons by modes of transport in the years 1995-2022 shows clear patterns, the parameters of the following linear development trend model were estimated (Model 1):

$$Y_{tr} = \alpha_{0r} + \alpha_{1r} T_t + \varepsilon_{tr} \quad (1)$$

where:

Y_{tr} - transport volume in tonnes in year t by transport *r*,

T_t - time variable (trend) taking the following values: 1, 2, …, 21,

ε_{tr} - random variable,

α_{0r}, α_{1r} - structural parameters of the model.

The calculation results are presented in Table 4, which shows that there are no clear regularities in the transport of cargo by mode of transport. Only for sea shipping and road transport, quite high coefficients of determination were obtained: R2 = 0.86 for sea transport and R2 = 0.72 for road transport. Although the a0 estimates of the α0 parameter are statistically significant for all types of transport, a statistically insignificant a1 estimate was obtained for rail transport. The critical value of the Student's t-test for the significance coefficient of 0.05 is 2.19 in this case. For other types of transport, the a1 estimates are statistically significant, but the low values of the R2 determination coefficients do not allow the use of a linear model of development trends to prepare forecasts (Fajczak-Kowalska, 2016).

There are also no clear regularities in the structure of cargo transport in thousands of tons. Based on the calculation results presented in Table 5, it can be concluded that the estimates of the α0 parameter for all types of transport are statistically significant, as the Student's t-test values significantly exceed the critical value of 2.19. However, statistically significant estimates of the α1 parameter were obtained for road transport (2.86), inland navigation (4.24) and sea navigation (9.30). The lack of regularity in the structure of transport according to individual modes of transport is evidenced by the low values of the determination coefficients R2. Only for maritime shipping, the value of the determination coefficient of 0.82 can be considered satisfactory.

4.2. Average cargo transportation distance

The basic measure of transport activity is the transport of loads of a specific size (weight) expressed in tons. Adopting this criterion may prove insufficient in some situations. Therefore, the distances over which loads are transported by particular types of transport are taken into account.

Information on the average distance of transporting 1 ton of cargo by type of transport in the years 1995-2022 is presented in Table 6, which shows that the average distance of transporting 1 ton of cargo was subject to quite significant fluctuations. A steady increase in the average distance was only recorded for road transport. In the years 2010-2022, the average distance of transporting one ton of cargo by rail increased. It is worth noting here that it is desirable for this distance to be as large as possible, because the competitiveness of this form of transport increases with the increase in the distance over which given loads are transported. During the same period, the average transport distance in air transport increased significantly, while the average transport distance in sea transport decreased significantly.

The changes taking place in the average transport distance of 1 ton of cargo in the period under study are presented in the calculation results in Table 7, which show that in air transport in the years 2005-2010 there was a decrease in the average transport volume, which in 2010 reached the level of 83.6%. In 2015 we saw an increase to 123.2%. In pipeline transport, distances increased compared to 2016, but in 2017 they stopped. In land transport, in 2010 there was a more than two-fold (212.7%) increase in the average transport distance of one tonne of cargo; since 2019, there has been a decrease in the average transport distance. However, in maritime shipping there was a very significant decrease in the average transport distance and amounted to only 19.1% compared to 1995. It can be said that in maritime transport, the relationship between ocean transport and short sea transport has completely changed (Nowak et al., 2018).

In order to determine whether there are clear patterns in individual modes of transport, the parameters of the trend model were estimated. The calculation results obtained for this model are presented in Table 8, which shows that the continuing trend of changes in the average transport distance is indicated primarily by: road transport (growing trend with an average increase in distance of 7.79 km per year) and sea transport, characterized by an average annual decrease in transport distances of almost 330 km. For the remaining industries, due to irregular changes in the category in question, it was not possible to map them using a linear trend model.

4.3. Cargo transportation according to transport work

A more universal measure of the volume of cargo transport is transport performance expressed in tonne-kilometers, taking into account both the transported weight of the cargo and the transport distance. Information on the volume of transport in tonne-kilometers is presented in Table 9, which shows that since 1995 there have been noticeable fluctuations in transport performance when transporting the entire load. The constant growth concerns only road and air transport, in other industries there were declines and increases in the period in question. Pipeline transport has achieved some stability, the condition of which is the existence of long-term contracts for the supply of raw materials. In the years 2015-2022, there is a noticeable increase in freight transport (Fajczak-Kowalska, Misztal, 2019).

The structure of transport in tonne-kilometers is presented in the calculation results in Table 10, which shows that the share of freight transport in tonne-kilometers has changed over time. In 1995, the largest share was taken by sea transport, which amounted to 55.1%, second place was taken by rail transport, with a share of 23.0%, and only third was road transport, with a share of 17.0%. The lowest share had air transport - 0.1% and land transport - 0.3%. The primacy of sea transport remained until 2005, when road transport took the leading position, gradually increasing its share in the following years. Since 2010, there has been a decline in the share of rail, pipeline and sea transport in transport (Fajczak-Kowalska, 2012b).

During the period under study (1995-2022), there were very significant changes in the share of individual modes of transport. A downward trend can be observed in rail transport. In 2010, the share of this type of transport decreased by 7.6% compared to 1995. In the remaining years of the analyzed period, the share of rail transport ranged from 9.5% in 2020 to 23% in 1995. In road transport there was a systematic increase in transport from 17.0% in 1995 to 85.4% in 2020. In the years 2005-2018, the increase in the share of transport was probably due to Poland's accession to the European Union on May 1, 2004. The share of air transport in transport expressed in tonne-kilometers was very small and amounted to 0.1 throughout the period under study. Quite large fluctuations occurred in pipeline transport, ranging from 3.7% in 2021 to 11.1% in 2005. The share of inland navigation was small and ranged from 0.1% in 2020-2022 to 0.6 % in 2015. Such a low share of transport is influenced by the short length of waterways in Poland. Moreover, the condition of these roads and the means of transport used to transport goods by inland navigation leave much to be desired. The largest decline in the share of transport, reaching almost 50%, occurred in maritime transport. The main reason for this decline was the systematic liquidation of transport fleet and the liquidation or restructuring of enterprises dealing with this type of transport.

Changes in transport (transport performance) in tonne-kilometers compared to 1995 are presented in the calculation results in Table 11, which show that the largest increase in total transport, amounting to 79.8%, occurred in 2020. Increase in transport compared to 1995 occurred in the case of road and air transport. It is worth noting a clear increase in the dynamics

of transport work in the inland navigation sector in 2015 - compared to 2010, the increase was 132.1%. According to data from the Central Statistical Office, road transport has the largest share in freight transport. In 2015, the volume of cargo transported by this form of transport, measured by transport performance, reached 1,767.8 billion tonne-kilometers and was 2.4% higher than that recorded in the previous year. The leading position in terms of transport performance was taken by Germany (314.7 million tonne-kilometers), Poland was second and Spain was third. Analysts point out that transport companies from the East are becoming more and more competitive, which affects the situation on the domestic and international markets. Obtaining a satisfactory transport order is becoming more and more difficult. They emphasize that the main problem when it comes to Western markets are not competitors, but administrative and legal barriers that are intended to protect domestic markets, thus harming the competitiveness of the Community market (Fajczak-Kowalska, 2021).

It is significant that Polish dominance in the road transport market is based on companies operating in Poland, and not on Polish companies. It should be noted that the largest enterprises of this type belong to foreign capital. These include the Dutch concern Raben, the German DB Schenker, and the French FM Polska and DPD Polska. Even Pekaes is now owned by Strada Holding from Luxembourg. When it comes to the leading road transport companies in Poland, only one of them has a Polish owner. This is ROHLIG SUUS Logistics. Interestingly, Polish entrepreneurs took it over over a decade ago from its German owner (Pawłowska, 2015).

As Table 12 shows, when looking at the trend model for freight transport by mode of transport, it can be seen that the trend for road and sea transport continues. As in the case of trend models for cargo transport distances, transport performance shows a constant trend only in two branches: road and sea transport. Comparing the trend model for the weight of transported loads, it should be concluded that changes in the volume of transport work were influenced to a much greater extent by changes in the transport distance than changes in the weight of the load. When analyzing the models of trends in the transport work structure, the only acceptable result is the result obtained for road transport, where the share of transport work in this branch was explained in 96%, and the statistically significant assessment of the $\alpha 1$ parameter indicates an increase in this share by an average of 3.5% year to year, as shown in Table 13.

5. Conclusions

The greatest changes affecting the structure and volume of demand for transport occur in the innovative and technological sphere of transport, in production technologies of other sectors of the economy, in the basis of location decisions and in the functioning models of societies. In the transport of goods, improving accessibility is a key location factor influencing the

distribution of facilities constituting the potential to generate traffic in truck transport. Assuming a macro scale, increasing the level of accessibility may result in a higher level of GDP and an increase in traffic (in the short term this is the result of demand effects, and in the long term it is the effect of supply effects). In turn, an increase in competitive advantage in the truck transport sector resulting from improved accessibility may result in a modal shift and an increase in traffic on road networks. As in passenger transport, limited accessibility due to limited journeys results in modification of the traffic schedule. Therefore, there is no doubt that infrastructure investments are advisable, which will enable greater market accessibility (Tokarski, 2022).

The development of forwarding and transport companies results from many factors, which include: spatial, economic, technological, production, cooperative and social motives (Dembińska, 2011). These are the needs resulting from human nature, the desire to move and live in society. Another element is the scope of people's activities - they produce goods based on resources available in different parts of the world, so they must transfer these products as quickly as possible. Many of these products are necessary for our lives, so someone has to provide them. To meet the numerous requirements for transport, there are many forwarding companies on the market. Their activity consists in organizing the transport of cargo and performing all or some of the activities related to it.

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Appendix

Table 1.
Freight transport in thousands of tons by types of transport in 1995-2022

Year	Type of transport						
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping	Total
1995	225348	1086762	22	33353	9306	24968	1379759
2000	187247	1083071	28	44342	10433	22774	1347895
2005	269553	1079761	34	54249	9607	9362	1422576
2010	216899	1551841	41	56208	5141	8362	1838492
2015	224320	1505719	38	54850	11928	6963	1803818
2016	222523	1546572	41	54058	6210	7248	1836652
2017	239501	1747266	53	52393	5778	8254	2053245
2018	249260	1873022	63	55287	5107	9149	2191888
2019	233744	1921073	77	52376	4681	8727	2220678
2020	218381	2331758	63	51489	3991	8135	2613817
2021	237915	1952465	91	49855	3465	9587	2253378
2022	237587	1976278	119	52591	2076	8442	2277093

Source: own study based on Central Statistical Office data.

Table 2.
Freight transport structure (by weight) in percentage in the years 1995-2022

Year	Type of transport					
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping
1995	16.3	78.7	0.1	2.4	0.7	1.8
2000	13.8	80.3	0.1	3.3	0,8	1.7
2005	18.9	75.8	0.1	3.8	0.7	0.7
2010	13.1	83.1	0.0	3.1	0.3	0.4
2015	12.4	83.5	0.0	3.0	0.7	0.4
2016	12.1	84.2	0.0	2.5	0.3	0.4
2017	11.7	85.1	0.0	2.5	0.3	0.4
2018	11.4	85.5	0.0	2.5	0.2	0.4
2019	10.5	86.5	0.0	2.4	0.2	0.4
2020	9.9	87.2	0.0	2.3	0.2	0.4
2021	10.6	86.6	0.0	2.2	0.2	0.4
2022	10.4	86.8	0.0	2.3	0.1	0.4

Source: own study based on Central Statistical Office data.

Table 3.
Dynamics of cargo transport by weight for types of transport (year 1995 = 100)

Year	Type of transport						
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping	Total
2000	83.1	99.7	127.3	133.0	112.1	91.2	97.7
2005	119.6	99.4	154.6	162.7	103.2	37.5	103.1
2010	96.3	142.8	186.4	168.5	55.3	33.5	133.3
2015	99.5	138.6	172.7	164.5	128.2	27.9	130.7
2016	98.8	142.3	186.4	162.1	66.7	29.0	133.1
2017	106.3	160.8	241.0	157.1	62.1	33.1	148.8
2018	110.6	172.3	286.3	165.8	54.9	36.6	158.9
2019	103.7	176.8	350.0	157.0	50.3	34.9	160.9
2020	96.9	214.6	286.4	154.4	42.9	32.6	189.4
2021	105.6	179.7	413.6	149.5	38.4	38.4	163.3
2022	105.4	181.9	540.9	157.7	22.3	33.8	165.0

Source: own study based on Central Statistical Office data.

Table 4.
Parameter estimates and statistical characteristics for Model 1

Type of transport	Model parameters					
	Rating a_0	$t(a_0)$	Rating a_1	$t(a_1)$	Se	R^2
Rail transport	223754	16.73	1288	1.18	30202	0.08
Road transport	901083	14.86	30842	6.73	128666	0.72
Air transport	27.12	12.79	0.82	4.47	4.90	0.53
Pipeline transport	38640	19.37	943	6.07	4300	0.70
Inland shipping	9837	12.04	- 147.25	2.19	1866	0.25
Sea shipping	28889	19.07	- 1199.3	9.83	3388	0.86
Total	1202293	24.23	32541	7.76	113308	0.77

Source: own study based on calculations.

Table 5.
Parameter estimates and statistical characteristics for model 1 for the structure of freight transport in thousands of tons

Type of transport	Model parameters					
	Rating a_0	$t(a_0)$	Rating a_1	$t(a_1)$	Se	R^2
Rail transport	17.30	14.84	- 0.20	2.20	2.58	0.19
Road transport	76.59	55.46	0.31	2.86	3.05	0.30
Air transport	0.002	15.80	0.000007	2.66	0.0003	0.02
Pipeline transport	3.13	13.98	0.001	2.19	0.50	0.00
Inland shipping	0.77	13.20	- 0.02	4.24	0.13	0.49
Sea shipping	2.20	16.70	- 0.10	9.30	0.29	0.83

Source: own study based on calculations.

Table 6.
Average distance of transporting 1 tonne of cargo by type of transport in 1995-2018 in kilometers

Year	Type of transport					
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping
1995	307	47	3359	405	94	6643
2000	291	67	3120	459	112	5869
2005	185	111	3142	468	133	3389
2010	225	144	2807	430	200	2364
2015	226	181	4139	398	183	1830
2016	228	196	4598	411	134	1137
2017	229	199	4868	402	152	1134
2018	238	202	4934	386	153	833
2019	234	206	4852	370	140	783
2020	234	198	3587	397	129	818
2021	229	210	3757	370	142	788
2022	250	206	3739	364	214	1374

Source: own study based on Central Statistical Office data.

Table 7.

Dynamics of the average distance of transporting 1 ton of cargo by mode of transport in the years 1995-2022 (1995=100)

Year	Type of transport					
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping
2000	94.8	142.6	92.9	113.3	119.1	88.3
2005	60.3	236.2	93.5	115.6	141.5	51.0
2010	73.3	306.4	83.6	106.2	212.7	35.6
2015	73.6	385.1	123.2	98.3	194.7	27.5
2016	74.3	417.0	136.9	101.5	142.6	17.1
2017	74.6	423.4	144.9	99.3	161.7	17.1
2018	77.5	429.8	146.9	95.3	162.8	12.5
2019	76.2	438.3	144.4	91.4	148.9	11.8
2020	76.2	421.3	106.8	98.0	137.2	12.3
2021	74.6	446.8	111.8	91.4	151.1	11.9
2022	81.4	438.3	111.3	89.9	227.7	20.7

Source: own study based on Central Statistical Office data.

Table 8.

Estimation of a trend model for average transport distance

Type of transport	Model parameters					
	Rating a_0	$t(a_0)$	Rating a_1	$t(a_1)$	Se	R^2
Rail transport	295.62	20.32	- 5.12	4.42	32.16	0.52
Road transport	33.50	9.19	7.79	23.39	8.06	0.97
Air transport	3006.01	13.86	4.19	0.24	479.8	0.05
Pipeline transport	455.80	47.54	- 1.35	1.76	21.20	0.16
Inland shipping	95.53	9.33	3.76	4.59	22.70	0.54
Sea shipping	7170.5	24.36	- 329.79	11.94	650.1	0.89

Source: own study based on calculations.

Table 9.

Transport performance in millions of tonne-kilometers by type of transport in 1995-2022

Year	Type of transport						
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping	Total
1995	69116	51200	74	13493	876	165863	300622
2000	54448	72843	88	20354	1173	133654	282559
2005	49972	119740	107	25388	1277	31733	228217
2010	48707	223170	114	24157	1030	19773	316951
2015	50603	273107	156	21843	2187	12739	360635
2016	50650	303560	190	22204	832	8242	385678
2017	54797	348559	257	21080	877	9362	430784
2018	59388	377778	313	21314	782	7619	467253
2019	54584	395311	374	19394	656	6830	477149
2020	51096	461582	227	20437	516	6658	540516
2021	54387	410224	341	18429	493	7554	491428
2022	59306	406902	445	19132	445	11602	497832

Source: own study based on Central Statistical Office data.

Table 10.
Structure of cargo transport work by mode of transport in 1995-2022 (%)

Year	Type of transport					
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping
1995	23.0	17.0	0.1	4.5	0.3	55.1
2000	19.3	25.7	0.1	7.2	0.4	47.3
2005	21.9	52.4	0.1	11.1	0.6	13.9
2010	15.8	69.5	0.1	7.9	0.3	6.4
2015	14.0	75.7	0.0	6.1	0.6	3.5
2016	13.1	78.7	0.1	5.8	0.2	2.1
2017	12.6	80.1	0.1	4.8	0.2	2.2
2018	12.7	80.9	0.1	4.6	0.2	1.6
2019	11.4	82.8	0.1	4.1	0.2	1.4
2020	9.5	85.4	0.0	3.8	0.1	1.2
2021	11.1	83.5	0.1	3.7	0.1	1.5
2022	11.9	81.7	0.1	3.9	0.1	2.3

Source: own study based on Central Statistical Office data.

Table 11.
Transport performance dynamics in percent (1995 = 100)

Year	Type of transport						
	Rail transport	Road transport	Air transport	Pipeline transport	Inland shipping	Sea shipping	Total
2000	78.8	142.3	118.9	150.9	133.9	80.6	94.0
2005	72.3	233.9	144.6	188.2	145.8	19.1	75.9
2010	70.4	435.9	154.1	179.0	117.6	11.9	105.4
2015	73.2	533.4	210.8	161.9	249.7	7.7	120.0
2016	73.3	592.9	256.8	164.6	95.0	5.0	128.3
2017	79.3	680.8	347.3	156.2	100.1	5.6	143.3
2018	85.9	737.8	423.0	158.0	89.3	4.6	155.4
2019	78.9	772.1	505.4	143.7	74.9	4.1	158.7
2020	73.9	901.5	306.7	151.5	58.9	4.0	179.8
2021	78.7	801.2	460.8	136.6	56.3	4.5	163.5
2022	85.8	794.7	601.4	141.8	50.8	6.9	165.6

Source: own study based on Central Statistical Office data.

Table 12.
Parameter estimates and statistical characteristics of freight transport by mode of transport in tonne-kilometers for the trend model

Type of transport	Model parameters					
	Rating a_0	$t(a_0)$	Rating a_1	$t(a_1)$	Se	R^2
Rail transport	62666	26.0	-798.8	4.16	5332	0.48
Road transport	7529	0.9	12193.1	17.22	19651	0.96
Air transport	76.98	11.1	2.5	4.56	15.39	0.52
Pipeline transport	17455	14.4	338.3	3.50	2678	0.39
Inland shipping	9735	7.0	10.8	0.97	307.9	0.05
Sea shipping	184789	18.5	- 9694.1	12.20	22043	0.89
Total	273553	16.8	2052	1.59	35912	0.12

Source: own study based on calculations.

Table 13.
Parameter estimates and statistical characteristics of the transport structure trend model in tonne-kilometers

Type of transport	Model parameters					
	Rating a_0	$t(a_0)$	Rating a_1	$t(a_1)$	Se	R^2
Rail transport	22.34	29.32	- 0.36	5.92	1.68	0.65
Road transport	8.21	3.68	3.53	19.83	4.96	0.96
Air transport	0.03	14.42	0.0006	3.57	0.005	0.42
Pipeline transport	6.60	8.24	0.06	1.01	1.79	0.06
Inland shipping	0.37	7.07	0.0009	0.22	0.11	0.04
Sea shipping	0.007	18.48	- 0.00004	1.31	0.0009	0.09

Source: own study based on calculations.