

CONDITIONS OF CHANGES IN RAILWAY TRANSPORT IN THE REGIONAL SYSTEM

UWARUNKOWANIA ZMIAN W TRANSPORCIE KOLEJOWYM W UKŁADZIE REGIONALNYM

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Abstract: The subject of the study is to show the basic conditions of changes that are taking place on the rail transport market in Poland in the regional system. The statistical analysis was conducted by provinces. Significant regional differences in the use of railways as a means of transport are characteristic for Poland. Individual voivodships differ in terms of the parameters of the railway network, the manner and scope of its use, the density of railway lines, and the location of stations. Statistical analysis has shown that a high degree of economic and social activity of the population is conducive to better use of railways. There is also a feedback loop here. It is the railway that has had a positive impact on the growth of the region's GDP, counteracting social exclusion and unemployment.

Keywords: regional system, rail transport, sustainable development, intermodal transport, regional diversity by voivodships, passenger and freight transport

Streszczenie: Przedmiotem opracowania jest ukazanie podstawowych uwarunkowań zmian zachodzących na rynku przewozów kolejowych w Polsce w układzie regionalnym. Analizę statystyczną przeprowadzono w podziale na województwa. Dla Polski charakterystyczne są znaczne różnice regionalne w wykorzystaniu kolei jako środka transportu. Poszczególne województwa różnią się między sobą parametrami sieci kolejowej, sposobem i zakresem jej wykorzystania, gęstością linii kolejowych oraz lokalizacją stacji. Analiza statystyczna wykazała, że wysoki stopień aktywności ekonomicznej i społecznej ludności sprzyja lepszemu wykorzystaniu kolei. Istnieje również zakres sprzężenia zwrotnego. To właśnie kolej pozytywnie wpływa na wzrost PKB regionu, przeciwdziałając wykluczeniu społecznemu i bezrobociu.

Słowa kluczowe: układ regionalny, transport kolejowy, zrównoważony rozwój, transport intermodalny, zróżnicowanie regionalne według województw, transport pasażerski i towarowy

Introduction

Rail transport in Poland is of great importance both in the movement of passengers and cargo. The railway meets the transport needs of people related to the implementation of their individual social goals, enabling them to travel to work, schools, universities and allows them to carry out holiday trips. Thanks to the railway system, it is possible to deliver goods manufactured by various production plants to customers interested in purchasing them, who are located in various, often remote places in the country and abroad (Płatje, Paradowska, Kociszewski, 2018).

In order to assess the transport services provided by the railway network in Poland, it is necessary to compare it with other modes of transport. (Mendyk, 2009) The popularity of

railway transport is significantly influenced by the high safety of this type of transport. The accident rate during the movement of people and goods by rail is low compared to road transport. Accessibility to this type of transport is of significant importance in the demand for railway services. It is much greater than in air or sea transport. Rail transport is also much cheaper than air transport on the same routes.

The provision of services by rail transport is the sphere of activity which in the 20th century contributed to the development of industry and trade and took an active part in shaping modern economies. At the beginning of the 21st century, however, rail transport reached a stage where it had to compete with other modes of transport. The share of this branch of transport in 2005-2021 in the total weight of transported cargo decreased

from 18.9% to 10.6%. The strong impact felt was mainly from road transport. Its share in the same period increased from 75.9% to 86.6% (Transport activity results, 2022).

The aim of the study is to show the basic conditions of changes that are taking place on the rail transport market in Poland in the regional system. Both the freight transport market, with particular emphasis on intermodal transport, and the conditions in passenger transport were analysed. These issues were considered on a national and regional basis, broken down into individual voivodeships.

Literature review

Rail transport is characterised by certain specific features that determine its advantages and limitations. The factor determining the development of railways is the ability to transport a large number of passengers or significant loads at a time (Bešinović et al., 2022). Transport in this branch is characterised by relatively few externalities, due to relatively lower energy consumption and low emission of harmful compounds into the ecosystem. The railway is also characterised by a low degree of land occupancy (Rydzkowski, Wojewódzka-Król, 2008).

An important aspect of this branch is safety, the high level of which results from traffic management and the organisation of the rail network. Rail transport also does not allow door-to-door deliveries. This means that it is almost always necessary to support road transport in the transport of goods (Otto et al., 2019). The possibility of using substitute infrastructure is also limited, which makes the railway susceptible to difficulties during renovation and modernization works – this determines its low flexibility (Jarašūnienė, 2016).

In the market context, a certain barrier to the development of railways is the difficulty of new carriers entering the market – due to high costs, licences, access rights to infrastructure, and low level of rolling stock availability (Słowiński, 2008). Although rail transport is considered more ecological than road transport, it also emits exhaust fumes, noise, vibrations and limits the functions of areas adjacent to elements of railway infrastructure (Giuffrida et al., 2021). Although railway is characterised by high transport capacity, it is often treated mainly as a substitutive branch for car transport.

The answer to society's search for new, more effective, less cost-intensive and more environmentally friendly ways of transport is the

development of intermodal transport (Mindur, Gąsior, 2006). To a large extent, it uses rail transport as safer, greener and potentially more efficient on long distances (Zhang et al., 2022).

Intermodal transport has the ability to transport a large amount of cargo over long distances, it is less sensitive to weather conditions and other disturbances (Shipunova et al., 2022). It is very important to avoid restrictions specific to road transport in intermodal transport (e.g. traffic ban on weekends, traffic restrictions at night, drivers' working time restrictions). Its ever wider use represents a curb on the presence of heavy vehicles on roads and border crossings, which is undoubtedly important for transit countries (Stokłosa, 2019).

Material and methodology

The main subject of the study is to show the basic conditions of changes that are taking place on the rail transport market in Poland in the regional system. Freight transport and rail passenger transport were analysed. Data from the Central Statistical Office and information from the Office of Rail Transport were used for the analysis. The research period concerned mainly the years 2010-2021.

The analysis covered changes in the freight transport market. The analysis was carried out by assessing the total weight of transported goods, the volume of transport performance (performed work) and the volume of train operations. The scope of changes in the intermodal transport market was analyzed in detail. The scope of container transshipments in individual seaports, the location of reloading terminals broken down into sea and land were indicated.

The subject of the study was the assessment of changes in the passenger transport market. Here, the number of transported passengers and the involvement of individual railway carriers in the implementation of the transport process were analysed. In addition, the factors influencing the diversification of the railway utilization rate were examined. Statistical analysis was carried out by voivodship.

Results and discussion

The size of production means that rail transport, both in terms of freight and passenger transport, is affected by the condition of infrastructure. Linear infrastructure in rail transport is highly diversified in individual voivodeships. The characteristics of the condition of the railway infrastructure are presented in Table 1.

Table 1. The scope of diversification of infrastructure in rail transport in Poland by voivodships in 2021

Name of the province	Length of railway lines in km	Density of the railway network in km per 100 km ²	Share of the voivodship in total lines operated in %	Share of double-track lines in %	Share of lines with electric traction in %
Dolnośląskie	1 775	8,9	9,19	44,03	61,17
Kujawsko-pomorskie	1 199	6,7	6,21	44,66	46,99
Lubelskie	1 092	4,3	5,65	35,23	44,92
Lubuskie	913	6,5	4,73	43,92	36,60
Łódzkie	1 080	5,9	5,59	63,38	91,03
Małopolskie	1 080	7,1	5,59	44,72	84,42
Mazowieckie	1 718	4,8	8,89	64,60	83,37
Opolskie	784	8,3	4,05	56,89	55,50
Podkarpackie	978	5,5	5,06	23,81	55,50
Podlaskie	758	3,8	3,92	14,03	29,32
Pomorskie	1 212	6,6	6,27	35,41	38,16
Śląskie	1 872	15,2	9,68	55,64	92,09
Świętokrzyskie	722	6,2	3,73	51,72	75,91
Warmińsko-mazurskie	1 090	4,5	5,64	27,60	45,17
Wielkopolskie	1 881	6,3	9,73	61,60	67,17
Zachodniopomorskie	1 171	5,1	6,06	39,49	64,01
Poland	19326	6,2	100,00	46,21	62,89

Source: Own study based on: Sprawozdanie z funkcjonowania rynku transportu kolejowego w 2021 [Report on the functioning of the rail transport market in 2021] (2022).

The analysis of the data contained in Table 1 shows that in 2021 the longest railway line was in the Wielkopolskie, Śląskie, Dolnośląskie and Mazowieckie voivodeships. In each of these voivodeships, the total length of railway lines exceeded 1,700 km. With an average density of railway lines in Poland of 6.2 km/100 km², the voivodeships with the highest ratio were Śląskie (15.2), Dolnośląskie (8.9) and Opolskie (8.3). The lowest density of the railway line was in Podlaskie and Lubelskie Voivodeships (3.8 and 4.3 km/100 km², respectively). The presented range of differentiation is the result of, on the one hand, historical events, and on the other hand, it is associated with the varying degree of industrialization of the country and the social activity of the population living there.

Single-track lines are still the dominant model of functioning of railway lines in Poland. Their share is 53.79%. Podlaskie (14.03%), Podkarpackie (23.81%) and Warmińsko-Mazurskie (27.60%) voivodeships had a particularly low share of double-track lines. Also, the process of electrification of railway lines is one that takes place unevenly. Apart from voivodeships such as

Śląskie, Łódzkie, Małopolskie and Mazowieckie, where the share of electric lines exceeds 80%, there are still those where this indicator does not exceed 37%. These are the Podlaskie and Lubuskie voivodeships.

In 2021, rail freight transport in most EU countries increased compared to 2020, which was the beginning of the coronavirus epidemic. Among the EU countries, Germany and Poland showed the largest transport of goods by weight. In 2021, 357.6 million tonnes were transported by rail in Germany and 243.6 million tonnes in Poland (Table 2). The increase in transported weight in absolute terms also concerned these two countries to the greatest extent (32.3 million tonnes in Germany, 20.3 million tonnes in Poland). Germany was also a leader in Europe in terms of the volume of rail transport performance. In 2021, it amounted to 123.1 billion tonne-kilometres in this country. It was more than twice as much as in Poland, which in this respect also ranked second among EU countries. Compared to 2020, in absolute terms, this increase amounted to 13.8 billion tonne-kilometres.

The analysis of the volume of carried freight transported by train in Poland, we can state that a growth was observed over the period 2010-2011. This also concerned transport and operational performance (Table 2). The years 2012-2016 are the period of reducing the weight of transported cargo. A significant improvement was brought only in 2017. Compared to the previous year, both the volume of transported cargo as well as transport and operational performance increased significantly (by about 8%). The upward trend was also maintained in 2018.

The freight transport market in 2021 was characterised by higher operational parameters than in 2020. The weight of transported goods in 2021 increased by 9.1%. Rail carriers not only transported more goods year-on-year, but also achieved the second best result in the last decade (the best was in 2018, in which 250.3 million tonnes were transported). Over the years 2017-2021, operational work in 2020 alone fell below 80 million train-km. In 2021, it reached the level of 81.6 million train-km, which meant an increase of 5.3% compared to the previous year. It was the third best result over the decade. At that time, operational work was higher in 2018-2019.

Table 2. Changes in rail freight services in Poland over the period 2010-2021

Year	Volume of rail freight in million tons	Performance in billion train-km	Train operations in million train-km	Average service distance
2010	235,3	48,8	71,5	207,4
2011	249,2	54,0	79,3	216,5
2012	234,3	51,1	74,4	212,1
2013	233,2	50,9	74,3	218,1
2014	228,9	50,1	74,9	218,9
2015	224,8	50,6	74,8	225,1
2016	222,2	50,6	74,0	227,8
2017	239,9	54,8	80,0	228,6
2018	250,3	59,6	88,0	238,3
2019	236,4	55,9	82,3	236,6
2020	223,2	52,2	77,5	233,9
2021	243,6	56,0	81,8	229,7

Source: Own study based on: Statystyka przewozów towarowych www.utk.gov.pl (16.10.2022).

An important problem limiting the increase in the volume of freight transport on the railway is the speed at which cargo moves. Changes in the average commercial speed of freight trains in 2010-2021 are shown in Figure 1. The speed in total freight transport in 2010-2021 decreased by 2 km/h from 25.4 to 23.4 km/h. Two key factors contributed to the re-decrease in the speed of freight trains in Poland. These are the modernization of railway lines and the increase in transport performance. Low commercial speed has had a negative impact on the competitiveness of rail transport and has made many logistics operators choose another mode of transport (Abramov et al., 2022).

Data analysis shows that in the years 2010-2021 there was a systematic increase in the volume of intermodal rail transport. In 2021, 26.5 million tons of cargo were transported, while in 2020 it was 23.8 million tons. This means an increase of 11.3%. The share of intermodal transport in the entire rail transport market measured by the weight of transported cargo reached the level of 10.9%. For comparison, in 2020 this share was 10.7%, while in 2019 it was 8.3%. The share of transport performance in intermodal transport in 2021 amounted to 14.6%. Positive changes concerned all transport parameters.

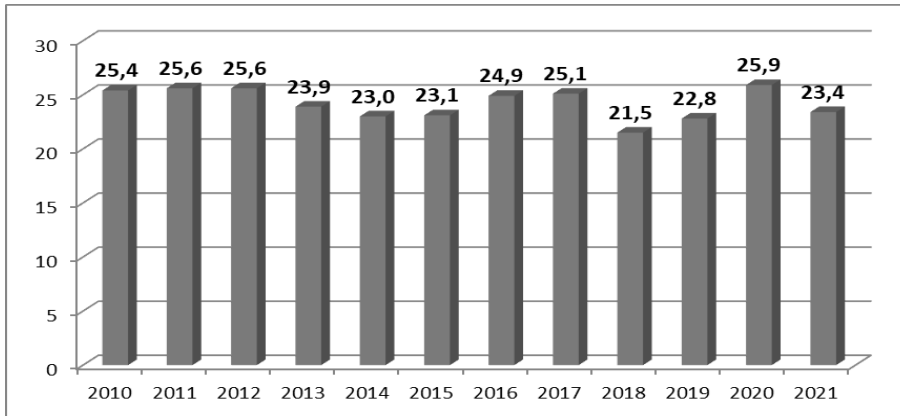


Figure 1. Average commercial speed of freight trains in the years 2010-2021 in km/h

Source: Own study based on: Statystyka przewozów towarowych www.utk.gov.pl (19.10.2022).

As in previous years, in 2021 PKP Cargo had the largest share in intermodal transport. This concerned both weight and transport performance (30.7% and 37.4% market share, respectively). However, the importance of other participants in this market segment is growing year by year.

Among other carriers, a significant share in terms of transported weight in intermodal transport in 2021 was recorded by: PCC Intermodal, DB Cargo Polska, Ecco Rail, LTE Polska and Captrain Polska. Their total market share, taking into account the transported weight, amounted to approx. 39.8%. In the case of transport performance, this ratio amounted to 42.9%.

The intermodal terminal is a place that allows for the quick and safe trans-shipment of cargo units between means of transport of two different types of transport. In 2021, there were 39 active terminals in Poland. Four of them, being sea terminals, handled sea-rail and sea-road cargo. There were much more land terminals. 35 terminals handled rail-road shipments (Fig. 2). Most of them were located in the following voivodeships: Śląskie, Dolnośląskie, Łódzkie, Wielkopolskie and Lubelskie.



Figure 2. Distribution of intermodal terminals in Poland by region

Source: Transport intermodalny w Polsce w 2021 r. GUS, Warszawa 2022.

Table 3. Characteristics of intermodal terminals depending on their location in 2021

Itemization	Sea terminals	Land terminals	Total
Storage area in ha	183,0	96,5	279,5
Capacity of storage yards in thousands TEU	100,7	133,4	234,1
Parking area in ha	6,1	24,9	31,0
Track length in km	17,0	83,2	100,2
Number of cranes in pieces	109	13	122
Volume of transhipments in thousands TEU	5 856	3 776	9 632
Reloading of 40' containers in thousands	4 703	2 909	7 612

Source: Own study based on: Transport intermodalny w Polsce w 2021 r. GUS, Warszawa 2022.

Both the infrastructure and the volume of transshipments were significantly differentiated by the location of the terminals (Table 3). Sea terminals dominated both in terms of the volume of transshipments and the number of cranes and available storage space in ha. Among the reloading of containers, 40`definitely dominated. Land terminals definitely dominated in terms of parking space and the total length of tracks.

An equally important area of rail transport activity is the transport of passengers (Dedík et al., 2020; Kramarz et al., 2022). In 2021, rail passenger transport was partially recovering after a difficult year, due to the coronavirus pandemic, in 2020. In 2021, the epidemic situation and the related restrictions continued. Passenger railways operated under sanitary restrictions, a large group of professionally active people continued to work remotely, remote learning was also introduced at schools and universities.

The aforementioned factors had a direct impact on the transport results. In 2021, 245.1 million passengers used rail, which is 35.7 million more (+17%) than in 2020. Despite the increase, the number of rail passengers has not returned to pre-pandemic levels. In 2021, passenger transport reached the level of 73% of the number of passengers from 2019. It should be emphasised that 2019 was, from the beginning of 2010, the

period with the greatest interest in passenger transport services by rail (Fig. 4). In 2021, transport performance amounted to 15.9 billion passenger-kilometres, which is over 3.2 billion passenger-kilometres more (+25.6%) than in 2020. However, this value is only 72% of the transport performance performed by carriers in 2019. It was in 2019 that the highest value of this parameter was recorded.

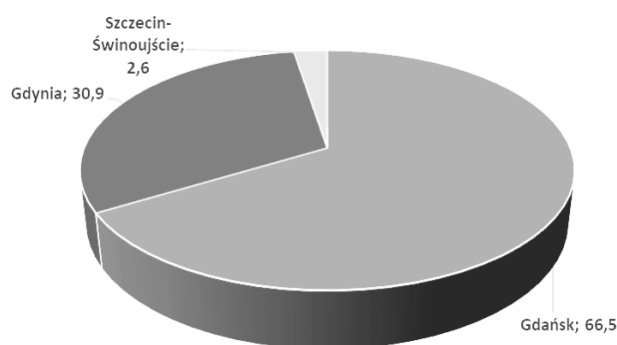


Figure 3. Share of individual seaports in container handling in 2021
Source: Own study based on: Sprawozdanie z funkcjonowania rynku transportu kolejowego w 2021 [Report on the functioning of the rail transport market in 2021] (2022).

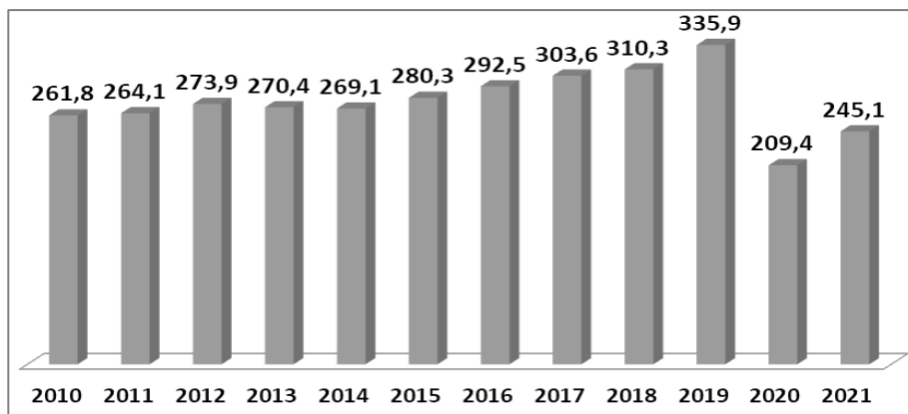


Figure 4. The number of passengers carried by rail transport in the period 2010-2021 (in million)
Source: Own study based on: Statystyka przewozów pasażerskich. Przewozy pasażerskie w 2021 roku [Passenger transport statistics. Passenger transport in 2021] (2022).

The volume of rail transport shows significant regional differences (Table 4). In 2021, 74.0 million passengers were checked in in the Mazowieckie Voivodeship. The share of this voivodeship in the passenger transport market amounted to 30.2%. The second place in the transport structure was taken by the Pomorskie Voivodeship (19.1%). 46.7 million passengers checked in here. The

scope of railway use in individual regions of the country is also characterised by the number of journeys per 1 inhabitant of the voivodeship. In Poland, the value of this indicator in 2019 was 8.7 trips per inhabitant. As expected, under the influence of the situation related to the COVID-19 epidemic, this parameter fell to 5.5 in 2020, and in the following year it increased to 6.4 trips per

capita. In 2021, it reached the highest level in the Pomorskie (19.9), Mazowieckie (13.6) and Dolnośląskie (7.8) voivodeships. Wielkopolskie Voivodeship was ranked fourth with the indicator of 6.3 journeys per capita. The highest level of this indicator characterised voivodeships with a well-developed network of agglomeration and regional

railways. Passengers here chose rail transport, relieving individual transport by passenger cars. This had a direct impact on reducing the phenomenon of transport congestion and supported aspects of sustainable development (Vojtek et al., 2019).

Table 4. Number of passengers transported and railway utilization rate in Poland by voivodships in 2019-2021

Name of the province	Number of passengers carried in million			Railway use rate per capita		
	2019	2020	2021	2019	2020	2021
Dolnośląskie	32,6	19,2	22,7	11,2	6,6	7,8
Kujawsko-pomorskie	9,0	5,9	6,2	4,3	2,8	3,0
Lubelskie	4,1	2,9	3,5	1,9	1,4	1,6
Lubuskie	3,7	2,4	3,0	3,6	2,3	3,0
Łódzkie	15,8	9,9	11,4	6,4	4,0	4,7
Małopolskie	16,0	10,0	12,8	4,7	2,9	3,8
Mazowieckie	105,0	67,4	74,0	19,4	12,4	13,6
Opolskie	5,4	3,1	3,6	5,4	3,1	3,7
Podkarpackie	4,9	2,9	3,8	2,3	1,3	1,8
Podlaskie	2,5	1,6	1,7	2,1	1,3	1,5
Pomorskie	61,0	37,3	46,7	26,1	15,9	19,9
Śląskie	26,6	16,2	19,3	5,9	3,6	4,3
Świętokrzyskie	3,1	2,2	2,7	2,5	1,8	2,2
Warmińsko-mazurskie	5,0	3,3	3,9	3,5	2,3	2,8
Wielkopolskie	31,6	18,9	22,0	9,1	5,4	6,3
Zachodniopomorskie	9,8	6,3	7,7	5,8	3,7	4,6
Poland	335,9	209,4	245,1	8,7	5,5	6,4

Source: Own study based on: Sprawozdanie z funkcjonowania rynku transportu kolejowego w 2021 [Report on the functioning of the rail transport market in 2021] (2022).

The analysis of changes in the railway utilization rate shows that the interest in this means of transport/increased in most voivodships. However, despite the fact that passengers are more willing to travel by train, there is still a problem of limited access to railways and problems with the not always satisfactory functioning of connections (Popova et al., 2021). The railway is available in every provincial capital in Poland. However, many towns, which are important for the region, cannot be reached by train or access to the railway is limited (Shchepkina et al., 2022).

The system of factors influencing the use of railways in Poland is multifaceted. The correlation analysis was performed on: the density of the railway network per 100 km², the average number

of train stops in the voivodship per hour, GDP per capita, unemployment rate and the share of local transport. The entire statistical analysis was carried out by voivodship (Fig. 5).

A comparison of the density of railway lines and the level of railway use by travellers in a given voivodship shows that there is not always a correlation between these parameters. The higher density of railway lines does not translate directly into a high level of railway use. Two voivodships – Pomorskie and Mazowieckie – are characterised by a / railway use much higher than the other voivodeships (at the level of 19.9 and 13.6), with the density of the railway network, respectively: 6.6 and 4.8 km/100 km². The efficiency of railway use in these voivodeships results from, among others, from a well-developed network of railway

lines within and around both agglomerations. Railway lines are being modernised and, additionally, both regions have independent fragments of linear infrastructure, i.e., the Pomeranian Metropolitan Railway and the Warsaw Commuter Railway. The highest density of railway

lines (as much as 15.2 km of lines per 100 km²) is in the Śląskie Voivodship. However, the level of railway use in this region is 4.3 journeys per capita, which is two journeys less than the national average.

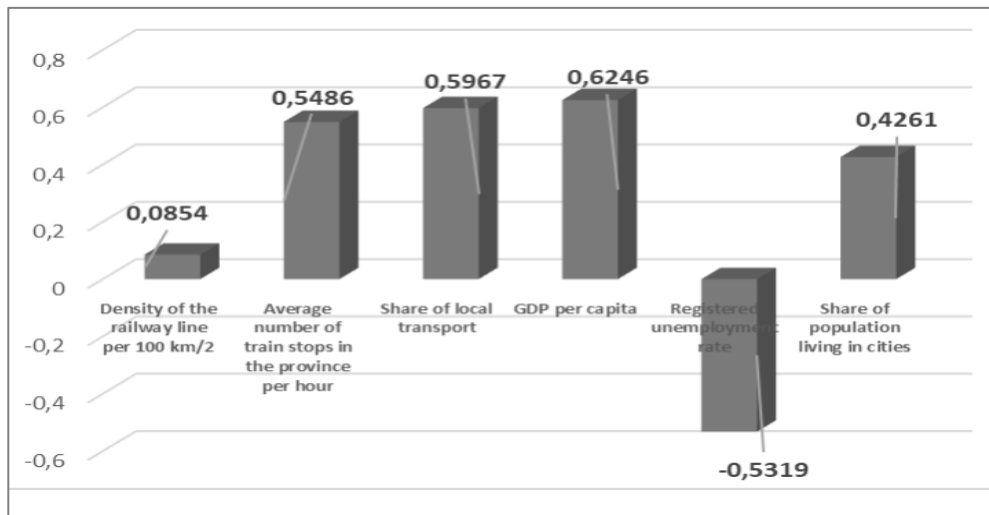


Figure 5. The value of correlation coefficients between the railway utilization index and selected features

Source: Own study based on: Central Statistical Office in Warsaw.

On the other hand, a highly significant correlation occurred between the railway utilization rate and the GDP per capita in individual voivodships. In richer regions, the number of rail journeys per capita was higher. The fact that the economic activity of the population had a positive impact on the use of railways is evidenced by the negative correlation regarding the unemployment rate. In voivodships with a high unemployment rate, the demand for railway crossings was significantly lower.

A significant range of correlations also occurred between the railway utilization rate and the average number of train stops per hour in the voivodship, the share of local transport and the share of urban population. This proves that a higher number of journeys per passenger was often associated with the dominance of short-distance connections in a given voivodship. At the same time, more urbanised areas generated better use of railways as a means of transport.

Conclusions

Changes in the rail transport market are taking place under the strong pressure of road transport. The share of rail transport in the total weight of transported cargo is currently about 10%. In 2021, rail freight transport in most EU countries increased compared to 2020, which was the

beginning of the coronavirus epidemic. Among the EU countries, Germany and Poland showed the largest transport of goods by weight. The weight of transported goods in Poland in 2021 increased by 9.1% compared to 2020. This was due to the increase in economic activity after the first year of the COVID-19 epidemic, the increase in international transport, and the increase in the number of railway companies performing transport.

The situation on the rail freight market has been improved by intermodal transport. This type of transport enables the creation of modern supply chains combining two or more modes of transport into one coherent system. Its current functioning in Poland is based on four sea and 39 land terminals with various equipment and range of influence. In the years 2010-2021, there was an over six-fold increase in both the weight of transported cargo and the number of load units carried out as part of intermodal rail transport. The share of intermodal transport in the entire rail transport market, measured by the weight of transported cargo, reached 10.9% in 2021.

Significant regional differences in the use of railways as a means of transport are characteristic for Poland. Individual voivodships differ in terms of the parameters of the railway network, the manner and scope of its use, the density of railway lines, and the location of stations. Statistical analysis has

shown that a high degree of economic and social activity of the population is conducive to better use of railways. There is also a feedback loop here. It is the railway that has a positive impact on the growth of the region's GDP, counteracts social exclusion and unemployment. The voivodships that are distinguished by attractive activities for the promotion and strengthening of railways include, among others: Pomorskie, Dolnośląskie, Wielkopolskie or Łódzkie.

Among the good practices implemented in the voivodships and conducive to the popularization of rail transport, the following can be mentioned:

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