

THE EFFICIENCY OF THE SELECTED POLISH REGIONAL RAIL CARRIERS IN THE YEARS 2017 - 2020

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Abstract – The provision of transport services is a crucial element of the modern economy and it is not an easy task. It requires taking into consideration a number of factors and expectations of travelers. Meeting these expectations results in the degree of use of a given carrier by travelers. In the article, using the method of documentation analysis, an assessment and comparison of the efficiency of the selected regional rail carriers providing transport services mainly within different provinces in Poland in the years 2017-2020 were made.

Key words – transport efficiency, rail transport, regional carriers in Poland

JEL Classification – L92

INTRODUCTION

Transport companies fulfill and implement a number of significant tasks both for the economy as well as social development. Providing the ability to move from point A to point B allows for the implementation of a number of very important requirements of the modern world. This applies to both cargo and passengers.

The role of transport in everyday life is very clearly visible in meeting the daily transport needs of society in a given region or area. These needs are closely related to the implementation of daily necessary activities, such as:

- travel to and from work,
- travel to and from school / university,

and other generators of transport needs, such as the implementation of official matters, social meetings, etc. [1] Undoubtedly, the COVID-19 pandemic has considerably limited some of these needs (due to the transition, for example, of a significant part of education to the remote education system). Hopefully, this is a temporary situation and in some time there will be a shift to increased transport needs.

It is worthwhile to mention that for over a dozen years, various actions have been taken in Poland to reverse the negative trend of using largely

individual transport for the benefit of collective transport, which, for example, due to the high costs in comparison to other means of transportation (e.g. bicycles) [2] congestion (and its consequences) [3-4], lack of parking spaces in cities, environmental protection and its transport efficiency (understood as the possibility of transporting in one means of transport a large number of people) is the preferred mode of transport, which is being more and more developed and rebuilt by decision makers [5, 6]. Similar activities are also carried out in other areas of the world [7]. This increases the importance, also in the activities of local government organizations, of the role of public transport both within the city and between cities, e.g. in an agglomeration (e.g. the Upper Silesian agglomeration in Poland) and between the main cities of the region and neighboring cities where also quite large numbers of travelers are often generated.

With this right (in the author's opinion) approach, which also takes into account the development of transport infrastructure, both the launch and development of regional rail transport organized and performed by various carriers are implemented. This in turn can effectively implement and meet the transport needs for several years. Importantly, an element having an influence on the

positive aspects of using rail transport is the fact that, according to the literature, it allows for better use of energy than other modes of transport [8].

1. RAILWAY CARRIERS IN POLAND

Currently in Poland, based on information from the Office of Rail Transport (UTK) of February 18, 2021 [9], 31 carriers has had a license for passenger transport, while in 2017 [10], activities related to the provision of passenger transport services in rail transport were carried out by 35 rail carriers, and 15 of them provided regular passenger transport services.

Railway carriers providing their services in Poland can be divided into 2 types:

- carriers providing services throughout the country,
- carriers providing services mainly in the area of a voivodeship (the area administered by a voivode - Governor in several countries of central and eastern Europe) or agglomeration.

The second group of carriers plays the most important role in ensuring efficient and effective public transport in cities and agglomerations. The quality of the services they provide depends on whether travelers will change their habits, also habits related to the use of mainly road transport. Of course, this is not an easy task and a number of factors should be taken into account here, such as:

- number of connections,
 - travel time,
 - travel comfort,
 - the cost of travel,
- in relation to both collective and individual car transport.

The railway carriers try to take into consideration these factors while providing their services (e.g. when preparing the transport offer). This is especially noticeable not only with national but also local carriers. The rolling stock of railway carriers is constantly being modernized and extended. The advantage of these carriers is also the fact that most of them have been operating on the market for about 15 years or less, so their structures and organizational model were prepared from the very beginning to operate in a free market economy and to compete for travellers as well.

Carriers providing services in a given voivodeship and agglomeration, which is often its capital, are particularly interesting in terms of the effectiveness of operations. Among these carriers are:

- Koleje Śląskie,
- Koleje Dolnośląskie,
- Koleje Małopolskie,

- Koleje Wielkopolskie,
- Koleje Mazowieckie.

The individual railway companies are briefly described in the author's earlier works and on their own websites.

The activities and performance of the above-mentioned carriers were subject to a comparative analysis.

2. RESEARCH METHODOLOGY

In this article, which is a continuation of the research presented in the author's earlier works in order to assess the effectiveness of the operation and to carry out a several-year evaluation of the functioning of railway carriers, an analysis and comparison of the effectiveness of the operation of selected companies providing passenger transport services in rail transport have been performed. All the analyzed companies provide their services mainly within one voivodeship (they have only a few connections with neighboring voivodships or neighboring countries to ensure transport accessibility). The research and analyses were carried out with the use of the document analysis method. On the basis of information obtained from the Office of Rail Transport (UTK) as well as reports and annual reports of carriers, valuable information was collected which enabled the author to calculate and compare the selected performance indicators.

There are many definitions of efficiency that are created. They depend on the specificity of the issue or the main analyzed problem, such as determining the efficiency of rail transport on the basis of the distance and time of travel [11] or the energy used (in the form of reducing electricity consumption [12], fuels or reducing the emission of harmful substances [13]). Moreover, a lot of authors deal with the issue of the efficiency of rail transport and the factors influencing it [14-16].

According to [17], efficiency is difficult to define unequivocally but it can be defined as "carrying out activities much better than others in the same industry are doing, carrying out the same concept of business operation" [17]. Another definition given by [18-19] is that it is maximizing profits while minimizing inputs. In respect of the above, the following measures were proposed and can be called indicators of effectiveness:

$$a) \text{ Number of passengers carried} \\ n \text{ [pass.]} \quad (1)$$

where:

n - Number of passengers [pass.]

$$b) \text{ Transport work} \quad W \text{ [pass.km]} \quad (2)$$

where:

W - Transport work [pass.km]

c) *Punctuality*

$$P = [\%] \quad (3)$$

where:

P - punctuality [%]

d) *Rolling stock efficiency*

$$w_{\text{tab}} = n / \text{tab} [\text{pass.} / \text{item.}] \quad (4)$$

where:

w_{tab} - Rolling stock efficiency [pass./item]

n - number of passengers [pass.]

tab - number of rolling stocks [item.]

e) *Demographic efficiency*

$$w_d = n / n_m [\text{pass.} / \text{inhab.}] = [-] \quad (5)$$

where:

w_d - demographic efficiency [pass./inhab.] = [-]

n - number of passengers [pass.]

n_m - number of inhabitants [inhab.]

Since such parameters as: network size, size and condition of rolling stock, number of employees, number of inhabitants living in the area served by the carrier are not taken into account, indicators (1) - (2), most likely will not be suitable for assessing

the effectiveness of carriers. However, they constitute a good and significant supplement to the information that will be obtained from indicators (3) - (5).

3. CARRIERS EFFICIENCY

Based on the data obtained from the Office of Rail Transport and the Annual Reports as well as Reports on the Implementation of Services prepared by railway carriers, a data summary was prepared and used to calculate the efficiency indicators.

Table 1 and Figure 1 show the number of passengers transported and the transport work performed by carriers.

As shown in Table 1 and Figure 1 Koleje Mazowieckie carried the largest number of passengers in the analyzed group of carriers, followed by Koleje Śląskie in second place. The above fact may result from the largest population in the voivodships served by these carriers and from the relatively well-developed network of connections offered by carriers [20]. Koleje Dolnośląskie was in third place. Very similar relationships can be observed for the transport work, which is presented in Table 1 and Figure 2. Importantly, there is a noticeable decrease in the number of passengers and transport work in 2020, which is unfortunately caused by the aforementioned COVID-19 pandemic.

Table 1. The number of passengers transported and the transport work performed by railway carriers in 2017-2020 (source: own study, based on UTK data)

| Year | 2017 | | 2018 | |
|----------------------|-----------------------------|-------------------------------|-----------------------------|-------------------------------|
| | Number of passengers [mln.] | Transport work [mln. pass.km] | Number of passengers [mln.] | Transport work [mln. pass.km] |
| Koleje Śląskie | 15.73004 | 687.408443 | 16.958381 | 757.1217823 |
| Koleje Dolnośląskie | 9.380451 | 508.047568 | 11.72567 | 601.188189 |
| Koleje Małopolskie | 5.730428 | 168.350904 | 6.4387 | 239.121283 |
| Koleje Wielkopolskie | 8.096779 | 357.430154 | 10.9616 | 406.641422 |
| Koleje Mazowieckie | 62.041365 | 2187.961181 | 59.702687 | 2105.56797 |

| Year | 2019 | | 2020 | |
|----------------------|-----------------------------|-------------------------------|-----------------------------|-------------------------------|
| | Number of passengers [mln.] | Transport work [mln. pass.km] | Number of passengers [mln.] | Transport work [mln. pass.km] |
| Koleje Śląskie | 20.405556 | 721.908909 | 12.982212 | 424.2446632 |
| Koleje Dolnośląskie | 14.113636 | 680.852113 | 9.154426 | 426.614015 |
| Koleje Małopolskie | 6.479082 | 247.2002375 | 3.902544 | 175.6997354 |
| Koleje Wielkopolskie | 12.166467 | 439.0110242 | 7.572236611 | 300.3641051 |
| Koleje Mazowieckie | 62.105138 | 2140.551528 | 41.804989 | 1317.746408 |

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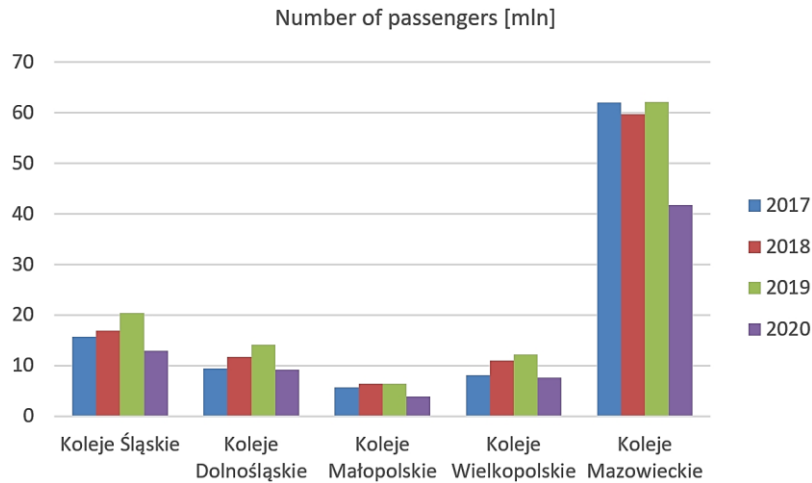


Fig. 1. The number of passengers carried by railway undertakings in the years 2017 - 2020
(source: own study, based on table 1)

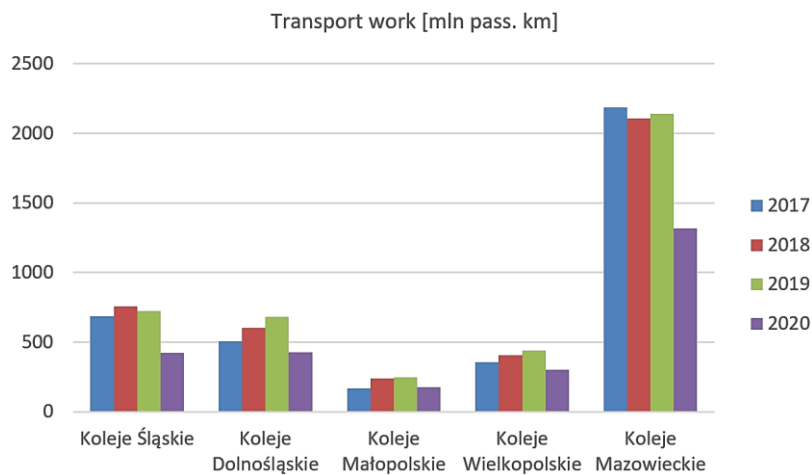


Fig. 2. Transport work performed by railway carriers in the years 2017 - 2020
(source: own study, based on table 1)

Restrictions in movement, lockdown and the transition to remote learning and work began in Poland at the end of the 1st quarter of the 2020 and except for certain periods of reduction of restrictions (mainly during the summer when the school-related traffic congestion is smaller) they are maintained with less or greater intensity, so their impact on the operation of railway undertakings is also visible.

Another significant parameter, which is also a very good quality indicator of a given carrier, is punctuality. This parameter is always important,

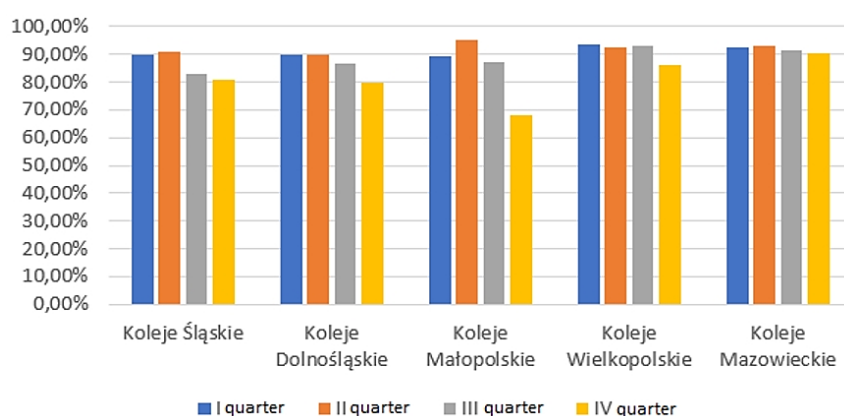
but in the case of cyclical, systematic trips related to the implementation of daily mandatory activities (e.g. commuting to and from work), it becomes particularly significant and can strongly influence the decisions made by travelers regarding the choice of the means of transport.

Therefore, in Table 2 and Figures 3 and 4, the punctuality of carriers in 2017-2020 is presented. Figure 3 shows the punctuality by year divided into quarters, while Figure 4 shows the annual punctuality in 2017-2020.

Table 2. Punctuality of carriers in 2017 - 2020 (source: [27 - 29])

| Year | 2017 | | | | |
|-----------------------------|-----------|------------|-------------|------------|---------------|
| Carrier | I quarter | II quarter | III quarter | IV quarter | average |
| Koleje Śląskie | 90.13% | 91.09% | 83.11% | 81.00% | 86.33% |
| Koleje Dolnośląskie | 89.91% | 89.97% | 86.77% | 79.88% | 86.63% |
| Koleje Małopolskie | 89.47% | 95.16% | 87.24% | 68.19% | 85.02% |
| Koleje Wielkopolskie | 93.38% | 92.72% | 93.21% | 86.12% | 91.36% |
| Koleje Mazowieckie | 92.38% | 92.88% | 91.53% | 90.64% | 91.86% |
| Year | 2018 | | | | |
| Carrier | I quarter | II quarter | III quarter | IV quarter | average |
| Koleje Śląskie | 90.76% | 88.27% | 88.57% | 88.04% | 88.91% |
| Koleje Dolnośląskie | 87.77% | 80.94% | 85.23% | 84.41% | 84.59% |
| Koleje Małopolskie | 73.44% | 84.04% | 78.75% | 81.29% | 79.38% |
| Koleje Wielkopolskie | 89.02% | 86.56% | 86.75% | 89.24% | 87.89% |
| Koleje Mazowieckie | 91.45% | 87.69% | 86.71% | 87.38% | 88.31% |
| Year | 2019 | | | | |
| Carrier | I quarter | II quarter | III quarter | IV quarter | average |
| Koleje Śląskie | 90.76% | 91.83% | 90.50% | 87.24% | 90.08% |
| Koleje Dolnośląskie | 93.77% | 93.68% | 91.31% | 89.95% | 92.18% |
| Koleje Małopolskie | 87.90% | 94.15% | 93.88% | 91.58% | 91.88% |
| Koleje Wielkopolskie | 95.72% | 95.15% | 94.88% | 93.11% | 94.72% |
| Koleje Mazowieckie | 92.47% | 92.32% | 93.13% | 92.62% | 92.64% |
| Year | 2020 | | | | |
| Carrier | I quarter | II quarter | III quarter | IV quarter | average |
| Koleje Śląskie | 92.45% | 95.13% | 91.36% | 88.96% | 91.98% |
| Koleje Dolnośląskie | 94.71% | 97.21% | 94.83% | 92.80% | 94.89% |
| Koleje Małopolskie | 94.64% | 98.24% | 95.66% | 96.30% | 96.21% |
| Koleje Wielkopolskie | 95.60% | 96.37% | 94.22% | 93.67% | 94.97% |
| Koleje Mazowieckie | 95.20% | 96.97% | 94.41% | 93.94% | 95.13% |

Punctuality in 2017 [%]



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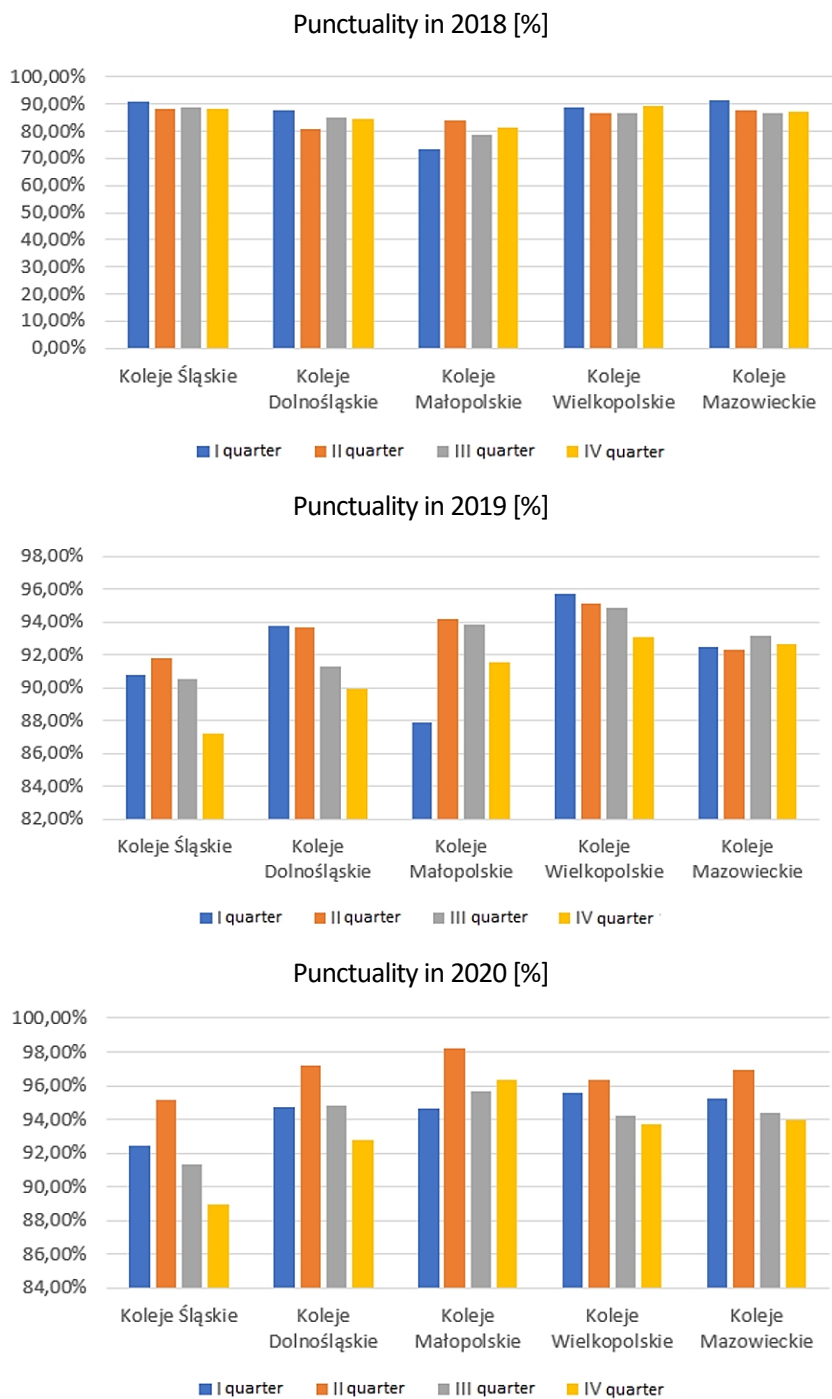


Fig. 3. Quarterly punctuality of carriers in 2017 - 2020 (source: own study, based on table 2)

Figure 4 shows the average annual punctuality of selected carriers.

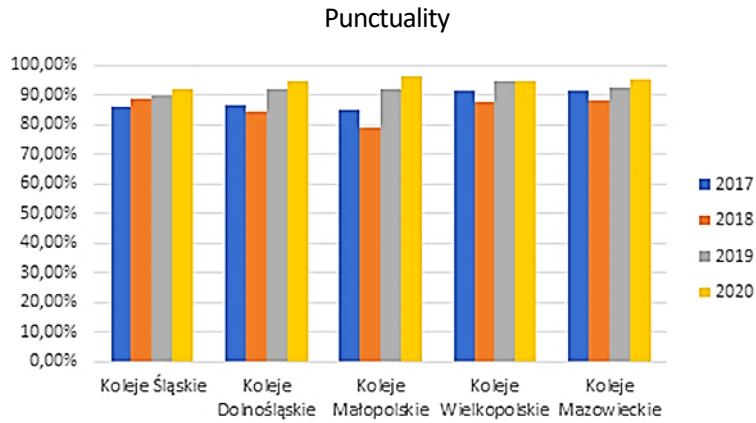


Fig. 4. Average annual punctuality of carriers in 2017-2020 (source: own study, based on table 2)

As shown in Table 2 and Figures 3 and 4, the punctuality of all carriers has been between 85 and 96% in recent years. The values obtained in 2019 and 2020 (for which, due to the reduced transport performance, the author approaches with caution in the interpretation) are above 90%, so there is a considerable improvement in the punctuality of carriers. The increase in punctuality over the years can be seen clearly for Koleje Śląskie, Małopolskie and Dolnośląskie, which in the author's opinion remains optimistic. If this tendency is maintained, taking into consideration the specificity of the operation of these specific carriers (the implementation of significant transport between the center of the agglomeration and its "periphery"), it may be another crucial element of the policy of reducing the use of car transport not only within the city and

agglomeration but also in the entire region. It is important that this parameter does not decrease, but is constantly raised. This is especially significant for Koleje Śląskie since work on the Metropolitan Railway and its variants is already well advanced [21], which should be a great complement of the current rail transport offer in the voivodeship - to achieve this goal, high punctuality of carriers is one of the key factors.

Then, the other 2 performance indicators of carriers were calculated. Employee and demographic efficiency were calculated as well. For this purpose, table 3 presents data on the number of workers employed by individual companies in 2017-2019, obtained from UTK reports and reports of carriers [10, 22-29].

Table 3. Number of employees in individual companies in 2017 – 2019
(source: own study, based on UTK Reports as well as Reports and reports of carriers)

| | Employees [person] | | |
|-----------------------------|--------------------|------|------|
| | 2017 | 2018 | 2019 |
| Koleje Śląskie | 1040* | 1041 | 1069 |
| Koleje Dolnośląskie | 682 | 724 | 720 |
| Koleje Małopolskie | 384* | 317 | 349 |
| Koleje Wielkopolskie | 473 | 656 | 720 |
| Koleje Mazowieckie | 2825* | 2830 | 2882 |

* approximate data, calculated on the basis of UTK data

In order to calculate the demographic efficiency (5), Table 4 was used. The Table presents information on the number of inhabitants in individual

voivodeships in which the analyzed railway carriers operate. The data for the Table were obtained from the National Statistical Office data (GUS) [24-26].

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Table 4. Population in 2017-2019 in voivodships where railway carriers operate (source: [24 – 26])

| Voivodship | Population [person] | | |
|---------------|---------------------|---------|---------|
| | 2017 | 2018 | 2019 |
| Śląskie | 4559164 | 4533565 | 4517635 |
| Dolnośląskie | 2903710 | 2901225 | 2900163 |
| Małopolskie | 3382260 | 3400577 | 3410901 |
| Wielkopolskie | 3481625 | 3493969 | 3498733 |
| Mazowieckie | 5365898 | 5403412 | 5423168 |

Based on the data in Tables 1, 3 and 4, the ratios (4) - (5) were calculated. The obtained results of the calculations are presented in Table 5 and Figure 5.

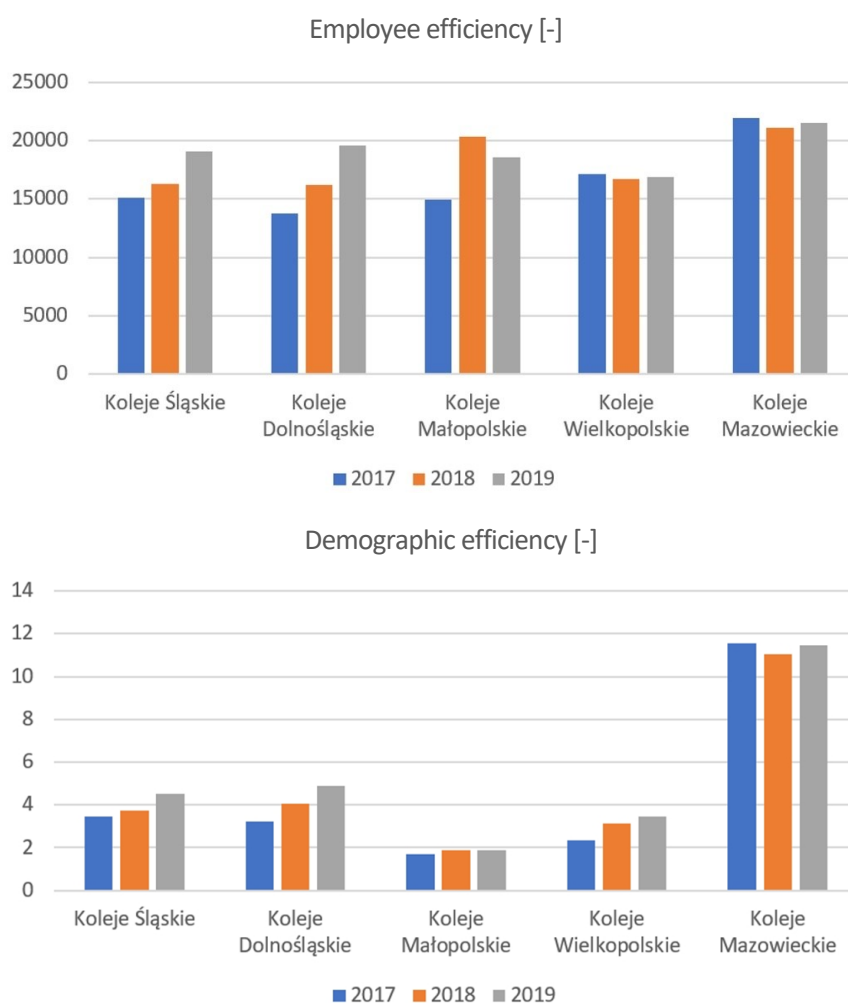


Fig. 5. Employee and demographic efficiency index in 2017-2019 for the analyzed carriers (source: own study, based on table 4)

Table 5. Employee efficiency index for the analyzed railway carriers in 2017-2019

(source: own calculations, based on tables. 1, 3 and 4)

| Carrier | Employee efficiency index [-] | | |
|----------------------|-------------------------------|----------|----------|
| | 2017 | 2018 | 2019 |
| Koleje Śląskie | 15125.04 | 16290.47 | 19088.45 |
| Koleje Dolnośląskie | 13754.33 | 16195.68 | 19602.27 |
| Koleje Małopolskie | 14922.99 | 20311.36 | 18564.70 |
| Koleje Wielkopolskie | 17117.93 | 16709.76 | 16897.87 |
| Koleje Mazowieckie | 21961.55 | 21096.36 | 21549.32 |

Table 6. Demographic efficiency index for the analyzed railway carriers in 2017-2019

(source: own calculations, based on tables. 1, 3 and 4)

| Carrier | Demographic efficiency index [-] | | |
|----------------------|----------------------------------|-------|-------|
| | 2017 | 2018 | 2019 |
| Koleje Śląskie | 3.45 | 3.74 | 4.52 |
| Koleje Dolnośląskie | 3.23 | 4.04 | 4.87 |
| Koleje Małopolskie | 1.69 | 1.89 | 1.90 |
| Koleje Wielkopolskie | 2.33 | 3.14 | 3.48 |
| Koleje Mazowieckie | 11.56 | 11.05 | 11.45 |

CONCLUSIONS

Rail transport plays a particularly important role in the implementation of public transport in urban and agglomeration areas. In order to compete with the currently popular road transport, rail transport has to carry out its activities in an effective manner. The article describes and proposes exemplary performance indicators of transport companies.

Indicators 1 and 2, as mentioned, clearly show the degree of use of a given carrier by travelers (especially in statistical terms when comparing data by year), but they do not take into account changes that may occur in the structure of a given carrier (changes in rolling stock or in the number of employees).

These indicators are also prone to external factors, such as the restriction of movement, which was in force for most of 2020. The restrictions introduced at that time, mentioned earlier in the article, resulted in a significant decrease in the number of travelers and transport work.

As mentioned in the article, a very good indicator of the carriers' assessment is their punctuality, which is a very good measure of the quality of the organization and planning of trips. Of course, there is always a risk of fortuitous events, reasons beyond the carrier's control affecting the delay (e.g. failure of railway traffic control devices, an accident on the route, etc.), but despite this, achieved punctuality, even quarterly,

shows that an element that still requires improvement and should be an element of thorough analysis and care by each carrier. As it was mentioned, the high rate of punctuality and its stability will guarantee travelers' awareness of the reliability of the carrier, and this may be a very important element of competitive advantage when choosing a means of transport for the trip.

According to the author of the study, very good indicators for assessing the effectiveness of carriers are the proposed indicators of both employee and demographic efficiency. The employee efficiency index in particular seems to have such features.

The demographic efficiency index allows us to assess the effectiveness of the services provided in relation to people living in a given area. The analyzes clearly show that Koleje Mazowieckie is also the best in this case. This may be related to other factors, such as the specificity of the area of operation of Koleje Mazowieckie since it includes the area of the Warsaw agglomeration (the capital of Poland). The obtained result may generate significant flows of people arriving and departing from the agglomeration due to professional and educational needs, which results in a large transport congestion in the city. In the remaining analyzed regions, this effect is not as intense and is not concentrated in such a relatively small area as in the Warsaw agglomeration (car congestion may positively influence the choice of another means of transport). Very similar values of the indicator were

observed for Koleje Śląskie and Dolnośląskie and, which is a very positive phenomenon, it shows an upward trend in the analyzed carriers. Importantly, the demographic efficiency indicator should be analyzed in relation to the other proposed indicators.

When it comes to the employee efficiency index, as shown in Table 4 and Figure 4, the highest value was achieved by Koleje Mazowieckie and in the analyzed period of several years, it remains at a relatively stable level. At the same time, the author of the work is optimistic about the stable growing trend of this indicator in the Koleje Śląskie and Koleje Dolnośląskie. Unfortunately, the same cannot be said of the Koleje Małopolskie and Koleje Wielkopolskie. It is suggested that the management boards of these companies conduct comparative analyzes in order to try to find the factors enabling the improvement of the aforementioned indicators, and thus the functioning of enterprises.

Taking everything into consideration, the proposed indicators can be a good tool for analyzing the effectiveness of the company's operation, especially when performing statistical analyzes for a period of several years, as is the case in this article. This can be a very good tool for "self-control" of the company's efficiency (for instance, the example of Koleje Małopolskie whose employee efficiency index after a rapid increase in 2017-2018 in the next period decreased slightly).

A significant advantage of the proposed indicators is also the availability of data used in them. This enables not only to analyze one's own enterprise, but also, as it is suggested, make a comparison (Benchmarking) of the effects of own actions with the actions of enterprises with a similar profile of activity.

EFEKTYWNOŚĆ WYBRANYCH POLSKICH KOLEJOWYCH PRZEWOŹNIKÓW REGIONALNYCH W LATACH 2017 - 2020

Świadczenie usług transportowych stanowi bardzo istotny element współczesnej gospodarki i nie jest ono zadaniem łatwym. Związane jest ze spełnieniem szeregu czynników oraz oczekiwań podróżnych. Spełnienie tychże oczekiwań przekłada się później na poziom wykorzystania, przez podróżnych, danego przewoźnika do realizacji podróży. W artykule z wykorzystaniem metody analizy dokumentacji, dokonano oceny i porównania efektywności funkcjonowania w latach 2017 - 2020 wybranych regionalnych przewoźników kolejowych świadczących usługi transportowe głównie w ramach poszczególnych województw w Polsce.

Słowa kluczowe: efektywność transport, transport kolejowy, przewoźnicy regionalni w Polsce

REFERENCES

- [1] Siti Nur Awanis Mohamad Zulkifli, Abdul Azeez Kadar Hamsa, Norzailawati Mohd Noor, Mansor Ibrahim (2017) "Evaluation of land use density, diversity and ridership of Rail Based Public Transportation System", *Transportation Research Procedia*, Vol. 25, pp. 5266-5281, ISSN 2352-1465. <https://doi.org/10.1016/j.trpro.2018.02.053>
- [2] Gössling S., Choi A. S. (2015) "Transport transitions in Copenhagen: Comparing the cost of cars and bicycles" *Ecological Economics*, Vol. 113, pp. 106-113, ISSN 0921-8009. <https://doi.org/10.1016/j.ecolecon.2015.03.006>
- [3] Mfinanga D., Fungo E. (2013) "Impact of Incidents on Traffic Congestion in Dar es Salaam City", *International Journal of Transportation Science and Technology*, Vol. 2, Issue 2, pp. 95-108, ISSN 2046-0430. <https://doi.org/10.1260/2046-0430.2.2.95>
- [4] Nagy A. M., Simon V. (2021) "A novel congestion propagation modeling algorithm for smart cities", *Pervasive and Mobile Computing*, Vol. 73, 101387, ISSN 1574-1192. <https://doi.org/10.1016/j.pmcj.2021.101387>
- [5] Grunicke C., Schlüter J., Jokinen J-P. (2021) "Evaluation methods and governance practices of new flexible passenger transport projects" *Research in Transportation Business & Management*, Vol. 38, 100575, ISSN 2210-5395. <https://doi.org/10.1016/j.rtbm.2020.100575>
- [6] Glotz-Richter M., Koch H. (2016) "Electrification of Public Transport in Cities (Horizon 2020 ELIPTIC Project)", *Transportation Research Procedia*, Vol. 14, pp. 2614-2619, ISSN 2352-1465. <https://doi.org/10.1016/j.trpro.2016.05.416>
- [7] Rachman F. F., Nooraeni R., Yuliana L. (2021) "Public Opinion of Transportation integrated (Jak Lingko), in DKI Jakarta, Indonesia", *Procedia Computer Science*, Vol. 179, pp. 696-703, ISSN 1877-0509. <https://doi.org/10.1016/j.procs.2021.01.057>
- [8] Cheron C., Walter M., Sandor J., Wiebe E. (2012) "ERRAC Roadmap. Towards 2030: Energy, Noise and Vibration European Railway Roadmaps", *Procedia - Social and Behavioral Sciences*, Vol. 48, pp. 2221-2229, ISSN 1877-0428. <https://doi.org/10.1016/j.sbspro.2012.06.1195>
- [9] <https://www.utk.gov.pl/pl/rejstry/licencjonowani-przewozni/16855,Wykaz-przewoznikow-licencjonowanych.html> (access date: 19.02.2021)
- [10] Sprawozdanie z funkcjonowania rynku transportu kolejowego w 2017 r., UTK 2018

- [11] Jiao J., Zhang F., Liu J. (2020) "A spatiotemporal analysis of the robustness of high-speed rail network in China", *Transportation Research Part D: Transport and Environment*, Vol. 89, 102584, ISSN 1361-9209.
<https://doi.org/10.1016/j.trd.2020.102584>
- [12] Lai X., Dai M., Rameezdeen R. (2020) "Energy saving based lighting system optimization and smart control solutions for rail transportation: Evidence from China", *Results in Engineering*, Vol. 5, 100096, ISSN 2590-1230.
<https://doi.org/10.1016/j.rineng.2020.100096>
- [13] Batty P., Palacin, R. (2015) *The Circumvention of Barriers to Urban Rail Energy Efficiency*. *Urban Rail Transit* 1, pp. 71–77.
<https://doi.org/10.1007/s40864-015-0014-9>
- [14] Jaržemskis A., Jaržemskis V. (2014). "The Differences in Efficiency Measurement: the Case of European Railways". *Transport and Telecommunication Journal*. 15.
<http://dx.doi.org/10.2478/ttj-2014-0014>
- [15] Jaržemskis A., Jaržemskienė I. (2017) "Comparison of Rail Freight Transportation Markets in Lithuania and Poland", *Procedia Engineering*, Vol. 187, pp. 492-497, ISSN 1877-7058.
<https://doi.org/10.1016/j.proeng.2017.04.405>
- [16] Moyano A. (2016) "High Speed Rail Commuting: Efficiency Analysis of the Spanish HSR Links", *Transportation Research Procedia*, Vol. 18, pp. 212-219, ISSN 2352-1465.
<https://doi.org/10.1016/j.trpro.2016.12.029>
- [17] Rutkowska A. (2013). *Teoretyczne aspekty efektywności – pojęcie i metody pomiaru*, *Zarządzanie i Finanse*, Vol. 1, Issue 4, pp. 439-453
- [18] Vitosoglu Y., Ozden R., Yaliniz P., Bilgic S. (2014) "Comparison of Light Rail Systems in Turkey with the Method of Comparative Standard Determination", *Transportation Research Procedia*, Vol. 3, pp. 670-679, ISSN 2352-1465
<https://doi.org/10.1016/j.trpro.2014.10.046>
- [19] Doomernik J.E. (2015) "Performance and Efficiency of High-speed Rail Systems", *Transportation Research Procedia*, Vol. 8, pp. 136-144, ISSN 2352-1465.
<https://doi.org/10.1016/j.trpro.2015.06.049>
- [20] Stawiarska, E.; Sobczak, P. (2018) "The Impact of Intelligent Transportation System Implementations on the Sustainable Growth of Passenger Transport in EU Regions", 10(5), 1318.
<https://doi.org/10.3390/su10051318>
- [21] Sobczak P. (2020) *Structural Analysis of The Connection Network of The W2 Variant of The Metropolitan Rail of The Silesian Voivodeship In Poland*. *Proceedings of the 35th International Business Information Management Association (IBIMA)*, ISBN: 978-0-9998551-4-0, 1-12 April 2020, Seville, Spain, p. 11763-11777
- [22] *Koleje Dolnośląskie raport roczny 2017*. PDF document 2018
- [23] *Koleje Wielkopolskie. Sprawozdanie z realizacji usług za rok 2017*. PDF document 2018
- [24] *Powierzchnia i ludność w ujęciu terytorialnym 2017*. GUS 2018
- [25] *Powierzchnia i ludność w ujęciu terytorialnym 2018*. GUS 2019
- [26] *Powierzchnia i ludność w ujęciu terytorialnym 2019*. GUS 2020
- [27] *Sprawozdanie z funkcjonowania rynku transportu kolejowego w 2018 r.*, UTK 2019
- [28] *Sprawozdanie z funkcjonowania rynku transportu kolejowego w 2019 r.*, UTK 2020
- [29] *Przewozy pasażerskie i towarowe, Podsumowanie 2020*, UTK 2021