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TIME EFFICIENCY OF TRANSPORT IN POLAND

Abstract

For several years, one can observe a clear upward trend in the mobility of Poles. Due to aspects concerning, in particular, environmental protection, the most desirable phenomenon would be a significant reduction in the use of private vehicles (passenger cars) for collective transport (especially rail). This is possible especially when there is access to an extensive communication network. The time and cost of traveling with alternative transport is very important. Therefore, the purpose of the publication is to analyze the time efficiency of rail and private vehicle transport, between provincial cities in Poland, based on the designed indicator. It was based on the average length of travel time and the average distance between points. The study covered private cars and railway transport.

Keywords: time efficiency, rail transport, private road transport
JEL: R410

Introduction

Under the second mobility package, more integrated and cleaner public transport is being promoted. It is possible to achieve, thanks to the transfer of long-haul transport from road transport to rail transport (cargo transport) (Komunikat, 2018). Similar guidelines also apply to passenger transport.

Rail transport is a convenient means of transport, independent of urban traffic, which gives it an advantage over other means of mass transport of people. Other positive features include low susceptibility to bad weather conditions, high frequency and regularity of connections, as well as low nuisance for the natural environment in terms of energy demand and emission of harmful substances.

However, in comparison to private car transport, there are factors that hamper the development of rail transport, i.e. no possibility of transport in the direct "door to door" relation, longer journey time resulting from the need to move

people directly to the departure point using other means of transport, as well as uneven distribution of the railway network. Therefore, the competitiveness of rail transport in relation to road transport is limited by the features that result from its characteristics.

The time and cost effectiveness of transport was analyzed by, among others, (Baltazar et al., 2014; Baron, 2010; Rohacs, 2010), however, it mainly concerned air transport. Among others, (Walter, 2009) he studied the efficiency of road transport, but he generally focused on cost aspects. In a large part of the studies, mainly for the analysis of cost-effectiveness, the DEA Sow method was used (Tran et. al., 2016).

In connection with the above, the aim of the study is to analyze the time efficiency of rail and road transport, between provincial cities in Poland, based on the designed indicator. It is also important to answer the question, whether passenger rail transport in Poland is characterized by lower time efficiency compared to private car transport.

1. Theory and methodology

Efficiency is defined as a measure of effectiveness that causes minimal losses of time, effort and skills (Archer, 2010). The concept of efficiency most often concerns the economic sphere, where efficiency is the relation of the obtained effects to the incurred expenditures. In passenger transport, it usually refers to the development of the lowest possible cost per passenger.

For the purpose of this study, it was assumed that the time efficiency of transport is the ratio of the length of the route covered in private car transport and in rail transport to the time of travel, taking into account the various routes available.

In order to facilitate the analysis process, the following simple indicator of the efficiency of temporary transport was proposed:

average distance (in km)/average travel time (in min),

where distance and travel time depend on the type of route selected and in rail transport additionally from the carrier.

The higher the value of the indicator, the greater the time efficiency. It should also be noted that the proposed indicator only illustrates the travel time/distance ratio.

Due to the fact that the length of the route between cities depends on the type of transport and the choice of the route of travel, the study was limited only to presenting the values of the obtained indicators, omitting the source data.

Google Maps were used to study the travel time of private car transport: https://www.google.com/maps/dir/. Due to the changes in travel time resulting from traffic at the peaks, average travel times were calculated on weekdays, three times a day (times: 8:00 a.m.–8:30 a.m., 12:00–12:30 and 6:00–6:30 p.m.). When analyzing the time efficiency of road transport, only the travel time was taken into account without considering possible breaks in the journey (e.g. rest of the driver).

In order to analyze rail travel data from the train schedule were obtained: http://rozklad-pkp.pl/. An analysis of railway connections was made, by determining

the average travel time, on a daily basis, from February 1st to February 10th, 2019. Where possible, the author focused on direct connections. If these were not available, the connections with the smallest number of transfers were taken into account. During the analysis, delays in connections were not considered.

The subject of the research is the length of railway roads and national roads, as well as the time of traveling by rail and car transport between individual capitals of voivodeships in Poland.

In two of the analyzed voivodeships, two capitals were considered. This applies to the Kujawsko-Pomorskie voivodeship, which has a voivod headquarter in Bydgoszcz, and the voivodeship regional council in Toruń. The situation is similar in the Lubuskie voivodeship, which has a voivod headquarter in Gorzów Wielkopolski, and the voivodeship regional council in Zielona Góra (Figure 1).

Figure 1. The administrative division of Poland including capitals of the voivodeships
Source: (https://encyklopedia.interia.pl/geografia-nauki-pokrewne/krainy-geograficzne/news-polska-podzial-terytorialny,nId,2025206)

When analyzing the state of railway and car transport, it is worth paying attention to the railway network and the road network density indicators. They are being determined by presenting density per 100 km^2 of the studied territory, or per 10,000 inhabitants. The indicators are calculated in accordance with the following formulas:

$$Ggk/Ggd = \frac{L}{P} \times 100$$

where:
Ggk/Ggd – geographical density of the railway network/national roads,
L – length of the railway line/national roads in Poland,
P – area of Poland.

$$Gdk/Gdd = \frac{L}{M} \times 10\,000$$

where:
Gdk/Gdd – population density of the railway network/national roads,
L – length of the railway line/national roads in Poland,
M – number of inhabitants of Poland.

According to the data of the Main Statistical Office for 2017, there are 19,209 km of standard-gauged railway lines in use, including 11,854 km of electrified lines. In addition, the length of standard-gauge two and more track lines amounts to 8,719 km.

The highest density of the railway network was recorded in the area of the Śląskie, Dolnośląskie and Opolskie voivodeships. This is related to the development of industry in this area. The smallest density of railway roads was recorded in the Lubuskie and Podlaskie voivodeships (Figure 2).

Figure 2. Map of the railway network in Poland
Source: (Map prepared by PKP Polskie Linie Kolejowe S.A., www.plk-sa.pl)

According to the data of the General Directorate for National Roads and Motorways (Figure 3), the length of motorways in Poland amounts to 1,638.5 km, and expressways, to – 2,101.2 km. The total length of all national roads amounts to 38,816.5 km[1].

The geographical density indicator of the railway network, amounts to 6.159 and is significantly lower than the road density indicator, which amounts to 12.446. The demographic density indicators are similar: for the railway network it amounts to 5.074 and for the national road network it amounts to 10.253.

Figure 3. Map of the road network in Poland
Source: (https://www.gddkia.gov.pl/pl/926/autostrady)

2. Results

Effectiveness indicators of railway (PKP) and car (CAR) transport are presented in Table 1.

[1] According to Art. 5 point 1. Act on public roads of March 21, 1985, as amended (Ustawa z dnia 21 marca 1985 r. o drogach publicznych [Dz. U. z 2018 r., poz. 317, Dz. U. z 2018 r., poz. 12]), national roads include, among others: motorways, expressways and roads lying in their runs until the construction of motorways and expressways, roads constituting other connections providing cohesion of the national road network, alternative roads for toll highways and roads constituting urban areas' bypass routes.

Table 1. Indicators of transport time efficiency

PKP / CAR	BIA	BGD	GD	GW	KAT	KIE	KR	LUB	Ł	OL	OP	POZ	RZE	SZC	TOR	WWA	WR	ZG
BIA	–	0.979	1.152	1.071	1.217	0.839	1.252	1.117	1.314	1.195	1.279	1.318	1.331	1.199	1.196	1.333	1.261	1.260
BDG	1.440	–	1.524	1.046	1.197	1.049	1.429	1.248	1.191	1.075	1.188	1.434	1.238	0.929	1.214	1.392	1.271	1.343
GD	1.484	1.462	–	1.194	1.498	1.285	1.629	1.205	1.321	1.233	1.251	1.576	1.443	1.209	1.413	1.705	1.357	1.403
GW	1.609	1.276	1.365	–	1.054	1.054	1.166	1.225	1.046	0.961	1.036	1.043	1.144	0.945	0.876	1.227	0.966	0.969
KAT	1.573	1.515	1.624	1.676	–	1.297	0.570	1.058	1.318	1.269	1.157	1.220	0.827	1.234	1.252	1.658	1.276	1.182
KIE	1.504	1.549	1.645	1.663	1.162	–	1.211	1.004	1.118	1.550	1.351	1.251	1.184	1.132	1.351	1.475	1.382	1.238
KR	1.501	1.500	1.615	1.659	1.051	1.094	–	1.329	1.642	1.439	1.328	1.315	1.285	1.257	1.409	1.775	1.384	1.152
LUB	1.154	1.510	1.550	1.655	1.312	1.195	1.331	–	1.159	1.257	1.066	1.372	1.019	1.226	1.263	1.247	1.070	1.167
Ł	1.662	1.422	1.623	1.750	1.249	1.060	1.250	1.237	–	1.532	1.103	1.020	1.208	1.305	1.065	1.416	0.988	1.066
OL	1.158	1.264	1.591	1.368	1.359	1.174	1.333	1.245	1.305	–	1.259	1.357	1.271	1.253	1.207	1.545	1.237	1.261
OP	1.566	1.254	1.650	1.461	1.358	1.202	1.481	1.262	1.298	1.441	–	1.139	1.289	1.223	1.213	1.678	1.344	1.304
POZ	1.640	1.104	1.415	1.382	1.394	1.567	1.519	1.440	1.434	1.348	1.283	–	1.218	1.193	1.270	1.536	1.024	1.207
RZE	1.290	1.473	1.568	1.753	1.390	1.093	1.585	1.032	1.250	1.361	1.849	1.655	–	1.223	1.258	1.767	1.302	1.226
SZC	1.783	1.140	1.182	1.372	1.683	1.598	1.746	1.529	1.583	1.331	1.553	1.438	1.738	–	0.972	1.259	1.277	1.320
TOR	1.502	1.020	1.488	1.396	1.498	1.529	1.433	1.408	1.318	1.174	1.597	1.321	1.529	1.420	–	1.343	1.109	1.228
WWA	1.414	1.335	1.579	1.668	1.276	1.239	1.259	1.076	1.145	1.361	1.502	1.661	1.269	1.730	1.417	–	1.448	1.302
WR	1.713	1.245	1.526	1.474	1.439	1.366	1.376	1.402	1.133	1.619	1.095	1.253	1.529	1.653	1.494	1.763	–	1.116
ZG	1.752	1.477	1.557	1.443	1.582	1.074	1.198	1.575	1.684	1.554	1.330	1.628	1.704	1.603	1.560	1.827	1.288	–

BIA – Białystok
BGD – Bydgoszcz
GD – Gdańsk
GW – Gorzów Wielkopolski
KAT – Katowice
KIE – Kielce
KR – Kraków
LUB – Lublin
Ł – Łódź
OL – Olsztyn
OP – Opole
POZ – Poznań
RZE – Rzeszów
SZC – Szczecin
TOR – Toruń
WWA – Warszawa
WR – Wrocław
ZG – Zielona Góra

Source: (own elaboration)

Considering private road transport, the highest time efficiency from individual cities was recorded on the following routes:

Białystok–Szczecin	1,783	Łódź–Gorzów Wielkopolski	1,750
Bydgoszcz–Kielce	1,549	Olsztyn–Wrocław	1,619
Gdańsk–Opole	1,650	Opole–Rzeszów	1,849
Gorzów Wielkopolski–Rzeszów	1,753	Poznań–Warszawa	1,661
Katowice–Szczecin	1,683	Szczecin–Rzeszów	1,783
Kielce–Gorzów Wielkopolski	1,663	Toruń–Opole	1,597
Kraków–Szczecin	1,746	Warszawa–Zielona Góra	1,827
Lublin–Gorzów Wielkopolski	1,655	Wrocław–Warszawa	1,763

The largest number of car routes characterized by high efficiency is concerned with the communication of Gorzów Wielkopolski, Szczecin, Warsaw, Opole and Rzeszów.

In the case of rail transport, the highest time efficiency from individual cities applies to routes:

Białystok–Warszawa	1,333	Łódź–Kraków	1,642
Bydgoszcz–Gdańsk	1,524	Opole–Warszawa	1,678
Gdańsk–Warszawa	1,705	Poznań–Gdańsk	1,576
Gorzów Wielkopolski–Warszawa	1,227	Rzeszów–Warszawa	1,767
Katowice–Warszawa	1,658	Szczecin–Zielona Góra	1,320
Kielce–Olsztyn	1,550	Toruń–Gdańsk	1,413
Kraków–Warszawa	1,775	Wrocław–Warszawa	1,448
Lublin–Poznań	1,372	Zielona Góra–Gdańsk	1,403

Warsaw and Gdańsk are characterized by the best connections in terms of the number of time-effective rail connections.

In order to better illustrate the results of the conducted research, Figure 4 presents the average values of time efficiency indicators for private car and rail transport for individual cities.

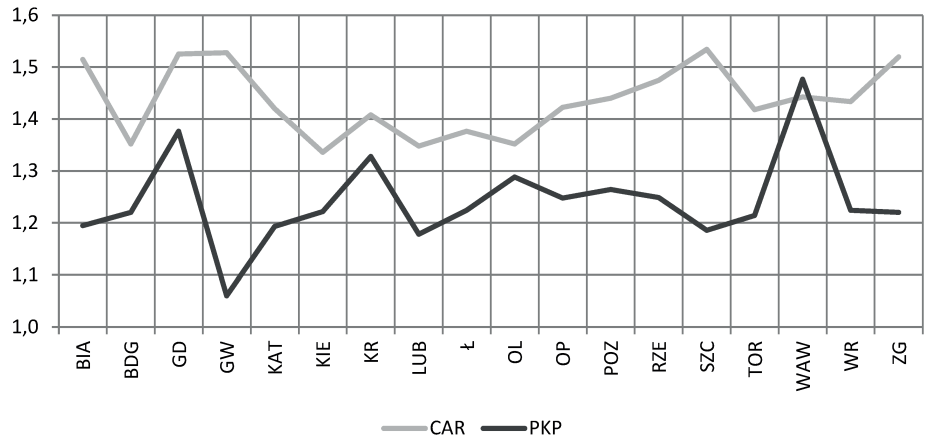

Figure 4. Average time efficiency indicators for individual cities
Source: (own elaboration)

Conclusions

As studies show, due to the time efficiency of transport, the smallest time modes on the routes between voivodeship capitals in Poland were recorded when private car transport was used (see Figure 4). This is due to: the geographical and demographic density of the railway network (which is lower than the density of the national road network by more than a half), and the spatial and temporal range of the railway transport offer.

Cities of Szczecin, Gorzów Wielkopolski, Gdańsk, Zielona Góra and Białystok are characterized by the highest time efficiency of private car transport. An analysis of the efficiency of rail transport indicates that the highest time efficiency occurs in the case of rail connections between the cities of Warsaw, Gdańsk, Kraków, Olsztyn and Poznań.

Knowing the results of the above studies, it is easier to decide on the choice of a convenient means of transport. However, it should be remembered that passengers are paying more and more attention to quality and living conditions. Therefore, it is likely that with increasing income, they will be choosing a higher travel comfort. Undoubtedly, private car transport will ensure more comfort, regardless of the travel time efficiency of the analyzed means of transport, on the analyzed routes.

References

Archer, T. S. (2010), *The Efficiency Theory*, Independent Publishing Platform CreateSpace, 1.

Baltazar, M. E., Jardim, J., Alves, P. et al. (2014), Air Transport Performance and Efficiency: MCDA vs. DEA Approaches, *Procedia – Social and Behavioral Sciences*, 111, pp. 790–799.

Baron, A. (2010), Air transport efficiency and its measures, *Prace Instytutu Lotnictwa*, 3(205), pp. 119–132.

Generalna Dyrekcja Dróg Krajowych i Autostrad, Serwis GDDKiA, Autostrady. Available from https://www.gddkia.gov.pl/pl/926/autostrady [Accessed 10 March 2019].

Google Maps, website https://www.google.com/maps/dir/ [Accessed 10–15 February 2019].

Komunikat Komisji do Parlamentu Europejskiego, Rady, Europejskiego Komitetu Ekonomiczno-Społecznego i Komitetu Regionów (2018), *Europa, która chroni: czyste powietrze dla wszystkich*, Bruksela 15.05.2018 [COM(2018)330 final].

PKP Polskie Linie Kolejowe S.A., website www.plk-sa.pl [Accessed 10 March 2019].

Polska. Podział terytorialny. Available from https://encyklopedia.interia.pl/geografia-nauki-pokrewne/krainy-geograficzne/news-polska-podzial-terytorialny,nId,2025206 [Accessed 10 March 2019].

Rohacs, J. (2010) Evaluation of the air transport efficiency definitions and their impact on the european personal air transportation system development, *Prace Instytutu Lotnictwa*, 3(205), pp. 14–32.

Rozkład PKP, website http://rozklad-pkp.pl/ [Accessed 1–10 February 2019].

Sow, O., Oukil, A., Ndiaye, B. M. et al. (2016), Efficiency analysis of public transportation subunits using DEA and Bootstrap Approaches – Dakar Dem Dikk case study, *Journal of Mathematics Research*, 8(6), pp. 114–127.

Tran, K. D., Bhakar, A., Bunker, J. et al. (2016), *Data envelopment analysis (DEA) based transit route temporal performance assessment: a pilot study*, In: 38th Australasian Transport Research Forum (ATRF 2016), 16–18 November 2016, Melbourne, Australia, Vic. Available from https://atrf.info/papers/2016/files/ATRF2016_Full_papers_resubmission_23.pdf.

Ustawa z dnia 21 marca 1985 r. o drogach publicznych (Dz. U. Nr 14, poz. 60, Dz. U. z 2018 r., poz. 317, Dz. U. z 2018 r., poz. 12 z późn. zm.).

Walter, M. (2009) *Efficiency and Competition in Public Transport. Dissertation*. Available from http://www.qucosa.de/fileadmin/data/qucosa/documents/2704/Walter_2009_Efficiency_Competition_Public_Transport.pdf.

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