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PRIVATE CAR TRANSPORT OR PUBLIC TRANSPORT? THE STUDY OF DAILY ACCESSIBILITY IN SZCZECIN

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Private car transport or public transport? The study of daily accessibility in Szczecin

The article presents the results of public and private/car transport accessibility modelling, making it possible to compare journey times and two types of transport throughout the day and during rush hours. The public transport model is based on the GTFS data (General Transit Feed Specification), while the car model has been created using data on driving times derived from Google Maps® API. Both models presented in the article have been constructed for a specified period. The models for public and private transport count 5.00 a.m. to 10.00 p.m in 15-minute intervals and represent 60 per cent of residents' travel during the working day. The analysis of the models mentioned above has allowed the comparison of the differences in accessibility and its deviations at different times of the day. The disparities revealed by the study have indicated that there are certain times of the day when public transport is competitive with private means of transport. The study focuses on analysing population living in areas inaccessible to public transport. During the day, public transport can compete with individual transport over two communication peaks: in the morning (between 7:00 and 8:30 a.m.) and in the afternoon (between 3:00 and 6:00 p.m.), but is still slower than a car. This spatial representation allows conclusions and recommendations to support low-carbon transport policies based on public transport and alternative travel options such as cycling plus public transport. The results show that many people live in areas that are obliged to use public transport, which, although slower than the car, can compete at peak times.

Key words: accessibility, GTFS, GIS, private/car transport model, public transport model, Szczecin

INTRODUCTION

There is an opinion among many researchers that excessive use of cars has contributed to increased greenhouse gas emissions and pollution (Newman and Kenworthy 1999, Banister 2005 and Gärling and Schuitema 2007). According to the 2014 IPCC report (IPCC 2014), until 2010 the transport sector had caused 14% of the global carbon dioxide emission, most of it had been produced by passenger cars. At the same time, a range of actions has been taken in recent years to reduce CO_2 emissions from transport. However, the total amount of CO_2 emitted has increased due to the measures implemented. According to the European Commission, transport is responsible for nearly 30% of the E.U.'s total CO_2 emissions, of which 72% comes from road transportation. As part of efforts to reduce CO_2 emissions, the E.U. has set a goal of reducing emissions from transport by 60% by 2050 compared to 1990 levels (European Commission 2021). The effort invested in reducing car-caused carbon dioxide emissions and the unsatisfactory results of those actions make it clear that it is necessary to strengthen the ecological approach to the road transport sector. According to the IPCC (2021), the share of transport in global CO_2 production increases in the number of cars. However, the transport sector is still responsible for many emissions (IPCC 2021). Under this approach, reducing the number of individual car journeys is essential, and may be achieved by introducing restrictions and limitations at various times during the day (Graham-Rowe et al. 2011). Moreover, many public transport solutions have been introduced in cities, e. g. free public transport services for drivers willing to give up personal car ownership (Meyer 1999 and Friman et al. 2013).

Regarding strategies to reduce private car use, car ownership is the most difficult to give up. They have become essential commodities in most developed and developing countries worldwide. In developed countries, pro-environmental attitudes and a high awareness of society have made it possible for many people to reduce the number of cars in their households and use public transport more often. According to the literature on the topic, car ownership strongly influences all household members. The more accessible access to a private car, the more car journeys are made (Senbil et al. 2009, Van Acker and Witlox 2010 and He and Thøgersen 2017). Car owners are usually assigned a particular material status (Lee et al. 2017). Therefore, car ownership is combined with prestige (Steg 2003 and Innocenti et al. 2013). Cars offer the possibility to move almost anywhere and at any time, which gives a sense of freedom, and the only restrictions are those resulting from traffic regulations. Therefore, people who have bought a car are usually reluctant to resign from using it and switch to public transport services (Dargay 2001 and Clark et al. 2016). The numerous benefits of car ownership only strengthen the habit of using it and make it more challenging to start using public transport (Simma and Axhausen 2001 and Gardner and Abraham 2010).

Moreover, studies show that some car owners feel a strong bond with their vehicles. Thus, they intentionally avoid alternative travel and commuting methods (Beirão and Sarsfield Cabral 2007). However, large campaigns organised to raise awareness of social and environmental results of everyday driving and free public transport services are actions to discourage drivers from using private cars and encourage them to switch to means of collective transport (Lo et al. 2013). The study conducted in Silesia (Poland) proved that economic factors such as petrol prices or public transport ticket fees are not efficient for changes in transport behaviour patterns. Instead, the research showed that psychological factors are most important (Urbanek 2021). However, the factors determining the choice of public transport over the car vary from city to city in Poland.

In the studies published, the authors mainly focused on the limitations of using private cars, reflected by the following steps to reduce road traffic (Bamberg et al. 2011 and Friman et al. 2013). Perception of different transport modes may be affected by many factors, e. g. lifestyle, preferences, previous experiences and broadly-understood surroundings (Currie 2004 and De Vos et al. 2012 and 2016). There were several studies aimed at comparing the attitudes of drivers and non-drivers (Faishal 2003 and Beirão and Sarsfield Cabral 2007). In some selected cities, there were studies on how attitudes to different transport modes may vary according to the efficiency of their transport systems and the range of transport alternatives available (Van et al. 2014). During the last few years public transport has been losing its significance. Yet, it is still the least onerous means of public transport that is capable of shuttling a large number of people. These advantages are of great significance when implementing sustainable transport systems in urban areas. In order to improve the quality of air as well as the whole environment, both locally and globally, it is advisable to popularise campaigns promoting alternative means of transport, including public transport.

This article shows that a simple cumulative gravity model, used for different sizes of study areas based on the standard gravity model, which allows the comparison of different transport modes in the Origin-Destination (O. D.) system. Analysing public and private transport data is a good research field that has been dynamically developing in recent years. Moreover, the results of analyses based on open data are becoming more and more accurate. Such analyses, taking different times of the day into account, show when differences in the operation of public and private transport are the smallest (Bach 1980, El-Geneidy and Levinson 2007, Salonen and Toivonen 2013, Shirgaokar 2014 and Beria et al. 2017). Such research may reduce the research gap and provide data concerning the issue of private and public transport competitiveness at different times of the day.

The main focus of this work is to compare two modes of transport using publicly available data, which will help conclude the competitiveness of public transport throughout the day (Elldér et al. 2012 and Goliszek 2017). Currently created models of individual transport are mainly based on data derived from online portals or systems gathering data on travel times from GPS transmitters in cars or mobile phones. The GPS data is processed by companies and then made public; e. g. they can be downloaded from the Google Maps® website for free. As for other companies, there are some fees for making the data available. Google Maps® gathers and visualises real-time traffic data, but it is also possible to check averaged travel time values (Wang and Xu 2011, Wang et al. 2013 and Lagrell et al. 2018). TomTom® and Google Maps®/Transit are the most well-known companies gathering and processing traffic data. However, if a regular user wants to download real-time data and create a model of a travel time matrix for several different destinations, it is not a simple procedure. In order to download data from Google Maps® API, a particular application generating real-time map loads and saving them is required.

The author of this article has created an original model of the road transport system in Szczecin using Google Maps® API data (Wang and Xu 2011) downloaded with an application written in Python 2.7. (Goliszek 2021 and 2022).

In the case of public transport, travel times are calculated using the door-to-door approach, explained and described by Salonen and Toivonen (2013) – Fig. 1. The door-to-door approach assumes that several time-consuming travel components shall be taken under consideration when calculating total travel times. They are as follows: reaching a tram/bus stop, waiting for a tram/bus, changing (if necessary) and walking back according to the times used in the pedestrian model. As for the private transport model, there are also four components – reaching a car, driving time (calculated using Google Maps® API data), parking and walking to the final destination. The values added as the parking time equal the walking time between the centre of a particular census area and the nearest road/street. Unfortunately, it is virtually impossible to measure parking time due to its variability in different cities in Poland (Goliszek 2021). Therefore, it may be random values. The only places where the parking time may be assessed are some newly built buildings with monitored parking areas. However, a correlation was demonstrated between the peak hours and the possibility of parking in city centres (Assemi et al. 2020).

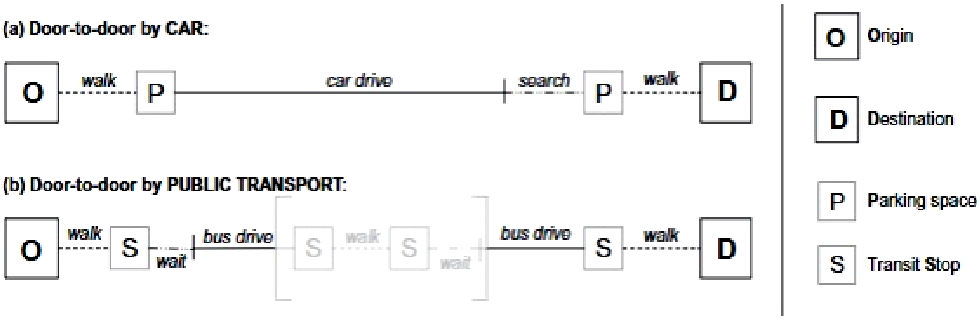

Fig. 1. Examples of the door-to-door approach in (a) car journeys and (b) PT journeys (Salonen and Toivonen 2013)

RESEARCH AREA, DATA AND METHODS

Research Area

The research area covers the city of Szczecin in its administrative boundaries, situated in north-western Poland. In 2018, the city had approximately 400 000 people (data published by the City Hall). The City Hall provides population data by the city districts. For this study, the population data obtained from the City Hall have been used to estimate an approximate number of citizens living in census areas. The city of Szczecin is divided into 1869 census areas. The population living in Szczecin is proportionally divided into census districts according to the population in the census districts in 2011. Therefore, the analysis presented in this article may be considered very detailed. A centroid has been designated for each census area, acting as a link between the areas – the centroids are placed in the most densely built-up areas with the highest population. For better orientation in the urban space, the boundaries of the following districts have been added: Zachód, Prawobrzeże, Północ and Śródmieście (Fig. 2).

Accessibility assessment

Out of the vide range of methods for measuring accessibility, including travel cost, potential accessibility, and cumulative accessibility (Handy and Niemeier 1997 and Geurs and Ritsema van Eck 2001), the authors use the last method mentioned above. Cumulative accessibility, also known as isochronic accessibility or contour measure, means accessibility measured by identifying sets of travel destinations accessible within a specific distance, at a specific time, travel cost or effort. In the case of a labour market, cumulative accessibility may pertain to the number of jobs accessible within a given isochrone from the place of residence (Geurs and Ritsema van Eck 2003 and Goliszek et al. 2020). The cumulative accessibility is also used for population (potential labour force) available within an isochrone departing from the journey starting point to the destination. (Kelobonye et al. 2019). In the latter case, which the authors chose for this study, the cumulative accessibility is defined as:

$$A_i = \sum_{j=1}^{j} B_j O_j$$

Cumulative accessibility *Ai* is the accessibility measured for a particular point and potential to activities *Oj* (in this article, it is the population), where *Bj* takes the binary value of 1 if the place of residence is within a predefined time threshold (isochrone) and 0 if it is beyond the time threshold.

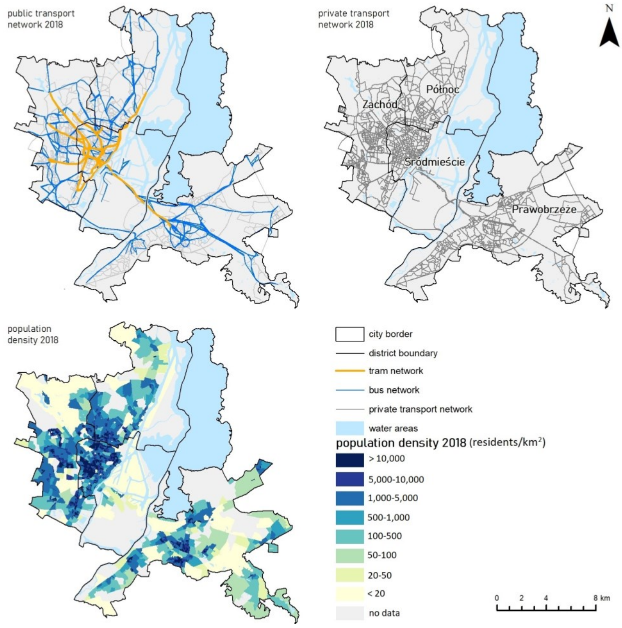

Fig. 2. Public transport based on GTFS (upper left map), road network (top right map), and population density 2018 (left bottom map)

Source: GTFS open data Szczecin.

Such an analysis assumes that all places are accessible within a particular time, which is presented using a cumulative time accessibility factor (Thompson et al. 2019 and Rosik et al. 2021a). It is the average accessibility to all places in a city using two modes of transport: private (car) and public (bus or tram). Time in this study is not weighted by distance, as is done, e. g. with potential accessibility models. Only the time based on the gravity model is used between all measuring points in this test. The average travel time was obtained using the cumulative accessibility method in this particular article.

Cumulative accessibility is often used in the literature on this topic as a direct and straightforward measure of accessibility equality to, for example, public facilities, services, culture or changes in accessibility resulting from infrastructural projects (Talen 1996, Talen and Anselin 1998 and Gutiérrez 2001). Everyone should have equal opportunity to access public services. This accessibility is a simple measure indicating whether or not a given object is accessible and within what period or distance (Shen 1998, Geurs and Ritsema van Eck 2003, Miller 2005 and Rosik et al. 2020 and 2021b).

The objective of this article is to address the issue of reaching different destinations using public or private means of transport by implementing a simple cummulative accessibility model, based on the standard accessibility model which can be applied for urban areas. These models allow to obtain O-D data sets. Determining the O-D relationship is based on several theories, such as the infrastructure-based, location-based, person-based, and utility-based ones. This research takes account of the infrastructure-based theory, usingtransport and person-based models that leverage data on population.

RESULTS

The road sections were selected based on the BDOT10k database of topographic objects (http://www.codgik.gov.pl/), presented in the upper right corner of Fig. 2. The created road network depicts travel times between particular road sections (sections between the junctions) in 15-minute intervals. In the first step, the app automatically downloaded travel times for origin-destination in Google Maps. The origin and endpoint always correspond to the O-D point of the road section under study. Next, the downloaded data is assigned to a specific time of the day (a particular hour between 5:00 a.m. and 10:00 p.m.) for a section of the road.

Data on the travel times apply to selected weekdays – from Tuesday to Thursday and certain times of the day – from 5:00 a.m. to 10:00 p.m. Mondays and Fridays have been intentionally excluded from the analysis as those days. This is because traffic may be heavier and caused by people returning from (Mondays) or going on (Friday) weekend trips. Therefore, it may affect the pattern of everyday commuting. Finally, the application allows the map generation and creates data on travel times between selected Origin and Destinations. Google Maps® API data has been assigned to particular sections of the urban road network (Goliszek 2021). The only restriction limiting the free-of-charge use of Google Maps® API is that it can generate not more than 2 500 map loads per day per API (Schwartz 2010, Calabrese et al. 2011 and Wang and Xu 2011).

The total length of the road network analysed in individual transport is 804 km. The data on travel times were downloaded in October and November 2018. In order to construct the individual transport model, over 60 thousand map loads with X and Y coordinates were generated in real-time between 5:00 a.m. and 10:00 p.m. The average speed for all analysed sections is 28.12 km/h. The average speed in 15 -minute time profiles for all analysed roads and streets in Szczecin is presented in Fig. 3 (Goliszek 2021). Assigning the data on travel times to the road network has made it possible to connect all destinations within the city and perform time calculations (Calabrese et al. 2011).

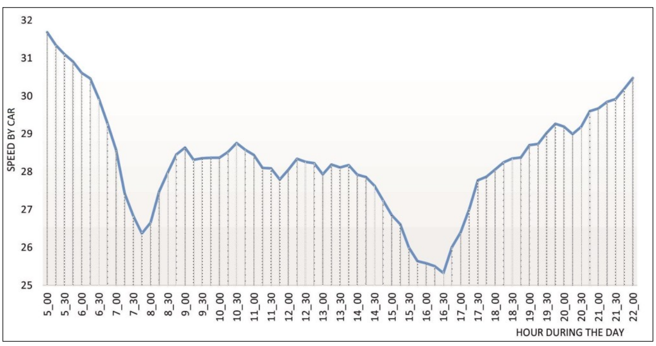

Fig. 3. Average speeds on roads in Szczecin (in km/h) by 15-minute intervals

Studies regarding transport accessibility in Szczecin with the use of the GIS (Geographic Information System) techniques have been carried out consecutively (Poelman and Dijkstra 2015, Goliszek and Połom 2016, Stępniak and Goliszek 2017, Stępniak et al. 2019, Goliszek et al. 2020 and Goliszek 2021 and 2022). The study is based on open GTFS data published by an official body managing the public transport system in the city (GTFS) and downloaded in 2019. For this study, a model of the public transport system in Szczecin has been created (Fig. 1, upper left corner). The road network added to the public transport model corresponds to the road network from the individual transport model. The data concerning public transport were calculated using the travel model based on the GTFS (General Transport Feed Specification) data. The model considers the following factors: departure time, the period within which a pedestrian reaches a tram/bus stop, waiting time, travel time and finally, the period required to reach the final destination (Fig. 1). The average walking speed adopted for the study is 4.5 km/h, the same as in the analysis by Stępniak and Goliszek (2017). In the literature, there is no consent on the average walking speed that should be adopted when analysing transport accessibility, e. g. Reyes et al. (2014) claim that the average walking speed for children is 3.2 km/h. Other researchers e. g. Ritsema van Eck et al. (2005) and Fransen et al. (2015) accept that a walking speed of 4 km/h is typical for most people. At the same time, Fransen claims it is also an average walking speed for adults. In Shirgaokar's (2014) study, the adopted average walking speed was 4.8 km/h. Krizek et al. (2012) stated that people between the ages of 14 and 64 usually walk at 5.4 km/h. The average walking speed is a significant factor when assessing potential public transport accessibility as it is part of a travelling route (Ritsema van Eck et al. 2005, Krizek et al. 2012, Reyes et al. 2014, Shirgaokar 2014 and Fransen et al. 2015).

The visible differences in the accessibility maps created for Szczecin's public and private transport systems resulted mainly from travel times included in the model. In the case of public transport, travel times are calculated using the door-to-door approach, explained and described by Salonen and Toivonen (2013). As for the private transport model, driving time (calculated using Google Map® API data) and walking to the final destination. After summing up all the components, the total travel time is always shorter in the case of private transport. The lower average time obtained by private transport is less than public transport because the bus or tram stops at every stop when travelling using public transport. In addition, the location of public transport stops requires one to walk to them, and at least three connectors connect each area with the stop. The same connectors correspond to the pedestrian crossing to the car, with the private car usually being in the parking lot under the block or underground garage. The average accessibility, while using the same values in the map legend, is presented in Figure 4. The door-to-door approach comprises three elements. The first element of the journey is leaving a particular place and walking to a car or public transport stop/station. The second element is the journey either by private car or public transport (including possible changes). The last element of the journey is walking from the stop/station/car park to the final destination.

Cumulative accessibility varies by day, month, and year (Goliszek et al. 2020). For this study's purpose, the day is understood as between 5:00 a.m. and 10:00 p.m. The accessibility of public transport is less differentiated for this period of time. Variations in accessibility are observed in places far away from stops with low bus or tram service frequency (Goliszek and Połom 2016). Usually, public transport accessibility is not internally differentiated, excluding morning and afternoon peak hours (Stępniak and Goliszek, 2017 and Stępniak et al. 2019), when the service frequency is linked to increased activity number of passengers travelling at the busiest time. However, maps of public transport accessibility in Fig. 4 show that the differences between the peak and off-peak hours are not substantial due to the frequency of public transport, which in Szczecin does not change significantly outside rush hour.

A slightly different situation is observed regarding accessibility using private transport. This transport mode is vulnerable to changes on the road, especially between 5:00 and 6:00 a.m. and between 8:00 and 10:00 p.m. when smooth traffic flow is observed, and the only restrictions result from traffic lights and the highway codes. The first signs of congestion are noticeable at 6:00 a.m. The heaviest morning congestion was observed between 7:00 and 9:00 a.m. The busiest quarter starts at 7:45 a.m. The period between 9:00 a.m. and 3:00 p.m. is characterised by smooth traffic flow – travel times are shorter than during the peak hours, yet longer than during the two periods mentioned above. The heaviest congestion observed on roads in Szczecin is between 3:00 and 6:00 p.m., with the absolute peak between 4:00 and 6:00 p.m. At that time, people usually leave work and deal with everyday business on their way home. This mixture of different motives behind afternoon road traffic jams makes it the heaviest during the day. The traffic slowly decreases between 6:00 and 9:00 p.m., and finally, the traffic flow becomes smooth between 9:00 and 10:00 p.m. Figure 4 presents variations in the average travel time for the selected hours.

Comparison of the public and private transport

When comparing the differentiation of accessibility between public and private transport, one regularity becomes obvious – public transport accessibility is less differentiated in the external areas of Szczecin, while private is less differentiated in the city centre. Furthermore, public and private transport accessibility varies according to the particular hours of the day.

In some places, accessibility by private transport is three times higher than by public transport. These are less inhabited or industrial areas. The abovementioned situation occurs mainly between 5:00 and 7:00 a.m. and 8:00 and 10:00 p.m. During periods of smooth traffic flow in Szczecin, private transport accessibility is better than public transport accessibility. The disparities in travel times between car and means of public transport are considerable and travelling by car is more convenient in this case.

The zones of comfort passage using public transport are located in the border districts of Szczecin. Such a situation usually occurs during the morning and afternoon peak hours, when speed on the roads decreases and the frequency of public transport services increases. During this period, the difference between public and private transport changes. Public transport is slower than cars and more competitive (Fig. 4).

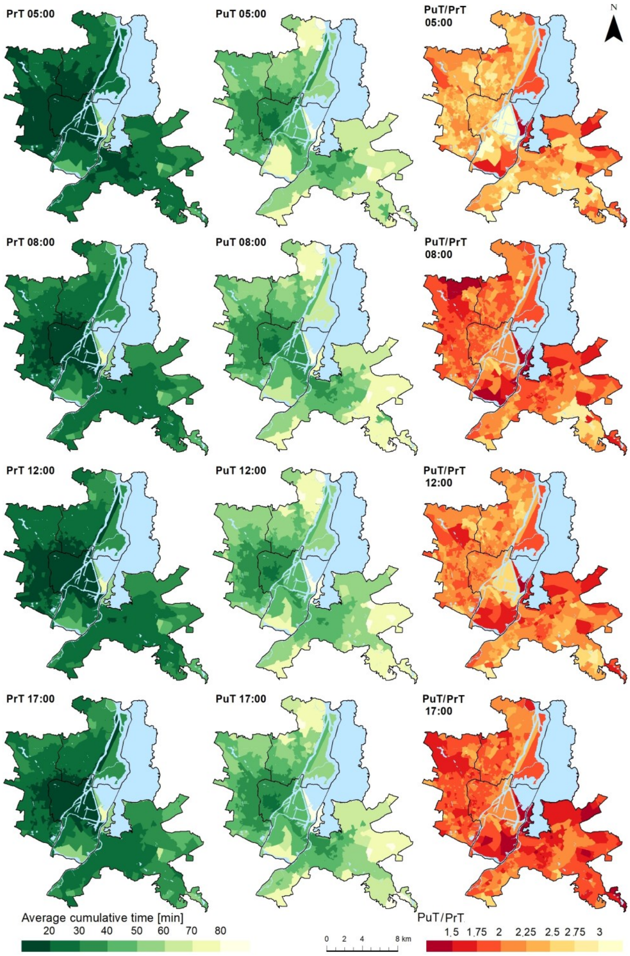

Fig. 4. Spatial and temporal variations of accessibility by private transport, public transport and PrT/PuT

Comparing individual results for the accessibility using public and private transport allows for the pointing out of specific hours during which the difference is the highest and the smallest throughout the day. The periods used for the comparative analysis are as follows: 5:00 – 7:00 a.m., 7:00 – 9:00 a.m., 9:00 a.m. – 12:00 p.m., 12:00 – 3:00 p.m., 3:00 – 6:00 p.m., 6:00 – 8:00 p.m. and 8:00 – 10:00 p.m. For each analysed period, the first and third quartiles of the results and median were presented in Figure 5. The results also include the maximum and minimum deviation and the median. For the period between 5:00 and 7:00 a.m., the median indicates that the travel time is 2.8 times shorter for private transport, while during the morning peak hours, it is 2.04, and still more than twice faster than public transport.

Furthermore, between 9:00 a.m. and 12:00 p.m., the analysed value increases to 2.13. During the next period, 12:00 – 3:00 p.m. – 3:00 p.m., the median or average public and private transport values reach 2.06. The lowest value of the median (1.88) was recorded between 3:00 and 6:00 p.m. This is the day when the difference in driving times using public and private transport is the smallest. The median is much higher in the evening between 6:00 and 8:00 p.m., reaching 2.25. The most significant difference in average driving times by public and private transport was observed between 8:00 and 10:00 p.m. It equals 2.46, which means it is 2.5 times faster to reach a given destination by private car than by bus or tram. More minor deviations in comparing public and private transport systems are observed during peak hours (Fig. 5).

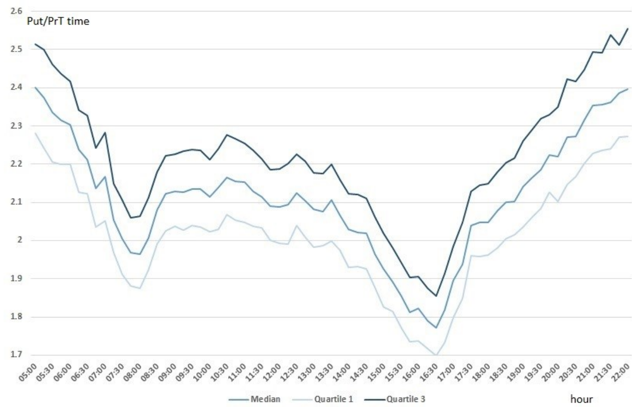

Fig. 5. Average travel time with first and third quartile values

Population living in areas of public and private transport competition

When planning public transport systems, it is essential to know the population density of a particular area where the' residents' commuting needs are satisfied. Determining such areas of convenient accessibility and assessing their population allows the comparison of travel times and the seeking of alternative ways of commuting at different times of the day. In this analysis, the author focuses on the percentage of people who live in areas that can compete with private transport. These places can be reached using public transport within a travel time that is not longer than 100 per cent of the travel time when using a private car. At the same time, for the places where the difference in the travel times by public and private transport is more than 100 per cent, it can be assumed that the residents use private cars and it will be tough for them to switch to the means of public transport. However, it is worth mentioning that the differences in travel times change very dynamically in space and time.

Between 5:00 and 7:00 a.m., most citizens, approximately 98%, live in the areas – people at this time commute faster using private transport. Between 7:00 and 9:00 a.m., the percentage of citizens living in the zones of improved commuting by public transport increases from 10 – 20% up to 60% at 8:00 a.m. when the gap between public and private transport narrows in favour of public transport. Then, between 9:00 a.m. and 2:00 p.m., better to commute by car as, during this period, approximately 80% of Szczecin citizens live in areas with better private transport accessibility. Between 2:00 and 3:00 p.m., the gap between public and private transport in favour of private transport decreases compared to the previous hours. During the afternoon rush hour, between 3:00 and 5:00 p. m., the accessibility of public transport is improved. In this time public transport is only 1.5 to 2 times less accessible than individual transport. For only 10% of the citizens using private cars is a better option during the period mentioned above, even though individual transport is still faster. However, between 5:00 and 7:30 p.m, the number of people living in an area where there is good accessibility by public transport to work decreases to only 10%. In the afternoon and at night, 7:30 – 10:00 p.m, the percentage is even smaller. During this period of time, the most significant disparity between the number of people living in areas faster public and private transport commuting is the largest, in favour of private transport (Fig. 6). Table 1 presents the number of people compared to the average travel time through private transport in the public transport system between 5:00 a.m. and 10:00 p.m.

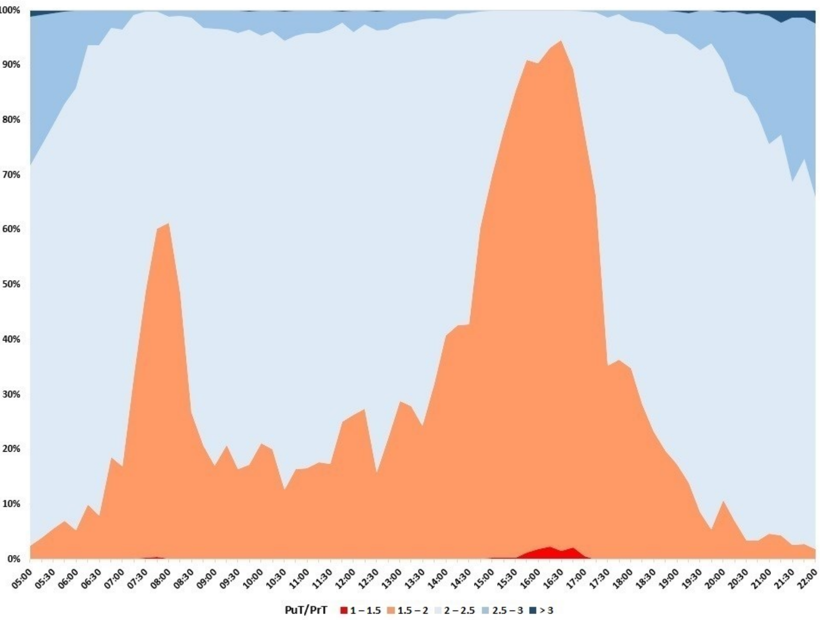

Fig. 6. Availability of percentage of people using public/private transport (car)

DISCUSSION

In order to draw any plausible conclusions, it is vital to use comparable data while modelling public and private transport accessibility. This is important when the analysis results may be used to improve a particular urban transport network and make it more sustainable. The travel time parameter calculated for both analysed transport times reduces the risk of data misinterpretation. The data used in transport models shall be publicly available and free to download. Thanks to the GTFS format, accessibility of transport data has significantly increased as they have started to be published by institutions responsible for urban transport management. More transit data is publicly available. More studies on public transport have been published (Calabrese et al. 2011 and Bok and Kwon 2016). Implementation of public transport models has become common since the GTFS data became available. However, it is worth emphasising that such models are not entirely reliable. The main disadvantage is that they do not take traffic jams into account. Currently, more and more GTFS take into account actual data on journeys made by different means of public transport at a given time, but not all operators are willing to publish this type of information.

Tab. 1. Number of residents in each zone of prevalence of private transport over public transport

Time	1 – 1,5	1,5 – 2	2 – 2,5	2,5 – 3	> 3
05:00 – 06:00	0	17,716	271,501	82,615	2,409
06:00 – 07:00	0	39,186	306,959	28,016	79
07:00 – 08:00	650	148,115	221,041	4,411	24
08:00 – 09:00	62	147,182	220,819	6,144	32
09:00 – 10:00	90	66,785	293,878	13,294	191
10:00 – 11:00	0	65,617	291,179	17,198	245
11:00 – 12:00	0	71,717	289,326	12,994	202
12:00 – 13:00	0	85,623	275,943	12,417	255
13:00 – 14:00	0	105,854	261,233	7,131	21
14:00 – 15:00	194	174,307	196,912	2,805	21
15:00 – 16:00	1,824	301,689	70,584	142	0
16:00 – 17:00	7,331	336,483	30,389	37	0
17:00 – 18:00	636	201,344	169,971	2,28	11
18:00 – 19:00	0	99,137	264,452	10,564	87
19:00 – 20:00	0	42,443	309,991	21,039	767
20:00 – 21:00	0	22,801	296,113	53,73	1,596
21:00 – 22:00	0	12,177	257,569	98,351	6,142

Using 15-minute intervals may affect the results for public transport, while for private means of transport, the impact is negligible, as it operates according to a timetable. In the case of the private transport model, the source of data is the most crucial factor. The TomTom® data are perceived as the most plausible, yet they are not open access data. On the other hand, the Google Maps® API data are free of charge and can be considered plausible. The Google Maps data can be downloaded free of charge using the application or by entering the start and endpoint of a given route. Travel time is estimated based on data provided by GPS receivers used by private car drivers.

Nonetheless, it is worth mentioning that it is always an average figure for a particular time of the day and road section. After verification, the model based on the Google Maps® API data is reliable (Wang and Xu 2011). The chosen model is significant when comparing public and private transport means as the final users' choice affects traffic and congestion. Wang et al. (2013) point out that people commuting by private cars pay more attention to comfort, travel time, and vehicle reliability. For travellers using public transport, cost-effectiveness and the opportunity to relax while travelling is more critical than shorter travel times (Wang et al. 2013).

Some of the results for Szczecin partially call into question the study by Benenson et al. (2010). They analysed Tel Aviv and stated that the difference between public and private transport observed in the city is smaller in favour of public transport. The analyses carried out in Tel Aviv were expanded, and measures of the relative and absolute loss of access as public transport decisions were investigated (Rofé et al. 2015). Both this research and the study presented herein do not include parking time and congestion. Erik et al. (2012) point out that the difference between the two analysed modes of transport becomes less significant when using more advanced models, including the time needed to reach a car and park it or changing times. Simple transport models generate much more significant disparities (Benenson et al. 2010).

In this article, the determined author areas in Szczecin with larger and smaller disparities in travel times using public and private transport. In the earlier study, Erik et al. (2012) indicated that those disparities are smaller in the city centre, while the study presented here showed otherwise (Erik et al. 2012). Including the potential accessibility in the analysis may have influenced the results for the city centre. Hess (2005) demonstrated that the modal difference between the two modes of commuting is more significant for the citizens living in the city centre. There are visible disparities in accessibility in Szczecin, favouring public transport during the morning and afternoon peak hours. It is much more convenient, up to three times faster, to use a private car outside these hours. It is an exciting result that may be an argument favouring switching to public transport, at least during peak hours (Giuffrida et al. 2017). This article indicates specific areas in the city where public transport is competitive, which may be an essential issue when choosing a place to live. The number of people who live in areas with twice as poor cumulative accessibility by public transport during the afternoon peak reaches 90% of all citizens. During the morning peak, 65% of the citizens who live in these areas have a competitive accessibility by public transport. Maybe the results presented herein contribute to strengthening the position of public transport in everyday commuting and help reduce the use of private cars in the city.

More than 60% of analysed journeys used public and individual transport, with the overall share of private cars during the research period. Some of the actions taken by the city are proper, including, for instance, the construction of park&ride car parks near the newly built tram stops in the Prawobrzeże district. However, it is necessary to make it possible for the residents of peripheral areas to reach the nearest public transport stop (preferably a tram stop). There is a policy of urban bike pursuit in the city. The urban bike stations are located near the bus and tram stops. In Prawobrzeże, there are no bike&ride stops that would allow the citizens to safely leave their bicycles and continue the journey through public transport. Another important recommendation is that more tram lines should be launched. The procedure for developing the second phase of the fast tram project is ongoing, and the authorities are now considering three possible options. It is a project which will improve the accessibility to public transportation for people living in peripheral areas of the Prawobrzeże district.

CONCLUSIONS

Advanced GIS methods and techniques, accessibility of open data sources, and processing possibilities allow using accessibility analyses in research and spatial planning. While having such a wide range of tools and methods available, it is significant to make proper methodological decisions when conducting such analyses. It is essential to select appropriate and comparable data. Equally important is the time of day or periods chosen. Again, these should be at appropriate intervals to assist in interpreting and drawing appropriate conclusions.

For this study, simple accessibility measures for private transport were applied – a model based on the GTFS data provided by Google Maps API was created. As for public transport, the model was created using the GTFS data with open access. The author states that comparing such models depicts the actual situation in the city. What is worth mentioning, is that the average speeds used to build public transport models based on the GTFS data do not include information on traffic jams and delays resulting from them. However, such information is indirectly included in the public transport timetables. Therefore, the most significant disparities between the private and public transport models may be recorded in the city centre, especially where private cars and buses are stuck in traffic jams during peak hours.

In the city centre, trams are the most commonly used means of transport, and they use their railway lines to move around. As for the private transport model, the data downloaded from Google Maps API are averaged and do not include parking time. In this model, the parking time was included as the time necessary to cover the distance between the centre of the zone and the nearest road or street. It is also worth noticing that travel times depend mainly on the day and time of the week (Lei and Church 2010). Therefore, these differences in travel times between public and private transport may vary according to a particular period. Currently, more accurate analyses of accessibility are impossible to carry out. The advanced public transport model includes accurate travel times, departure times, and differences in travel times according to road conditions throughout the day.

Simple public transport models assumed that the waiting time for public transport was half the waiting time between two of the same mode of transport running at different times. Today, simple public transport models are no longer used. A significant disadvantage of simple public transport models was the lack of optimisation of journey times, usually found in the operators' timetable if it is obliged, for example, by the same operator. As a result of the lack of optimisation, the data are distorted, especially for short distances, where the time to change and get to the stop is a large share of the whole trip (Salonen and Toivonen 2013). As for the private transport models, changes in accessibility resulting from traffic jams, appearing more or less randomly, were particularly difficult to grasp. Even during peak hours, it is still difficult to foresee if a particular one will be heavy or not. In the model presented in this article, the author used data for weekdays downloaded from Google Maps API. These data are imperfect yet accurately depicts road conditions and delays resulting from congestion. If detailed data on times needed to reach a car and park it were accessible, it would be possible to compare disparities in accessibility. The method, including parking time, would make this study on private car accessibility more accurate and advanced. In the analysed urban area, the public and private transport accessibility is highly diversified throughout the day. The advanced model used in the analysis makes it possible to perform a detailed comparison of both modes of transport.

The author did not include all the possible paths in the city that pedestrians can use, which may be a drawback of the study. The same road network was used for both models: private transport and pedestrians. However, such a procedure did not widely affect the final results on accessibility. The short journeys on foot are the most affected ones in this case.

The results may help improve the modal share by making the citizens use the means of public transport more often. Various studies have shown that most people are not ready to change their transport patterns even if they have to pay more for using private cars. There are also studies which prove that implementing free public transport may increase the number of citizens using it daily (Cats et al. 2017). Maybe implementing free public transport services for people using bicycles to reach the nearest station or stop will attract more citizens to use the public transport system, especially in areas characterised by relatively high accessibility.

Undoubtedly, urban policy on the accessibility of public transport should be fair. However, if there are some areas where public transport services are faster and more effective, the frequency in such areas should be higher. Maximising public transport services frequency during peak hours is not contrary to a just policy. The services in peripheral areas are of low frequency, and increasing the frequency and range of services in central districts may lead to the higher efficiency of public transport. In the long term, it may increase the share of modal transport and make the "bike + public transport" or the "car + public transport" solutions more popular among the citizens.

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REFERENCES

ASSEMI, B., BAKER, D., PAZ, A. (2020). Searching for on-street parking: An empirical investigation of the factors influencing cruise time. *Transport Policy*, 97, 186-196. DOI: https://doi.org/10.1016/j.tranpol.2020.07.020

BACH, L. (1980). Locational models for systems of private and public facilities based on concepts of accessibility and access opportunity. *Environment and Planning A: Economy and Space*, 12, 301-320. DOI: https://doi.org/10.1068/a120301

BAMBERG, S., FUJII, S., FRIMAN, M., GÄRLING, T. (2011). Behaviour theory and soft transport policy measures. *Transport Policy*, 18, 228-235. DOI: https://doi.org/10.1016 / j.tranpol.2010.08.006

BANISTER, D. (2005). Overcoming barriers to the implementation of sustainable transport. In Rietveld, P., Stough, R., eds. *Barriers to sustainable transport: Institutions, regulation and sustainability*. New York (Spon Press), pp. 54-68.

BEIRÃO, G., SARSFIELD CABRAL, J. A. (2007). Understanding attitudes towards public transport and private car: A qualitative study. *Transport Policy*, 14, 478-489. DOI: https://doi.org/ 10.1016/j.tranpol.2007.04.009

BENENSON, I., MARTENS, K., ROFÉ, Y., KWARTLER, A. (2010). Public transport versus private car GIS-based estimation of accessibility applied to the Tel Aviv metropolitan area. *The Annals of Regional Science*, 47, 499-515. DOI: https://doi.org/ 10.1007/s00168-010-0392-6

BERIA, P., DEBERNARDI, A., FERRARA, E. (2017). Measuring the long-distance accessibility of Italian cities. *Journal of Transport Geography*, 62, 66-79. DOI: https:// doi.org/10.1016/j.jtrangeo.2017.05.006

BOK, J., KWON, Y. (2016). Comparable measures of accessibility to public transport using the general transit feed specification. *Sustainability*, 8, 224. DOI: https://doi.org/ 10.3390/su8030224

CALABRESE, F., Di LORENZO, G., LIU, L., RATTI, C. (2011). Estimating Origin-Destination flows using opportunistically collected mobile phone location data from one million users in Boston Metropolitan Area. *IEEE Pervasive Computing*, 10, 36-44. DOI: http://hdl.handle.net/1721.1/101623

CATS, O., SUSILO, Y. O., REIMAL, T. (2017). The prospects of fare-free public transport: Evidence from Tallinn. *Transportation*, 44, 1083-1104. DOI: https://doi.org/10.1007/s11116-017-9785-z

CLARK, B., CHATTERJEE, K., MELIA, S. (2016). Changes to commute mode: The role of life events, spatial context and environmental attitude. *Transportation Research Part A: Policy and Practice*, 89, 89-105. DOI: https://doi.org/10.1016/j.tra.2016.05.005

CURRIE, G. (2004). Gap analysis of public transport needs: Measuring spatial distribution of public transport needs and identifying gaps in the quality of public transport provision. *Transportation Research Record: Journal of the Transportation Research Board*, 1895, 137-146. DOI: https://doi.org/10.3141/1895-18

DARGAY, J. M. (2001). The effect of income on car ownership: Evidence of asymmetry. *Transportation Research Part A: Policy and Practice*, 35, 807-821. DOI: https://doi.org/10.1016/S0965-8564(00)00018-5

De VOS, J., DERUDDER, B., Van ACKER, V., WITLOX, F. (2012). Reducing car use: Changing attitudes or relocating? The influence of residential dissonance on travel behaviour. *Journal of Transport Geography*, 22, 1-9. DOI: https://doi.org/10.1016/j.jtrangeo.2011.11.005

De VOS, J., MOKHTARIAN, P. L., SCHWANEN, T., Van ACKER, V., WITLOX, F. (2016). Travel mode choice and travel satisfaction: Bridging the gap between decision utility and experienced utility. *Transportation*, 43, 771-796. DOI: https://doi.org/10.1007/s11116-015-9619-9.

EL-GENEIDY, A., LEVINSON, D. (2007). Mapping accessibility over time. *Journal of Maps*, 3, 76-87. DOI: https://doi.org/10.1080/jom.2007.9710829

ELLDÉR, E., SOLÁ, A. G., LARSSON, A. (2012). Featured graphic. Spatial inequality and workplace accessibility: The case of a major hospital in Göteborg, Sweden. *Environment and Planning A: Economy and Space*, 44, 2295-2297. DOI: https://doi.org/10.1068/a44627

ERIK, E., SOLÁ, A. G., LARSSON, A. (2012). Featured graphic. Spatial inequality and workplace accessibility: The case of a major hospital in Göteborg, Sweden. *Environment and Planning A: Economy and Space*, 44, 2295-2297. DOI: https://doi.org/10.1068/a44627

EUROPEAN COMMISSION (2021). [Online]. Available: https://www.europarl.europa.eu/nefrom-cars-facts-and-figures-infographics [accessed 28 December 2021].

FAISHAL, I. M. (2003). Car ownership and attitudes towards transport modes for shopping purposes in Singapore. *Transportation*, 30, 435-457. DOI: https://doi.org/10.1023/A:1024701011162

FRANSEN, K., NEUTENS, T., FARBER, S., De MAEYER, P., DERUYTER, G., WITLOX, F. (2015). Identifying public transport gaps using time-dependent accessibility levels. *Journal of Transport Geography*, 48, 176-187. DOI: https://doi.org/10.1016/j.jtrangeo. 2015.09.008

FRIMAN, M., LARHULT, L., GÄRLING, T. (2013). An analysis of soft transport policy measures implemented in Sweden to reduce private car use. *Transportation*, 40, 109-129. DOI: https://doi.org/10.1007/s11116-012-9412-y

GEURS, K. T., RITSEMA van ECK, J. (2001). *Accessibility measures: Review and applications*. Bilthoven (National Institute of Public Health and the Environment).

GEURS, K. T., RITSEMA van ECK, J. (2003). Evaluation of accessibility impacts of land-use scenarios: The implications of job competition, land-use, and infrastructure developments for the Netherlands. *Environment and Planning B: Urban Analytics and City Science*, 30, 69-87. DOI: https://doi.org/10.1068/b12940

GARDNER, B., ABRAHAM, C. (2010). Going green? Modelling the impact of environmental concerns and perceptions of transportation alternatives on decisions to drive. *Journal of Applied Social Psychology*, 40, 831-849. DOI: https://doi.org/10.1111/j.1559-1816.2010.00600.x

GÄRLING, T., SCHUITEMA, G. (2007). Travel demand management targeting reduced private car use: Effectiveness, public acceptability and political feasibility. *Journal of Social Issues*, 63, 139-153. DOI: https://doi.org/10.1111/j.1540-4560.2007.00500.x

GIUFFRIDA, N., IGNACCOLO, M., INTURRI, G., ROFÈ, Y., CALABRÒ, G. (2017). Investigating the correlation between transportation social need and accessibility: The case of Catania. *Transportation Research Procedia*, 27, 816-823. DOI: https://doi.org/10.1016/j.trpro.2017.12.122

GOLISZEK, S. (2017). Space-time variation of accessibility to jobs with used by public transport – case study in Szczecin. *Europa XXI*, 33, 49-66. DOI: https://doi.org/10.7163/Eu21.2017.33.4

GOLISZEK, S. (2021). GIS tools and programming languages for creating models of public and private transport potential accessibility in Szczecin, Poland. *Journal of Geographical Systems*, 23, 115-137. DOI: https://doi.org/10.1007/s10109-020-00337-z

GOLISZEK, S. (2022). The potential accessibility to workplaces and working-age population by means of public and private car transport in Szczecin. *Miscellanea Geographica*, 26, 31-41. DOI: https://doi.org/10.2478/mgrsd-2020-0069

GOLISZEK, S., POŁOM, M. (2016). The use of general transit feed specification (GTFS) application to identify deviations in the operation of public transport at morning peak hours on the example of Szczecin. *Europa XXI*, 31, 51-60. DOI: https://doi.org/10.7163/eu21.2016.31.4

GOLISZEK, S., POŁOM, M., DUMA, P. (2020). Potential and cumulative accessibility of workplaces by public transport in Szczecin. *Bulletin of Geography. Socio-economic Series*, 50, 133-146. DOI: https://doi.org/10.2478/bog-2020-0037

GRAHAM-ROWE, E., SKIPPON, S., GARDNER, B., ABRAHAM, C. (2011). Can we reduce car use and, if so, how? A review of available evidence. *Transportation Research Part A: Policy and Practice*, 45, 401-418. DOI: https://doi.org/10.1016/j.tra.2011.02.001

GTFS open data Szczecin, [Online]. Available: https://www.zditm.szczecin.pl [accessed 10 November 2018].

GUTIERREZ, J. (2001). Location, economic potential and daily accessibility: An analysis of the accessibility impact of the high-speed line Madrid-Barcelona-French border. *Journal of Transport Geography*, 9, 229-242. DOI: https://doi.org/10.1016/S0966-6923(01)00017-5

HANDY, S. L., NIEMEIER, D. A. (1997). Measuring accessibility: An exploration of issues and alternatives. *Environment and Planning A: Economy and Space*, 29, 1175-1194. DOI: https://doi.org/10.1068/a291175

HE, S. Y., THØGERSEN, J. (2017). The impact of attitudes and perceptions on travel mode choice and car ownership in a Chinese megacity: The case of Guangzhou. *Research in Transportation Economics*, 62, 57-67. DOI: https://doi.org/10.1016/j.retrec.2017.03.004

HESS, D. B. (2005). Access to employment for adults in poverty in the Bufallo-Niagara region. *Urban Studies*, 42, 1177-1200. DOI: https://doi.org/10.1080/00420980500121384

INNOCENTI, A., LATTARULO, P., PAZIENZA, M. G. (2013). Car stickiness: Heuristics and biases in travel choice. *Transport Policy*, 25, 158-168. DOI: https://doi.org/10.1016/j.tranpol.2012.11.004

IPCC (2014). *Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects*, [Online]. Available: http://www.ipcc.ch/report/ar5/ wg2/ [accessed 30 June 2018].

IPCC (2021). *Climate change 2021: Impacts, adaptation, and vulnerability. The Working Group II contribution to the Sixth Assessment Report*, [Online]. Available: https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/ [accessed 29 December 2019].

KELOBONYE, K., XIA, J. C., SWAPAN, M. S. H., McCARNEY, G., ZHOU, H. (2019). Analysis and optimisation strategy of employment decentralisation in Perth through

density and accessibility indicators. In *Proceedings of the State of Australian Cities Conference and PhD. Symposium, Perth, Australia, 30 November – 5 December 2019*, pp. 1-14
KRIZEK, K., HORNING, J., EL-GENEIDY, A. M. (2012). Perceptions of accessibility to neighborhood retail and other public services. In Geurs, K. T., Krizek, K. J., Regianni, A., eds. *Accessibility Analysis and Transport Planning. Challenges for Europe and North America*. London (Edwar Elgar), pp. 96-117. DOI: 10.4337/9781781000106.00013
LAGRELL, E., THULIN, E., VILHELMSON, B. (2018). Accessibility strategies beyond the private car: A study of voluntarily carless families with young children in Gothenburg. *Journal of Transport Geography*, 72, 218-227. DOI: https://doi.org/10.1016/j.jtrangeo.2018.09.002
LEE, J., HE, S. Y., SOHN, D. W. (2017). Potential for converting short car trips to active trips: The role of the built environment in tour-based travel. *Journal of Transport & Health*, 7, 134-148. DOI: https://doi.org/10.1016/j.jth.2017.08.008
LEI, T. L., CHURCH, R. L. (2010). Mapping transit-based access: integrating GIS, routes and schedules. *International Journal of Geographical Information Science*, 24, 283-304. DOI: https://doi.org/10.1080/13658810902835404
LO, S. H., Van BREUKELEN, G. J. P., PETERS, G. J. Y., KOK, G. (2013). Proenvironmental travel behavior among office workers: A qualitative study of individual and organisational determinants. *Transportation Research Part A: Policy and Practice*, 56, 11-22. DOI: https://doi.org/10.1016/j.tra.2013.09.002
MEYER, M. D. (1999). Demand management as an element of transportation policy: Using carrots and sticks to influence travel behavior. *Transportation Research Part A: Policy and Practice*, 33, 575-599. DOI: https://doi.org/10.1016/S0965-8564(99)00008-7
MILLER, H. J. (2005). Place-based versus people-based accessibility. In *Access to Destinations*. Oxford (Elsevier), pp. 63-89. DOI: https://10.1016/B978-008044678-3/50064-8
NEWMAN, P., KENWORTHY, J. (1999). *Sustainability and cities: Overcoming automobile dependence*. Washington (Island Press).
POELMAN, H., DIJKSTRA, L. (2015). *Measuring access to public transport in European cities*. Regional Working Paper 2015, EU DG REGIO.
REYES, M., PÁEZ, A., MORENCY, C. (2014). Walking accessibility to urban parks by children: A case study of Montreal. *Landscape and Urban Planning*, 125, 38-47. DOI: https://doi.org/10.1016/j.landurbplan.2014.02.002
RITSEMA van ECK, J., BURGHOUWT, G., DIJST, M. (2005). Lifestyles, spatial configurations and quality of life in daily travel: An explorative simulation study. *Journal of Transport Geography*, 13, 123-134. DOI: https://doi.org/10.1016/j. jtrangeo.2004.04.013
ROFÉ, Y., BENNSON, I., MARTENS, K., BEN-ELIA, E., MEDNIK, N. (2015). *Accessibility and Social Equity in Tel-Aviv metropolitan area – examination of the current conditions and development scenarios*. Ministry of Transportation and Traffic Safety, Israel; Ben-Gurion University of the Negev; Tel-Aviv University. DOI: https://10.13140/RG.2.1.4141.3284
ROSIK, P., GOLISZEK, S., KOMORNICKI, T., DUMA, P. (2021a). Forecast of the impact of electric car battery performance and infrastructural and demographic changes on cumulative accessibility for the five most populous cities in Poland. *Energies*, 14, 1-12. DOI: https://doi.org/10.3390/en14248350
ROSIK, P., POMIANOWSKI, W., KOMORNICKI, T., GOLISZEK, S., SZEJGIEC-KOLENDA, B., DUMA, P. (2020). Regional dispersion of potential accessibility quotient at the intra-European and intranational level. Core-periphery pattern, discontinuity belts and distance decay tornado effect. *Journal of Transport Geography*, 82, 102554. DOI: https://doi.org/10.1016/j.jtrangeo.2019.102554
ROSIK, P., PUŁAWSKA-OBIEDOWSKA, S., GOLISZEK, S. (2021b). Public transport accessibility to upper secondary schools measured by the potential quotient: The case of

Kraków. *Moravian Geographical Reports*, 29, 15-26. DOI: https://doi.org/10.2478/mgr-2021-0002
SALONEN, M., TOIVONEN, T. (2013). Modelling travel time in urban networks: Comparable measures for private car and public transport. *Journal of Transport Geography*. 31, 143-153. DOI: https://doi.org/10.1016/j.jtrangeo.2013.06.011
SCHWARTZ, B. (2010). *How does Google's predictive traffic maps work?* [Online]. Available: https://www.seroundtable.com/archives/023155.html [accessed 20 December 2020].
SENBIL, M., KITAMURA, R., MOHAMAD, J. (2009). Residential location, vehicle ownership and travel in Asia: A comparative analysis of Kei-Han-Shin and Kuala Lumpur metropolitan areas. *Transportation*, 36, 325-350. DOI: https://doi.org/ 10.1007/s11116-009-9195-y
SHEN, Q. (1988). Location characteristics of inner-city neighborhoods and employment accessibility of low-wage workers. *Environment and Planning B: Urban Analytics and City Science*, 25, 345-365. DOI: https://doi.org/10.1068/b250345
SHIRGAOKAR, M. (2014). Employment centers and travel behavior: Exploring the work commute of Mumbai's rapidly motorising middle class. *Journal of Transport Geography*, 41, 249-258. DOI: https://doi.org/10.1016/j.jtrangeo.2014.10.003
SIMMA, A., AXHAUSEN, K. W. (2001). Structures of commitment in mode use: A comparison of Switzerland, Germany and Great Britain. *Transport Policy*, 8, 279-288. DOI: https://doi.org/10.1016/S0967-070X(01)00023-3
STEG, L. (2003). Can public transport compete with the private car? *IATSS Research*, 27, 27-35. DOI: https://doi.org/10.1016/S0386-1112(14)60141-2
STĘPNIAK, M., GOLISZEK, S. (2017). Spatio-temporal variation of accessibility by public transport – the equity perspective. In Ivan, I., Singleton, A., Horák, J., Inspektor, T., eds. *The rise of big spatial data, lecture notes in geoinformation and cartography*. Cham (Springer), pp. 241-261. DOI: https://doi.org/10.1007/978-3-319-45123-7_18
STĘPNIAK, M., PRITCHARD, J. P., GEURS, K. T., GOLISZEK, S. (2019). The impact of temporal resolution on public transport accessibility measurement: Review and case study in Poland. *Journal of Transport Geography*, 75, 8-24. DOI: https://doi.org/ 10.1016/j.jtrangeo.-2019.01.007
TALEN, E. (1996). After the plans: Methods to evaluate the implementation success of plans. *Journal of Planning Education and Research*, 16, 79-91. DOI: https://doi.org/ 10.1177/0739456X9601600201
TALEN, E., ANSELIN, L. (1998). Assessing spatial equity: An evaluation of measures of accessibility to public playgrounds. *Environment and Planning A: Economy and Space*, 30, 595-613. DOI: https://doi.org/ 10.1068/a300595
THOMPSON, C. A., SAXBERG, K., LEGA, J., TONG, D., BROWN, H. E. (2019). A cumulative gravity model for inter-urban spatial interaction at different scales. *Journal of Transport Geography*, 79, 102461. DOI: https://doi.org/10.1016/j.jtrangeo. 2019. 102461
URBANEK, A. (2021). Potential of modal shift from private cars to public transport: A survey on the commuters' attitudes and willingness to switch – A case study of Silesia Province, Poland. *Research in Transportation Economics*, 85, 101008. DOI: https://doi.org/10.1016/j.retrec.2020.101008
Van ACKER, V., WITLOX, F. (2010). Car ownership as a mediating variable in car travel behaviour research using a structural equation modelling approach to identify its dual relationship. *Journal of Transport Geography*, 18, 65-74. DOI: https://doi.org/ 10.1016/j.jtrangeo.2009.05.006
VAN, H. T., CHOOCHARUKUL, K., FUJII, S. (2014). The effect of attitudes toward cars and public transportation on behavioral intention in commuting mode choice – A comparison across six Asian countries. *Transportation Research Part A: Policy and Practice*, 69, 36-44. DOI: https://doi.org/10.1016/j.tra.2014.08.008
WANG, F., XU, Y. (2011). Estimating O-D travel time matrix by Google Maps API: Implementation, advantages, and implications. *Annals of GIS,* 17, 199-209. DOI: https://doi.org/10.1080/19475683.2011.625977

WANG, L., LI, L., WU, B., BAI, Y. (2013). Private car switched to public transit by commuters, in Shanghai, China. *Procedia Social and Behavioral Sciences*, 96, 1293-1303. DOI: https://doi: 10.1016/j.sbspro.2013.08.147

Sławomir G o l i s z e k

INDIVIDUÁLNA ALEBO VEREJNÁ DOPRAVA? ŠTÚDIA DENNEJ ČASOVEJ DOSTUPNOSTI SÚKROMNOU A VEREJNOU DOPRAVOU V MESTE ŠTETÍN

Tento článok ukazuje, že jednoduchý kumulatívny gravitačný model, používaný na rôzne veľkosti študovaných oblastí, založený na štandardnom gravitačnom modeli umožňuje porovnanie rôznych druhov dopravy v systéme východiskový bod – cieľ (Origin – Destination – O. D.). Analýza údajov o verejnej a súkromnej doprave je oblasť výskumu, ktorá sa v posledných rokoch dynamicky rozvíja. Navyše výsledky analýz založených na verejne dostupných údajoch sú čoraz presnejšie. Analýzy zohľadňujúce rôzne časy dňa ukazujú, kedy sú rozdiely v prevádzke verejnej a súkromnej dopravy najmenšie. Výskum môže vyplniť medzeru v bádaní a poskytnúť údaje týkajúce sa problematiky konkurencieschopnosti súkromnej a verejnej dopravy v rôznych denných časoch. Riešenie tejto otázky môže podnietiť aspoň časť občanov, aby častejšie využívali verejnú dopravu, čo prispeje k zníženiu znečistenia ovzdušia v centre mesta.

Hlavným cieľom štúdie je porovnať dva druhy dopravy s využitím verejne dostupných údajov, čo pomôže dospieť k záveru o konkurencieschopnosti verejnej dopravy počas dňa. V súčasnosti vytvorené modely individuálnej dopravy sú založené najmä na údajoch získaných z internetových portálov alebo systémov zhromažďujúcich údaje o čase cesty z GPS vysielačov v autách alebo mobilných telefónoch. Údaje GPS spracúvajú spoločnosti a následne ich zverejňujú, napr. je možné si ich bezplatne stiahnuť z webovej stránky Google Maps®. Pokiaľ ide o iné spoločnosti, niektoré si za sprístupnenie údajov účtujú poplatky. Služba Google Maps® zhromažďuje a vizualizuje dopravné údaje v reálnom čase, ale je možné skontrolovať aj priemerné hodnoty cestovného času. TomTom® a Google Maps®/Transit sú najznámejšie spoločnosti, ktoré zhromažďujú a spracúvajú dopravné údaje. Ak si však bežný používateľ chce stiahnuť údaje v reálnom čase a vytvoriť model matice času cestovania pre niekoľko rôznych cieľov, nie je to jednoduchý postup. Na stiahnutie údajov z rozhrania API Google Maps® je potrebná konkrétna aplikácia, ktorá generuje načítanie máp v reálnom čase a ukladá ich.

V článku sme určili oblasti v Štetíne s väčšími a menšími rozdielmi v cestovných časoch pri použití verejnej a súkromnej dopravy. Môže to však závisieť od zvolenej metódy analýzy dostupnosti. Zahrnutie potenciálnej dostupnosti do analýzy mohlo ovplyvniť výsledky pre centrum mesta. V Štetíne sú viditeľné rozdiely v časovej dostupnosti, ktoré uprednostňujú verejnú dopravu v rannej a popoludňajšej špičke. Mimo týchto hodín je oveľa pohodlnejšie, až trikrát rýchlejšie, použiť súkromný automobil. Zaujímavý výsledok môže byť argumentom v prospech prechodu na verejnú dopravu, aspoň v čase dopravnej špičky. Článok poukazuje na konkrétne oblasti v meste, kde je verejná doprava konkurencieschopná, čo môže byť zásadnou otázkou pri výbere miesta na bývanie. Počet ľudí, ktorí žijú v oblastiach s dvakrát horšou kumulatívnou dostupnosťou verejnou dopravou počas popoludňajšej špičky, dosahuje 90 % všetkých občanov. Počas rannej špičky má konkurenčnú dostupnosť 65 % občanov. Prezentované výsledky by mohli prispieť k posilneniu pozície verejnej dopravy pri každodennom dochádzaní do práce a zníženiu používania osobných automobilov v meste.

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