

Designation of Paid Parking Zones in Łódź

Marta Małgorzata Borowska-Stefańska

The University of Łódź, Poland

Szymon Adam Wiśniewski

The University of Łódź, Poland

This article has two aims: the cognitive one and the methodological one. The first one focuses on delineating city areas (of Łódź in this case), in relation to which a conscious parking policy should be implemented, including differentiation of the base parking fee and dynamics of parking cost increment in time. The methodological aim, in turn, consists in elaborating a research algorithm based exclusively on the geographical information system, which is based on generally available vector data, together with data obtained from intelligent transport systems. For their realization of the authors of this article elaborated their own methodology. It consists of five stages. The basic research unit is the surveying district. The area on the basis of which the research was made is the Łódź urban zone defined in the Strategy of Spatial Development for Łódź (2012). Each research stage corresponds to defining the power of impact of the variable which, as an research overview shows, affects the parking policy. Since the research is conducted on the basis different variables at individual stages and finally the coefficient assumes the form of five elements, it is necessary to standardize partial results. The article uses a procedure based on the quotient of the difference between the calculated value and the average for the whole group, divided by standard deviation. The results of the conducted research in the cognitive scope show that problems connected with parking organization do not concern only the very city centre (mostly the district of Śródmieście). Particular attention should be drawn to areas next to the city's main transport arteries which go latitudinally (for instance, Piłsudski avenue) or meridionally (e.g. Kościuszki street, Zachodnia street).

Keywords: paid parking zones, car parks, sustainable transport, Łódź, GIS.

1. INTRODUCTION

In the recent decades a surge in the level of motorization, street network density and number of parking places has contributed to a rise in mobility, street and car park congestion and, as a result, environmental pollution. The strategies used so far have resulted in making the city and its surroundings dependent on private transport. Consequently, the authorities of many European cities decided to bring about a change in their transport policy, aiming at optimization of the division of transport tasks between public and individual car transport in accordance with the principle of sustainable growth. Instruments of this strategy include, for instance, mobility management, extension of the network and ensuring the adequate quality of public

transport, promoting non-motorized traffic as well as activities concerning traffic organization, such as zones of restricted access and parking (Morris 1993; Maršanić et al. 2010; Ciastoń-Ciulkin, Starowicz 2014; Szymański, Kikulski 2015; Starowicz 2014; Quirini-Popławski 2016 after: White...2001; Rodrigue et al. 2006; Gaca et al. 2008; Schiller et al. 2010; Biała...2011).

Transport problems in cities, increased mobility of people and a growing number of vehicle users more and more often lead to overburdening the existing transport infrastructure. This concerns not only roads, streets or crossroads but also the parking space in cities (Buntić et. al. 2012; Cats et. al. 2015; Szczuraszek, Karwasz 2014; Vera-Gómez et. al. 2016). Parking is becoming a growing

problem, especially in big cities and agglomerations and, needless to say, car parks are an indispensable element of urban transport system (Naumov 2015; Szarata 2015). Presently however, the emphasis is laid on adequate management and use of the existing infrastructure and introduction of restrictions for individual car transport, in particular in city centres, since much of the free space in the city structure which could be used for road infrastructure has been already developed (Szcuzaszek, Karwasz 2014).

Paid parking zones are introduced in Poland in the case of cities in which the number of inhabitants exceeds 50 thousand people (Brzyszc et al. 2013; Kubala, Kulpa 2015) as it is precisely in such big cities that parking problems are the most burning (Brzeziński, Dybicz 2013; Franek, Kulpa 2013; Parkitny 2013; Sklorz 2013). Increased knowledge of threats connected with using transport, as well as growing environmental awareness, forced city authorities to impose restrictions on transport, especially in cities centres (Wiśniewski 2015). Means regulating the demand for parking places, including paid parking zones, are beginning to gain social acceptance (Franek, Kulpa 2013). Their main purpose is to manage accessibility of these areas. The biggest zones of this type can be found in Warsaw (about 22 thousand parking places), Kraków (11 thousand parking places), Szczecin (8.5 thousand parking places), Poznań (6 thousand parking places), Wrocław (2.8 thousand parking places) and Łódź (about 1.8 thousand parking places). The amount of the fee within paid parking zones should be a compromise which takes into account local conditionings, as both too high and too low charges may lead to a situation when the zone will fail to perform its functions (although the maximum value of the fee is regulated by state law). The zones in question are established on those areas which are characterized by a considerable deficiency of parking places if this is justified by traffic organization needs, increased car rotation or local transport policy. The aim of this is to lead to restricted accessibility of such an area for cars or to introduce preference for public transport (Brzyszc et al. 2013; Bujak 2014; Christiansen et al. 2017), pedestrian and bicycle traffic (Nitschke et al. 2013).

Paid parking zones may be divided into a number of subzones, each of which may have different fees. In accordance with the Regulation of the Minister of Transport, Construction and Maritime Economy as of 15 November 2013, as well as the Regulation of

the Minister of Infrastructure on detailed technical conditions for road signs and signals, as well as road traffic safety devices and their placement on roads (*Rozporządzenie Ministra Transportu, Budownictwa i Gospodarki Morskiej z dnia 15 listopada 2013 r.*, a także z *Rozporządzeniem Ministra Infrastruktury w sprawie szczegółowych warunków technicznych dla znaków i sygnałów drogowych oraz urządzeń bezpieczeństwa ruchu drogowego i warunków ich umieszczania na drogach*), paid parking zones in Poland should be marked, both on streets bringing the traffic into and out of the area of paid parking zones by means of adequate D-44 (Paid parking zone) and D-45 (End of paid parking zone) road signs. In turn, the necessity of marking parking places in the paid parking zone is regulated by the Regulation of the Council of Ministers on detailed principles of introducing parking fees for parking cars on public roads (*Rozporządzenie Rady Ministrów w sprawie szczegółowych zasad wprowadzania opłat za parkowanie pojazdów samochodowych na drogach publicznych*), in accordance with which “fees may be charged for parking vehicles in the marked place on certain days and hours or on a 24-hour basis” (Franek, Kulpa 2013; Owczarzak-Trzebiatowska et al., 2015).

There are three zones in the city which require different parking policy:

- city centre - the interchangeability of functions of facilities (and traffic) as well as dense development do not allow to delineate space for parking separately for each facility. This zone requires a special approach considering the road network, public transport and parking. It often introduces parking limitation to an extent dependent on the character and size of the city, function in the centre and local factors;
- residential zone – the needs for parking on the part of car owners living there should be satisfied within cadastral parcels;
- commercial zone – the needs of people working and visiting individual facilities should be satisfied within cadastral parcels, where the degree of their satisfaction results from the type of the city’s policy of transport task division (Friedberg 2013).

From the social standpoint, parking is conditioned by the destination. Hence, there are different types:

- connected with home;
- related to journeys to places of work and education;

- journeys connected with conducting a business activity or business trips;
- journeys for existential reasons, i.e. to work places, handling administrative matters;
- journeys connected with pursuing cultural or social goals.

The key issue is to solve problems of parking in residential areas and those connected with journeys to places of work and education (Friedberg 2013).

The introduction of Paid Parking Zones leads to changes in transport behaviour, an increase in rotation of parking vehicles, a restriction on the demand for long-term parking on the limited parking base in the space of road lanes in the centre, a drop in traffic intensity of vehicles looking for free parking places, better traffic safety conditions, respect for the existing road infrastructure (pavements) and the environment (reduced fuel emissions and improved air quality), (Marsden 2006; Sklorz 2013; Kostelecka 2015; Kubala, Kulpa 2015). Regrettably, it is still not possible to introduce fees for going through the centre of Polish cities (Ciastoń-Ciulkin, Starowicz 2014; Szarata 2015) as it is in the case of, for example, Edinburgh (Sumalee 2001; Rye et al. 2008; Ryley 2008), London (Desarnaulds et. al. 2004; Litman 2005; Mingardo 2008), Oslo or Stockholm. This is why Paid Parking Zones play the most important role in limiting the number of cars going to city centres (Ciastoń-Ciulkin, Starowicz 2014; Szarata 2015). However, as it is confirmed by research conducted by A. Ciastoń-Ciulkin and W. Starowicz (2014), the introduction of Paid Parking Zones does affect transport behaviour of travellers. Both the necessity of paying a parking fee, and the difficulty in finding a free parking place reduce the competitiveness of passenger cars, mainly for the benefit of public transport (Ciastoń-Ciulkin, Starowicz 2014).

This article has two aims: the cognitive one and the methodological one. The first one focuses on delineating city areas (of Łódź in this case), in relation to which a conscious parking policy should be implemented, including differentiation of the base parking fee and dynamics of parking cost increment in time. The methodological aim, in turn, consists in elaborating a research algorithm based exclusively on the geographical information system, which is based on generally available vector data, together with data obtained from intelligent transport systems.

2. CHARACTERISTICS OF THE RESEARCH AREA

Łódź is a centre in the case of which the subsystem of individual car transport plays an important role in the entirety of transport relations. Over the space of the last years, apart from the strategic investment of constructing the new Łódź Fabryczna train station, the vast majority of infrastructure investments were precisely related to the car transport organization (e.g. the W-Z route, the motorway bypass, the Urban Traffic Control System). Despite this, as statistics show (Fig. 1, 2.), there are fewer registered vehicles in Łódź than in smaller Wrocław, yet one may judge by activities of the local authorities that individual car traffic represents a vital problem for the city's efficient functioning in the sphere of the movement of people and goods.

This is confirmed by data on road incidents as a result of which the health of people involved suffered (tab. 1). Despite the fact that the level of motorizations of Łódź inhabitants remains far behind other provincial cities (Fig. 2.), the impact of other factors (e.g. infrastructure, driving etiquette, share of vehicles from outside the city in traffic) is so strong that Łódź is at the forefront considering the number of accidents per the population.

Parking policy is one of very important elements of local transport policy whose efficiency should translate itself, most of all, into safety of traffic participants. In Łódź, the current division of the paid parking zone has been in force since 1 February 2016. It was divided into two subzones A and B (Fig. 3), and for each of them new parking rates were introduced. In zone A the fees are as follows:

- for the first ½ h – 1,5 PLN,
- for the first hour - 3 PLN,
- for the second hour – 3,5 PLN,
- for the third hour - 4 PLN
- for the fourth and every following hour – 3 PLN.

In turn, fees in subzones B are lower and their amounts were established in the following way:

- for the first ½ h – 1 PLN,
- for the first hour – 2,5 PLN,
- for the second hour – 3 PLN,
- for the third hour – 3,5 PLN
- for the fourth and every following hour – 2,5 PLN (http://zdit.uml.lodz.pl/pl/strona/Strefa_parkowania/58).

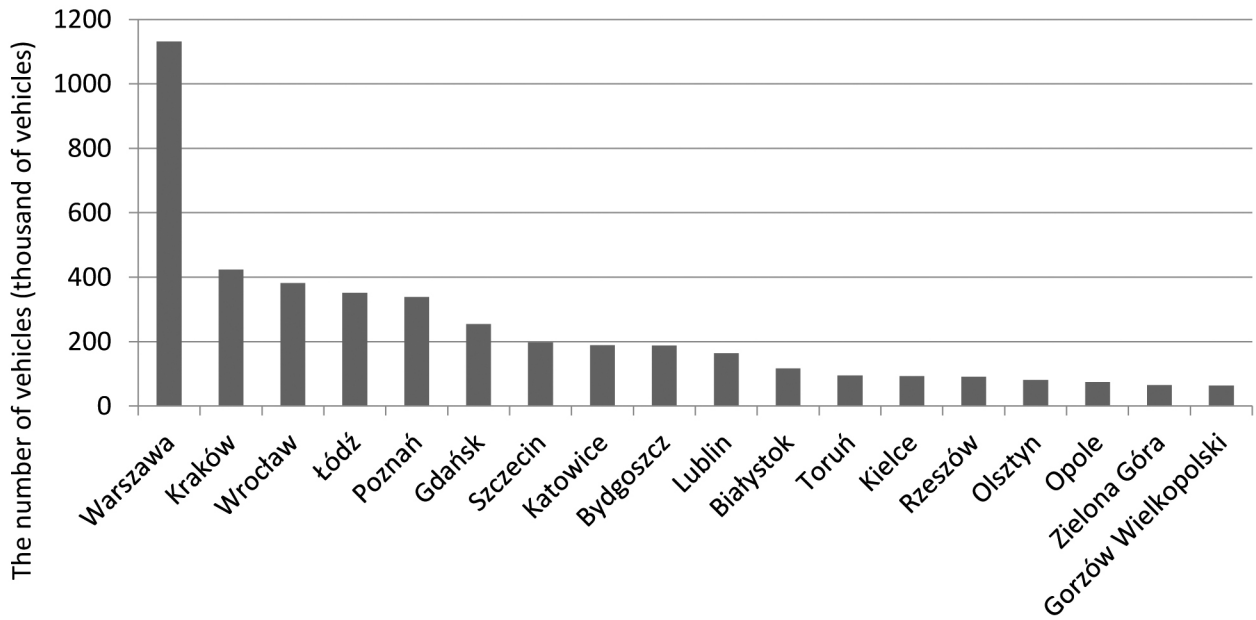


Fig. 1. The number of vehicles in provincial cities in Poland in 2016
 Source: own study based on: BDL GUS 2016.

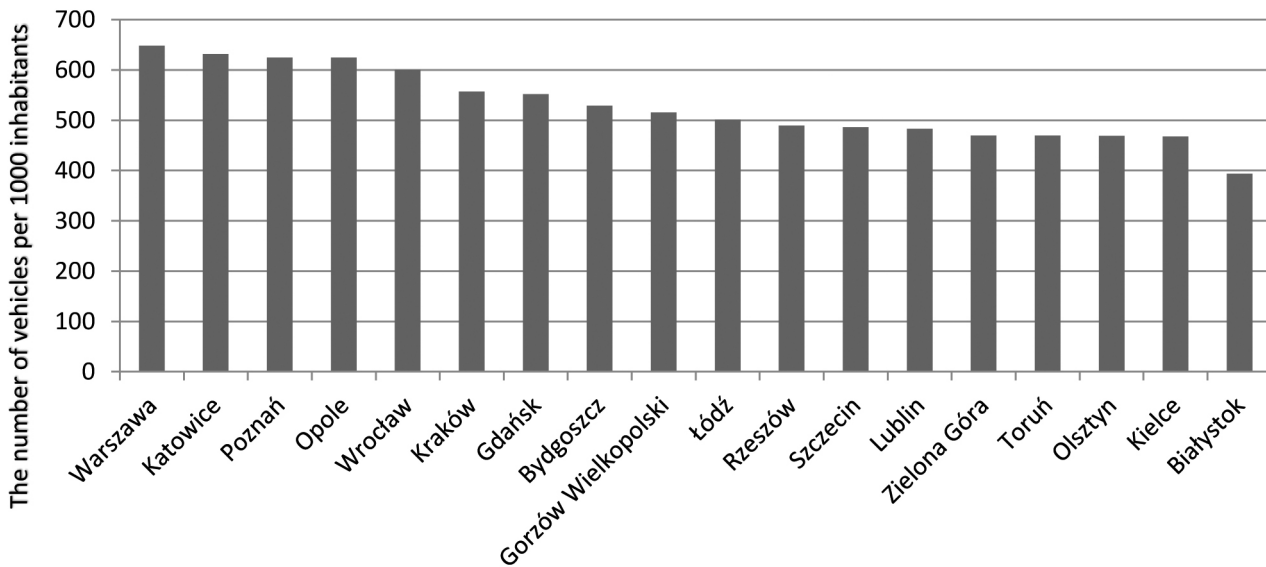


Fig. 2. The number of vehicles Per 1,000 inhabitants in 2016
 Source: own study based on: BDL GUS 2016.

Table 1. Indicator concerning road accidents in provincial cities in Poland in 2016

city	road accidents per 100 k inhabitants	death casualties per 100 k vehicles	death casualties per 100 k	people injured per 100 k vehicles
Białystok	51,7	2,0	1,0	113,3
Bydgoszcz	56,0	3,8	2,5	98,3
Gdańsk	109,2	4,2	2,8	195,7
Gorzów Wielkopolski	41,2	5,0	3,2	73,9
Katowice	93,7	5,4	4,3	130,2
Kielce	149,0	8,5	5,0	296,9
Kraków	152,0	3,3	2,2	247,6
Lublin	58,4	7,1	4,4	103,2
Łódź	244,7	4,5	2,7	486,1
Olsztyn	141,3	2,8	1,7	265,6
Opole	126,1	8,6	6,7	186,0
Poznań	56,4	3,3	2,6	76,6
Rzeszów	207,1	4,3	2,7	396,7
Szczecin	137,1	6,2	3,7	265,6
Toruń	21,2	5,8	3,4	36,3
Warszawa	55,1	4,4	3,4	79,1
Wrocław	87,1	1,9	1,4	142,8
Zielona Góra	67,8	10,9	6,5	124,5

Source: own study based on: BDL GUS 2016.



Fig. 3. Paid Parking Zones in Łódź
 Source: own study based on: <http://uml.lodz.pl/dla-mieszkanow/transport-i-komunikacja/kierowca/> (access: 25.09.2017).

In addition, the zone area is divided into five sectors – this concerns subscription fees for zone inhabitants (<http://uml.lodz.pl/dla-mieszkanow/transport-i-komunikacja/kierowca/>), (Fig. 3).

3. RESEARCH PROCEEDINGS

Data on disparate parking characteristics may be collected using methods which may be divided into 4 main groups. They include:

1. Detailed analysis of parking ticket sales bought both in parking metres and through mobile applications. This method is encumbered with the biggest error. It does not allow full identification of vehicles parking in Paid Parking Zones.
2. Survey research which represents the main source of information on the opinions of users in relation to different features of Paid Parking Zones.
3. Direct measurements which are based on the visual assessment of selected parking indicators. They consist in analysis of records of number plates together with assigning them the hour of reading or measurement of traffic intensity on roads leading to Paid Parking Zones.
4. Automatic measurements with the use of detectors for showing the occupancy of parking places (Szarata 2015).

Direct measurements represent the research method which is used most often in the case in question. They are labour-intensive and time-consuming yet easy to implement. They require, however, exceptional accuracy while making records so that they can be useful. If they are conducted correctly, they carry a lot of content and they may be used to assess and shape Paid Parking Zones. They were used in works of such researchers as Szarata et al. (2007), Gregorowicz, Trybuś (2013), Szczuraszek, Karwasz (2014), Kubala, Kulpa (2015). In turn, surveys represent the basic source of information on the perception of the zones in question by their users. They help shape and adjust areas with Paid Parking Zones to the expectations of inhabitants. They are often used as tools verifying the decisions taken and assessing the effects of implemented changes, e.g. zone extension or change in the number of parking places. This type of research is characterized, however, by a large degree of subjectivity and the answers are strongly

influenced by individual perception of reality. Despite this, they remain an invaluable source of information. They were used in the works by, for instance, Brzyszczyk et al. (2013), Gregorowicz, Trybuś (2013), Ciastoń-Ciulkin, Starowicz (2014), Kubala, Kulpa (2015).

Together with the development of technology and IT tools, newer and newer solutions are developed due to which it is possible to gather detailed data concerning the issue of parking. This group includes advanced devices which are based on, for example, video detection, radar detectors and ultrasonic detectors. They are characterized by a high degree of measurement accuracy as well as high elasticity of use but, unfortunately also involve high investment costs. However, thanks to their implementation it is possible to obtain a huge amount of data containing information about parking time, rotation or occupancy of parking places. Their greatest advantage is that data may be gathered in a continuous way, which offers a possibility of analysing measurement results, including rush hours, day of the week, or longer periods (Szarata 2015).

Yet in order to delineate Paid Parking Zones in Łódź and differentiate prices of parking fees, the authors of this article elaborated their own methodology. The prerequisite for looking for a new research “path” on the subject was the willingness to use two groups of input data as well as GIS software as a research platform. Firstly, easily available spatial data, or the Database of Topological Objects (BDOT) and data from the OpenStreetMap resources (OSM). These resources provide almost complete information on the development of the area selected for research. With regard to credibility of these sources it must be stressed that the Database of Topological Objects is an official state resource laid down in Polish legislation, while OSM is a social initiative, which is why accuracy and completeness of data from this source is by no means guaranteed. Nevertheless, research practice shows (comparison with the results of field inventory) that within the boundaries of large urban centres the contents of this database tend to be more complete and sometimes more up-to-date than the Database of Topological Objects. Secondly, data from the Urban Traffic Control System, whose accuracy and spatial range are impossible to obtain as a result of any other direct research or analysis of secondary data. These are two different kinds of data. The former deal with

the number of vehicles on the city’s road network recorded by induction loops in 15-minute intervals. The latter, in contrast, include data on time and route (order of points) of travel between ANPR (automatic number-plate recognition) cameras installed on key crossroads in Łódź (Fig. 4).



Fig. 4. Research area of Paid Parking Zones in Łódź
Source: own study.

On the basis of the range of input data defined in this way the following research procedure was launched. It consists of five stages. The basic research unit is the surveying district, the smallest spatial unit delineated for every commune in Poland. The area on the basis of which the research was made is the Łódź urban zone defined in the Strategy of Spatial Development for Łódź (2012). Each research stage corresponds to defining the power of impact of the variable which, as an research overview shows, affects the parking policy. Since the research is conducted on the basis different variables at individual stages and finally the coefficient assumes the form of five elements, it is necessary to standardize partial results. The article uses a procedure based on the quotient of the difference between the calculated value and

the average for the whole group divided by standard deviation.

The first research stage focuses on assessment of competitiveness of public transport as it was assumed that if there is a possibility of easy access to the researched area by means of public transport, parking fees in this area should be high to discourage from travelling by individual means of transport. The distance of up to 100 metres from the transport node to the destination was assumed to be comfortable. Research of public transport accessibility normally adopts much higher values (300-500 metres), which potential passengers are able to accept. Nevertheless, the criterion was toughened so that the competitiveness level was as high as possible. It is still necessary to explain the notion of public transport as it was decided that the research will be conducted on the basis of accessibility to nodes rather than stops. The node was defined as a group of stops concentrated spatially (at a distance not exceeding 50 metres from one another), which ensures a possibility of travelling in at least two directions. The location of the node is the arithmetic mean of coordinates of individual stops which form the node. Consequently, the number of nodes is naturally smaller than that of stops. Yet accessibility to the node guarantees actual access to public transport. In order to determine the competitiveness of public transport, the authors calculated the share of development surface of the surveying district covered by the equidistance of 100 metres from the node. The Manhattan matrix was used to make the results more real. It was assumed that the higher the share, the more severe the cost of parking should be.

The second variable concerns determining the power of generating potential vehicle traffic by the given surveying district. It was assumed that both traffic and the need to park can be blamed on (obviously apart from the inhabitants) business activities conducted on the given area. This is why in order to calculate this variable the authors calculated the share of surface of commercial and service buildings as well as production and storage facilities in the total surface of the surveying district. It was assumed that the bigger the share, the stronger the power with which the area attracts traffic and "forces" vehicles to park. Consequently, it was assumed that the bigger the share of these activities, the more dynamic increases in parking fees there should be, so as to increase the rotation of vehicles parking there.

Another variable included in the research is the ratio of the real parking surface to the surface which should occur to satisfy the needs of inhabitants of the given surveying district. The real parking surface was determined on the basis of OSM and inventory conducted on the basis of the research area orthophotograph. The demand for parking space was estimated in the following way. First, the number of inhabitants of every surveying district was calculated and then the number of parking places was estimated assuming the level of motorizations in Łódź after BDL GUS at 501.97 vehicles per 1,000 inhabitants. Then the parking surface was calculated in accordance with technical and construction regulations. As the minimum parking place measurements are 5 m per 2.3 m, the number of necessary places was multiplied by 11.5 m². It was assumed that the bigger the disproportion between the actual parking space and its minimum level to satisfy the inhabitants' needs to the disadvantage of the latter, the higher and more dynamically charged the parking fees should be.

The following variable included in the research was aimed at reflecting the city's parking policy. In this research it was assumed that the area which should be characterized by calmed traffic and majority of public transport in passengers' carriage work is the Łódź metropolitan area. In the case where there are regulations defining directly areas with restrictions concerning individual car traffic and consequently parking, at this stage they may be implemented in the analysis. In this way it was calculated what share in the surface of the surveying district is represented by the Łódź metropolitan area. It was assumed that the bigger the share, the higher the parking fees within the given surveying district should be for those who park their vehicles.

The aim of the final element implemented in the analysis is to present the pressure which is exerted by everyday vehicle movement on the research area (including parking surfaces). This feature was composed of two variables obtained from OSSR. On the basis of information sent by induction loops the authors determined the average number of vehicles going through the given surveying district during the afternoon rush hour (Monday-Friday; at 16:30). The results were obtained through averaging the values collected during weekdays in November 2016. It was therefore calculated what group of vehicles represents potential users of parking places. The second variable which was taken from OSSR includes

data on average length of vehicle stay on the area of the given surveying district. To obtain this average all journeys were collected between individual crossroads and cameras ANPR. Theoretical journey times (in accordance with traffic regulations) were subtracted from real journey times for individual sections. It was estimated in this way how long the vehicle was not in the traffic. It is naturally a very simplified assumption, omitting many other variables, yet because of the subject matter of the research they are of secondary importance. In this analysis it is important to consider only the time of possible parking rather than the reason for parking. Congestion is certainly a distortion of results which considerably perverts journey times. The product of the average number of vehicles and the average time of stay on the district served as an indicator informing about potential demand for parking places. It was assumed, therefore, that the higher it is, the more restrictive the parking policy on the given area should be.

All the presented variables affect parking costs in direct proportion, so their overall influence is represented by the product of their standardized values for every surveying district.

4. RESULTS AND DISCUSSION

As a result of the research conducted it was established that the best accessibility to transport nodes can be attributed to areas located in the northern part of the Śródmieście district and east and west of Śródmieście as well as in the south-eastern part of the researched area (a fragment of Zarzew), (Fig. 5). It is precisely on this area that the share of development within the equidistance of 100 metres from the nodes is the highest. In the northern part of Śródmieście it ranges from 36 to 48.8%, whereas in its immediate vicinity in the west and east as well as the south-western part of the research area it reaches 23.9-35.9% (Fig. 6).

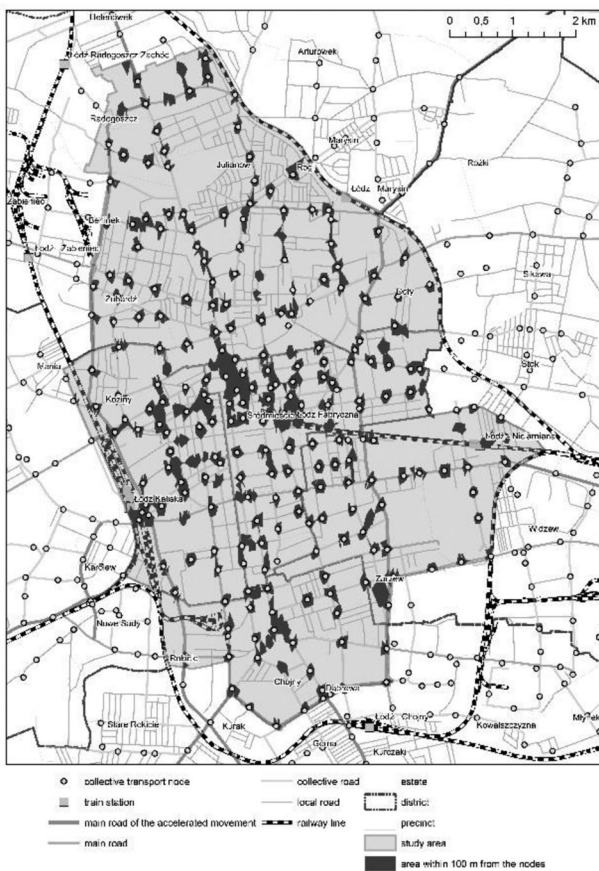


Fig. 5. Accessibility to public transport node within the boundaries of the analyzed area of Łódź
Source: own study.



Fig. 6. The share of development within 100 meters from the public transport node within the boundaries of the analyzed area of Łódź
Source: own study.

In turn, analyzing the total surface of development in the researched areas of the Łódź urban zone, it is worth pointing out that it is also the highest in Śródmieście, in particular in its northern fragment as well as areas located east and west of it: it is where the population density is the highest (Borowska-Stefańska, Wiśniewski (2017), (Fig. 7). Its lowest value can be found, in turn, in areas located in the direct vicinity of the ring railway.

Within the boundaries of the research area there is clear dominance of residential development, multi-family one in particular. However, single family buildings appear as the distance from the inner centre of the city increases. The main areas of concentration of residential buildings are to be found in the northern outskirts of the centre as well as in the south-central part of the Bałuty district (Dzieciuchowicz 2002) (Fig. 8). The city development zone in Łódź is characterized by certain specificity which was conditioned by its

history as a result of the development of the city and industry within its boundaries. “Old” industrial areas which date back to before 1939 can be still found in central districts along the north-south axis. They are interwoven with the residential tissue. “New” industrial areas appeared in the 1960s and 70s, mainly in the north-western and south-eastern part of the city, outside the line of the ring railway (May 2002), hence they were not included in this research. As a result of fast and frequent changes in the set of factors conditioning business activity, there is a need to adopt industrial plants. One effect of inability or impossibility of adapting facilities of this type is their shrinkage and, consequently, liquidation (May 2002). On the researched area industrial development can be found especially in the southern and south-eastern part as well as north of the centre. In contrast, service development is intermingled with residential buildings, predominantly in the very city centre (Fig. 8). It is



Fig. 7. Surface of development on the analyzed area
Source: own study.

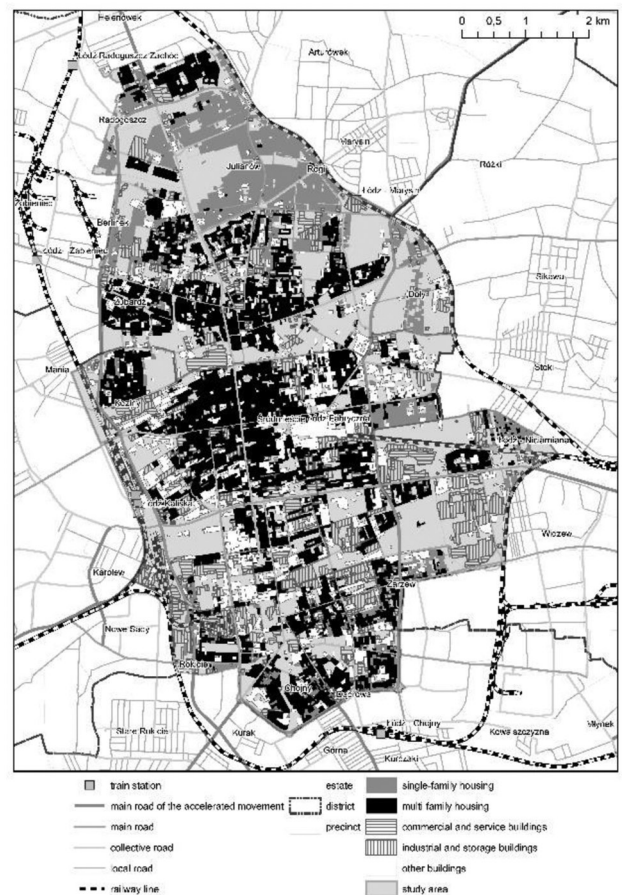


Fig. 8. Types of development on the analyzed area
Source: own study.

typical of the city in question to see a vast 19th-century centre which was shaped over the space of a mere couple of decades of the city’s intensive spatial development with dominating residential housing mixed with numerous post-factory complexes (Wojnarowska 2017).

Łódź urban area development structure according to type (Fig. 8.) shows unequivocally that in accordance with the adopted research method the areas which contribute in the highest degree to generating the need for parking vehicles are those neighbouring with the Łódź Kaliska station and, most of all, however, two surveying districts immediately adjacent to Piłsudskiego avenue. This is largely due to vast areas connected with industrial activity generating clear car traffic related to commuting workers (Fig. 9).



Fig. 9. The share of commercial and service development as well as industrial and storage development in the surface of the surveying district within the boundaries of the research area of Łódź
Source: own study.

In the light of the transport policy in force presently (Fig. 3.), attention should be drawn to the southern outskirts of the Śródmieście district. In the

case of the two surveying district from this area, shares of commercial and service buildings and industrial and storage ones reach even almost 28%.

Analysing, in turn, the existing parking space, it should be concluded that it is the biggest in the case of districts situated in the centre of Łódź as well as in its immediate vicinity (especially along the W-Z route) (Fig. 10). However, due to the fact that also population density is the highest in the city centre (Borowska-Stefańska, Wiśniewski 2017), it is precisely there as well as in the southern part of the Bałuty district that the deficiency of parking places is the biggest: in this case they fail to satisfy even the needs of the inhabitants alone (Fig. 11). This is why Paid Parking Zones were introduced within the city centre due to the considerable shortage of parking places.



Fig. 10. The existing parking surface within the boundaries of the researched area of Łódź
Source: own study.

The metropolitan zone covers the whole city centre and the areas located in its immediate vicinity, especially in the east, southern-east, west and northern-west of it (Fig. 12). This is an area



Fig. 11. Minimum parking space for the inhabitants within the boundaries of the research area of Łódź
Source: own study



Fig. 12. The share of the metropolitan area within the boundaries of the research area of Łódź
Source: own study.

which should be excluded from car traffic as quickly as possible. It is characterized by the biggest deficiency of parking places, which additionally affects the level of parking prices.

Figure 13 shows the average number of vehicles going through the given area during the afternoon rush hour. As the analyses show, the heaviest traffic is observed along the city's main arteries, especially national roads no. 14, 71, 72, 91 as well as the provincial road no. 713 (the W-Z route). When it comes to average vehicle parking time, it is definitely the shortest in the case of areas located in the subzone A (Fig. 3, Fig. 14) where parking fees are the highest, whereas it is slightly longer within the subzone B (Fig. 3, Fig. 14) where parking fees are slightly lower. Drivers leave their cars for the longest periods outside Paid Parking Zones, which proves that adequate management of parking in Łódź brings certain effects. In this case it is clearly visible that an introduction of parking fees in the inner centre of the city contributed to restricting the interest in accessing it by car (e.g. to work) and occupying parking

places in the most attractive regions and at the most convenient time. Due to this there is a possibility of increasing the city centre's accessibility (for short-term parking) for people using its different functions, such as commerce, services or culture (Brzeziński, Dybicz 2013). This correlation was also confirmed in research conducted by A. Ciastoń-Ciulkin and W. Starowicz (2014).

After juxtaposing the data on the number of vehicles and their potential parking time, it was possible to calculate the indicator of potential load of parking space (Fig. 15.). One area which clearly stands out is the central area (including New Łódź Centre with the Łódź Fabryczna station) where the pressure is the smallest. One should bear in mind, however, that office buildings will start functioning there in the near future, and their workers will considerably increase the demand for parking space. In the initial stage they will probably use the underground parking of the Łódź Fabryczna station. Yet, the moment the number of passengers using the station increases (for instance, on launching



Fig. 13. Average number of vehicles during the afternoon rush hour within the boundaries of the analyzed area of Łódź
Source: own study.



Fig. 14. Average time in which cars stay on the area of the geodesic district within the boundaries of the analyzed area of Łódź
Source: own study.

the cross-city tunnel, high speed railway or better connection with the A1 motorway), these spaces will have to be returned to passengers. Another vital moment for the parking policy of this area would be the launch of the EC1 revitalized power plant. As a considerable traffic generator, it is likely to cause a demand for parking places. This indicator achieved the highest values in the north-eastern and north-western parts of the research area as well as in the Koziny district and areas around the Łódź Kaliska station.

The overall approach to the adopted research aim shows that there is a clear need for spatial differentiation of the city's parking policy, at least with regard to the cost of occupying parking spaces (Fig. 16.). It seems to be particularly problematic in the case of neighbourhoods of surveying districts within the boundaries of which parking policy directions are divergent. Obeying directly the results obtained in the research would cause increased

parking on areas neighbouring with districts of high parking costs. This is why it is advisable to introduce some buffer solutions on these areas, such as a gradual increase in the parking cost the closer it gets to the most expensive zone. The situation is similar in the case of areas which were not included in the analysis, as those which are not affected by the problem of sanctioning the parking process. Within those boundary zones it is also advisable to conduct a detailed analysis of development as they may include facilities or areas (e.g. municipal parks) which generate a considerable need for parking. In such a case, the course of the zone boundary should be obviously modified.



Fig. 15. Standardized indicator of potential load of the parking space within the boundaries of the research area of Łódź

Source: own study

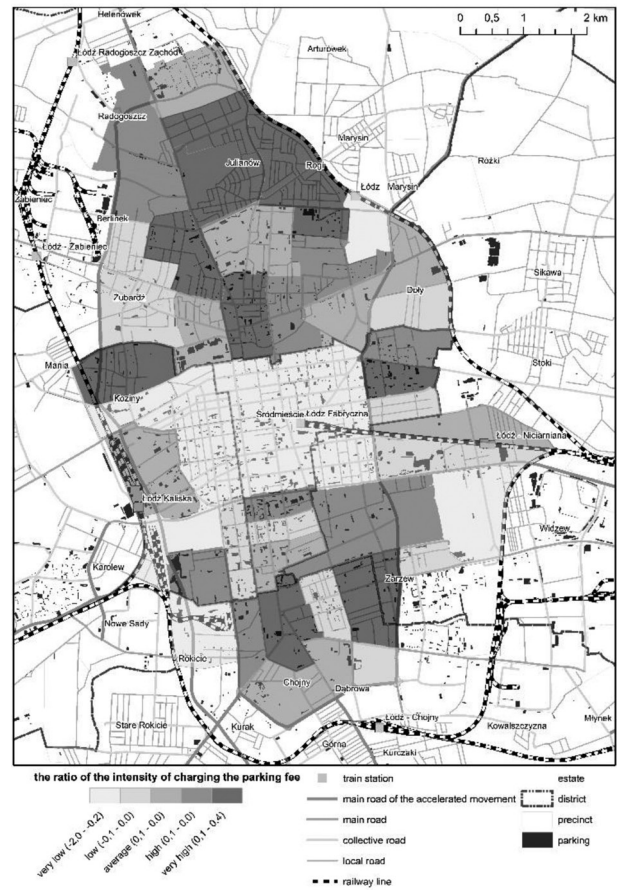


Fig. 16. Coefficient of intensity of charging the parking fee within the boundaries of the research area of Łódź

Source: own study.

5. CONCLUSIONS

The results of the conducted research in the cognitive scope show that problems connected with parking organization do not concern only the very city centre (mostly the district of Śródmieście). Particular attention should be drawn to areas next to the city's main transport arteries which go latitudinally (for instance, Piłsudski avenue) or meridionally (e.g. Kościuszki street, Zachodnia street). Analysis shows, moreover, that the current policy concerning parking space management (without scrutinizing its validity) brings real effects in the form of high accessibility level to parking places in the inner city centre. At the same time it must be stressed that the results presented in this article represent only starting material (diagnostic in a way) for findings on the spatial

scope and parking costs within Paid Parking Zones. It gives a clear picture on which city areas require in-depth analysis in this respect with the use of classic research methods in the form of, for example, a survey. Nonetheless, the utility of the elaborated method should be considered satisfying due to easy access to data, high work efficiency on a really vast scope of data as well as readability of both partial and final results which were obtained.

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Marta Małgorzata Borowska-Stefańska
The University of Łódź, Poland
borosia@op.pl

Szymon Adam Wiśniewski
The University of Łódź, Poland
szymon.wisniewski@geo.uni.lodz.pl

