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DOI: <https://doi.org/10.53052/9788366249851.05>

PARKING IN PAID PARKING ZONES - OVERVIEW OF THE SCIENTIFIC LITERATURE

Summary: Nowadays, we are dealing with a significant automotive development, which means that more and more passenger cars appear in the area of cities. This, in turn, makes it necessary to look for new solutions to meet the needs of vehicle drivers in the field of parking vehicles while using the existing transport infrastructure. The article presents an overview of selected research works dealing with parking in cities, with particular emphasis on parking in paid parking zones. Both, studies published in Poland, and abroad were paid attention to.

Keywords: parking in cities, paid parking zones, transport, road transport.

PARKOWANIE W STREFACH PŁATNEGO PARKOWANIA W MIASTACH - PRZEGLĄD LITERATURY PRZEDMIOTU

Streszczenie: W dzisiejszych czasach mamy do czynienia ze znacznym rozwojem motoryzacyjnym przez co na terenie miast pojawia się coraz więcej pojazdów osobowych. To z kolei powoduje konieczność poszukiwania nowych rozwiązań umożliwiających zaspokojenie potrzeb kierowców w zakresie parkowania pojazdów przy jednoczesnym wykorzystaniu istniejącej infrastruktury transportowej. W artykule przedstawiono przegląd wybranych prac podejmujących problematykę parkowania w miastach, ze szczególnym uwzględnieniem problematyki parkowania w strefach płatnego parkowania. Uwagę poświęcono zarówno badaniom, które zostały opublikowane w Polsce, jak i za granicą.

Słowa kluczowe: parkowanie w miastach, strefy płatnego parkowania, transport, transport drogowy.

1. Introduction

Nowadays, we are dealing with a significant automotive development, which means that more and more passenger cars appear in cities [1]. This, in turn, makes it necessary to look for new solutions that would allow to meet the needs of vehicle

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drivers in the field of parking with the simultaneous use of the existing transport infrastructure. The authorities of many cities are taking appropriate steps to increase the number of parking spaces, as well as to establish paid parking zones. These zones are designed to reduce the volume of vehicle traffic and force the rotation of parked vehicles in the city center through an appropriately selected time fee. Vehicle drivers in large cities spend many hours a year in order to finding a convenient parking space. To assist the vehicle driver in finding a parking space, intelligent parking systems are used to inform vehicle drivers about the number of free spaces in a given area. Often times, this infrastructure should also be adapted to the electric vehicles which start to appear in cities [2,3]. The article presents an overview of selected research works dealing with parking issues, with particular emphasis on the issue of paid parking zones in cities. In this literature review, attention was paid to studies that were published both in Poland and abroad.

2. Research works conducted in Poland

2.1. Research conducted by A. Kostelecką

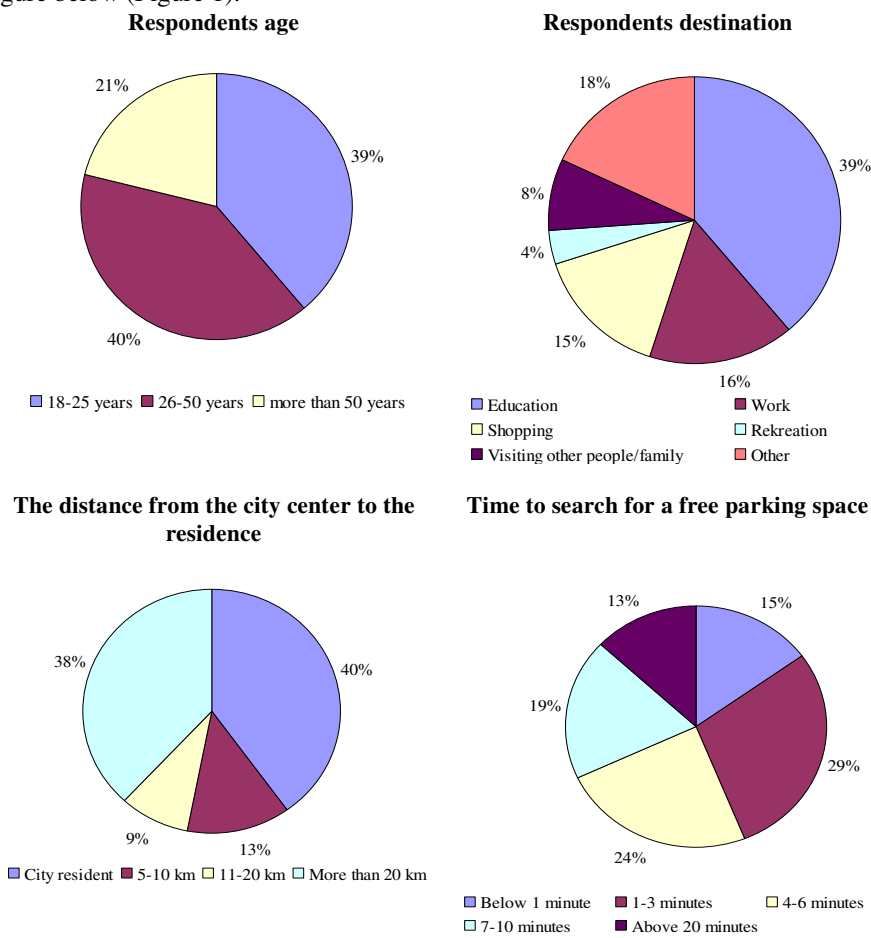
The research was conducted in order to determine the probability of abandoning the decision regarding parking in the paid parking zone depending on the impact of increasing the parking fee. The study covered five cities in Poland with a valid paid parking zone: Kraków, Warsaw, Poznań, Wrocław and Gdańsk. Additionally, the study covered the city of Rzeszów, which is on the eve of introducing paid parking zones. In the survey, 900 questionnaires were collected, 150 for each city survey [4]. The respondents were asked to answer questions such as age, education, the most common way to travel to the city center, whether it is possible to travel to the city center by public transport without changing, because of the choice of public transport to get to the city, the amount of the parking fee, which is would discourage them from parking in paid parking zones [4]. These studies showed that more than half of those surveyed use a private vehicle when traveling to the city centre. In this group, on average, half of the respondents use paid parking zones, while the other half park outside the paid parking zones. On average, 18% of the respondents use means of public transport. Further analysis of the results showed that over 70% of vehicle drivers commuting to the city by private cars have the possibility of getting to the same destination by means of public transport, without changing flights. The remaining 30% chose public transport due to problems with finding a parking space (61%), no need to pay for a parking space (45%), lower travel costs (46%), shorter travel times (31%) [4].

In this work, it was additionally checked whether the residents had knowledge of why paid parking zones were designed. Unfortunately, the vast majority of respondents believe that the zones are created only as a source of income for the city [4].

The last part of the discussed work were questions aimed at determining the acceptable amount of the parking fee. The results of the research showed that if the hourly fee was PLN 4, half of the people would resign from traveling by passenger car. The study also indicated that the inhabitants of Warsaw were the least sensitive to price increases, while the inhabitants of Poznań were the most sensitive.

2.2. Research conducted by P. Gorzelańczyk, T. Wiczorek

The aim of the research was to find out the opinion of the city residents on the functioning of parking lots in places where there are problems with finding a parking space. The study covered five cities with a valid paid parking zone, like Kraków, Warsaw, Poznań, Wrocław and Gdańsk. In addition, the study covered the city of Rzeszów, which is ahead of the introduction of paid packaging zones. The research used questionnaire surveys in which the respondents expressed their opinions. The questions included in the questionnaire concerned, inter alia, the purpose of the trip, the time needed to find a parking space [5]. Selected test results are presented in the figure below (Figure 1).



*Figure 1. Results of survey.
Source: Own research based on the data presented in [5]*

Research has shown that the vast majority of respondents travel for education and work reasons. People choosing the option "other" as the destination most often indicated health reasons, including visits to a specialist doctor or a doctor for tests.

Most of the respondents lived outside the city in question. Only 40% of the respondents lived in the analyzed city. About 40% of respondents find a parking space in less than 3 minutes, 24% in 4 minutes to 6 minutes, 19% in 7 minutes to 10 minutes, 13% needed more than 10 minutes to find a free space [5].

2.3. Research conducted by M. Mikę and E. Macioszek

The results of the survey conducted in the Gliwice city in Poland with a paid parking zone are presented in detail in the work. The results of these studies allowed for the conclusion that the main factors prompting the choice of a given parking space are the fee and the distance to the destination. In addition, more than half of the respondents indicated that they use their passenger cars several times a week, traveling from 5,000 up to 20 thousand km per year. Most respondents have at least two vehicles in their households and 5% of respondents have three or more vehicles. This is due to the need for comfort and independence for each person in the household to have their own car. During the hours of operation of the paid parking zones, most of the trips made resulted from the need to settle official matters, social meetings and work. The choice of a parking space was mainly determined by the proximity to the destination. Few were guided by the low fee or the lack of other free parking spaces in the area. Most of the respondents used paid parking zones less than once a week, so when asked about the form of payment for a parking space, the majority declared that they use parking meters for this purpose. Only half of the respondents used tools pointing to free parking spaces (48%). These people mainly used dynamic parking information boards (87%), other people used the possibilities included in the mobile application. 71% of respondents declared that they had not experienced any difficulties in finding a parking space. The respondents took up to two minutes to find a parking space on average. The respondents indicated angled parking spaces as the most convenient configuration (69%) for parking their vehicle. On the other hand, they indicated parking spaces located on the street (52%) and underground car parks (26%) as the type of car park, which, in their opinion, is the most convenient form of parking a vehicle.

3. Research works conducted abroad

3.1. Research conducted by K. Shaaban, A. Pandeb (Qatar)

The aim of the study was to determine the factors influencing the selection of a parking space. The research was carried out at two shopping centers in Qatar. A total of four car parks located at the aforementioned shopping centers were taken into account in the research. The car parks differed significantly, including distance to the destination, security, roof presence, pavement, and the amount of the fee. The difference could also be identified in the infrastructure of the intelligent parking system [6]. The first analyzed car parks were those located at the City Center Mall Doha shopping center. These were the car parks:

- P1 - it is a multilevel car park located in a shopping center, it is guarded, paid, hardened and roofed. It is equipped with intelligent parking systems that facilitate finding a free parking space,
- P2 - it is a parking lot at ground level, 350 m from the shopping center, which does not have an intelligent parking system, it is uncovered, unpaved and not guarded [6].

The second group of analyzed car parks located at the Souq Waqif shopping center were:

- P3 - three level underground car park 300 m from the shopping center, but it is connected to the center by an underground passage. It is paid, roofed and guarded. This car park is equipped with intelligent parking systems,
- P4 - ground level car park located next to the shopping center. It is also guarded with hard surface [6].

Survey forms were used as a research tool. The figures below present the results of the survey. Figure 2 shows the distribution of reasons why respondents selected paid parking at the Mall Doha center. On the other hand, Figure 3 shows the reasons for choosing a further located car park, near the shopping center of Souq Waqi.

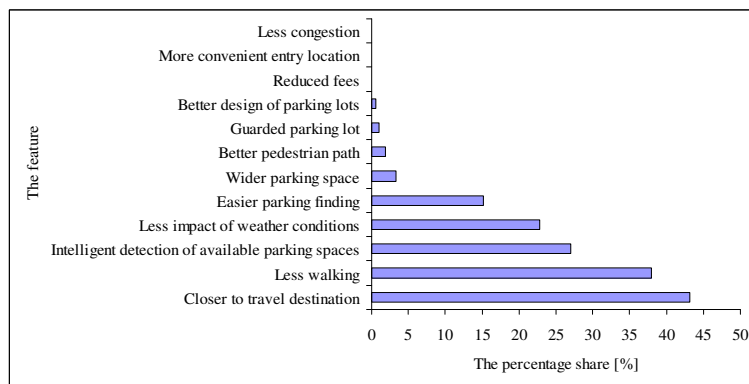


Figure 2. The distribution of factors determining the choice of a paid car park located at the Mall Doha shopping center.

Source: Own research based on the data presented in [6]

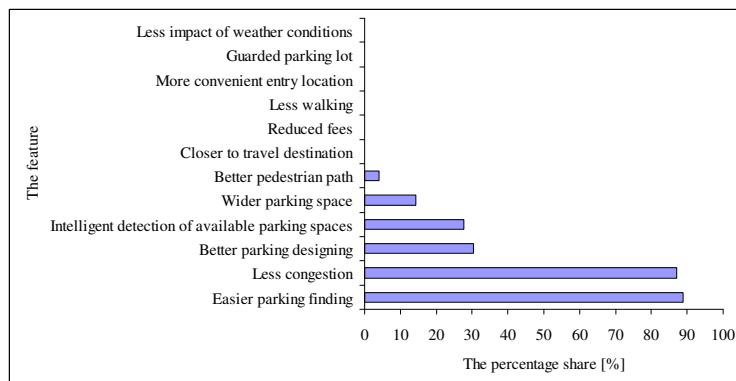


Figure 3. The distribution of factors determining the selection of a further car park located at the Souq Waqif shopping center.

Source: Own research based on the data presented in [6]

The responses of the respondents were collected in directly way. The questions included in the questionnaires concerned such questions like gender, age, nationality,

income, frequency of visits to the shopping center and duration of stay, and the reason for choosing a specific car park [6]. The research showed that the income of the respondents was an important factor when choosing a parking space. People with higher incomes were more likely to use paid parking lots. People with lower incomes were also inclined to use paid parking lots where the parking time was less than one hour. This result shows the need to implement short-term parking spaces that would encourage people with lower incomes to use paid parking spaces. Another interesting finding from the research is that vehicle drivers prefer parking lots with an intelligent parking space detection system than parking lots with wider parking spaces. This finding is interesting because the majority of vehicles in Qatar are SUVs, which are larger than the average passenger car [6].

3.2. Research conducted by N. Sari, I. Phan F. Radam (Indonesia)

The research consisted in identifying and analyzing the factors influencing the willingness of vehicle drivers to use parking lots within the commercial zone of the city of Banjarmasin in Indonesia. The research concerned only vehicles drivers of four-wheeled vehicles and two-wheeled motor vehicles. The research tool were questionnaires. The respondents were users of parking lots. The responses in the survey were constructed on the Likert scale from 1 to 5 (where 1 meant "Strongly disagree" and 5 "Strongly agree"). The car parks where the study took place were not equipped with a digital parking management system. A total of 240 questionnaires were collected, 150 of which concerned two-wheeled vehicles and the remaining 90 concerned four-wheeled vehicles [7]. The test results are presented in the table below (Table 1).

Table 1. The results of studies on the influence of individual factors on vehicle drivers according to N. Sari, I. Phan F. Radam (Indonesia)

No.	Factor	The impact of factors on drivers of two-wheeled vehicles	The impact of factors on drivers of four-wheeled vehicles	The impact of factors on aggregated data
1.	Parking fee	Insignificant	Insignificant	Insignificant
2.	Availability of the area	Significant	Significant	Significant
3.	Availability of the entry and exit	Significant	Significant	Significant
4.	Safety	Significant	Significant	Significant
5.	Cleanliness	Insignificant	Insignificant	Insignificant
6.	Parking signs	Insignificant	Insignificant	Insignificant
7.	Lighting	Insignificant	Znaczący	Znaczący
8.	The presence of policemen or officers	Significant	Significant	Significant
9.	The number of policemen or officers	Insignificant	Insignificant	Insignificant
10.	Shading of the parking lot	Insignificant	Significant	Significant

Source: Own research based on the data presented in [7].

When analyzing the impact of factors on drivers of two-wheeled vehicles, it was found that the following factors have a significant impact on decisions regarding parking places like availability of parking spaces, availability of car park entrances and exits, officers' or policeman's efficiency and safety. The safety factor was characterized by the most significant element [7]. The factors influencing the decision to select a parking space for a four-wheeled vehicle are almost identical to those for two-wheeled vehicles, with the exception of lighting and shading of the parking lot, which have been shown to have a significant impact on four-wheeled vehicles. Additionally, lighting is the factor with the greatest influence on parking decisions [7]. Summarizing the impacts of factors for both groups of vehicles, it can be concluded that the factors that encourage parking are the following availability of parking spaces, availability of car park entrances and exits, security, lighting, officers' efficiency and shading of the car park. Taking into account both groups of vehicles, lighting turned out to be the most important factor inducing drivers to park the vehicle [7].

3.3. Research conducted by A. Khaliq, P. Van Der Waerden, D. Janssens (Belgium)

The study were carried out in Belgium. The aim of this work was to understand and model the behaviors related to the selection of a parking space. Therefore, it is important to find and measure all the factors influencing individual decisions related to the choice of parking space. Understanding drivers' behavior has led to the development of an effective parking policy that can encourage people to use collective or bicycle transport [8]. These studies have shown that the choice of a parking space is a complex process and depends on many factors, including: availability of parking spaces, walking time to the destination, parking prices, distance to automatic payment machines, gender, age [8]. In order to determine the attributes, an online survey was carried out using a designed survey questionnaire on preferences in terms of parking on the street. The collected data was analyzed with the use of a multinomial logit model [8]. The results allowed for the conclusion that the lower the costs incurred in connection with parking, the greater the number of people parking on the street, outside the paid parking zone, where parking fees apply. The situation is similar in the case of the distance to the destination and the occupancy of parking spaces. Availability of security is the preferred attribute when parking on the street. The higher the value of this coefficient, the greater the number of people will be willing to park on the street [8].

3.4. Research conducted by X. Ma, X. Sun, Y. He, Y. Chen (China)

The research was conducted in China at six parking lots at the Lama Temple in Beijing. Survey questionnaires were used to conduct the research. Interviews with the respondents were conducted in the middle of the week from 8.00 a.m. to 20.00 p.m. In total, 218 interviews with vehicle drivers were conducted. The questions included in the questionnaires concerned such questions like the purpose of parking, the reason for choosing the car park, the travel time between the destination and the car park, and the issue of parking fees. The figure below (Figure 4) presents the results of the research regarding the purpose of parking, the assessment of the parking fee,

the travel time between the destination and the parking lot, and the reasons for choosing a parking space [9].

The car parks under study are intended exclusively for the Beijing Lama Temple, but the nearby shopping and entertainment areas attract tourists, so nearly half of the vehicle drivers parked there came for entertainment. The vast majority of respondents declared that the parking fee is too high. The above figure also shows that less than 90% of the respondents indicated the distance to the destination as the most important decision-making factor when parking. Which is directly related to the time to reach the destination, where about 70% of the respondents declared less than 5 minutes as the optimal time to reach the destination [9].

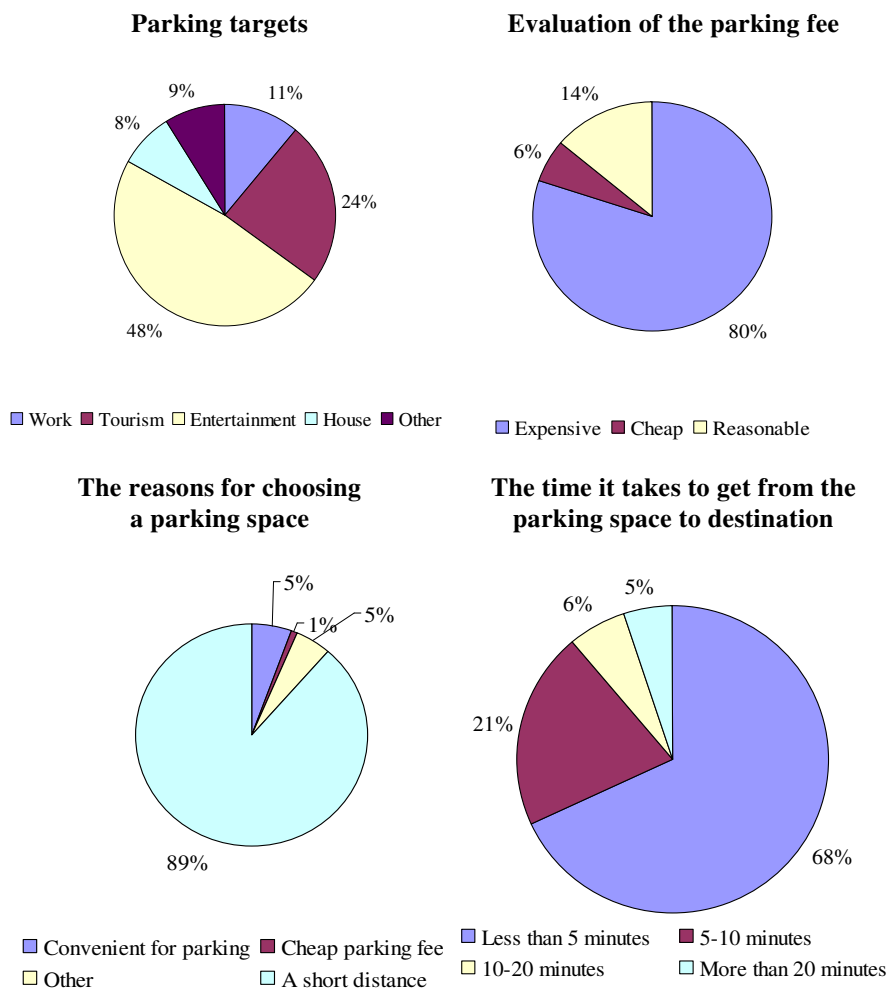


Figure 4. Distribution of survey results.

Source: Own research based on the data presented in [9]

3.5. Research conducted by X. Ye, C. Yang, T. Wang, X. Yan, S. Li, J. Chen (China)

The research involved examining the influence of factors determining parking decisions as well as the relationship between related parking decisions. The data was obtained in sixteen districts of Beijing through a survey. Off-street and on-street parking lots were analyzed. The questions included in the questionnaire concerned such questions like the number of passengers, parking time, payment method, time of departure from the parking lot. 6,947 people participated in the study [10].

The results of the research allowed to state that the decisive factor in the matter of parking are parking fees. In addition, research has revealed that people using street parking lots park for both short and long periods of time. This phenomenon is caused by illegally parked vehicles. This causes uneven vehicle distribution, which results in traffic jams. It follows that drivers prefer to park in illegal free car parks that are closer to their destination than in off-street paid car parks a little further away. The authors of the study proposed two solutions to the above problem. The first solution was to increase the toll on parking lots located on the street, so that the hourly rate on the street was higher than outside the street. The second solution was to lead drivers to off-street car parks using road signs, which was to result in balancing the occupancy of parking spaces on the street [10]. Studies have also shown that the likelihood of a vehicle driver selecting a parking space on the street increases with the increase in the number of people in the vehicle [10].

4. Summary

The creation of paid parking zones in cities is aimed, inter alia, at reducing the number of journeys to the city center by passenger cars, which results in limiting traffic, and thus increasing the accessibility of the city center, as well as reducing exhaust emissions and improving air quality. Based on the review of the research works presented in the paper, the following conclusions can be drawn:

- currently, paid parking zones are in force in most cities, and after their introduction, positive changes were generally observed in the number of cars parked in the city center and a reduction in the average parking time,
- despite the reduction in the number of cars parked in the city center and a reduction in the average parking time, car traffic in the centers of most cities is still too high, and the reasons for this state of affairs are seen, among others, in the amount of parking fees, which are so low that they do not discourage people from arriving in the city center by car and using paid parking,
- parking fees are the decisive factor in the matter of parking,
- drivers prefer to park in illegal, free parking lots closer to their destination than in off-street paid parking lots further away. Research has also shown that the likelihood of a vehicle driver selecting a parking space on the street increases as the number of people in the vehicle increases,
- the distance to the destination is an important decision-making factor when parking,
- when analyzing the impact of factors on drivers of two-wheeled vehicles, it was found that the following factors have a significant impact on decisions regarding parking places like availability of parking spaces, availability of car park entrances

and exits, officers' or policeman's efficiency and safety. The safety factor was characterized as the most significant element.

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