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## Clustering Megacity Districts upon Customer Satisfaction on Parking Services

ROMAN R. SIDORCHUK<sup>1</sup>, IRINA I. SKOROBOGATYKH<sup>2</sup>, SERGEY V. MKHITARYAN<sup>3</sup>, TATIANA A. VORONOVA<sup>4</sup> and NATALIA I. IVASHKOVA<sup>5</sup>

<sup>1</sup> Professor, Department of Marketing of Plekhanov Russian University of Economics, Moscow, Russia,  
Email: professor\_sidorchuk@mail.ru

<sup>2</sup> Professor, head of the Department of Marketing of Plekhanov Russian University of Economics, Moscow, Russia.

<sup>3</sup> Professor of the Department of Marketing of Plekhanov Russian University of Economics

<sup>4</sup> Professor of the Department of International business and customs of Plekhanov Russian University of Economics, Moscow, Russia.

<sup>5</sup> Associate Professor, Department of Marketing of Plekhanov Russian University of Economics, Moscow, Russia.

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### ARTICLE INFO

Received September 29, 2019  
Revised from October 28, 2019  
Accepted November 20, 2019  
Available online March 15, 2020

**JEL classification:** C38, J28, L62, L91, O18

**DOI:** 10.14254/1800-5845/2020.16-1.5

**Keywords:**

Parking spaces,  
Moscow,  
satisfaction,  
clustering,  
Ward Method,  
Euclidian Distance

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### ABSTRACT

*Purpose.* The problems of limited public parking spaces as well as the growing number of individual cars in mega-cities are very important, because of the growing number of individual and public cars, and limited open spaces in road infrastructure. *Methodology.* The online survey, conducted by marketing specialists of Plekhanov Russian University of Economics had been identified, whether the citizens of Moscow are satisfied with the organization of parking spaces. *Approach.* 1263 questionnaires were collected to analyze and rank the administrative districts of Moscow City in the framework of a cluster analysis with the use of Ward Method and Euclidean length. *Findings.* As a result, five clusters of administrative districts of the City were developed in accordance with customer (car owners) satisfaction with number, and quality of parking spaces in different districts, where respondents are living and where they are working. The recommendations of this study can be addressed to the Moscow City government to improve parking management and may be used in further studies of City citizens' satisfaction with other parameters of living conditions.

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### INTRODUCTION

Marketing science uses various approaches to the study of customer satisfaction for analysis and decision-making concerning goods and services. Transport is not an exception (Musatova et al., 2016; Sidorchuk et al., 2015). Current research declares that a huge influx of people into cities leads to the construction of new roads and parking areas for a growing number of public, commercial, and private cars (Fickling and He, 2018). A number of studies have shown that a rise in the number of parking spaces leads to an increase in the number of cars and a further increase in roads and parking areas, turning cities into huge parking lots surrounded by roads. The phenome-

non is known as the Lewis-Mogridge position (Szymalski, 2016). Since people are rational creatures, they get off public transportation and get into cars as new roads and parking spaces appear. As a result, an increase in the availability of car spaces and limited city areas contributes to the irrational use of the public areas. On the other hand, as shown in the literature, one of marketing's objectives is to develop models for the marketing management of customers' behavior (Shchepakina et al., 2018), considering their rational and irrational features. The "parking policy" factor mainly depends on the density of parking spaces, parking tariffs, and the availability of free parking at the place of work and the main parking at the place of residence of the driver. The combination of these elements influences citizens' transport behavior, making it possible to use various marketing solution models.

There is a gap in the literature devoted to the study of the clusterization of the megacity districts in the context of the drivers' satisfaction with parking space. Therefore, this issue requires a particular study. The purpose of the research is to analyze the car owners' satisfaction degree with the parking conditions and on this basis to carry out clustering the districts of Moscow megacity.

Methodology of the research is based on the classical marketing research approach (Malhotra & Birks, 2007). In addition, it includes online survey, comparative analysis of data and use of descriptive statistics for data analysis.

A sample of respondents is obtained by random, quotable sampling from the Market Research Agency OMI online panel (Online Market Intelligence). The survey is developed according to the principles of the Internet survey, introduced by the European Society for Opinion and Marketing Research (ESOMAR). The respondents should meet the following requirements: residence in Moscow, driving and parking in the city. Age restrictions correspond to the requirements for car drivers in Russia (18+). Gender and social representation were not considered in this study. The study was conducted using an online survey. Survey Monkey was used as a survey tool. Results were processed using IBM SPSS Statistics 20.

The survey results contributed the classification of 10 administrative districts of Moscow into five clusters in accordance with the received dendrogram, based on the results of cluster analysis. In addition, the survey results allowed ranking the city districts in accordance with the drivers' satisfaction with parking space and parking service quality. Cluster analysis was used with the help of Ward method and Euclidean length. The novelty of the study is determined by the use of the drivers' satisfaction with the parking space as a criterion for the city districts clusterization and the ranking of parking spaces provision.

Results of the study highlight the importance of the correlation of the degree of satisfaction with parking time and the rank of parking provision for the tariffs differentiation in different administrative districts of Moscow City and depending on the rank of parking provision and parking quality.

## 1. LITERATURE REVIEW

The problem of parking spaces for private vehicles in big cities is very important nowadays. During the recent decades, parking problems are of great importance in urban planning, mainly because the number of cars and their use have been growing, and urban space has been reducing (Mingardo, van Wee, and Rye, 2015).

Since 2007, when the urban population exceeded the rural population, another 700 million people have moved to the cities. By 2030, the population of the 25 largest and fastest growing urban agglomerations will increase by 113 million people, and about  $\frac{3}{4}$  of this growth will be in 10 megacities in developing countries: Delhi, Dhaka, Kinshasa, Shanghai, Lagos, Cairo, Chongqing, Karachi, Beijing and Mumbai. In terms of population density, Moscow City (Capital of Russian Federation) is similar to Tokyo, New York, Los Angeles (Fickling and He, 2018). The literature suggests,

“Emerging atmospheric science and epidemiological research indicates hazardous vehicle-related pollutants” (Houston, Wu, Ong and Winer, 2004). In addition, levels of rising noise from motor vehicles (Cohn and Koushki, 1991).

In this context, Moscow is not an exception but a center of agglomeration, which constitutes a complex multicomponent dynamic system with intensive production, transport and cultural links. According to the report “Moscow transport system development” presented by the Department for Transport and Road Infrastructure Development of the Moscow City Government (DTRID), Moscow caught up with the largest Asian and European megacities in terms of the number of cars per 1000 inhabitants (Moscow Transport System Development, 2017). At the same time, there is almost double excess of the most intensive passenger traffic and one of the smallest road networks. In this regard, the problem of the lack of parking spaces is important not only in the city center, but also in residential areas. As the surveys of citizens show, there has been increasing concern about the quality of the parking spaces (The citizens of Moscow about the problems of the city, 2019). When ranking urban problems, the respondents identified “Parking lots, fines” and “Traffic jams, congestion”. The results require further applicative management decisions. The study on Service quality variation across urban space showed that “There is currently a strong focus on alternative service delivery models and improved government service in the urban and public administration fields” (Kelly and Swindell, 2002). In some countries, city governments now implement the movement to use maximum parking standards. Some research shows that the decision of town authorities is to motivate realization of “...maximum parking standards is to decrease the number of trips made by private cars” (Al-Fouzan, 2012).

Any decisions made in this context can cause significant economic effect and risks. In modern conditions, the technological, economic, social and managerial decisions in the sphere of the urban management and parking spaces organization should implement the strategic approach. As researchers have pointed, “parking policy having significant urban consequences” (Barter, 2012). It is based on the analysis, accounting and management of consumer behavior in the sphere of parking spaces provision and in our mind it can help to understand the overall satisfaction of parking spaces, its quality and living conditions in the City as a whole.

Therefore, there is a necessity of marketing research of the citizens’ perception and satisfaction with the work of the transport system as a whole, as well as the analysis of the satisfaction with the existing parking space for individual cars.

As noted in the literature, “User satisfaction is considered one of the main factors of user loyalty contributing to fine reputation. When it comes to parking, user satisfaction contributes to increasing confidence in decisions made by parking management authorities, which is of cardinal importance to gain measure acceptance among users” (Milosavljevic and Simicevic, 2019). Managing customer satisfaction is a key marketing challenge.

The validity of the marketing approach, used in transport complex management, is presented in the literature (Seifullaeva, Skorobogatykh, Sidorchuk et al., 2018; Zavyalova, Sidorchuk et al., 2016; Musatov, Sidorchuk et al. 2016; Sidorchuk et al., 2015). Thus, in the urban environment, in order to reduce the “search” traffic and to ensure punctuality of the drivers’ trips, the parking places are necessary. Their accessibility is inseparable from the effective parking capacity and the quality of other parking services (Munawar and Prasetyo, 2000).

We should accept the idea of Rye, T., and Ison, S. that “... parking policy will continue to increase in importance for the foreseeable future” (Rye and Ison, 2005). Rye and Ison (2005) declare that “... this is, on the whole, an under-researched area of transport, not the least when compared to an area such as road user charging”. Researchers have noted: “There is little knowledge of how much parking infrastructure exists in cities”. (Hoehne, Chester, Fraser, and King, 2019).

According to Marsden, G. (2006), who notes, based on parking policy review “... *greater attention should be paid to the segmentation of the parking market*”. And further: “*We do not under-*

*stand nearly enough about how individuals respond to parking policy ...*". Therefore, because of the great interest for the marketing management of parking spaces in big cities, and because of the lack of this kind of study, it is necessary to conduct research in this direction.

Existing literature on parking, both scientific and practical, is very diverse and is divided in accordance with the particular aspects of parking or specific empirical data. If we narrow the scope of the study to the satisfaction with parking, we can note that these issues are also considered in a different context.

According to the surveys of Parasuraman A., Zeithaml V.A. and Berry L.L. (1988), the quality of service, from the users' point of view, can be analyzed with a set of customer satisfaction indicators, which typically include five aspects of service quality. It can be implemented indifferent service sectors, but satisfaction with parking spaces (number and quality) needs some adaptations.

Modern literature introduces various approaches to the studying of the satisfaction with parking space. Thus, Xue Y., Fan, H., Guan, H. (2019) when analyzing the parking, focus on the time of departure and the lack of the parking places. This research show that the drivers' satisfaction with the trip from the suburbs, as well as the time of departure, depends on the parking place status after the arrival to the destination (whether there are spare parking places or not). The satisfaction level decreases with a decrease of the remaining parking spaces number.

The literature provides detailed approaches to the study of user requirements for the quality of service at parking lots. (Milosavljevic and Simicevic, 2019). However, drivers aim of this kind of research is studying specific parking lots and not the general perception of parking in the city.

For example, researchers as Suksanguan, (2018) and Gumasing and Atienza, (2018) analyze the satisfaction with the parking places near the shopping malls and airport. On the one hand, the analysis of people of different wealth and age showed differences in satisfaction with public parking spaces. On the other hand, the regression analysis defined significant factors that influence the satisfaction with parking services, namely, the time spent on a parking space search and spare parking place indication.

There are studies that analyze the drivers' satisfaction with the quality of urban street services, including parking (Jena, Chakraborty and Bhuyan, 2018). The researchers point out that "the turnover of the parking place" influences drivers' comfort and satisfaction.

In turn, a study in Cambridge showed that "*the recognition that car park users are willing to pay for quality enhancements and that prices can be altered to reflect differing levels of demand.*" (Bain, 2002).

In addition to the surveys of the parking at the shopping malls, airports and public urban spaces, the literature contains studies of restricted areas, namely, university campuses (Budiani, et al, 2018). In this research, the descriptive statistics was used to process the results of the survey of drivers' satisfaction level.

Some researchers (Cruz, Cruz, and Ceretta, 2017) used Customer Satisfaction Index (CSI) to identify the level of satisfaction with the paid parking areas. The users of a paid system were selected not randomly and surveyed. Therefore, we accept the results as the satisfaction with the service of parking places, including its mobile application, which is operating in Moscow City.

In their study, Szarata, Nosal, Duda-Wiertel, and Franek (2017) examined the practical use of satisfaction surveys in the context of the parking system in the city of Krakow (Poland). Its research results can be adopted to make decisions on parking restrictions, as this is one of the most controversial aspects of urban transport policy. A similar study was conducted in Guangzhou City (People Republic of China) by Guan, Su, and Li (2017), as a part of which the authors analyzed the effectiveness of public parking service in terms of occupancy rate, total area, and driver satisfaction. Results of this research demonstrate the necessity to adjust the parking payments and optimize the spatial placement of parking spaces to meet the needs of both pedestrians and drivers.

Golias, Yannis and Harvatis (2002) considered model, which is based on data referring to a typical part of the central business district of a rather large city. Researchers have shown that besides for the parking price, all other factor variables with an impact on driver parking choice are time related: time for finding a parking space, duration of parking and walking time from the parking space to the final destination.

A similar study of parking in central Sydney (Australia) is presented by Hensher and King (2001). The work also shows a high dependence of the choice of parking on the cost of parking and the possibility of reducing the employment of parking spaces in the business part of the city through managing the cost of parking.

It should be noted that the works does not analyze the parking behavior and satisfaction of drivers at their place of residence.

Shoup (2006) presents a model of how drivers choose either to cruise or to pay for parking. The author explains that: "A model cannot predict how everyone will behave, but it does suggest how to behave if you want to be rational in your cruising". People's behavior is not always rational. Therefore, research is needed to take this factor into account for our study.

As evident from the literature review presented above, further research into driver satisfaction with opportunity to easily and quickly find parking place at the districts, where inhabitants live or work, and role of the satisfaction level in urban district ranking and clustering is needed, as one of the factor of living conditions.

Cluster analysis is normally used in order to classify data into groups (clusters) with similar characteristics (Fraley and Raftery, 1998). Maximizing the similarity of elements within a cluster and the differences between clusters allows using cluster analysis to segment consumers. There are works in the literature showing the use of clustering to analyze customer satisfaction (Westbrook and Oliver, 1991; Liljander and Strandvik, 1997). In transport studies de Oña, J., de Oña, R., & López (2016) used cluster analysis based on key factors influencing service quality assessment. In cluster analysis, Euclidean distance is used for parking spaces to calculate the similarities between objects in each cluster. Objects are grouped using the Ward's Method (Tong, Wong and Leung, 2004).

Therefore, the aim of the present study was to explore the possibility of ranking and clustering the administrative districts of megacities based on drivers' satisfaction with parking spaces.

## 2. RESEARCH SAMPLE AND METHODS

**Participants and data collection.** The present work introduces part of a large-scale research project, carried out by the professors, specialists, and students of Plekhanov Russian University of Economics in the framework of the parking space analysis during the period from December 26, 2018 until June 30, 2019. Methodology of research was based on classical marketing research approach (Malhotra & Birks, 2007) and Internet survey principles, introduced by the European Society for Opinion and Marketing Research (ESOMAR) (ICC/ESOMAR International Code, 2016) and principles of online automobile driver's survey (Shashkin and Pozdnjakova, 2006). The survey data were saved and exported to the SPSS for a detailed analysis with the use of descriptive statistics. The sample of online survey was selected from the consumer panel of 72,193 Moscow citizens, including drivers, developed by Market research Agency OMI (Online Market Intelligence). The quality of the respondent selection is justified by the ISO certification and ESOMAR membership of this Agency. Survey Monkey was used as a survey tool that allowed to create a standard web-based questionnaire and to export the gathered data to Excel and/or SPSS

**Survey questionnaire.** The questionnaire utilized in the survey contained 36 questions, 16 of which were designed for identifying the value orientation of car owners and others consists of the

satisfaction with different parameters of parking individual cars on the districts of residents and work of respondents. The study inclusion criteria were: (1) Moscow resident, (2) aged 18 years or older, (3) car driver and (4) user of parking spaces in the city. When analyzing the survey responses, the focus was given to gender, car use frequency, make and type of car, residence and workplace location, and time spent searching for a parking space in the area of residence, work, and leisure (discrete timeline was used). In addition, the researchers analyzed drivers' satisfaction level with the parking tariffs and parking conditions in general (cleanliness, marking, and lighting). The survey was conducted from April 5 until April 18 2019.

**Clusterization of the administrative districts of the city according to the parking spaces provision and satisfaction with the parking services.** The level of the parking spaces provision has a direct impact on the level of satisfaction with parking (individual perception of the service quality) and reverse impact on the time of the parking space search. The authors used this theory and the survey results to cauterize Moscow districts in accordance with the following aspects:

- The level of satisfaction with the parking tariffs in the area of residence;
- The level of satisfaction with the parking tariffs in the area of work;
- The level of satisfaction with the parking services in the area of residence;
- The level of satisfaction with the parking services in the area of work;
- The proportion of the drivers that spend less than five minutes on the parking search in the area of residence;
- The proportion of the drivers that spend more than ten minutes on the parking search in the area of residence;
- The proportion of the drivers that spend less than five minutes on the parking search in the area of work;
- The proportion of the drivers that spend more than ten minutes on the parking search in the area of work.

Variables were previously standardized to ensure their commensurability using the Z-transform. Cluster analysis is a combination of basic statistical methods of multidimensional classification based on natural intervals. Cluster analysis, in contrast to discriminant analysis and decision trees (classification), refers to classification methods without response, i.e. it does not use a dependent variable. In this case, clustering solves the problem of identifying groups of Moscow administrative districts with similar satisfaction rates for parking services and identifying these groups. Cluster analysis includes the following steps:

- Separation - the separation of objects of observation by cluster, to determine the number of clusters, in a hierarchical cluster analysis, a dendrogram is used for this;
- Determination of the number of observations in a cluster using frequency tables;
- Verification of the results of cluster analysis using a graph of the average values of variables across clusters, which allows us to characterize each cluster and give it a meaningful interpretation.
- Cluster analysis according to Ward method and Euclidean length was implemented (Jarrell, 1994).

**Ranking of the administrative districts of the city according to perceived provision of parking places.** Ranking of the administrative districts of the Moscow City according to perceived provision of parking places was based on the results of the survey. Provisionally, average values for each district were obtained using the survey data and summary tables. (Ajvazjan and Mhitarjan, 1998). In present research, authors used the following indicators for the ranking:

- The proportion of the drivers, that searched for the parking place for less than five minutes in the area of residence;

- The proportion of the drivers, that searched for the parking place for more than ten minutes in the area of residence;
- The proportion of the drivers, that searched for the parking place for less than five minutes in the area of work;
- The proportion of the drivers, which searched for the parking place for more than ten minutes in the area of work.

The researchers analyzed five-time intervals for parking place search:

- Less than 5 minutes;
- From 5 to 10 minutes;
- From 11 to 15 minutes;
- From 16 to minutes;
- More than 26 minutes.

However, in this paper, only two intervals were introduced:

- Less than 5 minutes;
- More than 10 minutes.

The selection of the intervals is based on the following statements:

- Correlation between the drivers, that spent less than 5 minutes and 5-10 minutes on the parking space search in the area of residence ( $r=0,92$ );
- Small proportion of the drivers that spent more than 16 minutes on the parking space search (7.1%).

Auxiliary indicators for the ranking were:

- The level of satisfaction with parking tariffs in the area of residence;
- The level of satisfaction with parking tariffs in the area of work;
- General level of satisfaction with parking in the area of residence;
- General level of satisfaction with parking in the area of work.

The administrative districts ranking algorithm includes the following steps:

- Calculation of the average share of drivers, who spend less than five minutes and more than ten minutes on the parking space search in the area of residence and work in each district.
- Ranking the districts according to the average time for the parking space search, that comprises five minutes and more than ten minutes.
- Calculation of a single rank for the parking space provision based on the ranks.
- Analysis of the connection obtained because of the districts ranking and additional parameters of the level of satisfaction with parking.

### 3. RESULTS

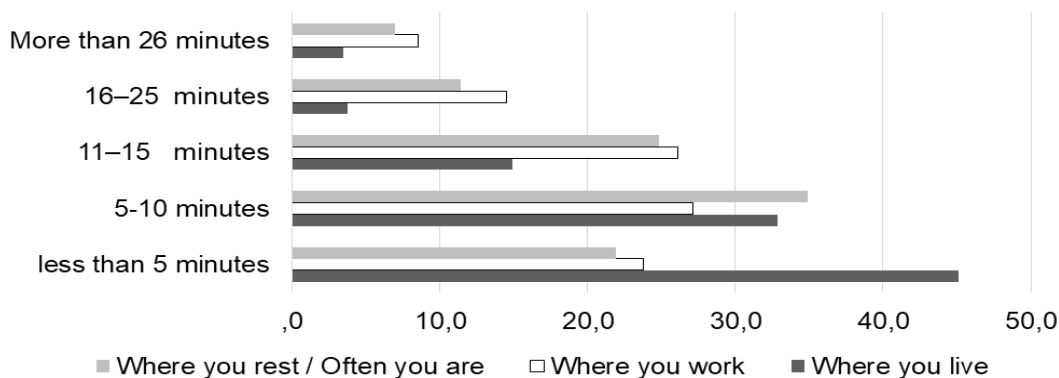
**Demographics.** Because of the online survey, 1,263 questionnaires were received. Sample included 48% of men and 52% of women, citizens of Moscow City, who drive individual cars quite often, and because of that need to find parking places in the areas of the residence and work. Most respondents (82.7%) are aged from 23 to 52. Further study dealt with the questionnaire of 1,203 respondents who answered positively to the question "Do you drive and use the parking space?"

**Frequency distribution.** One of the aspects of the research was the distribution of the respondents. Table 1 shows the respondents' distribution according to the areas of residence and of the work in Moscow City.

**Table 1.** Distribution of respondents according to the areas of residence and of the work

<i>Districts of the Moscow city</i>	<i>Valid Percent district of work of the respondent</i>	<i>Valid Percent district of home county of the respondent</i>
CAO	29.0	14.0
SEAO	12.0	13.0
SAO	10.2	12.1
NEAO	10.0	11.6
SWAO	9.0	11.3
EAO	8.4	9.5
WAO	7.7	9.5
NWAO	7.6	9.4
NAO	5.0	8.6
ZelAO	1.1	1.0

Distribution of the respondents in the areas of residence is more homogeneous than in the areas of work. Almost 29% of the respondents work in CAO that is 2.4 times more than in NEAO. The proportion of the respondents in accordance with the time spent on the parking space search is analyzed in the areas of residence, work, leisure or frequent presence (Figure 1).



**Figure 1.** Distribution of the respondents in accordance with the time spent on the parking space search

The search of the parking space in the area of residence takes less than 5 minutes for 45% of the respondents, while the number of such respondents in the areas of work and leisure is 24% and 22% respectively. The search of the parking space in the area of residence takes less than 10 minutes for 78% of the respondents, while the number of such respondents in the areas of work and leisure is 21% and 57% respectively.

Distribution of the respondents in the areas of residence and work in accordance with usual parking place is presented in Table 2.

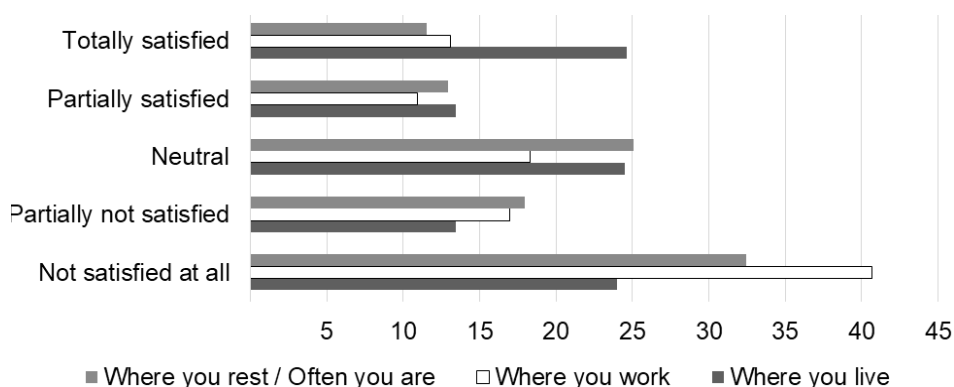


**Table 2.** Distribution of the respondents in accordance with usual parking place

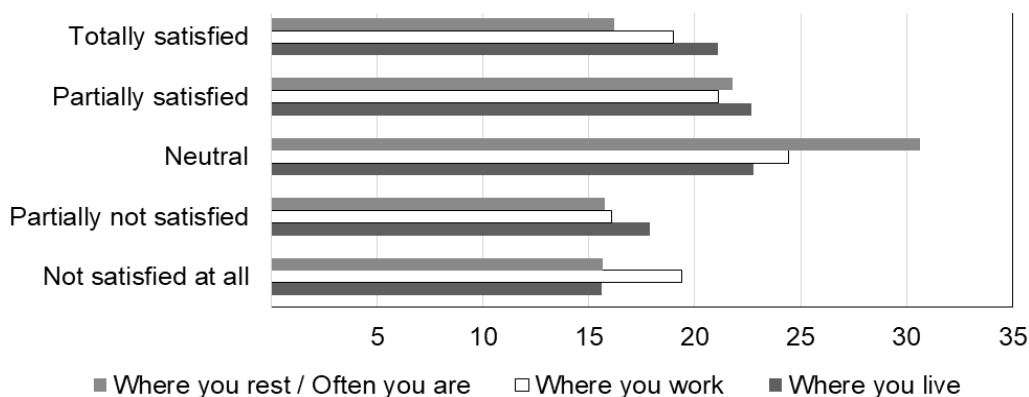
Parking Place	Where you live	Where you work
In the yard	72	41
On the roadway	10	30
In the garage	6	2
In the multilevel car park	5	9
In the underground parking in the house	5	5
In the intercepting parking lot	2	13

The most common parking option is in the yard and on the roadway. At the place of residence, the share of respondents parking in the yard is 7 times more than on the roadway, while at the place of work such excess is only 1.4 times. The proportion of the respondents parking in the intercepting parking lots in the area of residence is 2%, and in the area of work, this proportion comprises 13%. This is connected with the focusing of the sample on Moscow residents.

Figures 2 and 3 show the distribution of the respondents in accordance with the satisfaction with the parking tariffs and parking conditions in general (cleanliness, marking, lighting) in the areas of residence, work, leisure or frequent presence.



**Figure 2.** Distribution of the respondents in accordance with the satisfaction with the parking tariffs



**Figure 3.** Distribution of the respondents in accordance with the satisfaction with the parking conditions in general (cleanliness, marking, and lighting)

The greatest dissatisfaction is caused by parking tariffs at the place of work (58% of the respondents) and at the place of leisure or frequent presence (50% of the respondents). In the areas of residence, the proportion of the unsatisfied customers comprises 37%. More respondents are satisfied with the parking conditions than unsatisfied. In the areas of residence, 44% of the respondents are satisfied with the parking, and the proportion of the unsatisfied respondents is 34%. In the areas of work, 40% of the respondents are satisfied with the parking, and the proportion of the unsatisfied respondents is 36%. In the areas of leisure or frequent presence, 38% of the respondents are satisfied with the parking, and the proportion of the unsatisfied respondents is 31%. Thus, the authors come to conclusion that the level of satisfaction with parking is higher in the areas of residence than in the areas of work, leisure or frequent presence.

**Clusterization and ranking of the administrative districts of the Moscow according to the perceived provision and car driver's satisfaction of parking places.** Table 3 shows the values that were obtained because of the algorithm ranking of the administrative districts of the city. Highest average proportion of the drivers that spend less than five minutes on the parking space search is in SEAO (38%); the lowest one is in ZelaO (27%). Since this indicator has a direct impact on the parking space provision, the SEAO is assigned the first rank, ZelaO - the tenth. Highest average proportion of the drivers that spend more than ten minutes on the parking space search is in CAO (40%); the lowest one is in SEAO (29%). Since this indicator has a reverse impact on the parking space provision, the SEAO is assigned the first rank, CAO - the tenth. The rank of parking provision in the district is based on the product of the values of 2 received ranks. South-Eastern Administrative Okrug is on the first place, Central Administrative Okrug is the tenth place. Table 2 shows the rank of the districts according to parking space provision.

**Table 3.** Rank of the districts according to parking space provision

District	Average proportion of the drivers that spent less than five minutes on the parking space search, %	Average proportion of the drivers that spent more than ten minutes on the parking space search, %	Rank (proportion of drivers that spent less than five minutes on the parking space search)	Rank (proportion of drivers that spent more than ten minutes on the parking space search)	The product of the ranks (4)*(5)	Rank (according to the parking space provision)
SEAO	38	29	1	1	1	1
CAO	35	33	5	3	15	2
SWAO	37	38	2	9	18	3
ZelaO	27	32	10	2	20	4
NWAO	36	37	3	7	21	5
SAO	36	35	4	6	24	6
NEAO	34	35	6	5	30	7
EAO	29	34	9	4	36	8
WAO	32	37	7	7	49	9
CAO	31	40	8	10	80	10

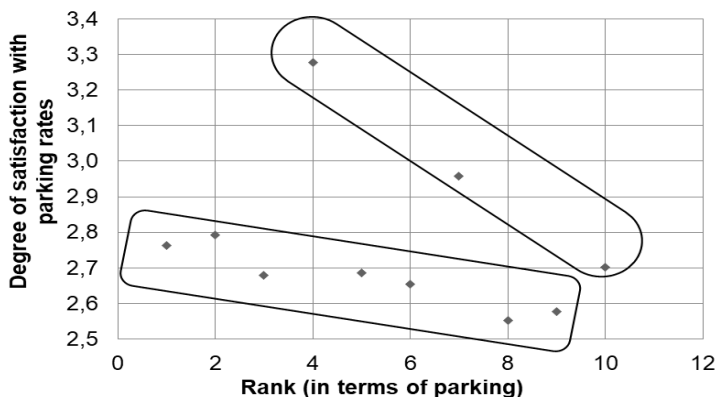
The authors used the results from Table 3 in scattering diagram (figures 4 and 5).

Horizontal axis on Figure 6 presents the rank of parking provision. The vertical axis presents the average degree of satisfaction with tariffs. The districts were ranked according to 5-point Likert scale, where 1 means totally unsatisfied, 5 means totally satisfied. We point out, that most districts have low level of satisfaction with parking that comprises from 2.5 to 2.8 scores. The exceptions are NEAO, taking three scores, and ZelaO, taking 3.3 scores. We point out that there are two diagram sections.

The first section includes SEAO, CAO, SWAO, NEAO, SAO, EAO, and WAO. They are character-

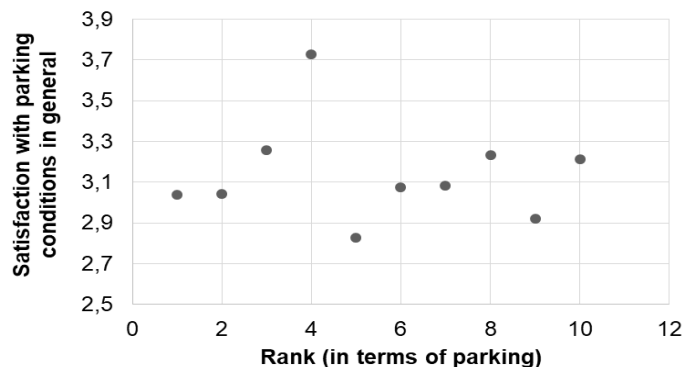
ized with the low level of satisfaction with tariffs and weak correlation between the level of satisfaction and the parking provision rank.

The second section includes ZelAO, NEAO and CAO, and is characterized with strong correlation between the level of satisfaction with tariffs and the parking provision rank.



**Figure 4.** Scattering diagram of Moscow districts: The level of satisfaction with the parking tariffs and parking spaces provision

Horizontal axis on Figure 5 presents the rank of parking provision. The vertical axis presents the average degree of satisfaction with parking in general. The districts were ranked according to 5-point scale, where 1 means totally unsatisfied, 5 means totally satisfied. We point out, that most districts have medium level of satisfaction with parking that comprises from 2.8 to 3.3 scores. The exception is ZelAO, taking 3.7 scores. We come to the conclusion that parking provision rank does not influence the satisfaction level in general. The authors assume that there are other significant factors, except parking tariffs and occupancy.



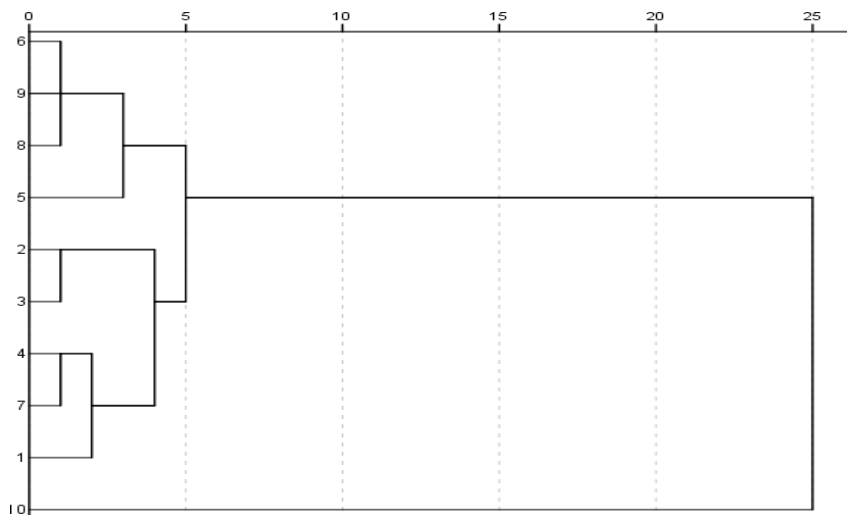
**Figure 5.** Scattering diagram of Moscow districts: The level of satisfaction with the parking in general and parking provision rank

The dendrogram of the cluster analysis is introduced in Figure 6. Dendrogram shows that Zelenograd administrative district of the Moscow City differs much from other districts. We assume that it should be analyzed as an abnormal phenomenon in the terms of a separate cluster. In addition, we should conduct cluster retest (Figure 7).

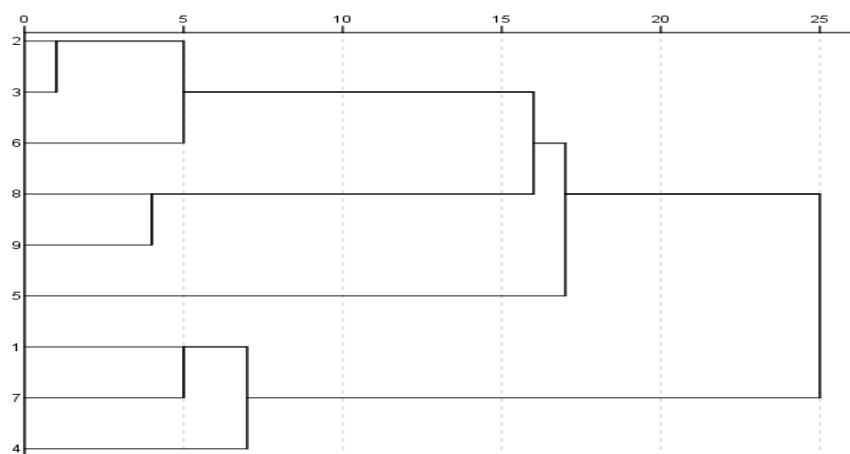
As a result of the clusterization, five clusters were identified (including Zelenograd):

- The 1<sup>st</sup> cluster includes CAO, SWAO and, EAO;

- The 2<sup>nd</sup> cluster includes NAO and NEAO;
- The 3<sup>rd</sup> cluster includes SEAO;
- The 4<sup>th</sup> cluster includes WAO, NWAO and SAO;
- The 5<sup>th</sup> cluster includes ZelAO.



**Figure 6.** Dendrogram of the cluster analysis of 10 administrative districts of Moscow (Ward method)

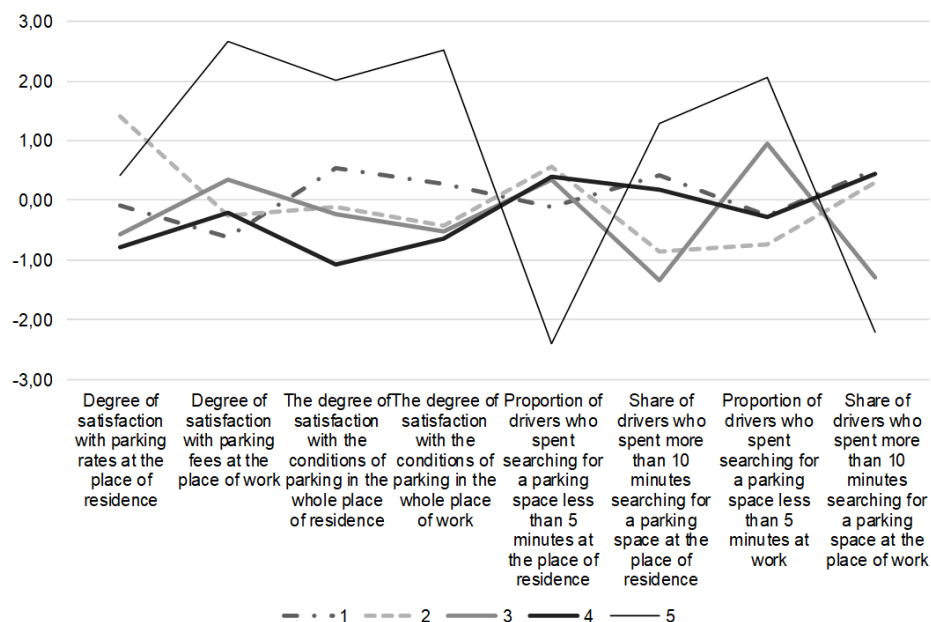


**Figure 7.** Dendrogram of the results of cluster analysis of 9 administrative districts of Moscow (Ward method)

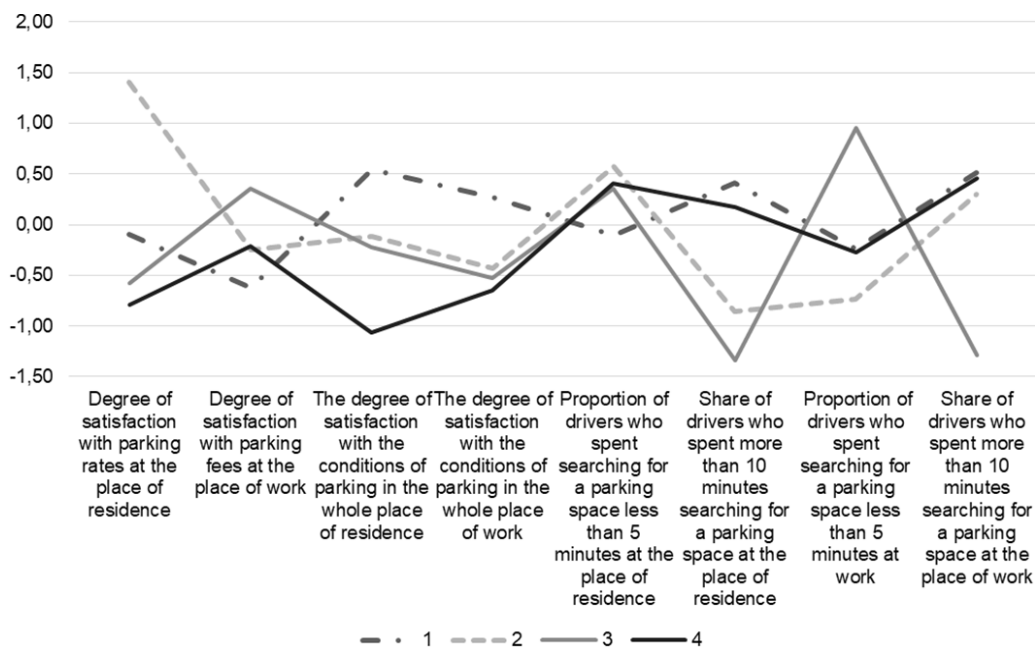
To determine the clusters profile and their ranking, we made a diagram of the average values of the standard indicators according to clusters (Figure 8 and 9). The analysis of the cluster profiles (diagram of the average values) contributes to the following conclusions:

- The 1<sup>st</sup> cluster (CAO, SWAO and EAO) has the lowest level of satisfaction with the parking in the area of work. More than 50% of the drivers spend more than ten minutes on parking space search;
- The 2<sup>nd</sup> cluster (CAO and NEAO) has the highest level of satisfaction with tariffs in the area of residence; the largest share of the drivers that spend less than 5 minutes on the parking search in the area of residence;
- The 3<sup>rd</sup> cluster (SEAO) has the smallest share of the drivers, that spend more than 10 minutes

- on the parking space search in the area of residence;
- The 4<sup>th</sup> cluster has the lowest level of the satisfaction with the parking tariffs in the area of residence, as well as the parking services in the area of work and residence;
- The 5<sup>th</sup> cluster has the highest level of the satisfaction with the parking rates in the area of work, as well as the largest shares of the drivers, that spent more than 10 minutes on the parking space search in the area of residence.



**Figure 8.** The diagram of the average standard indicators of 5 clusters of 10 administrative districts of Moscow, including Zelenograd (the 5th cluster)



**Figure 9.** The diagram of the average standard indicators of 4 clusters of 10 administrative districts of Moscow, except Zelenograd

## 4. DISCUSSION

**Limitations of the research.** Specifically, we are aware that, while the online database of registered respondents allowed us to create samples using Internet users' profiles, it may contribute to the emergence of a number of systematic errors stemming from:

- Focus on mostly "professional" respondents,
- "Burnout" effect caused by repeated participation of the same respondents in online surveys on similar topics,
- Influence of paid participation on the survey results.

In addition, this research covered only 10 of the 12 Moscow City administrative districts (okrug). This restriction is caused by low-density housing in new urban districts that allows provision of more spacious public parking spaces. In addition, an important study limitation stems from inadequate perception of the parking situation, as outlined below:

- Halo effect – a generalized perception of the observer, resulting in failure to grasp subtle differences.
- Errors of the central tendency (which emerge when the observer seeks to give an average estimation of the observed phenomenon).
- Errors of correlation (likely to occur when the estimation of a particular feature is made on the basis of other characteristics).
- Errors of contrast (when there is a tendency to indicate features reverse to those pertaining to the issue in focus).
- Errors of the first impression (when the first impression affects the overall perception).

Therefore, the term "perceiving provision" was introduced.

**Research Finding.** The study proved the possibility and solved the problem of ranking and clustering of administrative districts of the metropolis based on the satisfaction of drivers with parking spaces, a task very relevant the government of the metropolis for parking tariffs. The study was conducted on the example of the city of Moscow, the capital of Russia, where 7.2 million cars are registered for 2019 and 3.6 million cars move daily. Analyzing the results of the research, we should point out that the respondents' distribution according to the place of work is not homogeneous, thus, the parking space of the CAO is overcrowded during work hours. The number of working people in the CAO is 2.4 times more than in other districts. As a result, the parking spaces are overcrowded. In addition, this situation is observed not only on the roads, but also in the yards. They are 36% more crowded. We assume to consider this aspect in parking policy for the parking tariffs planning and construction of new parking lots.

The popularization and development of intercepting parking lots is necessary, since only 13% of drivers regularly use them when traveling to work. This could relieve parking spaces in the yards, since 41% of the respondents admitted that use them in the area of work. The parking space development in the "bedroom" suburbs along the street and road network could reduce the proportion of the drivers that park in the yards (72%). In the research, we introduce the approach to ranking of Moscow districts in accordance with the parking spaces provision. The citizens' survey results were implemented. This approach has not been previously presented in the literature. Researchers studied satisfaction with individual parking lots or their types without considering them in the context of the districts of the city as a whole. (Hensher and King, 2001; de Oña, de Oña, and López, 2016; Szarata, Nosal, Duda-Wiertel, and Franek, 2017; Thus, Fan, and Guan, 2019)

The results of the research show that the largest average share of the drivers that spend less than five minutes on parking search is in SEAO (38%), the smallest one is in ZelaO (27%). As this indicator has a direct impact on the parking space provision, SEAO is ranked the 1<sup>st</sup> place and ZelaO is assigned as the 10<sup>th</sup>. At the same time the largest average share of the drivers that spend more than ten minutes on parking search is in CAO (40%), the smallest one is in SEAO (29%). As

this indicator has a reverse impact on the parking space provision, SEAO is ranked the 1<sup>st</sup> place and CAO is assigned as the 10<sup>th</sup>. The rank of the parking provision in the district is based on the product of these two ranks. SEAO is ranked the 1<sup>st</sup> for the parking provision in Moscow, and CAO is assigned the 10<sup>th</sup>. The authors point out that this approach introduces the drivers' individual perception of the time spent on the parking search. In these conditions various subjective factors can appear, as we have pointed out in the restrictions of the research. Therefore, when making decisions on parking lots, it is necessary to use objective data of the number of parking lots in the district, the number of parking spaces and traffic.

At the next stage, the analysis of the correlation between the rank of parking provision by districts and the level of satisfaction with parking was conducted. It should be noted that for most administrative districts, the degree of satisfaction with parking tariffs is low and ranges from 2.5 to 2.8 scores (except NEAO, that has 3 points, and ZelaO, having 3.3 points). Here two aspects were distinguished. The first aspect is characterized with the low degree of satisfaction with tariffs and weak correlation between the satisfaction level and parking provision rank. The second aspect is characterized with the significant correlation between the satisfaction level and parking provision rank. When considering the respondents' answers about general satisfaction with parking (excluding tariffs for paid parking), it can be concluded that the parking provision rank does not affect the degree of satisfaction with the parking conditions in general. The authors assume that it could be caused by other significant factors.

## CONCLUSION

The results of the administrative districts clusterization according to the parking space provision and satisfaction with the parking services contribute to the following recommendations:

To fix the highest tariffs for CAO, SWAO and EAO, where there is the lowest level of satisfaction with parking in the area of work, and more than 50% of drivers spend more than 10 minutes on parking space search;

To fix differential tariffs for NAO and NEAO, where there is the highest level of satisfaction with tariffs in the area of residence, the largest share of the drivers that spend less than 5 minutes on the parking space search in the area of residence and the smallest share of the drivers that spend less than 5 minutes on the parking space search in the area of work. For these districts, the highest differentiation of tariffs during working and non-working hours is assumed. We recommend not to change the tariffs during the working hours, but to raise them outside the working hours;

To reduce tariffs for SEAO, where there is the smallest share of the drivers that spend more than 10 minutes on the parking space search in the area of residence (the first rank for the parking space provision). This could raise the level of satisfaction with parking;

The lowest level of satisfaction with the tariffs in the area of residence, as well as with parking services in the area of residence and work is in WAO, NWAO and SAO. We recommend tariffs reducing to the medium level in NWAO and SAO outside the working hours. In addition, it is necessary to improve the parking space conditions, analyzing Moscow citizens' perception of the parking services quality in these three districts;

We do not recommend changes for ZelaO. In this district, we observe the highest level of satisfaction with tariffs in the area of work, as well as with parking services in the area of residence and work. There is the highest share of drivers that spend more than 10 minutes on the parking space search in the area of residence and less than 5 minutes in the area of work.

We suppose that in future it is necessary to conduct the surveys of satisfaction with parking spaces alongside with the analysis of traffic data, time spent on parking space search during working hours and other possible objective observational data.

## ACKNOWLEDGEMENT

The authors thank the Department for Transport and Road Infrastructure Development of the Moscow City Government for the grant, as well as the teachers and students of Plekhanov Russian University of Economics who participated in the survey.

## REFERENCES

- Ajvazjan, A.S., Mkhitarjan, V.S. (1998), *Applied Statistics and the Basics of Econometrics*, Juniti-Dana, Moscow (in Russian).
- Al-Fouzan, S.A. (2012), "Using car parking requirements to promote sustainable transport development in the Kingdom of Saudi Arabia", *Cities*, Vol. 29, No. 3, pp. 201-211.
- Bain, R. (2002), "Improving the quality of city center parking: will the consumer pay", *Traffic Engineering and Control*, Vol. 43, No. 5, pp. 175-179.
- Barter, P.A. (2012), "Off-street parking policy surprises in Asian cities", *Cities*, Vol. 29, No. 1, pp. 23-31.
- Budiani, S.R., Iffani, M., Novianti, I., Alfana, M.A.F., Harini, R., Rofi, A. (2018), "User satisfaction level of parking space facility: a case of Faculty of Geography", *IOP Conference Series: Earth and Environmental Science*, Vol. 148, No. 1, pp. 012012.
- Cohn, L.F., Koushki, P.A. (1991), "Social attitudes and traffic noise: a study in Riyadh, Saudi Arabia", *Journal of Urban Affairs*, Vol. 13, No. 2, pp. 233-242.
- Cruz, F.C.D., Cruz, A.C.D., Ceretta, P.S. (2017), "Users' satisfaction measurement of the municipal paid rotational parking system", *Urbe. Revista Brasileira de Gestão Urbana*, Vol. 9, No. 1, pp. 19-34 (in Portuguese).
- De Beeck, P. (2017), *Customer satisfaction begins with parking*, <https://www.across-magazine.com/customer-satisfaction-begins-parking/> (accessed 18 august 2019).
- de Oña, J., de Oña, R., López, G. (2016), "Transit service quality analysis using cluster analysis and decision trees: a step forward to personalized marketing in public transportation", *Transportation*, Vol. 43, No. 5, pp. 725-747.
- Fickling, D., He, E. (2018), *The Future of Transport Is the Future of Cities*, <https://www.bloomberg.com/opinion/articles/2018-11-06/polluted-megacities-push-transport-s-future-toward-the-rails> (accessed 10 march 2019).
- Fraley, C., Raftery, A.E. (1998), "How many clusters? Which clustering method? Answers via model-based cluster analysis", *Computer Journal*, Vol. 41, pp. 578-588.
- Golias, J., Yannis, G., Harvatis, M. (2002), "Off-street parking choice sensitivity", *Transportation Planning and Technology*, Vol. 25, No. 4, pp. 333-348.
- Guan, S., Su, Z., Li, J. (2017), "Optimization of number of parking space and parking tariffs for the on-street metered parking: A case study of Guangzhou CBD (Conference Paper)" in *Transport and Society*, Proceeding of the 22nd International Conference of Hong Kong Society for Transportation Studies, HKSTS 20172017, pp. 140-146.
- Gumasing, M.J.J., Atienza, C.A.V. (2018), "A design of automated parking system for shopping centers in Metro Manila" in *The fifth International Conference on Industrial Engineering and Applications*, ICIEA 2018, pp. 415-419
- Hensher, D.A., King, J. (2001), "Parking demand and responsiveness to supply, pricing and location in the Sydney central business district", *Transportation Research, Part A: Policy and Practice*, Vol. 35, No. 3, pp. 177-196.
- Hoehne, C.G., Chester, M.V., Fraser, A.M., King, D.A. (2019), "Valley of the sun-drenched parking space: The growth, extent, and implications of parking infrastructure in Phoenix", *Cities*, Vol. 89, pp. 186-198.
- Houston, D., Wu, J., Ong, P., Winer, A. (2004), "Structural disparities of urban traffic in Southern California: implications for vehicle-related air pollution exposure in minority and high-poverty neighborhoods", *Journal of Urban Affairs*, Vol. 26, No. 5, pp. 565-592.



- ICC/ESOMAR International Code on Market, Opinion and Social Research and Data Analytics  
ESOMAR, [https://www.esomar.org/uploads/public/knowledge-and-standards/codes-and-guidelines/ICCESOMAR\\_Code\\_Russian\\_.pdf](https://www.esomar.org/uploads/public/knowledge-and-standards/codes-and-guidelines/ICCESOMAR_Code_Russian_.pdf) (accessed 10 march 2019) (in Russian).
- Jarrell, S.B. (1994), *Basic statistics*, WCB, McGraw-Hill, USA.
- Jena, S., Chakraborty, A., Bhuyan, P.K. (2018), "Performance Assessment of Urban Streets Addressing Improvement Issues for Automobile Mode of Transport", *Transportation Research Record*, Vol. 2672, No. 45, pp. 232-241.
- Kelly, J.M., Swindell, D. (2002), "Service quality variation across urban space: First steps toward a model of citizen satisfaction", *Journal of Urban Affairs*, Vol. 24, No. 3, pp. 271-288.
- Liljander, V., Strandvik, T. (1997), "Emotions in service satisfaction", *International Journal of Service Industry Management*, Vol. 8, No. 2, pp. 148-169.
- Lin, F.J., Chen, H. (2015), "Improving utilization and customer satisfaction of parking space with M2M communications" in *2015 IEEE 2nd World Forum on Internet of Things*, pp. 465-470.
- Malhotra, N.K., Birks, D.F. (2007), *Marketing Research: An Applied Orientation*, Pearson Education, New York.
- Marsden, G. (2006), "The evidence base for parking policies—a review", *Transport Policy*, Vol. 13, No. 6, pp. 447-457.
- Milosavljevic, N., Simicevic, J. (2019), *Parking demand. Sustainable Parking Management*, Elsevier, Serbia.
- Mingardo, G., van Wee, B., Rye, T. (2015), "Urban parking policy in Europe: A conceptualization of past and possible future trends", *Transportation Research Part A: Policy and Practice*, Vol. 74, pp. 268-281.
- Moscow transport system development, [http://transport.mos.ru/common/upload/public/Инфоцентр/транспортная%20система%20Москвы\\_rus.pdf](http://transport.mos.ru/common/upload/public/Инфоцентр/транспортная%20система%20Москвы_rus.pdf) (accessed 10 march 2019) (in Russian).
- Munawar, A., Prasetyo, H.P. (2000), "Parking Requirement in Master Program Building (Case Study: UGM Management Master's Building)", *Proceedings of the Symposium III*, Yogyakarta, FSTP Universitas Gadjah Mada.
- Musatova, Z., Mkhitarian, S., Nevostruev, P., Sidorchuk, R., Komleva, N. (2016), "SMART-technologies in public transport and their perception by the youth audience", *Indian Journal of Science and Technology*, Vol. 9, pp. 42 (in Russian).
- Parasuranman, A., Zeithaml, V.A., Berry, L.L. (1988), "SERVQUAL: A Multiple-Item Scale for Measuring Consumer Perceptions of Service Quality", *Journal of Retailing*, Vol. 64, pp. 12-40.
- Rye, T., Ison, S. (2005), "Editorial: parking", *Transport Policy*, Vol. 13, pp. 445-446.
- Sejfullaeva, M.Je., Skorobogatyh, I.I., Sidorchuk, R.R., Grineva, O.O. (2018), "Assessment of the perceived quality of the transport service: theoretical and practical approaches", *Bulletin of the Plekhanov Russian University of Economics*, Vol. 2, No. 98, pp. 122-134 (in Russian).
- Shashkin, A.V., Pozdnyakova, M.Y. (2006), *Online surveys in Russia: trends and prospects*, RAS Institute of Sociology Publishing, Moscow (in Russian).
- Shchepakina, M., Frisovna, E., Bzhennikova, J., Tolmacheva, O., Bazhenov, Y. (2018), "The impact of supply chain management on marketing frontiers in competitive business building", *International Journal of Supply Chain Management*, Vol. 7, No. 5, pp. 865-876.
- Shoup, D. C. (2006), "Cruising for parking", *Transport Policy*, Vol. 13, No. 6, pp. 479-486.
- Sidorchuk, R., Efimova, D., Lopatinskaya, I., Kaderova, V. (2015), "A parametric approach to assessing the attributes of the quality of service of city passenger transport in Moscow", *Modern Applied Science*, Vol. 9, No. 4, pp. 303-311 (in Russian).
- Suksanguan, W. (2018), "Study on the use of parking spaces and satisfaction of Thai people using Don Mueang Airport in Bangkok Metropolis, Thailand", *ABAC Journal*, Vol. 38, No. 2, pp. 147-160.
- Szarata, A., Nosal, K., Duda-Wiertel, U., Franek, L. (2017), "The impact of the car restrictions implemented in the city center on the public space quality", *Transportation Research Procedia*, Vol. 27, pp. 752-759.

- Szymalski, W. (2016), "Lewis-Mogridge position - the example of Warsaw", *Cultures of Motorway: Localities through Mobility as an Anthropological Issue*, *Poznan Ecological Studies*, Vol. 19, pp. 139-152 (in Polish).
- The citizens of Moscow about the problems of the city* (2019), <https://www.levada.ru/2019/05/30/moskvichi-o-problemah-goroda/> (accessed 10 march 2019) (in Russian).
- Tong, C. O., Wong, S. C., Leung, B. S. Y. (2004), "Estimation of parking accumulation profiles from survey data", *Transportation*, Vol. 31, No. 2, pp. 183-202.
- Westbrook, R.A., Oliver, R.L. (1991), "The dimensionality of consumption emotion patterns and consumer satisfaction", *Journal of Consumer Research*, Vol. 18, No. 1, pp. 84-91.
- Xue, Y., Fan, H., Guan, H. (2019), "Commuter Departure Time Choice Considering Parking Space Shortage and Commuter's Bounded Rationality", *Journal of Advanced Transportation*, Vol. 2019, pp. 1-7.
- Zavyalova, N.B, Sidorchuk, R.R, Lopatinskaya, I.V., Zavyalov, D.V., Saginova, O.V., Skorobogatykh, I.I. (2016), "Quality of transport services management in the city", *Marketing and Marketing Research*, Vol. 1, pp. 36-50 (in Russian).