Journal of Architectural Sciences and Applications
JASA 2023, 8 (1), 406-421.
Research article
e-ISSN: 2548-0170
https://dergipark.org.tr/en/pub/mbud

Examining the Effect of Weather Conditions on On-Street Parking Variables

Abdullah DEMİR [1*], Ali ÖZ [2]
ORCID 1: 0000-0003-4042-7626
ORCID 2: 0000-0002-0814-4020
[1] *Marmara University, Department of Automotive, Faculty of Technology, 34722, İstanbul, Türkiye.*
[2] *Mehmet Akif Ersoy University, Vocational School of Technical Sciences, Department of Motor Vehicles and Transportation Technologies, 15100, Burdur, Türkiye.*
***e-mail:** ademir@marmara.edu.tr*

Abstract

In this study, the effect of weather conditions on on-street parking variables is examined. In this context, data sets consist of 17 variables such as parking capacity, employee personnel, off-duty personnel, turn-over rate, first-hour parking price, daily parking price, number of transactions, number of cash transactions, average cash parking duration, 0-15 min parking duration, average parking duration, number of subscription, parking subscription price, daily transactions of subscription, subscription parking duration and income on the on-street parking spaces in the Anatolian Side of Istanbul for two years (2017-2018). In this study, turnover rate, parking duration, cash parking duration, and parking income variables are investigated by multiple regression analysis with dummy variables. Daily general weather data during this period are classified into 11 categories as sunny, cloudy, partly cloudy, light rain, rain, short-term heavy rainfall, heavy rainfall, light snow, light snowfall, snow, and a heavy snowstorm- as *dummy variables. Based on the estimation results, it is found that both sunny and light snow + light snowfall + snow + heavy snowstorm weather variables decrease parking duration by 0.528 and 1.293 min, respectively. Moreover, results also indicated that the same variables increase cash parking duration by 1.21 and 3.29 min, respectively. Both sunny and cloudy + partly cloudy weather variables increase parking income by 719 TL and 580 TL, respectively. Light snow + light snowfall + snow + heavy snowstorm weather variable decreases parking income by 1143 TL.*

Keywords: *ISPARK, parking variables, parking duration, weather conditions, multiple regression analysis.*

Hava Koşullarının Yol Kenarı Parklanma Değişkenleri Üzerindeki Etkisinin İncelenmesi

Öz

Bu çalışmada, hava koşullarının yol kenarı otopark değişkenleri üzerindeki etkisini incelemek için veri setleri iki yıl boyunca (2017-2018) İstanbul Anadolu Yakası'ndaki yol kenarı park yerlerinde park kapasitesi, çalışan personel, mesai dışı personel, devir hızı, ilk saat park fiyatı, günlük park fiyatı, işlem sayısı, nakit işlem sayısı, ortalama nakit park süresi, 0-15 dk park süresi, ortalama park süresi, abonelik sayısı, park abonelik fiyatı, abonelik günlük işlemleri, abonelik park süresi ve gelir gibi 17 değişkenden oluşmaktadır. Bu çalışmada, ciro oranı, park süresi, nakit park süresi ve park geliri değişkenleri kukla değişkenlerle çoklu regresyon analizi ile araştırılmıştır. Bu dönemdeki günlük genel hava durumu verileri kukla değişkenler olarak güneşli, bulutlu, parçalı bulutlu, hafif yağmurlu, yağmurlu, kısa süreli şiddetli yağış, şiddetli yağış, hafif kar, hafif kar yağışı, kar ve şiddetli kar fırtınası olmak üzere 11 kategoriye ayrılmıştır. Sonuçlara göre hem güneşli hem de hafif kar + hafif kar yağışı + kar + yoğun kar fırtınası hava değişkenlerinin park süresini sırasıyla 0,528 ve 1,293 dakika azalttığı bulunmuştur. Ayrıca, aynı değişkenlerin nakit park süresini sırasıyla 1,21 ve 3,29 dakika artırdığını da göstermiştir. Hem güneşli hem de bulutlu + parçalı bulutlu hava değişkenleri otopark gelirini sırasıyla 719 TL ve 580 TL artırmaktadır. Hafif kar + hafif kar yağışı + kar + yoğun tipi hava durumu değişkeni ise otopark gelirini 1143 TL azaltmaktadır.

***Anahtar Kelimeler**: İSPARK, otopark değişkenleri, otopark süresi, hava koşulları, çoklu regresyon analizi.*

Citation: Demir, A. & Öz, A. (2023). Examining the effect of weather conditions on on-street parking variables. *Journal of Architectural Sciences and Applications*, 8 (1), 406-421.
DOI: https://doi.org/10.30785/mbud.1292308

***Received:** 05/05/2023 – **Accepted:** 05/07/2023*

1. Introduction

With the rapid increase in the world population after the industrial revolution, industrialization has accelerated to meet the increasing needs. Motor vehicles, which are a component of today's lifestyle, increase with the increase in population and per capita income, and their use of them is also widespread (Hajimohamadipour, 2016). Ground, air, and water are natural supplies which state is worse and worse because of civilization development. One of the factors exerting an important effect on that is road transportation. Transportation affects the natural environment through infrastructure elements, -roads, bridges, car-parking facilities-, as well as vehicles that are exhaust emission, noise, and vibrations. The natural environment, and especially the weather, experts on drivers. We can notice the growth of the intensity of vehicles together with the deterioration of the weather. Especially when the weather is rainy in Istanbul, traffic flow rates decrease and traffic density increases. This is caused by the comfort of drivers and expected shorter journey time by own passenger car than by public transportation. The increase in the number of trips affects cities' crowds, including. car-parking facilities (Parkitny, 2017a).

Transport and accessibility is one of the most important factors in achieving city image and spatial quality. Controlling and strategically managing automobile-based transport and its components is of great importance, especially for a sustainable environment and a livable city (Özkan, Öz, Demir, Gül & Gül, 2020). Today, with the development of the economy and the increase in user needs and demands, car ownership and use has become a vital necessity. However, this situation has brought along other multifaceted problems (Gül, Öz, Demir & Gül, 2019). As a result of the increasing number of vehicles with urbanisation trends in our country and in the world, the car parking problem has become a major problem in the transportation system infrastructure and superstructure inadequacy (Gül et al., 2019). In order to create a more livable and sustainable transport system in cities, the main approach will be to try to adapt cities to automobiles and to try to adapt automobiles to cities instead of building more roads and/or car parks (Özkan et al., 2020). Within the scope of the city's transportation system, the main objective of car park management planning should be to associate and prioritise the parking space needs and demands of different users, and to produce equitable and balanced solutions according to social, economic, technological, spatial, environmental and climatic conditions (Gül et al., 2019).

The literature suggests that on-street parking demand is negatively related to on-street parking prices, but its sensitivity depends on the user and trip characteristics (Gragera & Albalate, 2016). On-street parking demand depended upon the journey purpose (Kelly & Clinch, 2006; Simicevic et al., 2012) decreases with income (Gillen, 1977; Shoup & Wilson, 1992), increases with the duration of stay (Khodaii et al., 2010; Kobus et al., 2013), and increases with the level of alternative modes of transportation (Hess, 2001; Weis et al., 2012). Furthermore, hostile weather conditions or climates can impact walking (Barter, 2016). Conditions such as weather conditions, car-park capacities, occupancy rates, and prices can be effectively created for driver's behavior as finding alternative parking, traveling at a different time, choosing a different mode of transportation, changing the destination, and avoiding the whole trip (ICPMMP, 2016). A study conducted by Parkitny (2017a), undertakes a trial of researching the effect of weather on the occupation of parking spaces. The investigation aims to check the dependence between the chosen weather conditions, e.g., temperature, falling, clouding, and the utilization of parking spaces. Observations in the study also show that road vehicle traffic in a city increases when the weather gets worse (Parkitny, 2017a). In the master thesis by Harris (2004), current United States parking regulations determine if and how well design principles with climate have been incorporated. Rules are then given to help in the construction of a parking regulation that aims to improve the city's microclimate. A design is created that shows how these parking rules can be incorporated into functional, aesthetically pleasing parking (Harris, 2004).

On-street parking locations in the Anatolian Side of Istanbul are chosen as the research area. Istanbul, which is one of the largest cities in Türkiye, encompasses nearly 15.06 million people, along with a high rate of motorization lately. The dynamic increase in population and expanding its territory in Istanbul

cause many problems. One of the most difficult problems to solve is the large parking problems in the megacity as well as the problem of the increasing number of vehicles, particularly passenger cars.

Since there are a few studies in the literature examining the relationship between weather conditions and street parking, the current study would make a significant contribution to the literature. In this context, some modeling approaches on car-parking spaces are shown in Table 1.

Table 1. Different models of car parks' functioning in literature

Models of car parks' functioning	*Researchers*
Checking dependence between the chosen weather conditions, e.g., temperature, falling, clouding, and the utilization of parking spaces.	Parkitny, 2017a
The thesis looks at current United States parking regulations to determine if and how well design principles with climate have been incorporated.	Harris, 2004
Analyzed the impact of garage fee and on-street parking regulation characteristics (price and type of dedicated spaces) on multi-story car-park demand (for both occasional parkers and subscribers).	Gillen, 1977; Shoup & Wilson, 1992; Khodaii et al., 2010; Kobus et al., 2013; Gragera, 2017; Demir, 2019.
Analyzed the specific behavior of garage users, and the interactions between on- and off-street parking regulation tools (i.e. fees, duration limits, parking permits, type of spaces, and the level of enforcement)	Tsamboulas, 2001; Khodaii et al., 2010; Simicevic et al., 2012, 2013; Kobus et al., 2013.
Taking advantage of parking transaction data	Kelly & Clinch, 2009; Pierce & Shoup, 2013; Kobus et al., 2013.
Both on-street parking and multi-story car-park demand are negatively related to parking price	Kobus et al., 2013; Simicevic et al., 2013.
The substitution effect between multi-story carpark and on-street parking was first empirically suggested. They estimated probit models on the choice between them, based on stay duration.	Kobus et al. (2013)
Empirical studies on parking demand have generally focused on the impact of on-street parking rules on commuters' travel choices using stated or revealed preference surveys	Concas & Nayak, 2012.
Model of setting parking prices	Nourinejad & Roorda, 2017.
About the Role of Drivers' psychological characteristics in the parking space selection process	Guo et al., 2013a.
Defining environmental costs associated with searching for parking spaces	Guo et al., 2013b; İnci & Robin, 2015; İnci et al., 2017.
Logit models to estimate the behavior of passenger car drivers concerning car parks choice	Parkitny, 2014.
Using game theory to describe the relationship between parking administrators and drivers	Zong et al., 2013.
Use the game theory in modeling equipment and parking fees. By modifying fees for parking as well as parking equipment, parking administrators can increase the attractiveness of car parking spaces and enlarge financial receipts from parking payments	Parkitny (2017-b)

Paid attention to data's credibility of information systems models about parking locations	Hoh et al., 2012.
Reviewing urban parking models	Young et al., 1991.
Effect of on-street parking locations on traffic flow speeds	Uzun, 2009; Praburam & Koorey, 2015; Uzun et al., 2021.
Other car parking models (game theory and et al.)	Goyal & Gomes, 1984; Hunt & Teply, 1993; Thompson & Richardson, 1998; Shoup, 2006; Arnott & İnci, 2010. Ayala et al., 2011; Ayala et al., 2012: Azari et al., 2013; Arnott et al., 2015; Mejri et al., 2016.

In this study, the effect of weather conditions on on-street parking variables is examined. For this purpose, data sets consist of 17 variables such as parking capacity, employee personnel, off-duty personnel, turn-over rate, first-hour parking price, daily parking price, number of transactions, number of cash transactions, average cash parking duration, 0-15 min parking duration, average parking duration, number of subscription, parking subscription price, daily transactions of subscription, subscription parking duration and income on the on-street parking spaces in the Anatolian Side of Istanbul for two years (2017-2018). Turn-over rate, parking duration, cash parking duration, and parking income variables are investigated by multiple regression analysis with daily general weather data as dummy variables classified in sunny, cloudy, partly cloudy, light rain, rain, short-term heavy rainfall, heavy rainfall, light snow, light snowfall, snow, heavy snowstorm. The weather data are used in regression analysis by firstly 6 and then 4 dummy variables, by combining both the correlation coefficients and frequency in general weather data. The study consists of five sections. In the first section: is the importance of the subject, in the second section: is a brief review of the literature, in the third section: is the creation of the data set related to the study areas, meteorological data and classification, dummy variable regression analysis, and information about the dependent and independent variables used in the analysis, in the fourth section: regression analyzes and other discussions on the subject, and the conclusion and suggestions are given in the last section.

2. Material and Methods

In this section, information on both Istanbul and especially car-parking operations on the Anatolian Side is given. The distribution of 2-year weather data recorded with daily observations in 11 categories is classified. In the next step, the dummy variable regression analysis is briefly introduced, and the dependent and independent variables used in the regression analysis (the values in the data sets used in the regression analysis are daily average values) are presented.

2.1. Study Area (Anatolian Side and Istanbul)

Istanbul which has 39 districts, 959 neighborhoods, approx. 3.9 million residential and a population of 15.067 million according to the address-based population registration system has a surface area of 5,461 km^2, a road network of 32,386 km, and 4,173,312 vehicles. In addition, approximately 465 new vehicles are registered daily, and 14.5 passengers are traveling by public transport (IETT, 2018; TUIK, 2017). As of the end of 2018, vehicle ownership is calculated as 276 vehicles / 1,000 people and car ownership is 193 cars / 1,000 people in Istanbul. Istanbul has 4.173 million road vehicles 2.887 million of which are passenger cars (IETT, 2018). These values tend to increase over time for Istanbul. When the values of the last 10 years are taken into consideration, an average of 355 new cars are registered every day in Istanbul. This value is equivalent to a large multi-story car park capacity. In other words, the construction of a large multi-story car park every day for vehicles participating in traffic in Istanbul will only be able to meet the need of vehicles registered newly. The mobility rate in Istanbul is approx. 2.07 (IETT, 2018).

Istanbul Parking Management Trade Inc (ISPARK Inc.), a semi-private establishment, was established in 2005 by Istanbul Metropolitan Municipality. The collections that continued with the counterfoil

ticket up to 2008 were gradually replaced by handheld terminals. On-street parking with SMS was implemented on a local basis in 2009, but it has not been currently continued. Multifunctional handheld terminals are used with software in which parking declaration can be made both by mobile phone and parking attendant. After a vehicle enters the parking space, the vehicle's number plate manually is written in the system by the attendant according to the relevant platform number and it is logged into the system with the relevant options by asking for the planned parking duration (Gurbetci et al., 2007; Demir & Çavdar, 2008; Yardım & Demir, 2009; Gurbetci et al., 2014; Demir, 2019). ISPARK has operated approx. 95,000 paid parking spaces in both on-street (most of which are operated during day times, generally between 08:00 am - 6:00 pm) and off-street parking facilities.

All on-street parking locations in the Anatolian Side of Istanbul are chosen in the study. The parking capacity of the Anatolian Side, approximately 33% of the total parking capacity, is given in Table 2

Table 2. Parking inventory of ISPARK (ICPMMP, 2016; Demir, 2019)

	Anatolian Side	***Europan Side***	***Total***
Number of locations	186	456	642
Total parking capacities	30624	61051	91675
On-street parking capacities	4804	10081	14885
Multi-story car parking capacities	5543	16075	21628
Surface parking capacities	13703	27558	41261
P+R parking capacities	6574	7287	13861
Number of transactions per day	38896	63594	102490

2.2. Meteorology Data and Their Classifications

Daily general weather data for two years are classified into 11 categories as sunny, cloudy, partly cloudy, light rain, rain, short-term heavy rainfall, heavy rainfall, light snow, light snowfall, snow, and heavy snowstorm. In Table 3, the weather data are used in regression analysis by firstly 11, then 6, and finally 4 dummy variables, by combining both the correlation coefficients and frequency in general weather data. In addition, 2-year weather statistics are given in Table 4.

Table 3. General weather conditions as dummy variables

11 variables	***6 dummy variables***	***4 dummy variables***
1. Sunny (S)		
2. Cloudy (C)		
3. Partly cloudy (PC)	1. Sunny	1. Sunny
4. Light rain (LR)	2. Cloudy + Partly cloudy	2. Cloudy + Partly cloudy
5. Rain (R)	3. Light rain	3. Light rain + Rain + Short-term heavy rainfall + Heavy rainfall
6. Short-term heavy rainfall (STHR)	4. Rain	
7. Heavy rainfall (HR)	5. Short-term heavy rainfall + Heavy rainfall	4. Light snow + Light snowfall + Snow + Heavy snowstorm
8. Light snow (LS)	6. Light snow + Light snowfall + Snow + Heavy snowstorm	
9. Light snowfall (LSF)		
10. Snow (SN)		
11. Heavy snowstorm (HS)		

Table 4. Two-year weather statistics (In the 2 years, on-street parking locations have been operated for 706 -days)

Weather conditions	*Number of working days*		
	On-street	*Surface*	*Multi-storey*
Sunny	226	237	237
Cloudy	63	64	64
Partly cloudy	271	277	277
Short-term heavy rainfall	4	4	4
Heavy rainfall	21	22	22
Light rain	58	58	58
Rain	54	57	57
Light snow	3	3	3
Light snowfall	3	3	3
Snow	3	3	3
Heavy snowstorm	-	2	2

2.3. Dummy Variable Multiple Regression Model

Whether or not there is a relationship between two variables, and if so, determining the extent of this relationship is a method often employed in statistical analyses. For this purpose, regression analysis is a widely used technique in examining the relationship between variables (Newbold et al., 2013). Regression analysis is the explanation of relations between dependent variables and independent or multiple independent variables through mathematical equations. Success in regression analysis depends on the availability of the appropriate and reliable dataset. In regression analysis, the relation between X_j independent variables and Y_j dependent variables is stated as a mathematical function. By plotting the scatter diagram between dependent and independent variables, it is determined whether a linkage between two variables can be correlated or not, and what kind of function will be considered if it can be correlated. For example, if a linear relationship is assumed between Y and X such as $Yj = \alpha + \beta X_j + \varepsilon_j$ (j= 1, 2, 3, ... n), then the first step is to estimate the unknown parameters (α and β) of the model. Once the unknown parameters of the model are estimated, estimating the value of the dependent variable for different values of the independent variables is another purpose of the regression (Newbold et al., 2013; Karaca & Karacan, 2016). In the multiple regression model, for p explanatory variables and n observations; it can be formulated as $Yj = \beta_0 + \beta_1 X_{1j} + \beta_2 X_{2j} + \ldots + \beta_p X_{pj} + \varepsilon_j$ (j = 1, 2, … n). It is necessary to provide some assumptions about the model for parameter estimates of the regression model, which are obtained by both simple and multiple regression analysis, to be reliable.

Dummy variables for regression models: Assuming the independent variables, xj, exist over a range and contain many different values. However, in the multiple regression assumptions, the only constraint on independent variables is that they are constant values. Thus, we can have an independent variable that takes on only two values: xj = 0 and xj = 1. This structure is commonly defined as a dummy variable, and we will see that it provides a valuable tool for applying multiple regression to the respective situations. An important example is a linear function that changes in response to some effects (Newbold et al., 2013).

In this study, dependent and independent variables in multiple regression models are given in Table 5. These parameters -turnover rate, average cash parking duration, average parking duration, and parking income- are variables that can be affected by weather conditions. Dummy variables used in the multiple regression model are given in Table 3.

Table 5. Dependent and independent variables in multiple regression model

Dependent variable	Independent variable(s)*	Number of the independent variable(s)	Observations
Turn-over rate	Capacity (C), employee personnel (EP), off-duty personnel (ODP), turn-over rate (TOR), first-hour parking price (FHPP), daily parking price (DPP), number of transactions (NoT), number of cash transactions (NoCT), average cash parking duration (ACPD), average parking duration (APD), number of subscription (NoS), parking subscription price (PSP), daily transactions of subscription (ToS), subscription parking duration (SPD), income (I), number of transactions - NoT (0-15 min), average parking duration - APD (0-15 min)	On-street: 16	706
Parking duration*, s			
Cash parking duration, s			
Parking income, TL			

***** Variable "parking duration" is the average of paid, free, and 0-15 min. parking duration

3. Results and Discussion

In this study, datasets in multiple regression analysis with dummy variables consist of 17 variables such as parking capacity, employee personnel, off-duty personnel, turn-over rate, first-hour parking price, daily parking price, number of transactions, number of cash transactions, average cash parking duration, 0-15 min parking duration, average parking duration, number of subscription, parking subscription price, daily transactions of subscription, subscription parking duration and income in the on-street parking spaces in the Anatolian side of Istanbul for two years (2017-2018). The effects of weather conditions on turn-over rate, parking duration, cash parking duration, and parking income variables are summarized as follows.

3.1. Effect of Weather Conditions On Turn-Over Rate

In the correlation analysis of the variables, it is determined that the first hour and daily parking price variables have the same correlation effect, and the first-hour parking price variable from these variables is included in the regression model (This is also applied to other regression analyzes). In the first regression analysis, off-duty personnel (ODP), number of transactions (NoT), average cash parking duration (ACPD), average parking duration (APD), and parking subscription price (PSP) that have P-values greater than 0.05 are also subtracted from the data set. The second regression analysis statistics with 706 observations are given in Table 6. The R square for the turnover rate is 99.6%. Ten of the coefficients in the regression statistics have P-values less than 5%. It is determined that the weather condition variables used as dummy variables do not affect the turnover rate. The first-hour parking price (FHPP) has also the biggest effect on it. For each unit (TL) increase in FHPP, the turnover rate increases by 0.446 units.

The estimated regression equation for turnover rate (1) is;

$$\mathbf{TOR} = -0.0013*C + 0.00503*EP + 0.446*FHPP + 0.00044*NoCT + 0.00013*NoT\ (0\text{-}15\ min) - 0.0081*APD\ (0\text{-}15\ min) + 0.00176*NoS + 0.00077*ToS + 0.00048*SPD + 0.000012*I \quad (1)$$

Table 6. The turnover rate in on-street parking spaces was analyzed using a dummy variable multiple regression model

Regression Statistics	
Multiple R	0.99798
R Square	0.99596
Adjustable R Square	0.99444
Standard Error	0.19953
Observation	706

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	14	6790.07	485.005	12182.6	0
Difference	692	27.5494	0.03981		
Total	706	6817.62			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Low 95%*	*High 95%*	*Low 95.0%*	*High 95.0%*
Intersection	0	-	-	-	-	-	-	-
C	-0.0013	4.5E-05	-28.894	5E-121	-0.0014	-0.0012	-0.0014	-0.0012
EP	0.00503	0.00096	5.26646	1.9E-07	0.00316	0.00691	0.00316	0.00691
FHPP, TL	0.44655	0.12876	3.46809	0.00056	0.19374	0.69935	0.19374	0.69935
NoCT	0.00044	4.5E-05	9.68566	6.8E-21	0.00035	0.00053	0.00035	0.00053
NoT (0-15 min)	0.00013	2.7E-05	4.725	2.8E-06	7.4E-05	0.00018	7.4E-05	0.00018
APD (0-15 min)	-0.0081	0.00112	-7.2	1.6E-12	-0.0103	-0.0059	-0.0103	-0.0059
NoS	0.00176	0.00034	5.15825	3.3E-07	0.00109	0.00244	0.00109	0.00244
ToS	0.00077	0.0003	2.54332	0.0112	0.00017	0.00136	0.00017	0.00136
SPD	0.00048	0.0002	2.47607	0.01352	0.0001	0.00087	0.0001	0.00087
I, TL	1.2E-05	4.9E-06	2.54363	0.01119	2.8E-06	2.2E-05	2.8E-06	2.2E-05
DV_{C+PC}	-0.191	1.04576	-0.1826	0.85516	-2.2442	1.86227	-2.2442	1.86227
DV_{S}	-0.1335	1.04311	-0.128	0.89822	-2.1815	1.91457	-2.1815	1.91457
$DV_{LS+S+HS}$	-0.1545	1.05251	-0.1468	0.88337	-2.2209	1.91203	-2.2209	1.91203
$DV_{LR+R+STHR+HR}$	-0.1487	1.0465	-0.1421	0.88703	-2.2034	1.90598	-2.2034	1.90598

3.2. Effect of Weather Conditions on Parking Duration

In the first regression analysis, TOR, EP, ODP, NoT, NoCT, and PSP variables that have P-values greater than 0.*05* are also subtracted from the dataset. The second regression analysis statistics with 706 observations are given in Table 7. The R square for parking duration is 97.3%. Nine of the coefficients in the regression statistics have P-values less than 5%. First-hour parking price (FHPP) has also the biggest effect on parking duration. For each TL increase in FHPP, parking duration decreases by 4.32 min. It is also determined that sunny (DV_S) and light snow + light snowfall + snow + heavy *snowstorm* ($DV_{LS+S+HS}$) weather variables used as dummy variables decrease parking duration by 0.528 and 1.293 min, respectively. None of the other weather condition variables in the model are significantly associated with parking duration.

The estimated regression equation for parking duration (2) is;

$$\textbf{\textit{APD}} = 45.61 + 0.00015*I + 0.00162*C - 4.322*FHPP - 0.0030*NoT\ (0\text{-}15\ min) + 0.491*ACPD + 0.405*APD\ (0\text{-}15\ min) + 0.024*ToS - 0.0099*NoS + 0.006*SPD - 0.528*DV_S - 1.293*DV_{LS+S+HS} \quad (2)$$

Table 7. Parking duration in on-street parking spaces was analyzed using a dummy variable multiple regression model

Regression Statistics	
Multiple R	0.986423
R Square	0.973031
Adjustable R Square	0.972604
Standard Error	1.519695
Observation	706

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	11	57827.6	5257.055	2276.301	0
Difference	694	1602.774	2.309473		
Total	705	59430.38			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Low 95%*	*High 95%*	*Low 95.0%*	*High 95.0%*
Intersection	45.61507	6.621681	6.888744	1.26E-11	32.61414	58.616	32.61414	58.616
I, TL	0.000148	1.95E-05	7.571008	1.18E-13	0.000109	0.000186	0.000109	0.000186
C	0.001621	0.000281	5.77702	1.15E-08	0.00107	0.002171	0.00107	0.002171
FHPP, TL	-4.321919	0.787366	-5.489085	5.67E-08	-5.867824	-2.776014	-5.867824	-2.776014
NoT (0-15 min)	-0.003064	0.000184	-16.6892	7.95E-53	-0.003424	-0.002703	-0.003424	-0.002703
ACPD, min	0.491828	0.008493	57.90787	6.1E-268	0.475153	0.508504	0.475153	0.508504
APD (0-15 min)	-0.405724	0.008662	-46.8399	4.6E-217	0.388717	0.422731	0.388717	0.422731
NoS	-0.009922	0.002402	-4.130865	4.05E-05	-0.014638	-0.005206	-0.014638	-0.005206
ToS	0.02444	0.001998	12.23228	2.7E-31	0.020517	0.028363	0.020517	0.028363
SPD	-0.00605	0.0015	-4.03296	6.12E-05	-0.003105	-0.008996	-0.003105	-0.008996
DV_S	-0.528763	0.133875	-3.949671	8.63E-05	-0.791611	-0.265914	-0.791611	-0.265914
$DV_{LS+S+HS}$	-1.293281	0.520509	-2.484646	0.013203	-2.315242	-0.271319	-2.315242	-0.271319

3.3. Effect of Weather Conditions on Cash Parking Duration

In the first regression analysis, TOR, EP, ODP, NoT, NoCT, and PSP variables that have P-values greater than 0.05 are also subtracted from the data set. The second regression analysis statistics with 706 observations are given in Table 8. The R square for cash parking duration is 88.8%. Nine of the coefficients in the regression statistics have P-values less than 5%. First-hour parking price (FHPP) has also the biggest effect on cash parking duration. For each TL increase in FHPP, cash parking duration increases by 9.36 min. It is also determined that both *sunny (DV_S) and light snow + light snowfall + snow + heavy snowstorm ($DV_{LS+S+HS}$)* weather variables used as dummy variables increase cash parking duration by *1.21 and 3.29 min*, respectively. None of the other weather condition variables in the model are significantly associated with cash parking duration.

The estimated regression equation for cash parking duration (3) is

$$\textbf{ACPD} = -77.9 + 1.684*APD - 0.00026*I - 0.0037*C + 9.36*FHPP + 0.0058*NoT\ (0\text{-}15\ min) - 0.626*APD\ (0\text{-}15\ min) + 0.022*NoS - 0.0419*ToS - 0.0153*SPD + 1.21*DV_G + 3.29*DV_{LS+S+HS} \quad (3)$$

Table 8. Cash parking duration in on-street parking spaces was analyzed using a dummy variable multiple regression model

Regression Statistics	
Multiple R	0.942328
R Square	0.887982
Adjustable R Square	0.885713
Standard Error	2.81611
Observation	706

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	14	43440.54	3102.895	391.2623	0
Difference	691	5479.958	7.930475		
Total	705	48920.49			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Low 95%*	*High 95%*	*Low 95.0%*	*High 95.0%*
Intersection	-77.9035	12.40699	-6.279	6.02E-10	-102.263	-53.5436	-102.263	-53.5436
APD, min	1.684183	0.029169	57.73896	1.3E-266	1.626912	1.741453	1.626912	1.741453
I, TL	-0.00026	3.87E-05	-6.77839	2.61E-11	-0.00034	-0.00019	-0.00034	-0.00019
C	-0.0037	0.000529	-6.99593	6.24E-12	-0.00474	-0.00266	-0.00474	-0.00266
FHPP, TL	9.361899	1.453591	6.440534	2.23E-10	6.507915	12.21588	6.507915	12.21588
NoT (0-15 min)	0.005853	0.000339	17.2504	1.01E-55	0.005187	0.006519	0.005187	0.006519
APD (0-15 min)	-0.62557	0.022496	-27.8076	8.7E-115	-0.66974	-0.5814	-0.66974	-0.5814
NoS	0.022188	0.004434	5.004033	7.13E-07	0.013482	0.030894	0.013482	0.030894
ToS	-0.04193	0.003771	-11.1192	1.55E-26	-0.04933	-0.03453	-0.04933	-0.03453
SPD	-0.01535	0.002764	-5.55568	3.95E-08	-0.02078	-0.00993	-0.02078	-0.00993
DV_{C+PC}	0.051368	0.40644	0.126386	0.899463	-0.74664	0.849374	-0.74664	0.849374
DV_{S}	1.213028	0.421449	2.878231	0.004123	0.385553	2.040503	0.385553	2.040503
$DV_{LS+S+HS}$	3.293337	1.019098	3.231621	0.001289	1.292438	5.294237	1.292438	5.294237
DV_{R}	0.040244	0.54095	0.074394	0.940718	-1.02186	1.102346	-1.02186	1.102346
$DV_{LR+STHR+HR}$	-0.62041	0.684982	-0.90573	0.365397	-1.9653	0.72449	-1.9653	0.72449

Table 9. Income in on-street parking spaces was analyzed using a dummy variable multiple regression model

Regression Statistics	
Multiple R	0.988828
R Square	0.977781
Adjustable R Square	0.977396
Standard Error	1715.023
Observation	706

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	12	8.97E+10	7.47E+09	2541.39	0
Difference	693	2.04E+09	2941303		
Total	705	9.17E+10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Low 95%*	*High 95%*	*Low 95.0%*	*High 95.0%*
Intersection	-111344.8	9700.151	-11.47866	4.82E-28	-130390	-92299.57	-130390	-92299.57
TOR	2282.144	302.9572	7.532893	1.55E-13	1687.32	2876.968	1687.32	2876.968
C	5.746847	0.433791	13.24798	7.16E-36	4.895146	6.598548	4.895146	6.598548
FHPP, TL	15772.13	944.105	16.70591	6.68E-53	13918.48	17625.78	13918.48	17625.78
NoCT	6.928914	0.278429	24.88575	3.62E-98	6.382249	7.47558	6.382249	7.47558
APD (0-15 min)	-83.24899	13.19134	-6.310884	4.95E-10	-109.1488	-57.34921	-109.1488	-57.34921
APD, min	84.05163	17.67854	4.754444	2.42E-06	49.3417	118.7616	49.3417	118.7616
NoS	28.29809	2.625609	10.77772	3.8E-25	23.14299	33.45319	23.14299	33.45319
PSP	-92.34547	28.2074	-3.273803	0.001114	-147.7277	-36.96326	-147.7277	-36.96326
ToS	-14.02526	2.233158	-6.280461	5.96E-10	-18.40982	-9.640692	-18.40982	-9.640692
DV_{C+PC}	580.2192	184.5786	3.14348	0.001741	217.8189	942.6196	217.8189	942.6196
DV_S	719.2909	193.4212	3.718779	0.000216	339.529	1099.053	339.529	1099.053
$DV_{LS+S+HS}$	-1143.241	595.4968	-1.91981	0.055292	-2312.435	25.95347	-2312.435	25.95347

3.4. Effect of Weather Conditions on Parking Income

In the first regression analysis, NoT, EP, ODP, NoT (0-15 min), ACPD, and SPD variables that have P-values greater than 0.05 are also subtracted from the data set. The second regression analysis statistics with 706 observations are given in Table 9. The R square for parking income is 97.7%. Nine of the coefficients in the regression statistics have P-values less than 5%. First-hour parking price (FHPP) has also the biggest effect on parking income. For each TL increase in FHPP, parking income increases by 15,772 TL. It is also determined that both *sunny (DV_S) and cloudy + partly cloudy (DV_{C+PC})* weather variables used as dummy variables increase *parking income by 719 TL and 580 TL*, respectively. (*Cloudy + partly cloudy (DVC+PC) weather conditions have had an increasing effect on the turnover rate. The average general turnover rate is 3.07; in cloudy + partly cloudy weather, it increases to 3.14 and the average cash parking time is reduced to a small extent).*

Light snow + light snowfall + snow + snow + heavy snowstorm ($DV_{LS+S+HS}$*)* weather variable, used as a dummy variable *decreases parking income by 1143 TL.* None of the other weather condition variables in the model are significantly associated with parking income.

The estimated regression equation for income (4) is

***I** = -111344.8 + 2282*TOR + 5.75*C + 15772*FHPP + 6.93*NoT – 83.24*APD (0-15 min) +84.05*APD + 28.30*NoS - 92.34*PSP – 14.02*ToS + 580.22*DV_{C+PC} + 719.30*DV_S – 1143.24*$DV_{LS+S+HS}$ (4)*

4. Conclusions

As a result of the increasing number of vehicles with urbanisation trends in our country and in the world, car parking has become a major problem due to the inadequacies of transportation infrastructure and superstructure. These problems cannot be solved due to traditional transport policies and planning. The appropriate positioning of open and closed car parks and the provision of holistic car park management and control is one of the most important factors that positively affect urban life and quality (Gül et al., 2019; Özkan et al., 2020).

The car parking problem should be addressed within the framework of the city's holistic transport planning and policy. According to the existing conditions (spatial, environmental, social and economic conditions) in public spaces, a balance should be achieved between the long and short-term parking needs of different user demands, pricing, duration of use and roadside and off-road car parking supply, and a consistent car parking policy and management should be established in line with the objectives (Gül et al., 2019).

In this study, the effect of weather conditions on on-street parking variables is examined. And to that end data sets are consisted of 17 variables such as parking capacity, employee personnel, off-duty personnel, turn-over rate, first-hour parking price, daily parking price, number of transactions, number of cash transactions, average cash parking duration, 0-15 min. parking duration, average parking duration, number of subscriptions, parking subscription price, daily transactions of subscription, subscription parking duration, and income in the on-street parking spaces in the Anatolian side of Istanbul for two years. Dependent variables (turn-over rate, parking duration, cash parking duration, and parking income) are investigated by multiple regression analysis with weather condition variables as dummy variables. Daily general weather data during this period are classified into 11 categories (sunny, cloudy, partly cloudy, light rain, rain, short-term heavy rainfall, heavy rainfall, light snow, light snowfall, snow, and heavy snowstorm). Obtained results from multiple regression analysis with dummy variables are summarized as follows:

- It is determined that the weather condition variables used as dummy variables do not affect the turnover rate.
- The first-hour parking price (FHPP) also has the biggest effect on it. For each unit (TL) increase in FHPP, the turnover rate increases by 0.446 units.
- It is determined that sunny (DV_S) and light snow + light snowfall + snow + heavy *snowstorm* ($DV_{LS+S+HS}$) weather variables used as dummy variables decrease parking duration by 0.528 and 1.293 min, respectively. None of the other weather condition variables in the model are significantly associated with parking duration.
- First-hour parking price (FHPP) has also the biggest effect on parking duration. For each TL increase in FHPP, parking duration decreases by 4.32 min.
- First-hour parking price (FHPP) has also the biggest effect on cash parking duration. For each TL increase in FHPP, cash parking duration increases by 9.36 min.
- It is determined that both sunny (DV_S) and light snow + light snowfall + snow + heavy snowstorm ($DV_{LS+S+HS}$) weather variables used as dummy variables increase cash parking duration by 1.21 and 3.29 min, respectively. None of the other weather condition variables in the model are significantly associated with cash parking duration.
- First-hour parking price (FHPP) also has the biggest effect on parking income. For each TL increase in FHPP, parking income increases by 15,772 TL.
- It is determined that both sunny (D_{VS}) and cloudy + partly cloudy (DV_{C+PC}) weather variables used as dummy variables increase parking income by 719 TL and 580 TL, respectively. Light snow + light snowfall + snow + snow + heavy snowstorm ($DV_{LS+S+HS}$) weather variable, used as a dummy variable decreases parking income by 1143 TL. None of the other weather condition variables in the model are significantly associated with parking income.

Acknowledgments and Information Note

The authors would like to thank ISPARK's managers and employees who provided data support for the study.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article.

References

Arnott, R. & İnci, E. (2010). The stability of downtown parking and traffic congestion. *Journal of Urban Economics*, Vol. 68, No.3, 260-276.

Arnott, R., İnci, E. & Rowse, J. (2015). Downtown curbside parking capacity. *Journal of Urban Economics*, Vol.86, 83-97.

Ayala, D., Wolfson, O., Xu, B., Dasgupta, B. & Lin, J. (2011). Parking slot assignment games. 19th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems.

Ayala, D., Wolfson, O., Xu, B., Dasgupta, B. & Lin, J. (2012). Parking in competitive settings: A gravitational approach. Proceedings – IEEE 13th International Conference on Mobile Data Management, MDM, 27-32.

Azari, K. A., Arintono, S., Hamid, H., Atiq, R. & Rahmat, O. K. (2013). Modelling demand under parking and cordon pricing policy. *Transport Policy*, No. 25, 1-9.

Barter, P. (2016). On-Street Parking Management - An International Toolkit, Sustainable Urban Transport Technical Document #14.

Barter, P. (2018). Promising urban parking policy innovation - international policy agendas and trends of possible relevance for German cities. Breakfast Meeting, Agora Verkehrswende, Berlin.

Concas, S. & Nayak, N. (2012). A meta-analysis of parking price elasticity. In: Proceedings of the TRB Annual Meeting, Washington, DC.

Demir, A. & Çavdar, A. (2008). On-street parking technologies and Istanbul application. OTEKON'08-4. The Congress of Automotive Technologies, Proceedings Book, 645-653, Bursa, [in Turkish].

Demir, A. (2019). Investigation of user's behaviors in paid on-street parking in İstanbul. *Teknik Dergi*, 30 (3), DOI: 10.18400/tekderg.366692.

Gillen, D.W. (1977). Estimation and specification of the effects of parking costs on urban transport mode choice. *J. Urban Econ*. 4, 186-199.

Goyal, S. K. & Gomes, L. F. A. M. (1984). A model for allocating car parking spaces in universities. *Transportation Research Part B*, 18 (3), 267-269.

Gragera, A. & Albalate, D. (2016). The impact of curbside parking regulation on garage demand. *Transport Policy* 47, 160–168.

Gragera, A. (2017). The economics of parking: essays on regulation. Competition and Information Frictions, Universitat de Barcelona, http://diposit.ub.edu/dspace/handle/2445/118745.

Gül, A., Öz, A., Demir, A. & Gül, İ. E. (2019). Planning and Design Principles of Car Parking in Urban Transportation (Kent Ulaşımında Otoparkların Planlama ve Tasarımı). (Chapter 2). Mühendislik ve Fen Bilimleri Kapsamında Güncel Akademik Çalışmalar Kitabı (Editörler: Abdullah Demir, Ali Öz & Çağatay Ersin). Strategic Researches Academy & Strategic Researches Academic Publishing. ISBN: 978-605- 69709- 9-3 p.13-44, Antalya/Türkiye.

Guo, L., Huang, S., Zhuang, J. & Sadek, A.W. (2013a). Modeling parking behavior under uncertainty: a static game theory versus a sequential neo-additive capacity modeling approach. *Networks and Statial Economics*, vol. 13, issue 3, 327-350.

Guo, L., Huang, S. & Sadek, A. W. (2013b) A novel agent-based transportation model of a university campus with application to quantifying the environmental cost of parking search. Transportation Research Part A. Policy and Practice, vol. 50, pp. 86-104.

Gurbetci, K., Demir, A. & Çavdar, A. (2007). Passenger cars at sustainable transportation in Istanbul. TRODSA - 4th National Road and Traffic Safety Congress, Proceedings Book, 201-211, Ankara, [in Turkish].

Gurbetci, K., Demir, A. & Karaahmet, A. (2014). Technology, Environment and Safety Factors in The Car-Parking Applications. Ilke Publishing, ISBN: 978-605-5961-38-1, [in Turkish].

Hajimohamadipour, O. (2016). An investigation of surface parking lots and developing design strategies. İstanbul Technical University, Master of Landscape Architecture.

Harris, A. M. (2004). Designing with climate: using parking lots to mitigate urban climate. Master of Landscape Architecture Department of Landscape Architecture College of Architecture and Urban Studies, Faculty of Virginia Polytechnic Institute & State University, April 8, 2004 Blacksburg, Virginia.

Hess, D. B. (2001). The effects of free parking on commuter mode choice: evidence from travel diary data. *Transp. Res. Rec.* 1753, 35–42.

Hoh, B., Yan, T., Ganesan, D., Tracton, K., Iwuchukwu, T. & Lee, J. (2012). TruCentive: A game-theoretic incentive platform for trustworthy mobile crowdsourcing parking services. IEEE Conference on Intelligent Transportation Systems, Proceedings, ITSC, 160-166.

Hunt, J. D. & Teply, S. (1993). A nested logit model of parking location choice. *Transportation Research B*, vol. 27B, No. 4, 253-265.

ICPMMP. (2016). Istanbul Car Parking Management Master Plan.

IETT. (2018). The Istanbul Electric Power, Funicular and Streetcar Board, General Directorate Information Notes, [in Turkish].

İnci, E. & Lindsey, R. C. (2015). Garage and curbside parking competition with search congestion. *Regional Science and Urban Economics*, Vol.54, 49-59.

İnci, E. & Robin, C. (2015). Garage and curbside parking competition with search congestion. *Regional Science and Urban Economics*, Vol.54, 49-59.

İnci, E., Van Ommeren, J. & Kobus, M. (2017). The external cruising costs of parking. *Journal of Economic Geography*, Vol.17, No.6, 1301-1323.

İSPARK. (2018). Istanbul Parking Management Trade Inc. (Received by Correspondence).

Kelly, J. A. & Clinch, J. P. (2006). Influence of varied parking tariffs on parking occupancy levels by trip purpose. *Transp. Policy* 13, 487–495.

Kelly, J. A. & Clinch, J. P. (2009). Temporal variance of revealed preference on-street parking price elasticity. *Transport Policy* 16 (4), 193-199.

Khodaii, A., Aflaki, E. & Moradkhani, A. (2010). Modeling the effect of parking fare on personal car use. *Trans. A: Civil Eng.* 17, 209-216.

Kobus, M. B. W., Guitiérrez-i-Puigarnau, E., Rietveld, P. & Van Ommeren, J. N. (2013). The on-street parking premium and car drivers' choice between street and garage parking. *Reg. Sci. Urban Econ*. 43, 395-403.

Mejri, N., Ayari, M., Langar, R. & Saidane, L. (2016). Con2PaS: A constrained congestion game for parking space assignment. 5th IFIP International Conference on Performance Evaluation and Modeling in Wired and Wireless Networks, PEMWN, 22-24.11.2016, Paris.

Newbold, P., Carlson, W. L. & Thorne, B. M. (2013). Statistics for Business and Economics. *Pearson Education*.

Nourinejad, M. & Roorda, M. J. (2017). Impact of hourly parking pricing on travel demand. *Transportation Research Part A, Policy and Practice*, vol. 98, 28-45.

Nourinejad, M. & Roorda, M. J. (2017). Impact of hourly parking pricing on travel demand. *Transportation Research Part A, Policy and Practice*, vol. 98, 28-45.

Özkan, F., Öz, A., Demir, A., Gül, İ. E. & Gül, A. (2020). Eğirdir Kent Merkezi Ulaşım Sisteminde Mevcut Sorunlar ve İrdelenmesi. (Suggestions and The Current Problems on Road Transportation of Eğirdir City Center). Eds. Atila Gül & Şükran Şahin, Isparta – Eğirdir Özelinde Mekânsal Planlama ve Tasarıma Yönelik Akademik Vizyon, Bölüm 19. s.271-297. Astana Yayınları, ISBN: 978-625-7890-39-7.

Parkitny, W. (2014). Analysis of chosen logit models to predict the behaviour of personal vehicles' drivers with reference to car parks choice. Logistyka, nr 6, listopad – grudzień 2014, Logistyka – nauka Artykuły recenzowane, DVD nr 3, 8383-8391.

Parkitny, W. (2017a). Analysis of dependences between using of parking places and chosen parameters of weather on the example of underground parking in cracow. IOP Conference Series: Earth and Environmental Science, IOP Conf. Series: Earth and Environmental Science 95 052011 doi :10.1088/1755-1315/95/5/052011

Parkitny, W. (2017b). Using the theory of games to modelling the equipment and prices of car parking. World Multidisciplinary Civil Engineering – Architecture - Urban Planning Symposium - WMCAUS 2017, Prague, Czech Republic, 11-15.06.2017, IOP Conference Series: Materials Science and Engineering, doi: 10.1088/issn.1757-899X, ISSN: 1757-8981, Online ISSN: 1757- 899X.

Pierce, G. & Shoup, D. (2013). Getting the prices right. *Journal of the American Planning Association*, 79:1, 67-81, DOI: 10.1080/01944363.2013.787307.

Praburam, G. & Koorey, G. (2015). Effect of On-Street Parking on Traffic Speeds, IPENZ Transportation Group Conference, Rydges Hotel, Christchurch.

Shoup, D. C. & Wilson, R. (1992). Employer-paid parking: the problem and proposed solutions. *Transp. Q.* 46, 169-196.

Shoup, D. C. (2006). Cruising for parking. *Transport Policy*, 13, 479-486.

Simicevic, J., Milosavljeciv, N., Maletic, G. & Kaplanovic, S. (2012). Defining parking price based on users' attitudes. *Transp. Policy* 23, 70–78.

Simicevic, J., Vukanovic, S. & Milosavljeciv, N. (2013). The effect of parking charges and time limit to car usage and parking behaviour. *Transp. Policy,* 30, 125-131.

Thompson, R. G. & Richardson, A. J. (1998). A parking search model. *Transportation Research Part A*, vol. 32, No. 3, Elsevier Science Ltd, Great Britain, 159-170.

Tsamboulas, D. A. (2001). Parking fare thresholds - A policy tool. *Transport Policy* 8, 115–124.

TSI. (2017a). Motorized road vehicles. Turkish Statistical Institute, January 2017, Issue No: 24596, March 10, www.tuik.gov.tr, [in Turkish], Date of access: 06.05.2017.

TSI. (2017b). Population statistics. Turkish Statistical Institute, www.tuik.gov.tr, Date of access: 06.05.2017, [in Turkish].

TUIK. (2017). Motorlu Kara Taşıt Sayısı, https://data.tuik.gov.tr/.

Uzun, Ö. L. (2009). The examination of the effects of the on-street parking strategy on traffic intensity and exhaust emission. Marmara University, Technical Education, Mechanical Teaching, MSc, İstanbul.

Uzun, Ö., Gümüş, M. & Demir, A. (2021). Ücretli yol kenarı parkların trafik akışına etkisinin incelenmesi. *İdealkent,* 12 (34), 1878-1899. DOI: 10.31198/idealkent.709333

Weis, C., Vrtic, M., Widmer, P. & Axhausen, K. W. (2012). Influence of parking on location and mode choice: a stated choice survey. In: Proceedings of the 91st TRB Annual Meeting, Washington, DC.

Yardım, M. S. & Demir, A. (2009). Use of intelligent transportation systems in Istanbul's parking management. IMO - 8th Transportation Congress, [in Turkish].

Young, W., Thompson, R. G. & Taylor, M. A. P. (1991). A review of urban car parking models: Foreign summaries. *Transport reviews*, vol. 11, Issue 1, January-March, 63-84.

Zong, F., Zhang, Y. S., Wang, Z. Z. & Li, Z. Y. (2013). Parking pricing analysis in urban central business district. *Journal of Jilin University (Engineering and Technology* Edition), vol. 43, Issue 5, 1235-1240.