Logistic regression model for user preference of online parking: A study case of Sidoarjo

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Logistic regression model for user preference of online parking: A study case of Sidoarjo

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Abstract. This paper investigated the factors affecting user preference of online parking in Sidoarjo Regency of Indonesia, using a binary logistic regression model approach. This model could predict user preference between online and offline parking system. Through a nonprobability convenience sampling technique, structured questionnaire was used to collect primary data from 384 respondents in three different parking location of Sidoarjo. The result of the binary logistic regression model revealed that gender, age, parking frequency, and parking duration are the four main factors that are significantly affect user parking decision. This will be definitely helpful to the government of transportation department as parking policy maker to evolve strategies in encouraging people to use online parking.

1. Introduction

The number of motor vehicles in Indonesia is increasing significantly from year to year and caused many problems such as traffic jams and parking problems. In a review of 16 studies conducted in 11 cities in the United States, an average 30% of the causes of traffic congestion occurred were parking spaces [1]. This happens because of the difficulty of finding parking spaces when the parking area is crowded, driver must search for available parking lot when they want to park their vehicles, this causes frequent queues of vehicles. The good governance of parking system is needed to deal with these problems.

Parking policies are one of the most effective ways that urban planners and government as policy makers to manage travel demand and traffic in the city center. In many countries, governments use parking policies as a way to reduce urban road traffic where an effective parking system is one that can reduce congestion. Local governments in Indonesia have begun to think about how to overcome parking problems in their areas by making parking policies that can provide optimal regional income and can also solve parking problems in Indonesia. Parking policies that has been developing in the industrial revolution 4.0 is an online vehicle parking reservation system. This system can provide smart parking management solutions by providing information on the availability of parking facilities and parking reservation systems [2]. The description of an online parking system where this system runs on a mobile platform and provides parking location information and available parking slots to users, making it easier for parking users to find an empty spot to park a vehicle. User can make a reservation of parking slot through the application and choose any payment method including cashless. There are certain things that must be research by parking policy makers when implementing an online parking system in Indonesia. Analysis of user preference should be performed to determine the factors that influence the

user in choosing online parking. So that parking policy makers can consider the strategies that must be taken to encourage people to switch from offline parking systems to online parking systems.

The case study in this research was conducted in Sidoarjo regency as in 2019 the Sidoarjo government had conducted a feasibility study on the Online Parking System as a parking system solution based on mobile apps. In 2018, parking income contributed Sidoarjo revenue only IDR 28,176,793,500 of the expected revenue IDR 102,146,595,652 [3]. This indicate that there is a leakage of parking revenue in Sidoarjo. To overcome this problem the government of Sidoarjo proposed an online parking system which is trusted to be able to facilitate the public in accessing local government parking facilities and could increase regional revenue since the parking payments go directly to the local treasury.

A certain previous research has explored the factors that influence parking user decisions. Most studies have shown that user parking decision is influenced by demographic variables. For example, Shiftan and Burd-Eden [4] found that younger individuals were more likely to change travel behavior in response to parking restrictions such as increased parking costs or reduced parking availability. Research conducted by Golias et al. [5] show that parking costs have the most important impact on alternative choices of on-street or off-street parking, besides all the other variables that have a significant impact on time-related parking choices. Zong et al. [6] shows that an increase in parking fees will shorten the duration of parking; tourists for work purposes will have a longer parking duration; and the greater the number of passengers, the higher the probabilities of on-street parking. But there is no research that has explored the factors that influence users in choosing online parking, where this research will analyze that problem. The results of previous research are used as a reference in determining factors that are expected influencing user's decision in choosing a parking system.

Logistic regression is one model for estimating the relationship between categorical response variables with one or more continuous or categorical predictor variables. In cases where the response variable is a qualitative variable which is binary then binary logistic regression is used. The binary response variable consists of two categories namely "yes (success)" and "no (failure)" and denoted 1 = "success" and 0 = "fail [7]. Therefore, binary logistic regression is used to analyze the problem in this research, which is to investigate the factors affecting user preference of parking system where the response variable is binary namely "online parking" and "offline parking". This will be definitely helpful to the government of transportation department as parking policy maker to evolve strategies in encouraging people to use online parking.

2. Literature Review

2.1 Online Vehicle Parking Reservation System

The online vehicle parking reservation system is an online-based application for parking lot reservations for vehicles and parking data processing. This system can provide smart parking management solutions by providing information on the availability of parking facilities and parking reservation systems [2]. Vehicle drivers who really need a parking lot in a short time can access this system without any other vehicles blocking. This is quite the opposite of conventional parking systems which take quite a long time. In addition, the existence of online and cashless payment patterns makes it easier for drivers to process parking briefly.

2.2 Factors Influencing Parking Decisions

A review of the various factors that influence the parking decision that has been identified in the literature will be carried out in this section. Demographic variables such as age, gender, parking frequent, parking duration, and level of education is demographic variables that expected affect the parking decisions. Shiftan and Burd-Eden [4] found that younger individuals were more likely to change travel behavior in response to parking restrictions such as increased parking costs or reduced parking availability. Mo et al. [8] found that men were more likely to park for short periods (<1 hour) than women, even though both sexes parked most often between 1 and 3 hours. Thompson et al. [9] found that tourists with high parking frequencies to an area tend not to need information about waiting times and parking location. Golias et al. [5] who examined the parking duration, parking costs, search time and egress time, and found an increase in preferences for off-street car parking. The influence of an individual's level of education on parking choice was investigated by Anastasiadou et al. [10] who found

university graduates were willing to pay, on average, higher parking charges than non-university educated individuals.

2.3 Logistic Regression Approach

Logistic regression is used if the response variable is categorical (nominal or ordinal) with continuous and categorical predictor variables [11]. Logistic regression is a regression method that describes the relationship between a response variable with one or more predictor variables, where the response variable is dichotomous (nominal or ordinal scale with two categories) or polychotomous (having a nominal or ordinal scale with more than two categories). In cases where the response variable is a qualitative variable which is binary or dichotomous, then binary logistic regression is used. Dichotomous variables are variables that have only two possible values, for example success and failure. Binary logistic regression is a logistic regression analysis between predictor variables and response variables consisting of two categories (dichotomous). The response variables consisted of two categories namely "yes (success)" and "no (failed)" and denoted 1 = "success" and 0 = "failed". The response variable (y) follows the Bernoulli distribution with the probability function as follows [7].

$$f(y_i) = \pi(x_i)^{y_i}\left(1 - \pi(x_i)\right)^{1-y_i} \text{ with } y_i = 0,1$$

$$If\ y_i = 0, then\ f(0) = \pi(x_i)^0\left(1 - \pi(x_i)\right)^{1-0} = 1 - \pi(x_i)$$

$$If\ y_i = 1, then\ f(1) = \pi(x_i)^1\left(1 - \pi(x_i)\right)^{1-1} = \pi(x_i)$$

The general form of the Logistic Regression model with p independent variables is as follows:

$$\pi(x) = \frac{exp\left(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p\right)}{1 + exp\left(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p\right)}$$

By using logit transformation, the binary logistic model can be written as follows:

$$g(x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p$$

3. Research Methodology

The purpose of this study is to predict the user preference of an online parking system when his/her exact demographic profile is known. At this stage the data was collected using primary data by conducting a survey directly to 384 respondents in three different on-street parking location of Sidoarjo which is managed directly by the city government. Respondents in this study were user who had parked their motorcycle on-street in Sidoarjo Regency. A nonprobability convenience sampling technique has been adopted for identifying samples from the population. A specific questionnaire was developed for this study and the same was used to collect data from the respondents.

The researcher has used the binary logistic regression as a part of model building where the dependent variable is a dichotomous variable like preference of parking system (online or offline parking system). The logistics regression analysis could identify the relation between user preference of

parking system and the factors that influence user preferences to choose online or offline parking system. The dependent variable is analyzed with respect to the 5 independent variables presented in Table 1. The response variable is user decision to choose parking system which assigns the value "0" to the "offline parking" answer and the value "1" to the "online parking" answers. Hence, the results are interpreted with respect to these values in the following section. The predictor variables used in this study can be seen in Table 1.

Table 1. Predictor variables

Predictor Variable (X)	References	Categories
Age(X_1)	Shiftan and Burd-Eden [4]; Golias et al. [5]; Van der Waerden et al. [9]; Anastasiadou et al. [10]; Tsamboulas [12]; Teknomo and Hokao [13]	1. 20-29 years 2. 30-39 years 3. 33-42 years 4. 43-52 years 5. > 53 years
Gender(X_2)	Golias et al. [5]; Mo et al. [8]; Tsamboulas [12]	1. Male 2. Female
Parking Frequent(X_3)	Golias et al. [5]; Tsamboulas [12]; Van der Waerden et al. [13]	1. < 30 times/month 2. 30-45 times/month 3. 46-60 times/month 4. >60 times/month
Parking Duration(X_4)	Shoup [1] ; Golias et al. [5]; Tsamboulas [12]; Van Ommeren et al. [14]	1. < 1 hours 2. 1-2hours 3. 2-4hours 4. 4 hours
Education Level(X_5)	Anastasiadou et al. [10]; Salomon [15]	High School Diploma bachelor's degree

4. Result and Discussion

4.1. Demographic Characteristics of Respondents

The demographic characteristics of respondents in this study were classified by age, gender, parking frequency, parking duration and education level. This demographic is cross tabulated with user preference on parking system. The results of this cross-tabulation are summarized in Table 2.

Table 2. Crosstab preferences with participant demographics

			Parking System Preference		Total
			Offline	Online	
Age	<19 years	Count	13	30	43
		%	30.2%	69.8%	11.2%
	20 - 29 years	Count	34	80	114
		%	29.8%	70.2%	29.7%
	30 - 39 years	Count	31	39	70
		%	44.3%	55.7%	18.2%
	40 - 49 years	Count	36	27	63
		%	57.1%	42.9%	16.4%
	>50 years	Count	49	45	94
		%	52.1%	47.9%	24.5%

Table 2. Crosstab preferences with participant demographics (*continued*)

			Parking System Preference		Total
			Offline	Online	
Gender	Male	Count	101	115	216
		%	46.8%	53.2%	56.3%
	Female	Count	62	106	168
		%	36.9%	63.1%	43.7%
Parking Frequency (/month)	<30	Count	56	69	125
		%	44.8%	55.2%	32.6%
	30-45	Count	81	130	211
		%	38.4%	61.6%	54.9%
	46-60	Count	14	13	27
		%	51.9%	48.1%	7.0%
	>60	Count	12	9	21
		%	57.1%	42.9%	5.5%
Parking Duration	< 1 hours	Count	41	66	107
		%	38.3%	61.7%	27.9%
	1 - 2 hours	Count	32	51	83
		%	38.6%	61.4%	21.6%
	2 - 4 hours	Count	28	54	82
		%	34.1%	65.9%	21.4%
	> 4 hours	Count	62	50	112
		%	55.4%	44.6%	29.2%
Education Level	High School	Count	134	175	309
		%	43.4%	56.6%	80.5%
	Diploma	Count	5	7	12
		%	41.7%	58.3%	3.1%
	Bachelor	Count	24	39	63
		%	38.1%	61.9%	16.4%
	Total	Count	163	221	384
		%	42.4%	57.6%	100.0%

Table 2 provides information that out of the 384 respondents in this study, based on classification of age groups '20-29 years' (29.7%), followed by age '>50 years' (24.5%), 30-39 years (18.2%), 40-49 years (16.4%) and '<19 years' (11.2%). 216 respondents (56.3%) were male and the remaining 168 respondents (43.7%) were female. Based on the classification of parking frequency in a month, 54.9% of respondents generally parking 30-45 times and only 5.5% respondents parking more than 60. The findings for parking duration indicated that the highest number of responses occurred for the longest duration '>4 hours' with 82 respondents (29.2%) selecting this option. This was followed by the shortest duration of '< 1 hours' with 107 respondents (27.9%). Classification by education level indicates that the majority of participants are at education level of high school (80.5%), followed by bachelor (16.4%), and diploma (3.1%).

Table 2 generally indicates that the majority of participants in this study had a tendency to choose to online parking system (61% of participants). Moreover, it also indicates that younger user, on contrary with older user in this study prefer to choose online parking.

4.2. Logistic Regression Results

The researcher has developed a logistic regression model for predicting user preference based on demographic factors that influence user to choose online or offline parking system. For selecting the

significant independent variables, the researcher has used backward likelihood ratio method of logistic regression analysis. Backward likelihood ratio has been selected that include all candidate variables at initial step and ended with the most significant variables. This method is removal testing which based on the probability of the likelihood-ratio statistic based on the maximum partial likelihood estimates. The final iteration results of the logistic regression model are given in Table 3.

Table 3. The results of binary logistic regression

Parameter	B	S.E.	Wald	df	Sig.	Exp(B)
Age_X1			17.183	4	0.002	
Age_X1(1)	0.905	0.411	4.849	1	0.028	2.472
Age_X1(2)	0.843	0.303	7.739	1	0.005	2.323
Age_X1(3)	0.174	0.332	0.274	1	0.601	1.19
Age_X1(4)	-0.365	0.343	1.135	1	0.287	0.694
Gender_X2(1)	-0.468	0.226	4.285	1	0.038	0.626
Parking_Frequency_X3			9.067	3	0.028	
Parking_Frequency_X3(1)	0.393	0.502	0.614	1	0.433	1.482
Parking_Frequency_X3(2)	1.003	0.496	4.091	1	0.043	2.726
Parking_Frequency_X3(3)	0.292	0.619	0.223	1	0.637	1.339
Parking_Duration_X4			12.814	3	0.005	
Parking_Duration_X4(1)	0.968	0.307	9.936	1	0.002	2.632
Parking_Duration_X4(2)	0.972	0.324	8.989	1	0.003	2.644
Parking_Duration_X4(3)	0.638	0.323	3.903	1	0.048	1.892
Constant	-1.036	0.548	3.569	1	0.059	0.355

Table 3 shows the logistic regression results, Wald's test and the odd-ratio ratio of each predictor variable in predicting user preferences of parking system. The significance level used in this study is 5%. At this level, age, gender, parking frequency and parking duration have a significant effect in predicting user preferences of parking system since the p-value (sig) is less than 0.05 while the variables of education level have no significant effect in the proposed model.

Table 3 also displays odd ratio value which is an important information to explain the influence of the independent variables on the increasing or decreasing of probability to occur the event measure by the dependent variable. For example, based on odds ratio of variable X2(1) (that is predictor variable, category 1: gender is male) is 0.626. These results indicate that under conditions where other variables in this study are the same, male user who prefer to choose online parking system application is 0.626 times more than female user. Table 3 shows the odd-ratio value of age decrease by the increasing age. It can be concluded that the increasing of user age causes a shrinkage of user preference to choose online parking system.

5. Conclusion

This study results demonstrate that user preferences of a parking system both online and offline are influenced by the demographic variables of a parking user. The logistic regression was created to predict user preference of online parking system. Through this model, the factors affecting the user preference of parking system were evaluated. Factors influenced by user age, gender, parking frequency and parking duration, were found to be significant. The study concluded that female more prefer to park online than male. Moreover, the study reveals that the younger user is, the more the chance they will choose to park online. Furthermore, no significant difference in education level group is revealed. As implications, this study identifies user parking system preferences and their tendency toward online parking. Government of transportation department as parking policy maker can be better prepared to

evolve strategies to encouraging people using online parking based on which factors have a significant influence on the preferences of users choosing online parking.

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