

## CAR USERS WILLINGNESS TO CHANGE TRAVEL MODE IN RESPONSE TO ON-STREET PARKING PRICING: A CASE STUDY OF DHAKA CITY

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Received: 22 November 2021

Accepted: 02 October 2022

### ABSTRACT

*Dhaka is facing severe on-street parking challenges as car ownership emerges. This situation has led traffic congestion not only in local roads but also in collector and arterial roads. Parking plays a significant function in the management of traffic and congestion. In Dhaka city most of the on-street parking spaces are free which persuades car users to park their car randomly. The objective of this research is to examine car users' behavior if on-street parking pricing is implemented. A questionnaire survey was conducted in arterial, feeder (or collector) and in local roads at 16 locations in Dhaka city. Attention was drawn to confirm that the survey could deal with either professional drivers or motorists driving their own car as respondents. A multinomial logistic regression model was developed by using the data collected from 500 respondents. Based on the analytical results along with in-depth on-site investigations it was found that the probability of changing mode due to on-street parking pricing is insignificant. Result demonstrates that educational qualification is the most important variable for switching mode from car to other if on-street parking charge is applied. Most of the users whose parking is associated with education and work trips will not change their transport mode if on-street parking charge is put into operation. Those trips are most closely associated with travel in peak periods and largely responsible for congestion. Car users usually face difficulties to find space for parking.*

**Keywords:** Parking Pricing, Multinomial Logistic Regression Model, Mode Change

### 1. INTRODUCTION

On-street parking issues draw significant observance in cities of developing and developed countries. Urban sprawl and increased car ownership have resulted severe parking issues in Asian region (ADB, 2011). Only limited number of Asian cities possess strategies to restrain parking provisions, yet in city centers where the alternatives to driving are the richest (ADB, 2011). As an effective TDM (traffic demand management) tool, parking pricing is commonly implemented by metropolitan cities. On the other hand, the returns of the parking operators and travelers' choices on types of modes, directions or routes, and parking amenities (Lam et al., 2006; Glazer & Niskanen, 1992) depend on the parking price. Due to on-street parking overall speed of the stream decreases and it obstructs other vehicles. Hence on-street parking management is essential, particularly with roads of high vehicular demand.

Dhaka is the capital city of Bangladesh and 10<sup>th</sup> largest city in the world having 18 million population. It is the main center of trade, industries, business, and education etc. With the increase of population, the number of private cars is also growing. Dhaka is facing severe on-street parking challenges as car ownership emerges. This situation has led traffic congestion not only in local roads but also in collector and arterial roads. Total number of registered private passenger cars in Dhaka from 2009 to 2015 are 209531 (BRTA, 2015). Private vehicles are mostly operated for personal purposes and comprised about 25% of all registered motor vehicles in Dhaka metropolitan area. The situation is worsened due he sluggish urbanization (Wenzhi & Bai, 2006).

Parking has a significant influence in controlling traffic congestion. Basic motivations for parking management are for example increasing road network efficiency, mobility management, decreasing parking challenges, generation of returns and city redevelopment (Marsden 2006; McShane & Meyer 1982). To keep pace with the rising auto use parking management and parking allocation should function collectively with the increasing number of vehicular usage (Tumlin, 2012). Car users should be encouraged to park only for short time in the adjacent parking and to avoid all the day long parking. Easing parking for residents instead of tourists is likewise a widespread practice. Priority setting in parking management is always challenged, with successes and failures, making it inherently controversial.

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ISSN 2075-4914 (print); ISSN 2706-6835 (online)

Among the parking management techniques parking pricing is an example of means where car users need to pay while using up the parking amenities (VTPI, 2005). The objectives of parking management are to decrease transport issues, to generate revenue and to reduce parking concerns. Often parking management is aimed to attain multiple objectives. Parking pricing is the most popular solution to control parking behavior on street. Regarding the on-street parking, several authors (Vickrey, 1954; Roth, 1965; Shoup, 2005) explored that at any specific time and location parking should deliver adequate space for decreasing parking search to reduce peripheral influences upon traffic.

Litman (2006) represents parking management as a “paradigm shift” corresponding to a major amendment in the way an issue is recognized and outcomes are assessed. Old paradigm outlines parking issue when parking supply is not adequate in a location. It attempts to increase parking provisions and reduce its cost to provide optimal parking supply and price. It believes both excessive or small supply of parking is detrimental and too little or high price is harmful as well. However, there is an evident relation between parking supply, parking cost, and mode selection, and it is a significant concern for decision makers to manage the parking area in a multi-modal transport structure (Rye et al., 2008; Weinberger et al., 2009).

Recently, motorizing cities around Asia are facing distressing difficulties in managing parking issues. It is a common scenario of Dhaka that commercial streets are blocked by cars. Numerous cars are parked on street and around curbs, and on many parts of footpaths. At times cars are double-parked. In most cases, off-street parking facilities remain somewhat unoccupied even though adjacent low-priced on-street parking stays supersaturated. It is mandatory for the city corporation to provide parking spaces for getting approval for construction of a structure. Sometimes shops are found in basement instead of parking (ADB, 2011).

Dhaka has very limited off-street parking facilities compared to its demand. As a result, a substantial loss in available roadway capacity is observed. It is estimated that up to 50% of the capacity of the arterial system is wasted due to poor operating conditions (2006). It is a massive work for Dhaka Metropolitan Police (DMP) to control the violations which occur frequently. Compared to other Asian cities like Taipei and Seoul having relatively high on-street parking prices (with variable prices in different locations), on-street parking prices are very little in Dhaka. Tokyo, Hong Kong and Singapore have remarkably reasonable on-street parking charges. On the other hand, Tokyo and Hong Kong add to their on-street appraising through time limits (ADB, 2011). It is believed that insufficient supply of off-street parking facilities results such undue on-street parking in Dhaka. Conversely, it is evident that ample off-street parking cannot assure of systematic on-street parking. In most cases, roadside shopping centers in Dhaka city do not have adequate provisions for parking. Most of the time car users are not concerned about the period and cost when they park their car at roadside. Due to uncontrolled on-street parking system traffic jam and pollution is very common scene in Dhaka city.

The objective of this research is to reveal the parking user's behavior if on-street parking pricing is applied by a discrete choice model. This article provides a brief literature review followed by methodology and explains the model development. Finally concluding remarks are made along with recommendations for future research.

## 2. LITERATURE REVIEW

Sometimes inadequate number of parking facilities results vehicles being parked along the streets. As a result, congestion may occur obstructing the flow of traffic. Parking pricing would help improve the vehicular flow as well as may become a source of revenue generation for the city. Regarding the on-street parking condition of Motijheel area, Dhaka Akter et al. (2013) showed that in general demand is 2.73 higher compared to the supply. This is happening due to the comparatively extensive duration of parking. Zannat et al. (2013) elucidated the parking scenario of New Market, Dhaka and showed that the average duration of parking is about 45 minutes while a considerable number of cars stay 3 to 5 hours in the parking area. An extensive study of Barter (2011) regarding the parking policy in Asian cities demonstrates that severe on-street parking problem exists in Dhaka city and lack of proper administration further deteriorates the situation. Chowdhury (2014) showed some faulty decisions of the authority. She emphasized on amendment of the approving guidelines of commercial buildings. Moreover, she critiqued the position of an off-street parking structure which would rather act as a congestion generator than mitigating as this did not consider self-induced parking demand. Sudipta et al. (2014) explored parking supply and demand for Agrabad, Chittagong, Bangladesh, which is one of the most business activity hubs.

Several models are employed by researchers for parking issues from different viewpoints. A logit model regarding the parking capacities and parking rationing constraints was developed by Bagloee and Asadi (2013). Stated preference data was employed by Axhausen et al. (1991) regarding users replies to modifications in parking features by logit models for selecting parking alternatives. Waraich and Axhausen (2012) employed a parking model into a present agent based traffic simulation that can apprehend the parking capacity and pricing. A mixed multinomial logistic regression model was developed Hess et al. (2009) to reflect the possible

correlative construction and personal heterogeneity. Ma et al. (2013) developed a multinomial logit model and revealed the connection between parking choice and rationale in Lama Temple, Beijing. A time dependent network equilibrium model was established by Lam et al. (2006) and result showed that parking activities is noticeably influenced by walking distance, travel demand, parking capacity and cost. A nested logit model was developed by Hensher et al. (2001) for mode and parking choices for parking allocations in Sydney central business district.

On the basis of several safety and operational studies, Box (2004) summarized that curb parking is responsible for congestion producing issues. Various viewpoints toward parking fees and congestion charge were assessed by Albert and Mahalel (2006) in order to explore their impact on travel time. The study showed that majority of the drivers want to get rid of congestion charges, therefore, they are willing to change the trip schedule. Hess (2009) conducted a study in central business districts (CBD's) of Portland (Oregon) to determine the effects of charge free parking in deciding the travel mode and the demand of parking for work trip purpose. A study by Vu (2017) revealed that the inadequacy of supply to accommodate the high demand of parking results in illegal parking. Biswas et al. (2017) explored that the effects of on-street parking vary upon the category of road and user's safety. If the charge for parking at work sites are increased then the tendency of driving to work alone will reduce. A study by Qian et al. (2012) examined parking charge, accessibility and parking design to minimize the total social costs.

Teknomo and Hokao (1997) conducted a study in the CBD of Surabaya to figure out the parking behavior of drivers in selecting a parking place. In the study three different parking location choice models were developed, namely Multinomial Logistic Model, Parking Demand Regression Model and Analytic Hierarchy Process. Result from the study showed that trip purpose, availability of parking spaces, parking fee, security, search and queue time, walking time and comfort-ability are the key influential factors effecting the behavior of parkers' in choosing a parking location.

Due to the underpricing of curb parking, some drivers are more interested to search for a curb space instead of paying comparatively higher amount for off-street parking. For this reason cruising has become a regular scenario in overfilled traffic. To find a way to eliminate cruising which is potentially causing more traffic congestion and wasting limited resource like fuel, many researches have been done throughout the last century. Most of the research showed that underpricing of curb parking is mainly responsible for cruising. So, these researches suggested that increasing charge for curb parking to fair market price will certainly help eliminating unwanted cruising. Simply, cruising is the individual response of driver's to the public pricing policy (ADB, 2011).

Glazer and Niskanen (1992) showed that conventional techniques, which usually decide the optimum pricing by marginal cost pricing model are not always adequate to evaluate these effects on travelers' selections and following alternates of demand of parking and network performance. Moreover, developing new parking facilities such as park and ride (P & R) facility makes the situation more complicated at those parking lots which are situated on the edge of any urban area as it encourages car drivers to park at those locations and enter the city by public transport. In case of higher cost or unavailability of off-street parking, many drivers will certainly look for curb parking as a realistic response to parking prices.

Parking in Asian cities become particularly significant and problematic due to fast increase of motor vehicle appeared in many countries. Due to this rapid growth of motor vehicle and uncertainty about its pace, policy of parking is getting quite challenging. Compared to world standards, most of the cities of this region are remarkably dense in terms of motor vehicles. Nonetheless, the parking problems become remarkably severe due to high densities. Associated high property prices with high density are impracticable to bring together with the desire among new car owners for parking to be low-priced and ample (ADB, 2011).

A study conducted in business district of Dhaka city (Motijheel) by Rahman (2007) showed that 60% of the parked vehicles are private cars. So, the workability of these commercial zones is governed by either the accessibility of convenient parking facilities nearby or availability of off-street parking facilities. Mahmud et al. (2012) revealed that the problem of illegal on-street parking in Dhaka got worse due to ineffective parking policies of it. This illegal on-street parking is a prime contributor to traffic congestion as on-street parking occupies a certain portion of the carriageway and reduces the available carriageway for traffic. According to Shoup (2007), in major cities of US around 8% to 74% of total traffic cruises an average of extra 3.5 to 14 minutes just to find a vacant spot for on-street parking. Moreover, Shoup (2007) claimed that the tendency of drivers to cruise instead of parking on an available off-street parking is because of the underpricing of on-street parking. Mahmood et al. (2009) recommended amending the parking problems of Dhaka city by ascertaining vacant parking spaces and commencing monthly-parking permits or introducing metered parking.

### 3. METHODOLOGY

A questionnaire survey was conducted in arterial, feeder (or collector) and in local roads at 16 locations in Dhaka city. An in depth literature review was undertaken to set questions in the questionnaire. It contains three sections. Section A of the questionnaire comprises respondent's demographic information such as their gender, age, educational status, occupation and respondent's main mode of travel. Section B deals with the existing parking condition in six different areas: reason for on street parking, reason for on-street parking rather than using off-street car parking, selection of parking provisions and its frequency, ease to find spaces for parking, parking duration and safety for cars. Section C is about opinion/willingness of parkers to pay for parking facilities. It includes opinion of driver about willingness to change transport mode if on-street parking pricing is applied and the amount/charge they are willing to pay. Attention was drawn to confirm that the survey could deal with either professional drivers or motorists driving their own car as respondents.

Data collection was conducted for seven hours starting from BST 08:00 to 15:00 for four days during September 20th to 23rd 2015. Out of 530 questionnaires 500 completed samples were considered for model development. Data collection was conducted to local road, feeder road and arterial road as well. Dhanmondi-9/A, Dhanmondi-8, Dhanmondi-8/A, Dhanmondi-7, Dhanmondi-7/A, Dhanmondi-6/A, Dhanmondi-3, Dhanmondi-15/A, Satmosjid road, Kamal Ataturk Avenue, Banani Road No-18, Shaid Syed Nazrul Islam Sharani, New Paltan, Motijheel, Mirpur road and Shaymoli Ring road were selected for questionnaire survey. These locations were selected because on-street parking was considered as a problem there causing severe congestion during most of the time of a day.

This study considers respondents whose main mode of travel is car and counts all types of trips. The respondents who parked their cars for any purposes as to get to work, educational institutions, shopping, leisure, and entertainment were asked about their most recent trip.

### 4. DATA ANALYSIS

Table 1 shows the general characteristics of the respondents. Majority of the respondents were male and most of them were professional drivers. Most of the drivers had primary education. Respondents' main mode of travel was car/cng (three-wheelers auto-rickshaws)/taxi. Users park their cars on-street for various reasons. Some park because the place is closer to their destinations, some park because they think off-street parking price is high and it is not much available or simply to save that money.

**Table 1:** General characteristics of the respondents.

Characteristics	Statistics
Gender	Male 95%, Female 5%
Occupation	Service holder/ student / businessman 7%, professional driver 93%,
Education qualification	Uneducated 35%, primary(j.s.c) 44%, s.s.c/h.s.c/post graduates/graduates 21%
Main mode of travel	Usage of car, cng or taxi 93%, Usage of cycle or rickshaw 7%
Main reason for on-street parking	Shopping 16%, educational purpose 42%, office/business 26%, leisure and others 5%, medical purpose 11%
Main reason for parking on-street rather than using public car parks	More convenient 24%, only want to park for a short time 43%, cost or availability of off-street parking 33%
If charge were made for car parks would you change mode of transport	Yes 7%, no 71%, sometimes 22%
If yes (change mode of transport) then shift to what	Shift to walk/ prefer not to make trip by car 22%, shift to taxi/ cng/cyclist/rickshaw 78%
Usual place of parking	Free car parks (on street) 86%, off street park/limited parking/valet parking 14%
Are you able to find space for park without difficulty	No 47%, yes 53%
How long do you normally stay	Less than one hour 54%, one to three hour 35%, three to six hours 10%. more than six hours 1%
How much do you willing to pay	Up to 30 BDT* 100%, more than 30tk 0% (86 BDT=1 US \$)

\*One can travel around 7-10 km by paying 30 BDT in public buses

Respondents' main reason for on-street parking is associated with educational purpose. The most important issue is that whether the users will change their mode if charges were applied for on-street parking. The majority of the users said that they will not change their mode even if charges were applied. For users who are willing to

change or shift their mode of transport will use car/cng (three wheelers auto-rickshaws)/taxi or walk or prefer not to make the trip. It was found that most of the users will shift to cycle or rickshaw.

#### 4.1 Multinomial Logistics Regression Model

The Multinomial Logistic Regression (MLR) model is usually adopted when the dependent variable is composed of more than two categories. MLR is used to describe data and to express the relationship between a dependent variable and one or more continuous-level independent variables. For describing the effect on categorical dependent variable by individual independent, variable logistic regression is highly appropriate and suitable (Wright, 1995). Considering a baseline category, the estimates for individual parameters are made in a multinomial logistic regression model (Long, 1997). In order to test and describe hypothesis about relationship between a dependent variable and one or more independent variable logistic regression is generally adopted (Lee et al., 2002). Logistic regression has been employed in literature for various types of decision and behavioral analysis (Johnson & Parrot, 1995).

A multinomial logistic regression (MLR) model was developed to assess the willingness of on-street parking user's to change transport mode in response to on-street parking pricing. The survey results have been analyzed to explore the current behavior, reasons of choosing on-street parking over other parking facilities, and individuals' opinion about parking related issues.

**Table 2:** Variables incorporated in the multinomial logistic regression model.

Variables	Explanation
v1	Gender (1 if male, 0 if female)
v2	Occupation (1 if professional driver, 0 if service holder/student/businessman)
v3	Education qualification (1 if uneducated, 2 if Primary/J.S.C, 3 if S.S.C or higher)
v4	Main mode of travel (1 if use car, cng or taxi, 0 if use Cycle or rickshaw)
v5	Main reason of on-site parking (1 if shopping, 2 if educational purpose, 3 if Office/business, 4 if leisure, 5 if medical purpose)
v6	Main reason for on-street parking rather than off-street (1 if more convenient, 2 if park for short time, 3 if off-street parking is less available or overpriced)
v7	Would you change travel mode from car to other if charges are applied (1 if yes, 2 if no, 3 if sometimes)
v8	If change mode, shift to which transport (1 if shift to taxi/cng/rickshaw, 0 if shift to walk/not to make trip)
v9	Which parking would you use (1 if on street parking, 0 if off street parking)
v10	Are you able to find space without difficulties (1 if yes, 0 if no)
v11	How long do you stay (1 if less than an hour, 2 if one to three hour, 3 if three to six hour)
v12	Is this place safe for parking ( 1 if yes, 0 if no)
v13	How much are you willing to pay (1 if up to 30 BDT, 2 if more than 30 BDT)

In this study, response variable is "Choice" which has three outcomes namely: change mode, will not change mode and sometimes change mode if parking pricing is implemented. In this logistic model the baseline-category logits with a predictor is used. In this paper "sometimes" was specified as the baseline category; where log odds of the outcomes are modeled as a linear combination of the predictor variables. In order to determine the factors affecting mode changing behavior of users, SP data are analyzed. Users travelling mode choice was compared on the basis of values for parking duration, parking fare, space finding difficulties and some other variables. The variables influencing the choice of users' daily travel modes are determined by focusing the local context. By employing multinomial logistic regression on SPSS, the relationships among variables were tested empirically. The various variable used in this study are shown in Table 2 along with their respective definitions. The models have been assessed to identify factors which most effectively strengthen the data for various modes for trip if on-street parking pricing is applied. In this research, certain parameters are anticipated that effect car owner's behavior, when various mode of transport are available to them.

Parameters like travel time and travel cost are regarded to be important in literature, while other parameters presented are entirely to deal with particular research issues. Several models were analyzed which had counter-perceptive signs or insufficient statistical goodness-of-fit; and hence they all were discarded.

Table 3 shows the multinomial logit model. The purpose of estimating the mode change model was to find out the influencing factors that encourage people of Dhaka to park on street, and the circumstances of parking pricing that may influence them to use other available modes of transport. The chi-square value has been adopted to show the relevance of the logit model. It has been computed as -2LL (Log Likelihood) for the null

model with only constants employed as the explanatory variables, without -2LL for the completely stated model. The coefficients of the model were significant ( $P < 0.05$ ), and the null hypothesis was rejected, indicating that, the independent variables had no difference in predicting the dependent variable. The -2LL shows how better the model suits the data. The chi-square value was found 72.636 for the logit model. In this study, the demographic variables like gender and age did not significantly contributed to describe the mode change behavior.

**Table 3:** Multinomial logit model.

Willing to change mode of transport	Variables	B	Std. error	Sig.	Exp(B)	95% C.I.	
						Lower	Upper
Yes	Intercept	-3.41	0.95	0.00			
	Occupation (Professional Driver)	1.65	0.78	0.03	5.18	1.13	23.80
	Uneducated	1.22	0.60	0.04	3.38	1.05	10.92
	Main mode of travel (Car/taxi/cng)	2.86	0.64	0.00	17.53	4.99	61.55
	Educational purpose	1.14	0.47	0.01	3.14	1.26	7.82
	Able to find space without difficulty	-0.98	0.48	0.04	0.38	0.15	0.95
No	Intercept	0.50	0.41	0.22			
	Occupation (Professional Driver)	0.82	0.57	0.15	2.26	0.74	6.92
	Uneducated	0.01	0.24	0.96	1.01	0.64	1.61
	Main mode of travel (Car/taxi/cng)	0.23	0.58	0.69	1.26	0.41	3.89
	Educational Purpose	0.80	0.23	0.00	2.24	1.43	3.50
	Able to find space without difficulty	-0.38	0.24	0.11	0.68	0.43	1.09
Summary of Statistics							
Number of observations			500				
(-2)Initial LL			349.936				
Chi Square			72.636				
(-2) Final LL			277.300				
Cox & Snell's R <sup>2</sup>			.135				
Nagelkerke value			.173				
McFadden's value			.096				

From the survey percentage of male respondent were way more than female respondent. The occupation was found significant.

Respondent's whose main mode of travel was private cars or cng/taxi has a probability to change mode. Education played significant role for changing mode if on-street parking pricing is applied. Most of the cars were driven by professional drivers who are mostly illiterate. For this reason the rules of parking weren't followed in most of the cases. Result signifies that if the drivers (on-street parking users) don't find a place to park or if they are forced to leave the parking place they will park another place in the vicinity, which may cause congestion. Result shows that if they are able to find space without difficulty then they will change their mode if parking pricing is employed.

Space finding difficulties' were also a reason for car users to change their modes. For car users who drive their own cars do not willing to park far from their destination for which they need both secure and close ranged parking place which makes them incapable to stay in their particular mode. Cars which are driven by drivers saved from this issue because drivers can take cars far and can bring it back on time. Result indicated that car users who usually come and park their cars on a regular basis will not change mode if on-street parking charges are applied. Users whose cars are driven by professional drivers but not owners will also not change mode due to charges. Those who come for short period showed willingness.

Respondents who are willing to change their mode, would like to choice either taxi or rickshaw. Respondents whose occupation is professional driver have a probability to change mode. From the model it can be seen that respondents who come for educational purpose do not have probability to change the mode. Most of the areas of this study are occupied with numerous educational institutes although their land use claimed them as residential. Lots of students usually use cars for commuting to the educational institutions. This is why roads are heavily occupied with private cars and probability of changing mode is very insignificant.

The reasons for individuals to change mode or not are investigated in this research. Parking fare does not have substantial effect for individual commuters to change modes whereas main mode of travel and purpose of

parking was more significant for the model. On the other hand, finding space was more important for users than parking fare. Respondents who have difficulties in finding parking space have the most possibilities to change modes. For car users who drive their own cars can't park far from their destination for which they need both secure and close ranged parking place. Education level and occupation were important factor affecting peoples' change of mode.

#### 4.2 Estimating Response Probabilities

The MLR model has different expression in terms of the responses probabilities, that is

$\pi_j = \frac{e^{\alpha_j + \beta_j x}}{\sum_h e^{\alpha_h + \beta_h x}}$ ,  $j = 1 \dots J$ . In this model, probability of sometimes (baseline category) was taken as  $\pi_0$  and the estimated value was  $\hat{\pi}_0$ , 'Yes' was  $\pi_1$  and the estimated value was  $\hat{\pi}_1$ , 'No' was  $\pi_2$  and the estimated value was  $\hat{\pi}_2$ . The probabilities can be calculated by two steps:

We can calculate  $\log \frac{\hat{\pi}_1}{\hat{\pi}_0}$ ,  $\log \frac{\hat{\pi}_2}{\hat{\pi}_0}$  as the response variable has three categories ( $J = 3$ ), which means that there are 2 equations as follow: Let  $y_1 = \log \frac{\hat{\pi}_1}{\hat{\pi}_0}$  and  $y_2 = \log \frac{\hat{\pi}_2}{\hat{\pi}_0}$ , so

$$y_1 = -3.406 + 1.645 (\text{Occupation}) + 1.218 (\text{Uneducated}) + 2.864 (\text{Main mode of travel}) + 1.144 (\text{Educational purpose}) - 0.982 (\text{Able to find space without difficulty}) \quad (1)$$

$$y_2 = 0.500 + 0.817 (\text{Occupation}) + 0.011 (\text{Uneducated}) + 0.228 (\text{Main mode of travel}) + 0.804 (\text{Educational purpose}) - 0.384 (\text{Able to find space without difficulty}) \quad (2)$$

According to Agresti (2007), including a term in a model should not be considered only depending on statistical significance. Variables should be included depending on the importance of the variable for the purpose of the study yet the variable is not statistically significant. Including such variable in the model may be helpful in reducing bias in terms of anticipating effects of other predictors. Also, it may be useful in terms of comparing outcomes with different studies where the result is significant. Although only few were significant still all variables were considered for model development.  $\hat{\pi}_1$ ,  $\hat{\pi}_2$ ,  $\hat{\pi}_0$  are calculated as below:

$$\hat{\pi}_1 = \frac{\exp(y_1)}{1 + \exp(y_1) + \exp(y_2)} \quad (3)$$

$$\hat{\pi}_2 = \frac{\exp(y_2)}{1 + \exp(y_1) + \exp(y_2)} \quad (4)$$

$$\hat{\pi}_0 = \frac{1}{1 + \exp(y_1) + \exp(y_2)} \quad (5)$$

where exp. or  $e = 2.71828$  is the base of the system of natural logarithms.

#### 4.3 Predictions by Using MLR Model

Every case includes a combination of explanatory variables. By classifying this combination in one of the three groups of the response variable prediction is made. The model estimates the probabilities of the combination of the three response variable groups and then classifies the case based on probability. For the application of the model case no. 102 was selected randomly. To estimate the three response probabilities ( $\pi_0$   $\pi_1$   $\pi_2$ ) by using equations (4.1 to 4.5) and by using Parameter Estimates data of case no. 102 given below:

$y_1 = 1.483$ ,  $y_2 = 1.965$  the probability to occur on each category can be calculated as following:

$$\hat{\pi}_1 = 0.351$$

$$\hat{\pi}_2 = 0.569$$

$$\hat{\pi}_0 = 0.079$$

This probability showed that case no. 102 has 56.9% chance to state a negative answer towards mode change behaviors. In other words it can be said that, this case has the highest probability that user will not change mode if charge is applied.

### 5. DISCUSSION

Due to illegally parked vehicles along the streets, congestion occurs obstructing the flow of traffic. Therefore, as a solution, a parking pricing would help improve the vehicular flow along the streets especially at peak periods

and at the same time would introduce revenues for the city. The space occupied by only a small number of cars can cause a great deal of interruption if the parking is done on streets having heavy vehicular as well as pedestrian traffic for an extended period, such as the entire working day. Illegal parking jeopardizes the safety and livability of a street and thus charge may be applied to encourage users to change their mode and thereby to free the road space. This research may be an overview for taking decisions about implementing charge for on-street parking.

This research focuses on finding out the willingness of car users' to change their mode of travel in response to parking pricing for developing country. In this paper, transport mode change behaviors of 500 respondents were analyzed at various locations in Dhaka, Bangladesh. Based on the conducted questionnaire survey, the significant factors affecting the on-street parking were identified. Respondents' main reason of parking has more significant impact on using on-street parking.

This paper also showed that parking users are willing to pay a fare between 20-30 BDT in the city to park. Users showed significant sign that they are ready to pay the parking price if fee is implied. Average time the car users wait in the parking area is less than an hour.

Result shows that majority of the respondent's main mode of travel is car, cng or taxi. Some car users said that if their destination is near to their home then sometimes they would use rickshaw instead of car. This study showed that car users parked their cars for different purposes namely for educational purpose, office/business, shopping, medical purpose and for leisure and other purposes. According to VTPI (2005), often accurate and flexible standards for the parking requirements are adjusted considering several factors like demographic, geographic and management issues that influences demand for parking and parking requirements at a particular location. Also, other issues such as type of users and trips including their urgency and aptitude to depend on alternatives; the cost and ease of adding parking capacity; the ability to implement parking management programs etc. are taken into account.

The result demonstrates the main reason of parking on-street instead of off-street or public parking. Car users expressed that they park on-street for a short time as it was more convenient for them while it is free of charge and off street car parking facilities needs to pay and they are not so common in those places. In the model, the occupation was found significant for mode change behavior. Result showed that users who parks on-street on a regular basis and cars that are driven by professional drivers but not owners will not change mode due to charges. Those who park for short period or come for some official work may change mode as they don't need to stay long and park. Respondents who are willing to change their mode would travel by either taxi or rickshaw. Education also played significant role in changing mode if on-street parking pricing is applied as majority of the cars were driven by professional drivers who are mostly illiterate. Parking regulations are not comprehended and obeyed by them in most of the cases. If on-street parking users are unable to find a place to park or driven from one location; they will change their parking position to nearby streets.

Space finding difficulties may also influence car users to change their modes. For car users who drive their own cars can't park far from their destination for which they need both safe and close ranged parking place which makes them unable to stay in the car mode if on-street parking pricing is implemented.

## 6. CONCLUSIONS

In Dhaka city most of the on-street parking spaces are free which persuades car users to park their car randomly causing serious congestion. Bari and Efrogmson (2006) showed that in 95% of their schedule on road, cars remain standing consuming large volume of road space. Due to limited supply and lack of parking provision, Dhaka city is unable to meet up with the required parking challenge. As the effective width of roadway is decreasing for the movement of traffic due to on-street parking, it is certainly contributing to traffic congestion. Inadequate parking supply is one of the prime reasons which are responsible for increasing traffic congestion as most of the motorists cruises around the busy road network to find out a parking space. In addition, the slow vehicular movement of motorists while looking for a parking space compared to other moving traffics delimits and affects mobility of the vehicles in the area (Shoup, 2006). Parking system presently practiced is not efficient as the drivers can park with little or no restriction and hence the off-street parking facility is not used to its utmost capacity.

Parking plays an essential role in the management of traffic and congestion. This paper shows that most of the respondent's operate their cars by drivers. If they don't find any parking place near to their destination they rather park in the nearby roads. Parking cost does not have substantial impact for individual commuters to change modes whereas main mode of travel and purpose of parking was more significant for the model. On the other hand, finding space was more important for users then parking fare. Educational facts and occupation was important factor affecting peoples' choice of mode. Result shows that majority of the respondents' parked on-

street. They also stated that the reason may be due to the availability of these assortments of parking types around the survey area and it is more convenient as users can save time to reach destinations, and also can save cost. It can also be added that users parked along the street because of the limited availability of off-street parking facilities and due to the lack of enforcement. Therefore, parking demand and parking supplied by off-street parking facilities also influence on-street parking since individuals tend to find or explore other possible parking areas when bringing their vehicles.

Parking demand of customers also influences the on-street parking since the tendency of individuals bringing cars are intended to explore for other possible parking areas when challenged with inadequate off-street parking facilities. Therefore, the tendency of on-street parking attracts people more when off-street parking is least available. On the other hand even some regions provide ample supply of off-street parking; still the culture of on-street parking is very common. This bad practice of on-street parking in spite of availability of off-street parking is going on due to peoples' tendency to park in nearby areas of their destination. They also select their parking location in response to easy parking accessibility and convenience and where penalty for parking on no parking region is very insignificant.

According to Shoup (2005), drivers adopt different strategies in order to economize on curb parking where they don't need to reduce their travel. They may drive during off-peak periods while the parking cost in curbs is cheaper; park at those locations where parking cost is lower and walk to their nearby destinations; park off-street; park for a shorter period; ride a bike, take public transit, or walk all the way to their destinations. Without decreasing human travel and all real travel by people, not cars carpools, cycling, public transit, and walking will decrease vehicle travel.

Around half of the respondent park on-street not due to financial reason but to save time for commuting to parking lots which clearly supports that off-street parking and curb parking can't be a suitable alternative to each other. Parking cost alone is not the factor that determines the choice between on-street and off-street parking. Walking distance and time to and from the final destination is another very crucial factor that influences the choice. Due to additional driving and walking time, off-street parking may seem inconvenient or less convenient to drivers compared to curb parking in spite of curb parking being unsafe sometimes. A study by Vickrey (1954) showed that often curb parking is found to be more advantageous compared to off-street parking. Therefore, as a solution to discourage parking in curbs and minimize unnecessary cruising, the research suggested to increase the cost for curb parking more than the cost for off-street parking. Setting the cost of curb parking a few times higher than off-street parking may play a vital role in creating vacant spaces in curbs.

It is natural to wander for parking if the cost of off-street parking is higher than on-street parking. Due to wandering traffic congestion takes place, accident occurs, air pollution occurs, fuel wastes and pedestrian environment degrades. City officials can't deny their liability in creating all these issues when they underprice curb parking. If the curb parking is underpriced then it creates a shortage. According to Shoup (2006), underpricing of curb parking is not appropriate in management of limited urban land, with extensive impacts on cities, environment, transportation and economy. Some authors (Chowdhury, 2006; Barter, 2011) described underpriced curb parking as vicious subsidies because it often causes unexpected harm to other people and it may not even provide any advantage to the drivers themselves. Therefore, cities need to arrange sufficient budget to settle the problem of pollution and congestion that the cities face. Comprehending curb parking price right will benefit everybody which may be pursued by cities.

The reasons why the car users are not interested in changing their travelling mode from car to others is that in Dhaka it is easily accessible; therefore, time saving and at the same time it is a much more comfortable way of travelling compared to others. Also, it provides users privacy and safety. Other reasons may include poor service quality of public transport and relatively much higher cost of taxis in Dhaka. Moreover, the poor quality of walking and biking facilities do not encourage travelers to use them. If parking charge is to be implemented in Dhaka city, comparatively higher parking fare should be set as respondents mentioned that they won't change their mode of travel if the parking charge is comparatively low. Some drivers may take the chance of paying fine by parking on a prohibited curb space. There are also alternatives available rather than parking on-street and paying fine. One may move to a neighboring location where prices for off-street parking is comparatively lower or where curb parking is available, and then walk to their destination. Despite all these, the simple message is that if cities cost nothing or too small for curb parking, motorists will park their car on street. Meanwhile, it is true that considerable environmental pollution will occur due to the additional cruising time of vehicles that is spent while looking for a vacant parking space.

Most of the users whose parking is associated with education and work trips will not change their transport mode if on-street parking charge is put into operation. These types of trips mostly take place during the peak periods which are largely responsible for congestion. Parking associated with medical, shopping, leisure, and

amusement tends to be associated with travel other than peak periods are usually between one to two hours. Car users usually face difficulties to find space for parking as suggested by result.

The city government is striving to build parking structures. The expensive projects have low returns. Moreover on-street parking is not prevented which creates chaos in their vicinities. Hence prevention of on-street parking is necessary to publicize off-street parking facilities. It is not possible to make parking cheap and abundant keeping pace with the increasing number of new cars in this era of high density and high property prices (ADB, 2011).

In conclusion, the findings of this study, is distinguishing because, it is a first attempt at modeling on street parking pricing for developing countries. It may be expected that this study will be very beneficial for parking demand management. Also, it may be helpful to private service providers, public transportation organizations as well as the government in taking proper decisions and avoid over/under designing of essential services and amenities. Outcomes of this research can be employed to assess current parking demand and future demands also.

This study was done with a small sample size and hence only a few places inside Dhaka city were covered. More comprehensive data from a wide range of locations as well as respondents would be more helpful for a better model. It is suggested to improve data by gathering more comprehensive information about other available modes of transport such as bus, taxi, cng, rikshaw etc. for similar type of studies in future where these modes may be considered as main mode of travel. Policy makers should sincerely focus on directing trips to public transportation considering the rapid growth of population as well as trips. Also, the transportation demand of all types of people can't be met successfully with the existing transportation facilities. This type of research can be neither attainable nor beneficial, without the understanding of related decision-makers and authorities in contemplating the outcomes and suggestions of this research.

## REFERENCES

- Parking Policy in Asian Cities, Asian Development Bank (ADB), Mandaluyong City, Philippines. 2011.
- Lam, Z. C. L., Huang, H. J., and S. C. Wong. Modeling Time-Dependent Travel Choice Problems in Road Networks with Multiple User Classes and Multiple Parking Facilities. *Transportation Research Part B*, Vol. 40, No. 5, pp. 368-395. 2006.
- Glazer, A. and Niskanen, E. Parking Fees and Congestion. *Regional Science and Urban Economics*, Vol. 22, No. 2, pp. 123-132. 1992.
- Wenzhi, C. and Bai, L. A Smart Roadside Parking Navigation System Based on Sensor Networks for ITS. IET International conference on Wireless, Mobile and Multimedia Networks, 2006, pp.1-4, 6-9 Nov. 2006.
- Vehicle Statistics and Route Permit Report. Bangladesh Road Transport Authority (BRTA), personal communication Dhaka, 2015.
- Tumlin, J. *Sustainable Transportation Planning: Tools for Creating Vibrant, Healthy, and Resilient Communities*. Hoboken. Wiley, 2012.
- Marsden, G. The evidence base for parking policies: a review. *Transport Policy* 13 (6), 447-457, 2006.
- McShane, M, and Meyer, M. D. Parking policy and urban goals: Linking strategy to needs. *Transportation* 11 (2), 131-152, 1982.
- Shoup, D. C. Cruising for parking. *Transport Policy* 13, p. 479-486, 2011.
- Strategic Transport Planning. Strategic Transport Plan (STP) for Dhaka. Final Report, Dhaka Transport Coordination Board, Dhaka, 2006.
- Litman, T. A. Parking Management Strategies, Evaluation and Planning. Victoria Transport Policy Institute, Victoria, BC, Canada, 2006.
- Rye, T., Hunton, K., S. Ison. The role of market research and consultation in developing parking policy. *Transport Policy*; 15: 387-394. 2008.
- Weinberger, R., Seaman, M. and C. Johnson. Residential off-street parking impacts on car ownership; vehicle miles traveled, and related carbon emissions: New York City case study. *Transport Res Rec*; 2118: 24-30. 2009.
- Litman, T. A. Parking Costs. *Transportation Cost and Benefit Analysis: Techniques, Estimates and Implications*, Victoria Transport Policy Institute, Canada, 2005.
- Vickrey, W. "The economizing of curb parking space" *Traffic Engineering*, November, pp. 62-6, 1954.
- Roth, G.J. *Paying for Parking*. Hobart Paper 33. London: The Institute of Economic Affairs, 1965.
- Shoup, D.C. *The High Cost of Free Parking*. Chicago: American Planning Association, 2005.
- Akter, M., Akter, T., Aktaruzzaman, A. Hussain. Review Of On-Street Parking Scenario of Motijheel Commercial Area (Dainik Bangla to Shapla Square). *Journal of Bangladesh Institute of Planners* Vol. 6, pp. 173-180. 2013.
- Zannat, K. E., Ahmed, T., Mitra, S. K., Rafiq, R., Hasan, M. A., Akhter, K. and Z. H. Fahad. Parking Demand

- and Supply Analysis of Major Shopping Centers In Dhaka – A Case Study of New Market Shopping Center Along Mirpur Road. *Journal of Bangladesh Institute of Planners* Vol. 6, pp. 161-172. 2013.
- Barter, P. Parking Policy in Asian Cities (Consultant's report), Financed by ADB under RETA 6416: A Development Framework for Sustainable Urban Transport – Parking Policy in Asia, 2011.
- Chowdhury, S., Chisty, K. U., Misuk, M. S. Demand and Supply of Parking System Analysis at Chittagong Commercial Area in Bangladesh. *International Journal of Scientific and Engineering Research*, Volume 5, Issue 7, July-2014.
- Bagloee, S.A., and M. Asadi. A parking planning model: logit-based mathematical programming method subject to parking capacity and parking rationing. In: *Transportation Research Board 92<sup>nd</sup> annual meeting*, Washington, DC, 13–17. Paper no. 13-0714. January 2013.
- Axhausen, K.W., and J.W., Polak. Choice of parking: Stated preference approach. *Transportation*, 18, pp.59-81, 1991.
- Waraich, R.A., Axhausen, K.W. Agent-Based Parking Choice Model. *Transportation Research Record: Journal of the Transportation Research Board* 2012; 2319:39–46. doi:10.3141/2319-05.
- Hess, S., and J. W., Polak. Mixed Logit Modelling of Parking Type Choice Behaviour. *Transportation Statistics*, pp.77-102. J.D. Ross Publishing, 2009.
- Vu, A. Analysis of Illegal Parking Behavior in Hanoi City. *Journal of the Eastern Asia Society for Transportation Studies*. 2017;12:421-37.
- Biswas A, Gopalakrishnan R, Dutta P. Managing overstaying electric vehicles in park-and-charge facilities. *Proceedings of the Twenty-Fifth International Joint Conference on Artificial Intelligence (IJCAI-16)*; 2016. p. 2465-2471.
- Ma, X., Sun, X., He, Y. and Chen, Y. Parking choice behavior investigation: A case study at Beijing Lama Temple, *Procedia – Social and Behavioral Science*, 96, pp.2635-2642, 2013.
- Hensher, D.A., and King, J., Parking demand and responsiveness to supply, pricing and location in the Sydney central business district. *Transportation Research Part A*, 35, pp.177-196, 2001.
- Box, P.C. Curb-parking problems: overview. *Journal of Transport Engineering*. 130: 1–5. 2004.
- Albert, G., and Mahalel, D. Congestion tolls and parking fees: a comparison of the potential effect on travel behavior *Transport Pol*; 13: 496–502. 2006.
- Qian ZS, Xiao F. E. and Zhang HM. Managing morning commute traffic with parking. *Transport Research: Part B Methodology*; 46: 894–916. 2012.
- Teknomo K. and Hokao k. Parking Behavior in Central Business District a Study Case of Surabaya, Indonesia. *EASTS Journal*, Vol. 2, 1997.
- Glazer, A., and E. Niskanen, Parking fees and congestion. *Regional Science and Urban Economics* 22 123-132, 1992.
- Rahman, K. N. Vehicular Parking: Policy and Guidelines for Dhaka. In S. Jahan, and K. M. Maniruzzaman (Eds.), *Urbanization in Bangladesh: Patterns Issues and Approaches to Planning*. pp. 80-91, Dhaka: Bangladesh Institute of Planners. 2007.
- Mahmud, K., Gope, K., & Chowdhury, S. M. Possible Causes and Solutions of Traffic Jam and their Impact on the Economy of Dhaka City. *Journal of Management and Sustainability*, 2(2), 112-135, 2012.
- Mahmood, M., Bashar, M. A., and Akhter, S. Traffic Management System and Travel Demand Management (TDM) Strategies: Suggestions for Urban Cities in Bangladesh. *Asian Journal of Management and Humanity Sciences*, 4(2-3), 161-178, 2009.
- Agresti, A. *An Introduction to Categorical Data Analysis*. John Wiley and Sons, Inc, 2007.
- Wright, R.E. Logistic regression Pages 217-244 in L. G. Grimm, and P. R. Yarnold, Eds. *Reading and understanding multivariate statistics*. American Psychological Association, Washington, DC, 1995.
- Long, J.S. *Regression models for categorical and limited dependent variables*. Thousand Oaks, CA: Sage, 1997.
- Peng, C. Y. Joanne, Lee, K. L. and Ingersoll, G. M. *An Introduction to Logistic Regression Analysis and Reporting*. *The Journal of Educational Research*, Vol. 96, No. 1., 3-14, 2002.
- Johnson, M., and Parrot, K. A logistic regression analysis of factors affecting recycling behavior in apartment communities. *Housing and Society*, vol. 22, no. 3, pp. 41–52.