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On-Street Parking Demand Estimation in Urban CBD using FI and CF Model: A Case Study – Kolkata, India

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Abstract

Objectives: To estimate the on-street parking demand in the urban Central Business Districts (CBDs). **Methods/Statistical Analysis:** To achieve the goal, the study formulates two parking demand estimation models i.e., the fee index (*FI*) model and the cost factor (*CF*) model, based on regression analysis using SPSSStatistical Package for the Social Science. *FI* Model estimates the on-street parking demand where the transit system is absent. On the other hand *CF* model estimates the demand by considering the mode shift from the private vehicle (*PV*) users to the public transit (*PT*). **Findings:** Priority wise requirements for selecting PT are found out in this survey. The existing demand in the both selected CBDs of Kolkata, viz. Dalhousie and Gariahat is found to be much higher than the present parking supply. *FI* Model shows that, the demand will satisfy the existing supply if unit *FI* can be achieved. *CF* model explain that, the transit fare need to be increased by 52% and 26% for Dalhousie and Gariahat area respectively to meet the demand with the existing supply. It is also found out that, the on-street demand is less in transit oriented CBDs. The forecasted demand is reduced by 69% and 71% and by 63% and 59% than the present demand using *CF* model and the *FI* model respectively. In this study, it has been attempted to evaluate the on-street parking demand and such type of works has not been found out by the authors particularly in India which make it a pioneer study for others. **Application/Improvements:** The users need to be shifted from *PV* to *PT* immediately and the government must take necessary actions to introduce sufficient transit service to counter the on-street parking problem.

Keywords: CBD, On-Street Parking Demand, Parking Demand, Parking Supply, Parking Demand Model

1. Introduction

India is one of the fastest growing countries in the world. With increase in population and their income, the numbers of 4-wheelers are also increasing, leading to parking problems in most of the metropolitan cities. The problem is more acute in the developing countries like India. The on-street parking reduces the flow speed and creates congestion on the street, particularly in the CBD[1]. Congestion leads to loss of time and cost. Insufficient space in the urban area, less off-street parking facilities, high land value, dense development, etc. are force the users to park their vehicles on-street. Proper parking management policy needs to be framed for each urban area to solve the parking problem.

Kolkata is the oldest metro cities in India with a population of 14.5 million and an area of 1,886.67 square km^2. The demand is increasing with the increase of population[3]. The demand can be controlled if the progress of birth can be estimated[4]. This type of data helps to evaluate many parameters. Two CBDs, viz. Gariahat and Dalhousie have been selected as the case study area. The existing parking supply of the selected areas has been obtained through secondary survey. The parking demand of the selected areas has been estimated based on thevariables as discussed in section 4. The related research works conducted earlier have been discussed in the next section.

2. Historical Background

A large amount of research has been carried out in the past on satisfaction of user on PT[5-12]. The PT has also impact on land use[13]. The pull and push policy is one of

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the method for mode shift and they found that a motorist cannot be pushed from private vehicle to transit service[14]. The behavior of transit employees, reliability, simplicity of the information, frequency and design are some significant attributes to attract the private vehicle users to PT[15,16]. The the total frequency of negative critical incident affects the overall satisfaction of a transportation system[17]. Almost all the developing countries are facing the lack of quality public transit system. The situation is more critical in India due to the low per capita income. As a result the country has to forcefully keep the transit fare low which results less revenue for both the Government and transit owners[18]. The parking policy and passenger behavior influence for choosing PV as their mode of transport than PT. Proper parking policy reduces the traffic congestion and maximized the utilization of the parking lot[19]. Various types of surveys are conducted to understand the mode shift and it is found that Willingness To Pay (WTP) survey yield better result[20,21]. Transit oriented development of CBD is preferred for any urban areas to avoid congestion due to on-street parking[22]. Frequency of service, shorter travel time and lower transit fares are the main factors that switch a number of users from *PV* to *PT*[23]. This switching reduces the parking demand[24]. Parking policy[25] and parking accumulation profile[26] have an important impact on demand estimation. The Mildura Planning Scheme[27] provides a glimpse of rate of vehicle parking based on land use.Efficiency or importance of any parking lot is mainly based on its location and trip purposes (like office, shopping etc.). A small search time per vehicle can create traffic congestion. Due to unavailability of parking space the cruising of parking may take place in both CBD and the nearby area. The average search time is found to be 8 minutes and about 30% of the traffic is cruising for parking[28]. The parking demand varies with varying trip generation rate. The study also discussed the effect of parking problems in daily traffic life. Small and medium cities along with the metro cities are also found to face the same. Economic system of a particular urban area is also affected by this problem[29]. Another study describes this happening in his work which helps the transportation planners to plan the parking system in the core area of a city[30]. Traffic congestion due to the parking problem can be considered an impediment to mobility as it occurs when demand will not meet the supply[31]. A number of methods and tools are there to reduce the parking pricing to avoid congestion. Based on present and future parking demand, parking management plan is to be provided[32].

The floor area is also an important parameter in this study and the individual building parking index affect more than the whole building parking index[33]. Parking space can be managed by enhancing car sharing program[34]. If a car sharing program is adopted maximum number of people gets benefited with less number of spaces utilized. Local authorities may also think to construct a new parking lot for monthly users[35]. This will minimize the parking load of the parking lot. More or less all cities are facing the problem on the mobility of people and the structure of land use. Urban planning and transportation are the main two factors to solve parking problem. Parking management links between these two factors. In another study describes the various methods to manage these two factors[36]. The parking demand can be estimated based on parking generation rate[37]. Effect of parking duration on all types of trips, viz. work trips, shopping trips, social trips, etc. have been described. Average turnover rate, parking occupancy, service level, parking fees, the growth rate of automobiles factors are considered to develop the parking demand model. Two modified parking generation rate models are developed in this study with the help of these factors. The reliability of this model is also high as it considers most of the important factors. The basic parking generation rate model as given in Equation 1:

$$Y = \sum_{i=1}^{n} (a_i \times r_i) \qquad i=1, 2, 3,\ldots., n \qquad (1)$$

Where,

Y: Parking demand in certain CBD area during rush hour (lot)

a_i : Parking generation rate

r_i : Individual land use area (in m^2).

In another study, the author emphasized 'pay and park method' for short term parking and for long term parking. The study also suggested construction of separate parking area within the radius of 1 km from the CBD to avoid the parking space problem[38]. Smooth flow of traffic movement can be obtained in all places by providing adequate parking facilities and monitoring[39,40]. Normally, a car remains parked for about 80% time of the week[41], i.e. the available parking space remains occupied, leading to high parking demand. Searching time for vacant space (cruising) is also considered as parking cost apart from parking fee. The combined effect of these two is termed as parking cost[42]. 'Usage-related parking model' can also consider while analyzing multiple vehicle classes

and multiple type of parking locations[43]. Adopting walking, cycling, and public transportation may be effective at supporting Travel Demand Management objectives[44]. Motorization in urban India is growing faster than the population growth. Automobile ownership growth rate per annum are reported to be 10 percent to 15 percent in Kolkata[45]. Another study discussed the procedure to balance the curbside parking fee while balancing the supply and demand[46]. The parameters like walking time, parking fee, occupancy rate, distance, travel time, search time, parking time restriction and expected fine for illegal parking are considered in this study. Sensitivity to walk also varies with different ages. Parking lot should be located such that, the people of different ages can easily walk to the parking lot from their destination[47].

The parking demand forecast model (Eq.1) has been modified by introducing some new variables and indicated in Section 4, Eq. 2 and Eq. 5. The methodology for the study has been discussed.

3. Methodology

It is found from the previous studies that many variables, like travel time[48-56], parking cost[48-50,52,53,55-64], travel cost[65], search time[49,61,66], parking demand[67], parking supply[67], trip generation[61,68,69], access time[49,54], distance and durat[51,57,67], age-sex-income[51], out of vehicle time[52,55], origin-park destination angle[62], walking distance[52,53,56-58,60,62,63,66,70], walk time[53,60,61,63,66], parking capacity[53,58,60,66,68,71], traffic flow[66] and waiting time[54], land use[72], floor area[73], transit facility[74], parking level of service (LOS)[72], driver's choice[75], population growth[2], vehicular growth[2] play a vital role in estimating parking demand. All parameters are initially considered for the study to develop the model. A regression analysis is carried out using SPSS. The variables which have less significant are eliminated. Parking generation rate for different land use (a_i), individual area of land use (r_i), parking turnover (μ_i), parking fee index (FI) parking accessibility index (AI_p), transit accessibility index (AI_t), vehicle growth factor (β) and preference of PV over PT (α) are found to be significant to formulate FI model (Eq. 2). Some new parameters like cost factor (CF), accessibility index of parking at present level of service [LOS] (AIP_L), comfort index (CI) and preference of car over transit (γ) are incorporated to generate CF model (Eq. 5) along with a_i, R_i, μi, AI_t and β. Sensitivity analysis may also be incorporated as it gives a glimpse of most important parameters on the demand model[76].

3.1 *FI* Model

a_i And r_i are measured using laser distometer. μ_i is obtained using in-out survey. Four variables - age (A), annual income (AI), number of 4-wheeler owned (N) and the distance between origin & destination (D) are considered in estimating the utility function (U_i). A regression analysis is carried out using SPSS to obtain Eq. 4. These four variables are found to be significant while estimating Eq. 4. α is estimated by using Eq. 4. Parking fees play a vital role on parking demand. It is reported that a differential parking fee can also control the parking demand[77]. Efficient parking pricing can provide numerous benefits including increased turnover, reduced traffic problem and increased revenues[78]. A variable FI is found to be significant to estimate and control the demand. To decrease the FI, the actual parking fee needs to be increased (Eq. 2). This may increase up to 'parking fee willing to pay' and in this condition the value of FI will be 1 and demand will be optimal. The FI model is shown below:

$$Y = \left[\sum_{i=1}^{n} \frac{a_i}{\mu_i} \times r_i\right] \times FI \times \frac{AI_p}{AI_t} \times \beta \times \alpha \qquad \text{i=1, 2, 3,…,n} \quad (2)$$

Where,

y = Parking demand during peak hour

a_i = parking generation rate for different land use (per unit area)

r_i = individual area of land use (m^2)

μ_i = parking turnover = $\dfrac{\text{Peak parking demand}}{\text{Total number of lots}}$

FI= Parking fee index = $\dfrac{\text{Parking fee willing to pay}}{\text{Parking fee actually paid}}$

AI_p = Parking accessibility index = $\dfrac{stt_{pv} + sst_{pv} + set_{pv}}{att_{pv} + ast_{pv} + aet_{pv}}$

Where,

stt_{pv} = standard travel time of PV

sst_{pv} = standard search time of PV

set_{pv}standard ease time of PV

att_{pv} = actual travel time of PV

ast_{pv} = actual search time of PV

aet_{pv} = actual ease time of PV

AI_t = Transit accessibility index = $\dfrac{stt_{pt} + swt_{pt} + set_{pt}}{att_{pt} + awt_{pt} + aet_{pt}}$

Where,

stt_{pt} = standard travel time of PT

swt_{pt} = standard waiting time of PT

set_{pt} = standard ease time of PT

stt_{pt} = actual travel time of PT

swt_{pt} = actual waiting time of PT

set_{pt} = actual ease time of PT

β = Vehicle growth factor = $\frac{\text{Number of vehicles in future years}}{\text{Number of vehicles in base year}}$ = assume 10% for Kolkata[79]

$$\alpha = \text{Preference of car over transit} = 1 - \left[\frac{e^{U_t}}{1+e^{U_t}}\right] \quad (3)$$

Where,

$$U_t = Y_1 \times A + Y_2 \times AI + Y_3 \times N + Y_4 \times D + Z \quad (4)$$

Where,

A, AI, N and D are mentioned in section 4.1.

Y_1, Y_2, Y_3, Y_4 = Coefficient of A, *AI*, N and D respectively

Z = Constant

3.2 *CF* Model

The factors considered for choosing a PT by the PV users is found out from WTP questionnaire survey. They are asked to rate the preference for selecting a PT based on four factors like, 'cost saving', 'time saving', 'comfort index (*CI*)' and 'reliability'. It is found from the survey that around 13 % of the respondents choose *CI* as the third preference for choosing PT after 'cost saving' and 'time saving'. *CI* is found to be an important parameter for mode shifting[80]. The *CI* is used to estimate the utility function (Eq. 7) along with other variables like *A*, *D*, *AI*[81]. Online questionnaire survey is conducted to collect the data to increase *CI*. A regression analysis is carried out using SPSS to obtain Eq. 7. γ (Eq. 6) is calculated using Eq. 7. The 'travel cost by PT' is needed to be increased to enhance the *CI*. This may be increased up to the 'travel cost by private car' and in this condition the value of *CF* will be 1 which will provide the optimal parking demand. The *CF* model is shown below:

$$Y = \left[\sum_{i=1}^{n} \frac{a_i}{\mu_i} \times r_i\right] \times CF \times \frac{AIP_L}{AI_t} \times \beta \times \gamma \quad \text{i=1,2,3,…,n} \quad (5)$$

Where,

y, a_i, r_i, μ_i, AI_t, β = same as Eq. 2

$$CF = \text{Cost factor} = \frac{tc_{pv}}{tc_{pt}}$$

Where,

tc_{pv} = travel cost of PV

tc_{pt} = travel cost of PT

$$AIP_L = \frac{stt_{pv} + sst_{pv} + set_{pv}}{att_{pv} + \left(\frac{sst_{pv}}{LOS}\right) + \left(\frac{set_{pv}}{LOS}\right)}$$

Where,

stt_{pv}, sst_{pv}, set_{pv}, att_{pv} are same as Eq. 2

$$\gamma = \text{Preference of car over transit} = 1 - \left[\frac{e^{U_f}}{1+e^{U_f}}\right] \quad (6)$$

Where,

$$U_f = P_1 \times A + P_2 \times AI + P_3 \times D + P_4 \times CI + Q \quad (7)$$

Where,

A, AI and D are mentioned in section 4.1.

CI = comfort index

P_1, P_2, P_3, P_4 = Coefficient of A, *AI*, D and *CI* respectively

Q = Constant

Various types of surveys[82] are used for data collection. Surveys like, in-out survey, license plate survey, WTP questionnaire survey, online questionnaire survey, are carried out to collect the data. The detailed of theses survey are discussed in Section 6. The demand is obtained from both *FI* model and *CF* model. The estimated demand is compared with the present supply and necessary measures are taken accordingly. Fee index for *FI* model and cost factor and comfort index for *CF* model are considered as the primary controlling parameters which isused to control the existing and forecasted parking demand. The methodology flow chart is indicated in Figure 1

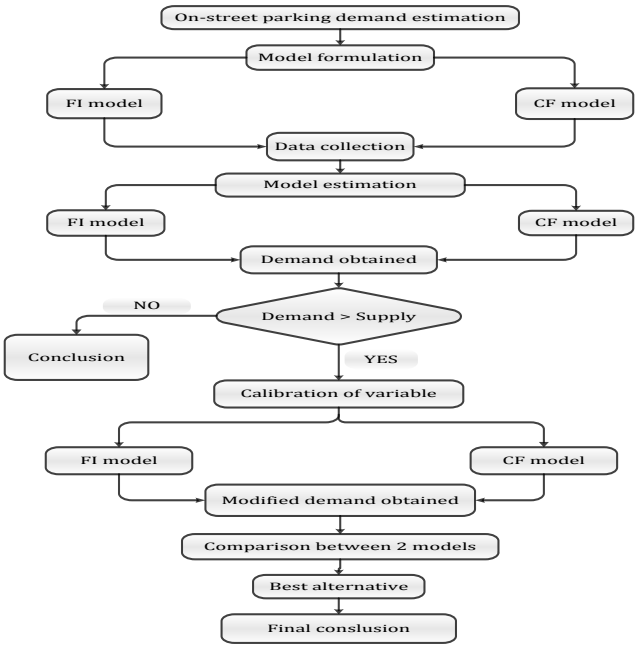

Figure 1. Methodology flow chart.

4. Study Area Selection

Two locations in the KMA are chosen as the case study area on the basis of the intensity and type of land use, trip purpose and on-street parking scenario. The CBD in Kolkata is distributed over a large space and not concentrated in a particular location like other cities. Two major CBDs – Dalhousie and Gariahat, which attract maximum work trips and shopping trips from all over the KMA, are selected in this study. Dalhousie is the oldest region of Kolkata, where maximum government and private offices are situated. Locally it is known as "office para" (office area). Even though the roads in that area are wide enough, it remains congested for most of the time in a day. The on-street parking is one of the main reasons for the congestion. Gariahat is an important junction that connects southern Kolkata with the central Kolkata. It is one of the main shopping hubs of the city. The locations of the CBDs are indicated in Figure 2.

5 Survey and Data Collection

Parking statistics like parking occupancy, parking volume, average parking duration, parking turnover, etc. can obtain from various types of parking survey. In-out survey, license plate survey and questionnaire survey are used in this study. Detailed of these surveys are discussed below.

5.1 In-Out Survey

This survey is used to determine the occupancy and parking turnover (μ_i) of the parking lot. Initial occupancy of the parking lot is taken. The number of vehicles entering and leaving for a particular time interval is counted. And at the end final occupancy of that lot is also taken. The labor required for this survey is very less. Only one person is enough to conduct this survey.

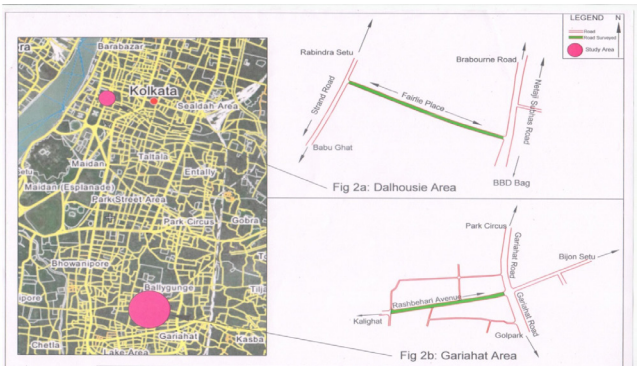

Figure 2. Survey location in the study area.

The survey was carried out from 9:00 hours to 18:00 hours in office area on weekdays and from 10:00 hours to 21:00 hours in the shopping area on weekends. Initially, a parking lot is chosen. The lot is divided into 3 sections for easiness in conducting the survey. The parking bays are marked as 1, 2, 3,…., n, for each section. After setting up, the survey is conducted both manually and video graphically. The survey is conducted at an interval of 30 minutes of each hour for above said time duration. The data obtained are transferred to excel sheet. Parking accumulation and occupancy were obtained from the excel sheet.

5.2 License Plate Survey

This survey provides the most accurate and realistic data. In this survey, every parking bay is monitored at a continuous interval of 15 minutes or so and the license plate number is noted. The parking duration for a particular vehicle in a bay is estimated from the data. Parking fee is estimated based on the parking duration. If the time interval is shorter, then there are less chances of missing short-term parkers. But this method is very labor intensive.

5.3 Questionnaire Survey

Two types of questionnaire surveys are conducted like, WTP questionnaire survey and online questionnaire survey. The detailed of this survey are discussed:

5.3.1 WTP Questionnaire Survey

The questionnaire survey was conducted in all the survey locations. Around 495 numbers of commuters are interviewed during the survey. A qualitative and quantitative analysis needed to be carried out to understand the situation of the existing parking and mode choice. Willingness to pay survey also needs to be conducted to understand the users' requirement for mode shift from private vehicle to public transit. The questionnaire consists of 4 major groups such as personal details, trip characteristics, parking characteristics and parking location choice. The data regarding age, sex, family size, family income and number of 4-wheeler owned are collected from 'personal details' group. Similarly, the data regarding use of alternative mode than private vehicle, purpose of visit, distance between origin and destination, travel time, travel cost,

factor affecting PT; preferable parking type, frequency of visit, parking fee, parking fee willing to pay, waiting time, search time, walking time; important factors for choosing parking location, preferable weather for selecting a particular parking lot are collected from 'trip characteristics', 'parking characteristics' and 'parking location choice' groups respectively. The data are arranged in excel. SPSS is used to obtain a linear relationship between the different parameters.

5.3.2 *Online Questionnaire Survey*

A set of twenty questions are asked in the survey. Around 287 commuters are replied to the survey. First five questions provide the commuters' personal information like age, sex, family size, family income and type of vehicle owned. Another three questions give the information about commuters' origin and destination places for both office and shopping area. Next six questions provide brief information of commuters' work trip like preferred mode to make trip, travel cost, rating the *CI* of *PT* in 5 point scale for both existing and desired condition, willing to pay additional fare for their desired *CI* and finally commuters' requirements and suggestion for a quality *PT*. Similarly last six questions are asked to get information of commuters' shopping trips. The collected data are arranged and analyzed. The affect of mode shift on parking demand and the percentage of fare needed to be increased for *PT* are estimated from this survey.

Result and discussion

Data collected from various surveys has been analyzed and presented in the following paragraph.

5.4 Demand Estimation using *FI* Model

The data are extracted from various types of survey, like in-out survey, questionnaire survey. Data are analyzed using SPSS and Excel and finally the parking demand is estimated using Eq. 2. Base year (with existing *FI*) parking demand is obtained and presented in Table 1. To compute the forecasted demand the changes in β value is considered. β is assumed to increased by 50 percent for each five years block starting from the base year. Using the enhanced β value and keeping the other variables constant the forecasted demand is computed and indicated in Table 1. The parking demand has been reduced by controlling *FI* . The existing parking fee needs to increase to reduce *FI*. Unit *FI* is obtained when existing parking fee is increased up to 'willingness to pay' and in this condition the parking demand will be minimized. Demand cannot be further reduced. The minimum controlled demand, thus computed, is found to be more than the present supply. The controlled parking demand for both present and future years are also indicated in Table 1.The base year supply collected from secondary sources is also indicated in Table 1 for comparison.

Table 1. Location wise change in parking demand by controlling *FI*

Locations	Parking Supply (base year)	FI	Parking demand year wise			
			2016 (Base year)	2021	2026	2031
Dalhousie	400	2.70 (Existing)	916	1374	1831	2290
		2.00	679	1018	1358	1698
		1.50	509	764	1018	1273
		1.00	339	509	679	849
Gariahat	190	2.43 (Existing)	372	558	743	929
		2.00	305	458	611	763
		1.50	229	343	458	573
		1.00	152	229	305	381

Even the base year parking demand for Dalhousie (916), with existing FI, is found to be much higher than the base year supply (400). A similar trend is observed for Gariahat. The shortage in parking supply is observed to be more serious in Dalhousie (base year demand is 2.29 times than the base year supply) than Gariahat (base year demand is 1.96 times than the base year supply). It is also found out that, at unit *FI* the demand meets the present supply, i.e. the parking demand is 339 and 152 at Dalhousie and Gariahat respectively.

5.5 Demand Estimation using *CF* Model

Both the questionnaire survey and online survey are conducted to estimate the demand using *CF* model. In the online survey, respondents are asked to rate the existing comfort index (CI_E) of PT (Section 6.3.2.). They are also asked to rate their desired comfort index (CI_D) for mode shift. The existing cost factor (CF_E) and desired cost factor (CF_D) also recorded from the response. The results from questionnaire survey are shown in Figure 3,4,5 and 6

It is observed from the result that 46 percent of respondents are marked the PT with 'avg. (Average)'

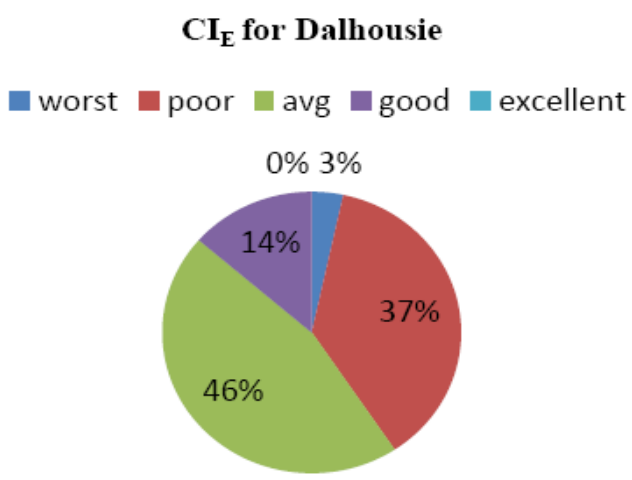

Figure 3. Existing comfort index rating for Dalhousie

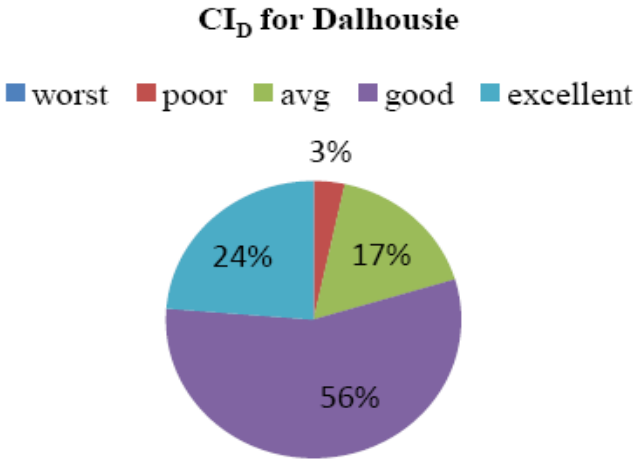

Figure 4. Desired comfort index rating for Dalhousie.

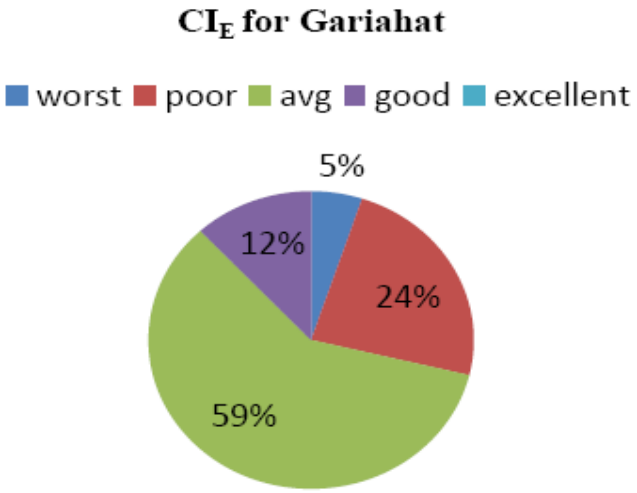

Figure 5. Existing comfortable index rating for Gariahat.

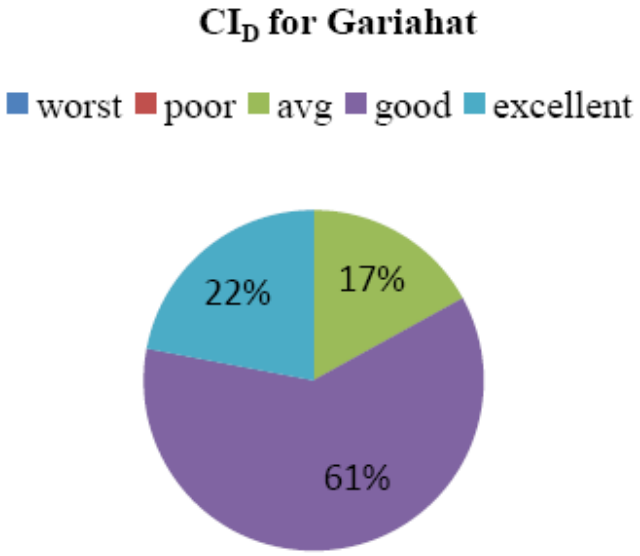

Figure 6. Desired comfort index rating for Gariahat.

comfort level and they desired a comfort level of 56 percent for Dalhousie area (Figure 3 and Figure 4). On the other hand 59 percent of the respondents are marked the PT service as 'avg' and around 61 percent are desired to have 'good' PT service for Gariahat area is shown in Figure 5 and Figure 6. The users are found to be agreed for mode shift even by paying the enhanced fare of PT, if the desired CI can be provided by the transit authority. List of their requirements for mode shift are also found out from questionnaire survey and listed in Table 2 on priority basis. Three types of PT service have been considered in this study - normal bus, air conditioned (AC) bus and local train/metro.

Users' requirements and the priority wise requirements have to be improved (Table 2) for satisfactory mode shift.

The online survey is conducted to estimate the demand and probable mode shift. The value of variables like *CF* and *CI* are collected from the respondents individually. Respondents are asked to rate the quality of service of *PT* for existing condition and desired scenario on the basis of 5 point scale (worst, poor, average, good and excellent) rating system. Then the data are extracted and transfer to Excel and the average of individual attribute i.e. CI_E, CF_E, CI_D, CF_D, are computed and considered to estimate the existing parking demand. To compute the forecasted demand the changes in β value are considered. β is assumed to increase by 50 percent for each five years block starting from the base year. Using the enhanced β value and keeping the other variables (CI_E, CF_E, a_i, r_i, μ_i,

Table 2. Priority wise user's requirement for mode shifting

Priority sequence	Priority wise requirements		
	Normal bus	AC bus	Local train/ Metro
Priority 1	More spacious (41%)	More buses should be introduced in office time (53%)	More local and metro should play in peak hours (48%)
Priority 2	Good seat quality (24%)	More standing space should be provided (29%)	Safety and security should be increased (22%)
Priority 3	More buses should be introduced (15%)	Maintenance of AC and seat (13%)	Maintenance should be improved (17%)
Priority 4	Separate lane for bus to reduce travel time (11%)	Separate bus lane to avoid congestion (5%)	Increase the number of AC rack (10%)
Priority 5	Safety issue (9%)	-------	Installation of AC in local train (3%)

Table 3. Existing and forecasted parking demand considering CF_E & CI_E and comparison with supply

Locations	Supply	CF_E	CI_E	Year wise parking demand			
				2016 (Base year)	2021	2026	2031
Dalhousie	400	3.23	0.53	926	1389	1852	2315
Gariahat	190	2.00	0.56	275	456	637	818

AI_t, AIP_L, β) constant the forecasted demand is estimated. The estimated demands are indicated in Table 3.

It is observed from Table 3 that, the existing parking demand is higher than the supply for both Dalhousie and Gariahat. The demand is further controlled by considering CI_D and CF_D and the result is shown in Table 4.

Unit parking CF_D is obtained when existing travel cost by transit is increased to travel cost by car and in this condition the parking demand will be minimum. Demand cannot be further reduced. The present supply is found to be even less than the minimum demand. It is found that the transit fare needs to be increased by 31 percent to provide their desired requirement for Dalhousie area and 26 percent for Gariahat area (Table 4). The increase in transit fare will decrease CF_D Decrease in CF_D indicates

Table 4. Existing and forecasted parking demand considering CF_D & CI_D

Locations	CF_D	CI_D	Year wise parking demand				% of transit fare need to be increased
			2016 (Base year)	2021	2026	2031	
Dalhousie	2.46	0.77	705	1058	1410	1763	31
	2.21	0.81	638	957	1276	1595	35
	1.96	0.82	540	811	1081	1351	41
	1	0.98	289	430	573	717	52
Gariahat	1.71	0.75	135	202	270	337	26
	1.64	0.77	127	191	254	318	29
	1.56	0.80	100	150	201	251	34
	1	0.98	81	121	162	203	42

Table 5. Comparison between *FI* model and *CF* model

Location	Rate of % decreased in the parking demand in FI model	Rate of % decreased in the parking demand in CF model
Dalhousie	63[a]	69[c]
Gariahat	59[b]	71[d]

increase in CI_D. The demand will be minimized if unit CI_D can be achieved and the corresponding demand is 289 for Dalhousie and 135 for Gariahat which meet the present supply. Estimated demand meets the present supply in both FI model and CF model. A comparison is also made between two models the result which is shown in Table 5.

$$\text{a, b} = \left(\frac{\textit{the parking demand with } FI_E - \textit{the parking demand with unit } FI}{\textit{the parking demand with } FI_E} \times 100\% \right)$$

$$\text{c, d} = \left(\frac{\textit{the parking demand with } CF_E - \textit{the parking demand with unit } CF}{\textit{the parking demand with } CF_E} \times 100\% \right)$$

Parking demand reduced up to 63 percent and 59 percent in FI model for Dalhousie and Gariahat respectively. But with help of CF model the demand is reduced up to 69 percent and 71 percent for Dalhousie and Gariahat. It is clearly observed that the CF model controls the on-street parking demand more efficiently than FI model.

6. Conclusion

The parking demand has been estimated for the selected study areas. Priority basis user's requirements to choose

PT are listed in Table 2. It is found that more space, good seating quality, more buses, separate bus lane and safety are the priority wise requirement for selecting normal bus. Similarly, increase the number of buses, more spaces, maintenance of buses, separate bus lane and increase the number of local train/metro, safety-security, maintenance, increase the number of AC racks, installation of AC in local trains are priority wise requirements for AC bus and local train/metro respectively. If these requirements can be provided, the car users are likely to shift PT and there by the on-street parking demand will be controlled. The existing and controlled demand from *FI* model and *CF* model are shown in Table 1 and Table 3 and Table 4 respectively. It is found from the Table 1 that the existing parking demand does not meet the present supply in both the areas. *FI* and *CF* & *CI* are the key factors to control the demand. It is found that the reduced demand meets the present supply if unit *FI* and *CF* is obtained. Around 52 percent and 42 percent *PT* fare need to be increased to obtain the unit *CF* for Dalhousie and Gariahat respectively. It is found from Table 5 that *CF* model reduce the parking demand by 6 percent and 12 percent more than *FI* model for Dalhousie and Gariahat respectively. The *CF* model found to be better than the *FI* model from this study. As the demand is observed very high both in Dalhousie and Gariahat area compared to the present supply, the users need to be shifted from PV to PT immediately as explained in this study. The present and the future gap between the demand and the supply are obtained in this study, which can be effectively used by the policy maker for solving the on-street parking issues.

7. Reference

1. Zeng YE, Changping LI, Ning GU. Research on different parking supply in Beijing. Journal of Transportation Systems Engineering and Information Technology. 2009 Dec; 9(6):47–51. Available from: Crossref
2. Kolkata CDPA report, City assessment: Analysis of the existing situation, chapter1. Crossref
3. Alawin M, Al-Hamdi M, Alomeri M. Determinants of Electricity Demand in Jordan. Indian Journal of Science and Technology. 2016 May; 9(15):1–7 Available from: Crossref
4. Vikram V, Ajay T, Chandra S, Malik AK. A Trade Credit Inventory Model with Multivariate Demand for Non-Instantaneous Decaying products. Indian Journal of Science and Technology. 2016 May;9(15):1–6. Available from: Crossref
5. Churchill GA, Surprenant C. An investigation into the determinants of customer satisfaction. Journal of marketing research. 1982 Nov;19(4):491–504. Available from: Crossref
6. Cadotte ER, Robert BW, Roger LJ. Expectations and mode shift in models of consumer satisfaction. Journal of Marketing Research, 1987; 24:305–14. Available from: Crossref
7. Fornell C. A national customer satisfaction barometer: The Swedish experience. The Journal of Marketing. 1992 Jan; 56(1): .6–21. Available from: Crossref
8. Oliver RL. A cognitive model of the antecedents and consequences of satisfaction decisions. Journal of marketing research. 1980 Nov; 17(4): 460–9. Available from: Crossref
9. Oliver RL, DeSarbo WS. Response determinants in satisfaction judgments. Journal of consumer research. 1988 Mar;14(4): 495–507 Available from: Crossref
10. Oliver RL. Satisfaction: A behavioral perspective on the consumer. Routledge. Newyork, 2014 Dec.
11. Tse DK, Wilton PC. Models of consumer satisfaction formation: An extension. Journal of marketing research. 1988 May; 25(2): 204–12. Aailable from: Crossref
12. Westbrook RA. Product/consumption-based affective responses and postpurchase processes. Journal of marketing research. 1987 Aug; 24(3): 258–70. Available from: Crossref
13. Steven EP. Transportation/land-use relationship: Public transit's impact on land use. Journal of urban planning and development. 1999 Dec; 125(4): 135–51. Available from: Crossref
14. Stradling SG, Meadows ML, Beatty S. Helping drivers out of their cars Integrating transport policy and social psychology for sustainable change. Transport policy. 2000 Jul;7(3): 207–15. Available from: Crossref
15. Friman M, Edvardsson B, Gärling T. Frequency of negative critical incidents and satisfaction with public transport services. I. Journal of Retailing and Consumer Services. 2001 Mar; 8(2): 95–104. Available from: Crossref Available from: Crossref
16. Lauren R, Friman M, Gärling T, Hartig T. Quality attributes of public transport that attract car users: A research review. Transport Policy. 2013 Jan; 25:119–27. Available from: Crossref
17. Friman M, Gärling T. Frequency of negative critical incidents and satisfaction with public transport services. II. Journal of Retailing and Consumer Services. 2001 Mar; 8(2):105–14. Available from: Crossref Available from: Crossref
18. Pucher J, Korattyswaroopam N, Ittyerah N. The crisis of public transport in India: overwhelming needs but limited resources. Journal of Public Transportation. 2004;7(3): 1–20. Available from: Crossref Availale from: Crossref

19. Zhang X, Shao Y, Wu Y, Li X. Parking demnd in the Hich tech business district of urban. In Proceedings of the Eastern Asia Society for Transportation Studies. 2005; 5: 891–9. PMCid:PMC1550707
20. Maitra B, Dandapat S, Chintakayala P. Differences between the Perceptions of Captive and Choice Riders toward Bus Service Attributes and the Need for Segmentation of Bus Services in Urban India. Journal of Urban Planning and Development. 2014 May; 141(2).
21. Phanikumar CV, Maitra B. Valuing urban bus attributes: An experience in Kolkata. Journal of Public Transportation. 2006; 9(2): 1–19. Availale from: Crossref
22. Nelessen Associates, Parking study report, Journal Square. 2008. Available from: Crossref
23. Eriksson L. Car Users' Switching to Public Transport for the Work Commute.Faculty of Economic Sciences, Communication and IT, Department of Psychology. 2011; 1–32. PMCid:PMC3024212
24. Land tansport and authority. Code of practice for vehicle parking provision in developments. 2011; 1–80.
25. Wong SC, Tong CO, Lam WC, Fung RY. Development of parking demand models in Hong Kong. Journal of Urban Planning and Development. 2000 Jun; 126(2): 55–74. Available from: Crossref
26. Tong OC, Wong CS, Leung YS. Estimation of parking accumulation profiles from survey data, Transportation. 2004; 31: 183–202, Available from: Crossref
27. Mildura Rural City Council. The development of a local planning policy for vehicle parking in the CBD Area, Vehicle Parking Policy in the CBD Area. 2005.Available from: Crossref
28. Shoup DC. Cruising for parking. Transport Policy. 2006 Nov; 13: 479–86. Available from: Crossref
29. Regidor JR. A review of trip and parking generation rates in the Philippines. Philippine Engineering Journal. 2010 Jul;27(1): 1–262.
30. Rastogi R. validating stated parking duration of drivers in kota city. INDIA, May 2014.
31. Singh A, Sarkar PK. Determination of Congestion Cost in Central Business District of New Delhi: A Case Study. In Journal of the Indian Roads Congress 2009 Jul.
32. Parking Study-A report, City of La Crosse Wisconsin, Rich and Associates, Inc. 2009.
33. Qin H, Xiao Q, Guan H, Pan X. Analysis on the Parking demand of the Commercial Buildings Considering the Public Transport Accessibility. Nature and Science. 2010; 63–8.
34. Parking and transportation demand management master plan. University of California, Berkeley. 2011. Available from: Crossref
35. Abrm Associates, Traffic and Parking study, Shattuck and university traffic and parking study.www.cityofberkeley.info/uploadedFiles/Planning_and_Development/Level_3_-_Land_Use_Division/2011-06-23%20Traffic%20and%20Parking%20Study.pdf. Date Accessed: 23/06/2011.
36. Diallo A, Bourdeau JS, Morency C, Saunier N. Methodology of parking analysis. Canadian Journal of Civil Engineering. 2015 Mar;42(4): 281–5. Available from: Crossref
37. Tiexin C, Miaomiao T, Ze M. The model of parking demand forecast for the urban CCD. Energy Procedia. 2012 Dec; 16: 1393–400. Available from: Crossref
38. Subramani T. Parking Study on Main Corridors in Major Urban Centre. International Journal of Modern Engineering Research (IJMER), ISSN. 2012; 2(3): 742–8.
39. Asiyanbola RA, Akinpelu AA. The challenges of on-street parking in Nigerian Cities' transportation routes. International Journal of Development and Sustainability. 2014; 4(20): 1–11.
40. Olorunfemi SO, Basorun JO. Appraisal of Regional Mobility in Lokoja, Nigeria. Journal of Society and Communication. 2013 Oct,
41. Marsden G. The evidence base for parking policies: A review. Transport policy. 2006 Nov;13(6): 447–57. Available from: Crossref
42. Madsen E, Mulalic I, Pilegaard N. A model for estimation of the demand for on-street parking. 2013 Dec; 1–24
43. Tong CO, Wong SC, Lau WW. A demand-supply equilibrium model for parking services in Hong Kong. HKIE Transactions. 2004 Jan;11(1): 48–53.
44. Hamre A, Buehler R. Commuter mode choice and free car parking, public transportation benefits, showers/lockers, and bike parking at work: Evidence from the Washington, DC Region. Journal of Public Transportation. 2014; 17(2):1–4. Available from: Crossref
45. Chakrabartty A, Gupta S. Estimation of Congestion Cost in the City of Kolkata - A Case Study. Current Urban Studies. 2015 May; 3(2): 1–10. Available from: Crossref
46. Zhang R, Zhu L. Curbside parking pricing in a city centre using a threshold. Transport Policy. 2016 Nov 30; 52:16–27. Available from: Crossref
47. Gatta V, Marcucci E. Behavioural implications of non-linear effects on urban freight transport policies: The case of retailers and transport providers in Rome. Case Studies on Transport Policy. 2016 Mar;4(1): 22–8. Available from: Crossref
48. Algers S, Hansen S, Tegner G. Role of waiting time, comfort, and convenience in modal choice for work trip. Transportation Research Record. 1975; (534): 1–29.
49. Axhausen KW, Beyerle A, Schumacher H. Choosing the type of parking: a stated preference approach. InUTSG Conference Paper, London. 1988 Jan; 1–18 PMid:3281506
50. Brown GR. Analysis of user preferences for system characteristics to cause a modal shift.TRIDthe TRIS and ITRD database. 1972; (417): 25–36.
51. Ergün G. Development of a downtown parking model. TRID the TRIS and ITRD database. 1971; (369): 118–34.

52. Galbraith RA, Hensher DA. Intra-metropolitan transferability of mode choice models. Journal of Transport Economics and Policy. 1982 Jan; 1–23.
53. May T, Jones D, Rigby J. Parking policy assessment: The contribution of a parking location model in York. Traffic engineering and control. 1989; 30(5): 251–6.
54. Polak J, Axhausen KW. CLAMP: A macroscopic simulation model for parking policy analysis. University of Oxford Transport Studies Unit, 1989.
55. Talvitie A. Comparison of probabilistic modal-choice models: estimation methods and system inputs. Highway Research Record. 1972; (392): 111–20.
56. Whitlock EM. Use of linear programming to evaluate alternative parking sites. Highway Research Record. 1973; (444):9–19.
57. Austin TW, Lee MJ. Estimation of potential use of peripheral parking for Los Angeles CBD. Highway Research Record. 1973,z (444), pp.20-26.
58. Ellis RH, Rassam PR, Bennett JC. Development and implementation of a parking allocation model. Highway Research Record. 1972, (395), pp.5-20.
59. Florian M, Los M. Impact of the supply of parking spaces on parking lot choice. Transportation Research Part B: Methodological. 1980 Mar; 14(1-2): 155–63. Available from: Crossref
60. Gray VO, Neale MA. Parking space allocation by computer model. Highway Research Record. 1972; (395): 21–32.
61. Gur YJ, Beimborn EA. Analysis of parking in urban centers: equilibrium assignment approach. Transportation Research Record. 1984; (957): 55–62.
62. Hunt JD. Parking location choice: insights and reresentations based on observed behaviour and the hierarchical logit modelling formula. Ininstitute of transportation engineers meeting. 1988; 1–29.
63. Wildermuth H. Cencimm. A transport model to test Perth central area policies. Western Australian, Department of Transport Report 301. 1986; 1–56.
64. Traffic planning and Design, Incorporatio. Parking analysis Allentown arena and mixed-used development, city of Allentown, Lehigh County, PA, May 31 2011. Available from: http://www.allentownpa.gov/Portals/0/files/ANIZDA/Documents/2011-05 31%20allentown%20arena%20parking%20analysis.pdf.
65. Bajic V. Choice of travel mode for work trips: some findings for metropolitan Toronto. International Journal of Transport Economics/Rivista internazionale di economia dei trasporti. 1984 Apr;11(1): 79–96.
66. Nourht CC, El-Reedy TY, Ismail HK. A Combined Parking and Traffic Assignment Model. Traffic Engineering & Control. 1981 Oct; 22(10): 524–30.
67. Bates JW. A gravity allocation model for parking demand. Highway Research Record. 1972; (395): 1–4.
68. Bullen AG. Development of computerized analysis of alternative parking management policies. 1982; (845):31–7.
69. Cotterill T, Lee J, Liston T. Transport and future development. In Transport, Communication and Urban Form, edited by W. Young (Department of Civil Engineering, Monash University: Clayton, 1987.
70. Oppenlander JC, Dawson RF. Optimal location of sizing of parking facilities. Institute of Transportation Engineers. In 58th Annual Meeting, Vancouver (Technical Paper 428) 1988; 428–30.
71. Goyal SK, Gomes LF. A model for allocating car parking spaces in universities. Transportation research Part B: methodological. 1984 Jun; 18(3): 267–9. Available from: Crossref
72. Chakrabarti S, Mazumder T. Behavioral Characteristics of Car Parking Demand: A Case Study of Kolkata. Institute of Town Planner, India Journal. 2010; 7(4): 1–11.
73. Hensher DA, King J. Parking demand and responsiveness to supply, pricing and location in the Sydney central business district. Transportation Research Part A: Policy and Practice. 2001 Mar; 35(3): 177–96. Available from: Crossref
74. Hensher DA, Stanley J. Performance-based quality contracts in bus service provision. Transportation Research Part A: Policy and Practice. 2003 Jul; 37(6): 519–38. Available from: Crossref Available from: Crossref
75. Kolhar P. On Street Parking Management Plan and Cost-Benefit Analysis for Dharwad City, Karnataka, India. International Journal of Engineering Research and Applications (IJERA). 2012; 2(3): 165–65.
76. Kim KW, Li G, Park ST, Ko MH. A Study on Birth Prediction and BCG Vaccine Demand Prediction using ARIMA Analysis. Indian Journal of Science and Technology. 2016 Jun; 9(24): 1–7. Available from: Crossref
77. Briefing Note on Parking demand Elasticity in the CBD: An Analysis Comparing Calgary with 43 International cities (2010), Calgary.ca/economy. 2010 Nov.
78. Litman T. Parking pricing implementation guidelines. Victoria transport policy institute. 2010 Nov; 1–35.
79. A report, parking policy in Kolkata Metropolitan area, KMA, India. 2000. Available from: http://www.cseindia.org/userfiles/Parking%20Policy_KMDA.pdf.
80. Cantwell M, Caulfield B, O'Mahony M. Examining the factors that impact public transport commuting satisfaction. Journal of Public Transportation. 2009; 12(2):1–21. Available from: Crossref
81. Kingham S, Dickinson J, Copsey S. Travelling to work: will people move out of their cars. Transport policy. 2001 Apr; 8(2):151–60. Crossref
82. Norhisham S, Ismail N. Case Study on Supply and Demand for University Parking Facilities in College of Engineering UNITEN. InInternational Conference on Construction and Building Technology. Grand Seasons Hotel, Kuala Lumpur 2008; (36): 435–48.