

DEVELOPMENT OF MODEL ESTIMATION TO DETERMINE PARKING ACCUMULATION BASED ON PARKING CHOICE PATTERN OF THE TRIP MAKERS

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Abstract

Parking demand mainly depends on trip characteristics and parking behavior characteristics. To study these characteristics various parking demand models were reviewed. For parking demand estimation based on the accumulation of parking the methodology is proposed. As per proposed methodology, the data required are socio economic characteristics of parkers for primary analysis and parking behavior and parking condition characteristics for model development. Primary analysis is carried out for different socio economic characteristics that are trip purpose, age and income for different modes. Variations in parking behavior characteristics with respect to these socio economic characteristics are discussed. The model development for estimation of parking accumulation based on parking behavior characteristics was presented. Then the calibration of Multi Linear Regression Model (MLR) carried out to bring out the accumulation expression. Finally Regression equations and R^2 values are obtained for a particular parking location. The model was applied for selected stretch in Vijayawada city for two wheelers and cars separately. For the perception of the urban parking problems, data collected from online surveys. Primary analyses were carried out and the necessary issues were identified.

Key words: Parking demand, primary analysis, parking behavior, Multi Linear Regression Model, parking problem.

1. INTRODUCTION

Parking demand is the major concern in the transportation study for any city. Demand mainly depends on the usage of parking lots willing to park. So it is necessary to study the characteristics of parkers for choosing a particular parking location in order to use parking lots effectively. This study represents parking behavior characteristics of parkers for choosing parking location. This study gives parking accumulation and demand based on parking characteristics. As mentioned above, the core of the problem lies in the perception of the urban parking problem. A lot of problems are seen in different perspectives. Different stakeholders have different opinions about certain problems, while others don't see a problem at all. It is hard to develop widespread accepted parking policies when there is no shared understanding of the actual problem. This brings to problem statement: *'Professionals and decision makers within the parking world perceive the urban parking problem in different ways, making it hard to develop effective parking policies'*. The aim is to see this research as a starting point for new discussions, ultimately leading to a more cohesive understanding of the urban parking problem. Therefore research question is: *'How is the urban parking problem perceived by professionals within the parking world and what are the main topics where further research and discussion is needed?'* As part of development of parking demand estimation model based on the parking choice pattern of the trip makers a detailed study is carried out on a selected stretch of Vijayawada City with following objectives: 1) to analyze the existing parking demand and behavioral characteristics i.e walking distance, walking time, parking duration and search and queue time. 2) to evolve a methodology for development of parking demand estimation model based on the parking choice pattern of the trip makers. 3) to estimate the regression equation for parking choice based on parkers behavioral characteristics using Multi Linear Regression Analysis and 4) to analyze the perception of the urban parking problems.

2. DATA COLLECTION AND ANALYSIS

For the present study Vijayawada cross-road stretch is selected. The stretch selected consists of both on street and off street parking facilities with at least two parking choices. The parkers who are willing to park at the selected stretch are asked to respond for the questionnaire to know the parking behavioral characteristics of the respondent. This

information is used to know probabilities of parking choice, which gives the parking choice preference of parkers. The stretch consists of on street parking are having both sides parking, off street parking and cellar parking where there is no parking fee. Questionnaire survey is conducted among the parkers who are willing to park at the parking location are asked about the parking condition characteristics of parking choice i.e. on street and off street parking. Preliminary analysis is done for socio economic characteristics. Percentage Distribution of vehicles based on mode, variations in trip purposes, number of parking trips made based on different income levels and parking accumulation for peak period are presented. Parking demand in terms of parking accumulation that is number of vehicles parked for every 15 minutes is determined for 3 hours duration of 10:00 am to 1:00 pm. Different modes are existing in the selected stretch. The existing modes are two wheelers, cars, auto rickshaw and others. The majority of modes parking at the stretch are two wheelers. Parking accumulation values that are number of vehicles parked for 15 minutes interval for a peak period of 3 hours is summarized in Figure 1 below. It shows the Parking accumulation at Vijayawada cross-road between 10:00 am to 01:00 pm duration. The demand values are less for car and other modes when compared to two wheelers at the stretch.

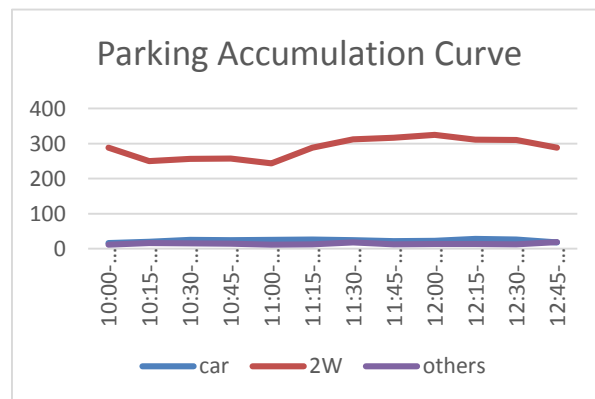


Figure 1 Parking accumulation curve

Figure 2 shows the distribution of modes at the stretch. The existing modes at the stretch are two wheelers, cars and other modes. The two wheeler percentage (89%) is more when compared to other modes.

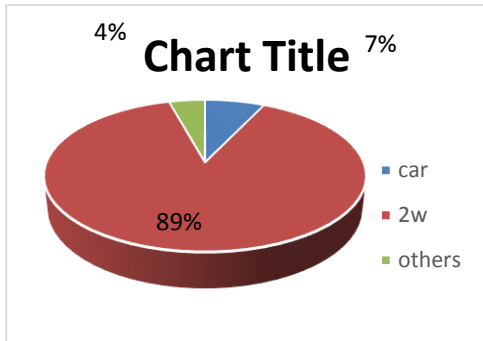


Figure 2 Composition of modes

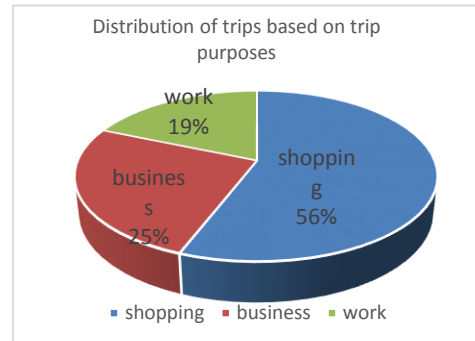


Figure 3 Composition of trip purposes

Figure 3 shows the distribution of trips based on the trip purpose. Three types of trip purposes are existed at the study area. Shopping trips (56%) are more at the study area. The family income range distribution for 2-wheeler users is shown in Figure 4. It was observed that the highest percentage (47%) was for the income range Rs. 15,000 to Rs. 30,000. Similarly for car users the family income range distributed in Figure 5. It was observed that the highest percentage (36%) was for the income range Rs. 60,000 to Rs. 1,00,000.

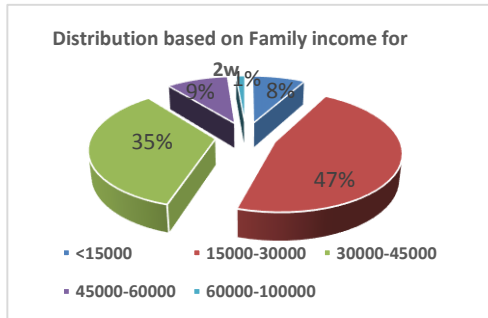


Figure 4 Income range for 2-wheelers

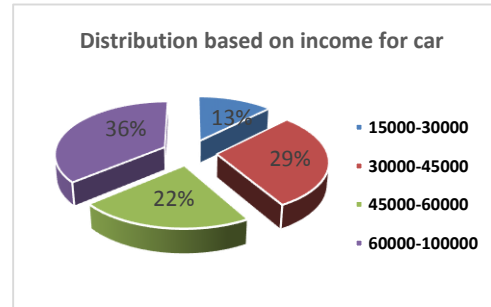


Figure 5 Income range for cars

Figure 6 shows the percentage distribution based on age parameter for 2-wheeler users. It was observed that the highest percentage (50%) of 2-wheeler user's age is in between 25-30 years. Figure 7 shows the percentage distribution based on age parameter for car users. It was observed that the highest percentage (34%) of car user's age is in between 40-45 years.

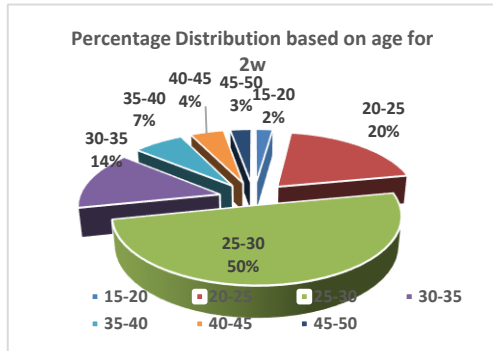


Figure 6 Composition on age for 2-W

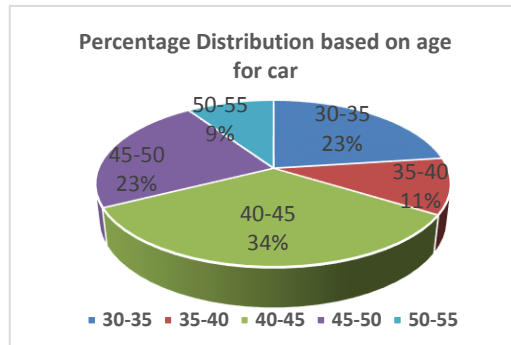


Figure 7 Composition on age for car

3. DATA COLLECTION ANALYSIS

Analysis of parking behavior characteristics based on socio economic characteristics is done separately for on street and off street parking for two wheelers and cars.

For two wheeler users on street parking: The variation of parking characteristics for 2-wheeler users based on age group parameter for on street parking are shown in below Figure 8. In the case of on street parking, it is observed that the parking duration is high for the age group of 41-45 years, similarly walking distance is high for the age group of 31-35 years. Walking time and search time is almost similar for all age groups.

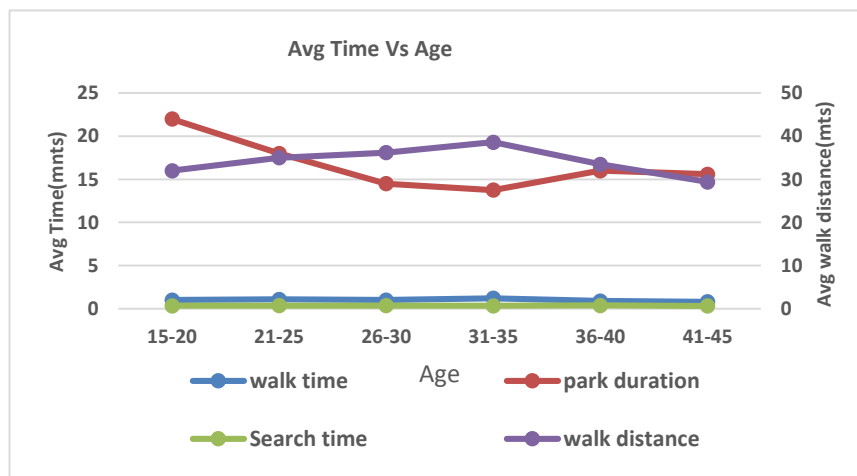


Figure 8: Average parking characteristics of age for on street parking for 2W

For two wheeler users off street parking: The variation of parking characteristics for 2-wheeler users based on age group parameter for off street parking are shown in below Figure 9. In the case of off street parking, it is observed that the parking duration is high for the age group of 41-45 years, walking distance from parking lot to destination is high for the age group of 15-20 years, walking time is high for the age group 15-20 years. Search time is almost similar for all age groups.

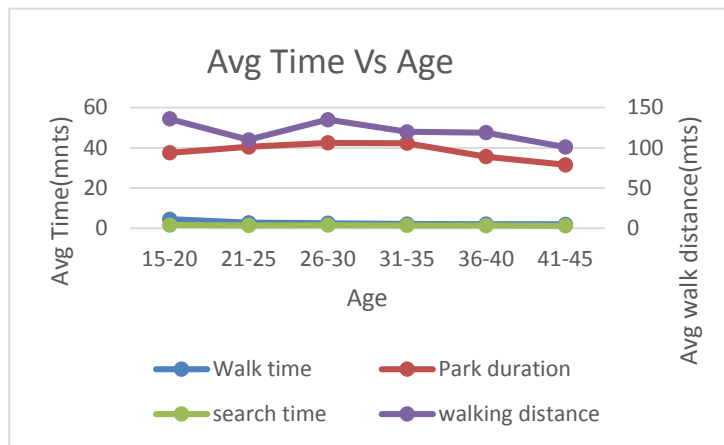


Figure 9 Parking characteristics of age for off street parking for 2W

For car users on street parking: The variation of parking characteristics for car users based on age group parameter for on street parking are shown in below Figure 10. In the case of on street parking, it is observed that the parking duration is high for the age group of 36-40 years, similarly walking distance is high for the age group of 30-35 years. Walking time and search time is almost similar for all age groups.

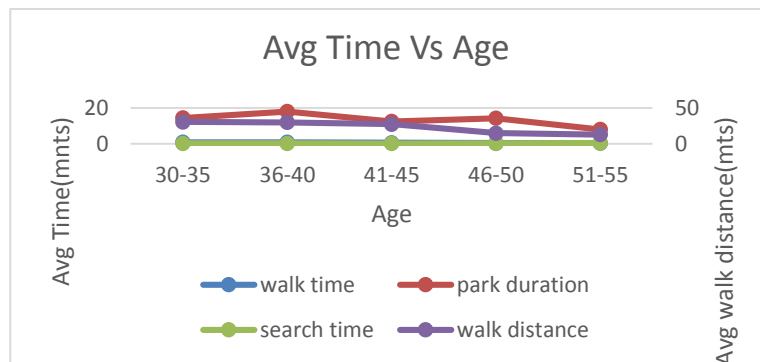


Figure 10 Parking characteristics of age for on street parking for car

For car users off street parking: The variation of parking characteristics for car users based on age group parameter for off street parking are shown in below Figure 11. In the case of off street parking, it is observed that the parking duration is high for the age group of 36-40 years, walking distance from parking lot to destination is high for the age group of 41-45 years, walking time is high for the age group 30-35 years. Search time is almost similar for all age groups.

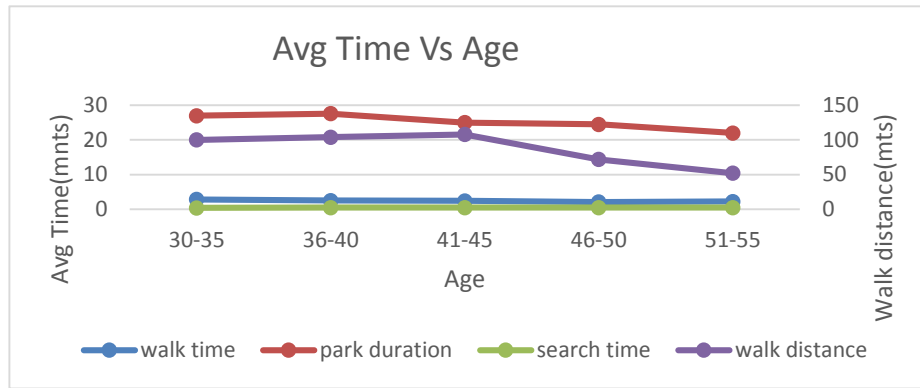


Figure 11 Parking characteristics of age for off street parking for car

For two wheeler users on street parking: Analysis of parking behavior characteristics based on socio economic characteristics is done separately for on street and off street parking for two wheelers and cars. The variation of parking characteristics for 2-wheeler users based on family income parameter for on street parking are shown in below Figure 12. In the case of on street parking, it is observed that the parking duration is high for the income group of Less than Rs.15000, Walking time and search time is almost similar for all income groups.

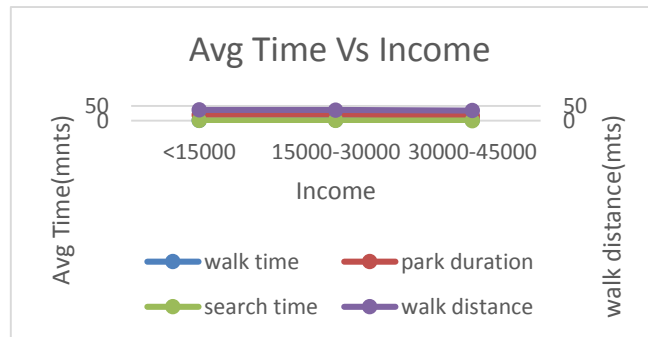


Figure 12 Parking characteristics based on income for on street parking for 2W

For two wheeler users off street parking: The variation of parking characteristics for 2-wheeler users based on family income parameter for off street parking are shown in below Figure 13. In the case of off street parking, it is observed that the parking duration is high for the income group of Rs.15000-Rs.30000, walking distance is high for the income group of Rs.15000-Rs.30000, similarly walking time is maximum for the income group Less than Rs.15000, and search time is almost similar for all income groups.

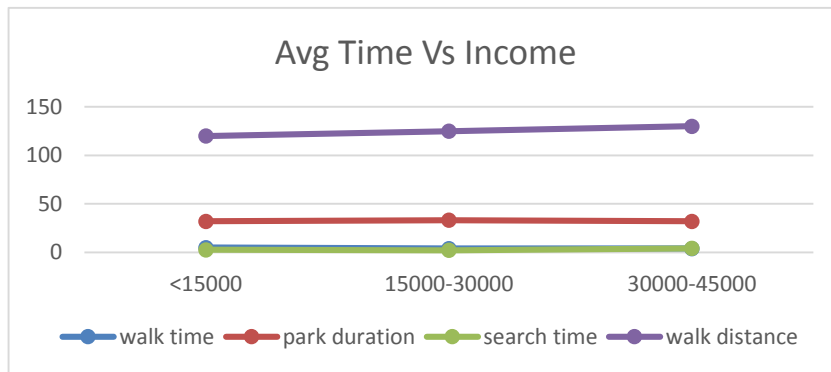


Figure 13 Parking characteristics based on income for off street parking for 2-W

For car users on street parking: The variations of parking characteristics for 2-wheeler users based on family income parameter for on street parking are shown in below Figure 14. In the case of on street parking, it is observed that the parking duration is high for the income group of Rs.60000-Rs.100000, similarly walking distance is high for the income group of Rs.45000-Rs.60000. Walking time and search time is almost similar for all income groups.



Figure 14 Parking characteristics based on income for on street car parking

For two wheeler users off street parking: The variation of parking characteristics for car users based on family income parameter for off street parking are shown in below Figure 15. In the case of off street parking, it is observed that the parking duration is high for the income group of Rs.30000-Rs.45000, walking distance is high for the income group of Rs.60000-Rs.100000, similarly walking time is maximum for the income group Rs.30000-45000, and search time is almost similar for all income groups.

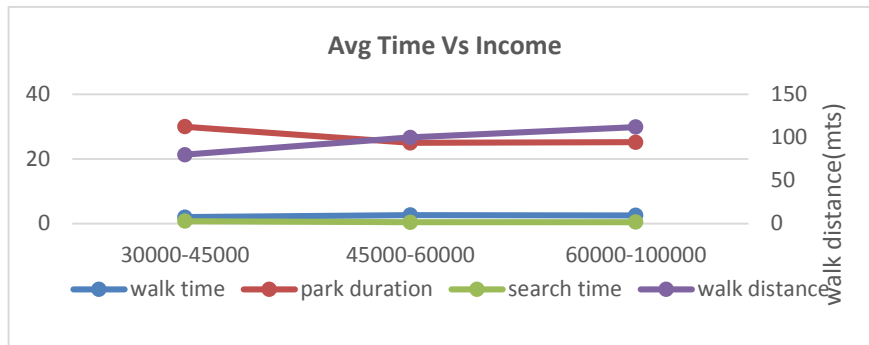


Figure 15 Parking characteristics based on income for off street car parking

OBSERVATIONS: The major vehicles parking at the stretch are two wheelers. The main trip purpose at the stretch is shopping. Majority of two wheeler users have family income between Rs.15000 to Rs.30000 per month. Majority of car users have family income between Rs.60000 to Rs.100000 per month. Majority of two wheeler users average group between 25-30 years. Majority of car users have age group between 40-45 years. The variation in the parking behavior characteristics with respect to age and income are discussed.

4. ANALYSIS AND RESULTS

Multi linear regression model for 2w: Regression model on 2w parking demand, which were based on parking information along Vijayawada Cross-road stretch. The model formula is shown as Equation 1.

$$\text{Accumulation} = 1475.79228 + 0.13912 * \text{Duration} + 0.05898 * \text{Total2W} + 0.114.32799 * \text{DIST_DEST} + 103.75365 * \text{WALK_T} + 13.80663 * \text{SEARCT_T} \quad (\mathbf{R^2} = \mathbf{0.9294}) \dots\dots\dots(1)$$

Model Testing: The model was first tested for its applicability using the data on the corresponding dependent and independent variables collected during the study. The data obtained from corridors along Vijayawada cross-road stretch were used to test the applicability of the model. The Chi-squared test at a 5 percent significance level was used to test the applicability of the model for the data collected from 10.00 A.M. to 1.00 P.M. The results of the Chi-squared analysis shown in Table 1 indicate that the model can be accepted as representing the data at this parking place

Table 1 Chi-squared test at Vijayawada cross-road stretch for 2W

S.No	Estimated frequency (E)	Observed frequency (O)	(O-E) ² /E
1	297	297	1.450
2	303	302	0.625
3	312	311	0.251
4	332	333	0.778
5	290	289	0.076
6	297	297	0.024
7	319	320	0.041
8	319	316	0.221
9	303	304	0.263
10	305	305	1.003
11	308	308	0.898
12	318	320	1.659
		Total	7.288
	Df=12-1=11	alpha=5%	
	Theoretical Chi-squared=21.03		
		7.926<21.03	Accept it

Multi linear regression model for cars: Regression model on car parking demand, which were based on parking information along Vijayawada Cross-road stretch. The model formula is shown as Equation 2.

$$\text{Accumulation} = 92.84482598 + 0.250568472 * \text{Duration} + 0.226622363 * \text{Total2W} + 1.582839 * \text{DIST_DEST} + 53.2723 * \text{WALK_T} + 17.8283 * \text{SEARCH_T} \quad (\mathbf{R^2} = \mathbf{0.5897}) \dots\dots\dots(2)$$

Model Testing: The model was first tested for its applicability using the data on the corresponding dependent and independent variables collected during the study. The data obtained from corridors along Vijayawada cross-road stretch were used to test the applicability of the model. The Chi-squared test at a 5 percent significance level was used to test the applicability of the model for the data collected from 10.00 A.M. to 1.00 P.M. The results of the Chi-squared analysis shown in Table 2 indicate that the model can be accepted as representing the data at this parking place

Table 2 Chi-squared test at Vijayawada cross-road stretch for car

S.No	Estimated frequency (E)	Observed frequency (O)	(O-E) ² /E
1	18	15	0.067
2	14	15	0.831
3	15	16	0.498
4	14	15	0.024
5	15	14	0.547
6	13	14	2.065
7	14	12	4.466
8	15	16	0.221
9	15	12	0.263
10	13	17	1.003
11	14	14	0.898
12	16	17	1.659
		Total	12.540
	Df=12-1=11	alpha=5%	
	Theoretical Chi-squared=21.03		
		12.5401<21.03	Accept it

CONCLUSION

Numbers of methodologies are used for estimating parking demand model using parking behavior characteristics. Multi linear Regression model is used for the present study. It gives the regression equation of parkers for choosing a particular lot. The factors considered are total no of parkers, parking duration, walking distance from parking lot to destination, walking time from parking lot to destination and search and queue time. Using these parameters as input variables the model is developed. Output is the MLR equation for choosing particular parking lot. The observed data were tested by using Chi-squared test. The future parking demand estimated. Comparisons of consensus measurements were tested.

The following conclusions are made from the present study

1. Parking behavior characteristics mainly influence the choice of parking location. From the present study, usage of parking is mostly for two wheelers other than any other mode that is two wheeler compositions is about 60 to 80%. So it is necessary to regulate the parking lots for their efficient use.
2. As walking distance from parking lot to destination, walking time, search time for parking lot increases the probability of choosing particular parking location reduces.
3. The models developed for estimating the demand for parking at different locations give reasonable results and indicate that if no action is taken, shortfalls of parking spaces will occur along roads.
4. The factors that affect the demand for parking include the number and percentage of 2w/cars in the traffic stream, the distance between a parking space and the destination, parking duration, walking time from parking lot to destination and search time.
5. If the parking facilities for 2w/cars are not expanded, it is highly probable that more vehicles will be parked on the shoulders adjacent to the rest areas.

SCOPE OF THE FUTURE WORK

Present study considered only two parking choice locations; this model can be applicable to other parking choice locations like multi-level parking. Greater attention should be paid to the segmentation of the parking market. Understanding the zones of influence of parking restraint policies, particularly for commuter traffic is need to be researched.

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