Available online at www.sciencedirect.com
ScienceDirect
Procedia - Social and Behavioral Sciences 96 (2013) 2635 – 2642
Procedia
Social and Behavioral Sciences

13th COTA International Conference of Transportation Professionals (CICTP 2013)

Parking choice behavior investigation: A case study at Beijing Lama Temple

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Abstract

Understanding parking choice behaviour is important in parking facility design and service evaluation. Lack of sufficient studies on parking choice behaviour investigation has been an issue in parking facility planning in China. Using six parking facilities in Beijing Lama Temple as an example, this paper investigates the parking behaviour at the tourist site. Based on the data collected at these six parking facilities through a stated-preference survey, a multinomial logit model was developed, which reveals the relationship between parking decision and influential factors.

Keywords: Parking, Parking Choice Behavior, Multinomial Logic Model (MNL)

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doi:10.1016/j.sbspro.2013.08.294

1. Background

As the vehicle ownership rapidly increasing, parking is becoming a serious problem in Beijing. An efficient parking policy is an important component of urban transport planning. As the aim of parking policy measures is to influence decisions made during the parking process, it is important to gain an understanding of the factors affecting parking behaviour. In this paper we conduct a survey of the parking lots around the Lama Temple in Beijing.

The study area consists of Lama Temple, Guozijian Street, Ditan Park. This area is mainly for tourism and also there is resident and business. Most of the visitors of the Ditan Park are the residents. The other scenic regions attract lots of foreign tourists. Fig.1. shows the location of the parking lots and study area.

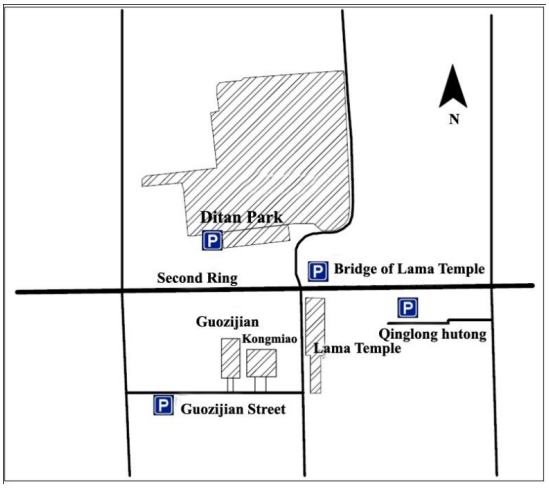

Fig. 1. Location of the parking lot and study area

2. Literature Review

Spiess (1996) uses a logit model to model the parking lot choice in a park and ride context. Young (2000) distinguishes 5 types of parking models: parking design models, parking-allocation models, parking-search models, parking-choice models and parking-interaction models. Hess (2001) uses an MNL model to assess the impact of the availability of free parking on mode choice and parking demand for work related travel. Guan Hongzhi et, (2003)conducted a parking behaviour survey in Xidan area of Beijing. A parking lot choice model is provided with disaggregated method. According to the analysis, there is a great possibility in parking cost to adjust the parking lot choice behaviour. Stephane Hess (2004) uses a mixed multinomial logit (MMNL) model to analysis the parking choice behaviour. The model reveals important differences in parking behaviour with different journey purposes. Yao Sheng yong (2008) analyze the relationship between parking-charge and parking behaviour in CBD. Michele Ottomanelli (2011) etc. present a discrete choice model for evaluating parking users' behaviour. There are also other scholars using multinomial logit (MNL) model analysis the parking behaviour. (Bates,Bradley ,1986;Hensher and Button, 2000).

3. Data Collection

Two types of basic data were manually collected. One is the parking facility's basic information such as parking charge rate and capacity, and another is the parking duration and number of parking turnovers for individual parking space. The performance data were collected on a typical weekday (Thursday) during the peak tourist season. There is 604 spaces in all and all the parking spaces were observed from 8:00 a.m. to 20:00 p.m. This was accomplished by recording the last three digits of each vehicle's license plate number in each parking space.

We also conduct a face-to-face parking survey in three parking lots: Guozijian Street, the Bridge of Lama Temple, and Ditan Park. Interviewers approached drivers as they left or returned to their parked vehicles. Each interview lasted approximately 15 minutes. Totally, 218 drivers were interviewed. Table 1 summarises the data collection.

Table 1. Data Collection Summary

Name of parking lot	Number of recorded license plates		The number of parking behavior surveys	Space	Fees
	number of original records	number of valid records			
Ditan park	1209	1028	91	415	8 yuan/h daytime
The bridge of Lama Temple	200	200	51	68	10 yuan for the 1st hr. then 15yuan/h
Guozijian Street	1080	658	76	100	Free
Qinglong Hutong	28	28	--	21	8yuan/h day time
total	2517	1914	218	604	--

4. Results

4.1 Parking lot utilization

Based on the collected data, we analysis the utilization ratio of parking spaces, peak hour occupancy, turnover, average parking time. Utilization ratio of the spaces γ can be less than 1.0 indicating that the parking lot being analyzed is not being fully used; it also can be greater than one indicating that all spaces were being completely utilized each hour. The following equation gives the utilization rate calculation and the peak hour occupancy:

$$\gamma = \frac{\sum_{i=1}^{s}(t_i \cdot P_i)}{T \times C} \times 100\% \quad (1)$$

γ ——utilization rate;

t_i —— length of parking time of vehicle$_i$;

P_i —— number of parked vehicles with parking time as t_i;

T——length of the observation time;

C—— total spaces

$$\rho = \frac{n}{c} \tag{2}$$

ρ —— peak hour occupancy;

n ——number of vehicles in the parking lot in peak hours;

c ——total spaces.

Figure 2 illustrates the Utilization ratio and peak hour occupancy by parking lots at the Lama Temple.

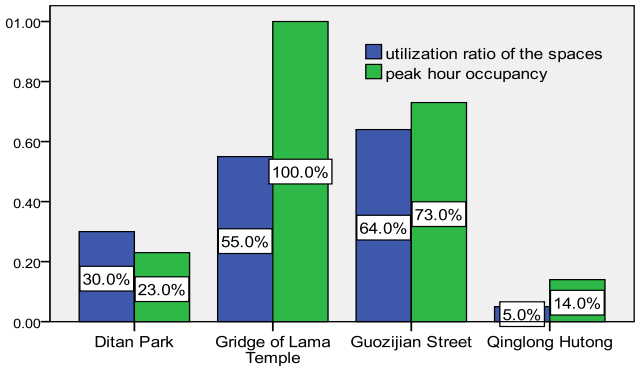

Fig. 2. A comparison of utilization ratio of the spaces and peak hour occupancy between different parking lots

As shown in Figure 2, the utilization ratio and peak hour occupancy vary greatly at this tourist site. The lowest utilization ratio is only 5% at Qinglong Hutong parking lot, which is mainly because of its remote location with a narrow roadway connection. The highest peak hour occupancy rate is 100% at the Bridge of Lama Temple parking lot (68 spaces). There are lots of tourists going to Lama Temple in peak hour. The peak hour occupancy rates of Guozijian and Ditan is 73% (100 spaces) and 23% (415 spaces) respectively. The results of present demand indicated that all the lots (except for the Bridge of Lama Temple) have a surplus of parking. The parking turnover frequency and duration is displayed in Figure 3.

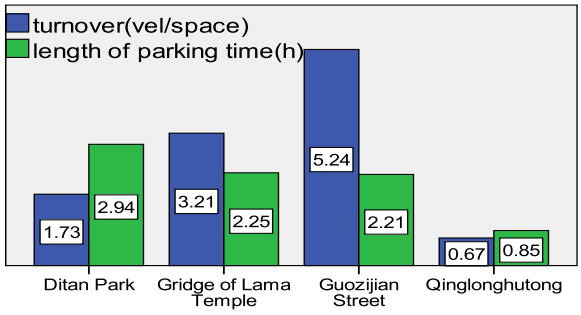

Fig. 3. A comparison of turnover and length of parking time

It is clear from Figure 3 that Guozijian Street has the highest turnover rate (5.42vel/space). Parking along Guozijian Street is free but illegal. However, not a single driver was ticketed for parking in Guozijian Street during our observation time. Lack of enforcement encouraged drivers to park along Guozijian Street for free and convenience particularly when the close parking lot at Bridge of Lama Temple had 100% occupancy rate. It is also interesting to see that drivers were fully aware of the illegal parking risk evidenced by its shorted parking duration and highest parking turnover rate as shown in Figure 3. At the designated parking locations, the parking time is between 2 and 3 hours. To demonstrate dynamic nature of parking situation, Figure 4 is developed to show the parking occupancy rate by hour.

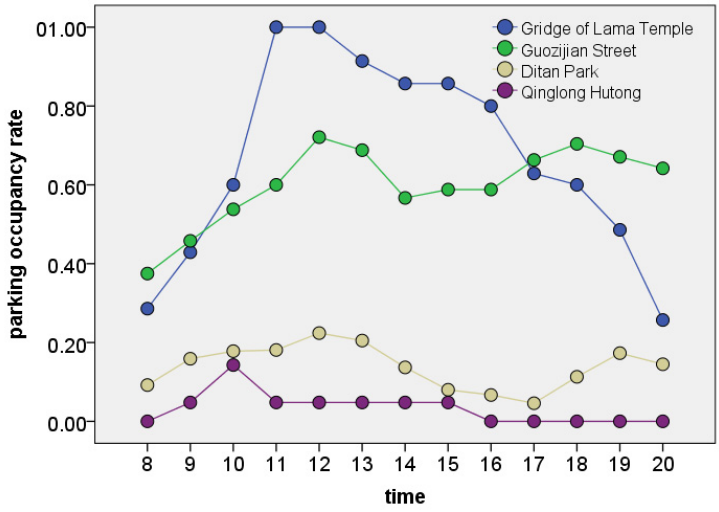

Fig. 4. Parking occupancy rate every hour

It is important to note that rates vary significantly by location and time of day within the study area. As shown in Figure 4 the parking lots close to the core area (the Bridge of Lama Temple and Guozijian Street) have a significantly higher occupancy rate than the rates in the fringe area (Qinglong Hutong and Ditan Park) during the time period from 8:00am to 20:00 pm. The Bridge of Lama Temple parking capacity was fully occupied during the peak hour 11am-12pm.. After 12:00 it began to decrease because the number of the tourists started to leave.

Guozijian Street parking spaces were utilized at 72.1% percent at 2:00 p.m. and 74% percent during the evening peak hour occupancy. In the afternoon the local residents come back from home. Ditan Park and Qionglong Hutong exhibited extremely lower parking occupancy which is less than 20%. This attributes to the location of the lot itself far away from the Lama Temple and also because Ditan Park has a large amount of parking spaces (415spaces).

4.2 Characteristic of Parking Choice Behaviors

Understanding how users select parking facility is curtail in parking planning and design. The objective of the interview was to investigate the users' attitudes and behavioural patterns with regard to parking. The purpose of parking is illustrated in Figure 5.

Although these parking facilities are designated for the Beijing Lama Temple, the surrounding commercial and entertainment areas also attract visitors. Figure 5 shows that almost half of people parked vehicles there are

for amusement, and 24% from tourists. Due to the mixed land use development, there are 11% parking for work and 8% for going home. The responses to parking charge are displayed in Figure 6.

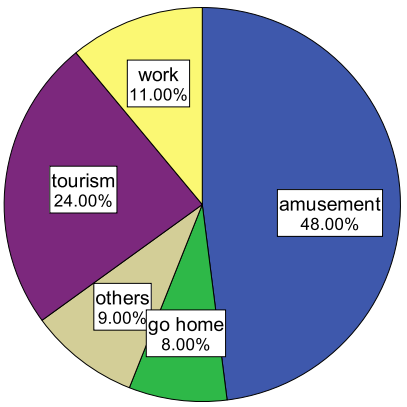

Fig. 5. A distribution map of parking purpose

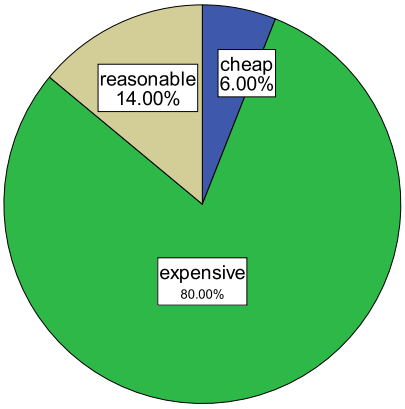

Fig. 6. Responses to parking charge

It is not surprised to see that about 80% of drivers consider the price being high, and only 13.64% consider the price being reasonable. The considering factors for parking location is summarized in Figure 7.

From Fig.7 we can see that approximately 90% of drivers consider distance is the most important factors when choosing which place to park. Only 0.81% of the drivers put price as first place when choosing the parking the parking lot. The walking time between the destination and the parking lot is given in Figure 8.

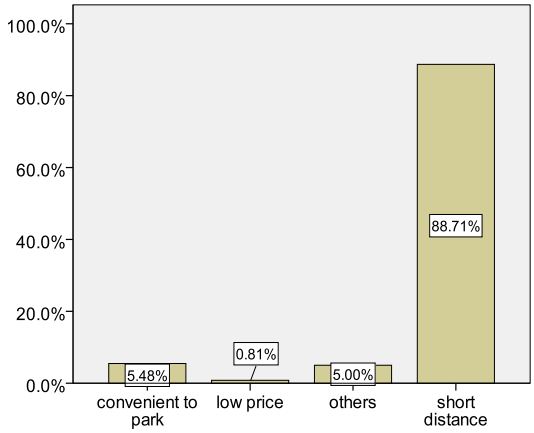

Fig. 7. The reason for parking lot choice

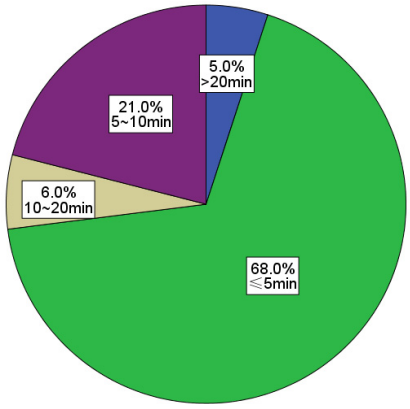

Fig. 8. The walk time between the destination and the parking lot

As expected parking users choose the smallest travel distance if the charge is similar. Approximately 70% of walk time is within 5 minutes. Drivers prefer to choose the parking lot close to the destination.

5. Modeling the parking choice behavior

A multinomial logit (MNL) model was developed based on the survey data. The model is designed for analyzing the choice between discrete alternatives. Table 2 shows the three parking choice behaviour models with different factors.

Table 2. Estimation result of parking choice behaviour model

Parameter	Estimate	t Test	ρ^2	$\overline{\rho}^2$
(1)Model with constant and purpose, fare, walk time and sex				
purpose	0.840116	2.364863		
fare	-0.010681	-1.989175		
walk time	-2.802511	-7.387498	0.61149	0.580979
sex	0.365339	***0.347438***		
constant_1	1.585814	***1.15601***		
constant_2	2.342614	4.666839		
(2)Model with constant and purpose, fare, walk time				
purpose	0.773507	2.170024		
walk time	-2.831061	-7.492039		
fare	-0.08248	-1.961837	0.605262	0.579836
constant_1	1.684522	2.588686		
constant_2	1.956857	4.562349		
(3)Model with constant and purpose, walk time				
walk time	-2.879032	-7.723807		
fare	-0.08793	-1.987831	0.596211	0.575871
constant_1	2.284763	4.250046		
constant_2	2.315711	4.732821		

ρ^2 is the goodness-of-fit index, $\overline{\rho}^2$ is the adjusted goodness-of-fit index. When $0.2 \leq \rho^2$ and $\overline{\rho}^2 \leq 0.4$, it indicates that the model has a high level of precision.

From Table 2 we can see that all the t Test > 1.96 (except for t_{sex}). The model reveals that parking purpose, walking time and charge are significant variables shaping the parking choice behaviour. Similarly, gender has a little effect on the parking choice.

There is a minus sign ('-') before the coefficient of fare. This indicates that drivers tend to choose the low price parking lot. Similarly, the minus sign('-') before the coefficient of distance means that drivers tend to choose a parking lot which is close to the destination. This is in accordance with the reality.

The coefficient of fare is too small which exhibits that price has a little effect on the decision make. Because in reality the price difference among the three lots is not significant (except for illegal parking).Similarly, distance (also the walk time) is the first consideration when they make a choice.

In general all three models describe the parking behaviour with different factors.

6. Conclusion

The study results have clearly showed that proper parking facility design and operation are very important in urban transportation, particularly in an urban area with a high degree of mixed land use. Although our parking study was conducted in a tourist site, the parking facilities are used by a mixed of customers and their demand for parking varies by time of the day and location. With distance and parking charge as the most important decision making factors, there are parking lot fully used (100% in peak hour), others is not (about 20% in peak hour). In Ditan Park there is lots of empty spaces, however, under the Bridge of Lama Temple all the spaces are fully used (100% used in peak hour).

The models reveal an important location effect, in such that the results of the analysis vary substantively across the three locations. Drivers are most sensitive to walk time and not very sensitive to the price.

We should consider the location difference when setting parking price. So we can balance the demand between different parking lots. In the central area, the parking price should be high. However, if the price is too high, maybe the number of tourists will be reduced.

The results of this study suggest using parking charge as leverage to balance the parking facilities utilization. For instance, lowering the price at remote parking facility to such a level that its parking utilization will be the same as one close all destinations. How much the leverage is will be the future study objective.

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