Analysis on the Parking demand of the Commercial Buildings Considering the Public Transport Accessibility

——Commercial Buildings in Beijing as an Example

Huanmei Qin [1], Qing Xiao [1], Hongzhi Guan [1], Xiaosong Pan [1]

1. Beijing Key Laboratory of Traffic Engineering, Beijing University of Technology, Beijing 100124, China
hmqin@bjut.edu.cn

Abstract: Parking index is the fundamental basis for the buildings' parking supply in city. Researches on the parking demand takes prepare for establishing the buildings' parking index. Based on the parking survey of the commercial buildings in Beijing, this paper first analyzes the parking demand of the shopping centre and supermarkets. Further it analyzes the relationship between the parking demand of the commercial buildings and the public transport accessibility. The conclusion is that the parking demand rate of the shopping centre and supermarkets decreases with the increasing of the public transport accessibility. It also provides the parking demand rate under the different levels of the public transport accessibility and the parking demand model with the accessibility. The conclusions are valuable for the researches on the parking demand and the making of the parking index for the commercial buildings.[Nature and Science. 2010;8(3):63-68]. (ISSN: 1545-0740)

Key words: commercial buildings; public transport accessibility; parking demand analysis; parking index

1. Introduction

The parking index of the buildings is the important basis for the construction of city's parking facilities. It's very important for the sustainable development of urban transport. The national parking standards in China are "Parking Planning and Design Rules" and "Parking Construction and Management Temporary Rules" which were promulgated by Ministry of public security of the people's republic of China and Ministry of housing and urban-rural development of the people's republic of China in 1989. Today these standards can't meet the requirements of the rapid economic development and motorization in city. In recent years, many cities in China have established there own standards according to their own features.

Most of these standards only consider the parking demand and ignore the influence of public transport on parking demand. With the promotion of Transit-Oriented Development mode, the services of transportation system are improving and becoming more important in the parking demand factors. Considering the influence of the public transport accessibility on the parking demand, this paper analyze the parking demand of shopping centre and supermarkets and bring forwards the parking demand rates of these commercial buildings under the different levels of the public transport accessibility by the parking demand survey data in Beijing. This research will hope to provide new thinking for the parking demand analysis of commercial buildings and other buildings and further give references for the establishment of parking standards.

2. Survey introductions

Generally, the commercial buildings include shopping centre, supermarket, market, restaurants and entertainments etc. This paper chooses the typical shopping centre and supermarket as research objects. The selection of survey places mainly depends on the regional location and scale of the buildings. The survey places selected should have adequate parking lots and the information of them is easy to gain (Zhou, 2004; Nan, 2005). So this paper selected 17 survey places which were investigated at the peak parking period between December of 2008 and March of 2009 in Beijing as shown in figure.1.

The survey contents have three aspects. (1) the information of the buildings include GFA (Gross Floor Area), usage status, location of the matched parking lots, the number of parking spaces and the parking fee etc; (2) the information of public transport around of the buildings with the radius of 500 meter include the distance from the building to the public transport stops and the frequency and routes of the buses or metros etc; (3) parking features include the parking demand at the peak parking period and the flow of customers of the buildings. The first two parts were gained by site investigation and the third part by investigators who count the number of vehicles entering and leaving the parking lot (Guan, 2003).

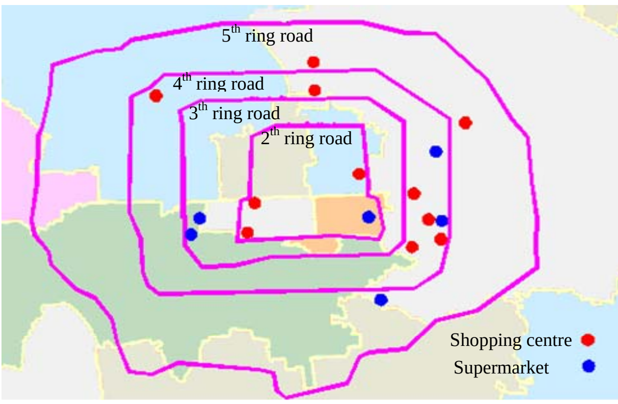

Figure 1. Distribution of Parking Survey Places of the Commercial Buildings in Beijing

3. Analysis on the Parking Demand of commercial buildings

The general research method of the parking demand of buildings is Parking Demand Rate which could obtain parking demand number per unit land index by analysis of the relationship between the parking demand and land index of the buildings (Li, 2007). It always chooses the land indices with better relativity and high maneuverability such as GFA, the number of employment post or seats. The typical formulation of Parking Generation Rate model is just like this:

$$P_i = \sum_{j}^{n} R_{ij} L_{ij} \qquad (1)$$

Where:

P_i： the peak parking demand of the i^{th} region;

R_{ij}： the unit parking generation rate of the j^{th} land use type of the i^{th} region;

L_{ij}： the land use index value of the j^{th} land use type of the i^{th} region;

n： the number of the land use types in the i^{th} region.

There are many land use indices of the buildings. In view of the maneuverability, GFA is chosen to analyze the parking demand. To test the rationality of the selection of GFA, SPSS is used to analyze the correlation between GFA and the parking demand by the survey data as shown in table 1. When the Pearson correlation bigger and the Asymp. Sig. smaller, the correlation in variables is more remarkable. The correlation indices of shopping centre and supermarkets are both above 0.70. This proves that the correlation is good. So this paper takes GFA as unit of parking demand rate (1 per 100 square meters of GFA).

Table 1. Correlation Test between Utilizable Building Area and Parking Demand

	Pearson correlation	Asymp.Sig. (2-sided)
Shopping centre	0.79	0.004
supermarket	0.70	0.083

Table 2. Means and Range of Parking Demand Rate of Business Buildings

Building type	Number of samples	Mean per 100 sq m	Parking demand range per 100 sq m	Parking standard o 2003* per 100 sq m
shopping centre	10	0.64	0.48~1.71	0.65
supermarket	7	0.93	0.74~1.61	

Note：*quote from《Guidelines for construction project's planning and design in Beijing》2003

From Figure 2 and Table 2, the parking demand rate of commercial buildings is between 0.22 and 1.97 per 100 square meters. The mean parking demand rate of shopping centre is 0.64 per 100 square meters and supermarket is 0.93 per 100 square meters. Both of them are close to or higher than the standard index of 2003 in Beijing. This proves that the parking demand increases rapidly. The range of the parking demand rate is 0.48~1.71 per 100 square meters for shopping centre and 0.74~1.61 per 100 square meters for supermarkets, which take 85% of parking demand as upper limit and 15% as lower limit.

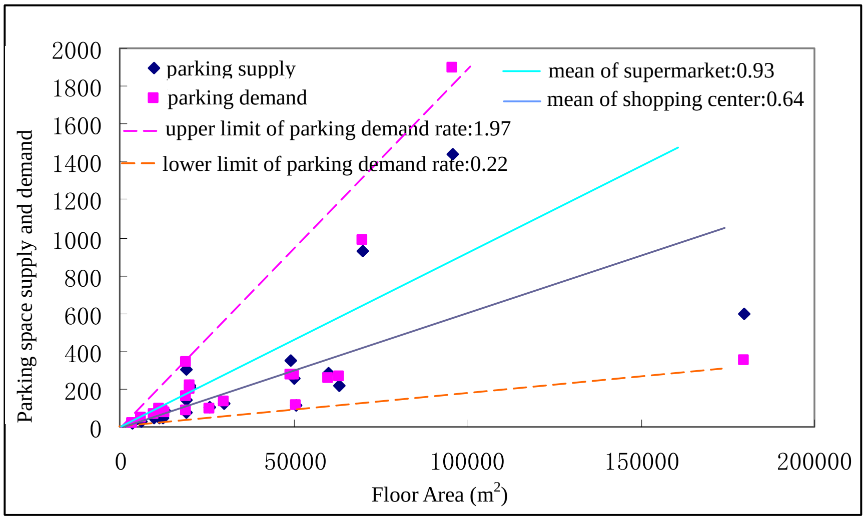

Figure 2. Peak Parking Demand of Business Buildings

4. Analysis on the effect of public transport accessibility on parking demand of the commercial buildings

4.1 Definition and calculation for public transport accessibility

There are many scholars have researched on the public transport accessibility (Zhao, 2005; Murray, 2003; Morris, 1979; Zhang, 2009). The scholars in Britain have considered the public transport accessibility in the analysis of parking demand in early time. They have considered that the parking spaces could be reduced in the region or buildings with high public transport accessibility around and encouraged the transfer of traffic modes to the public transportation.

The calculation of public transport accessibility is based on the distance between the buildings and public transport stops and the public transport service level (Simon, 2003). The distance is expressed with walking time and the service level is expressed with waiting time for the public transport. The formulation is as follows:

$$AI_q = \frac{30}{T_{mi}+T_{ni}} + \frac{1}{2}\sum_j \frac{30}{T_{mj}+T_{nj}} \qquad (2)$$

$$AI = \sum AI_q \qquad (3)$$

$$T_m = St/V \qquad (4)$$

$$T_n = 0.5\times 60/a + k \qquad (5)$$

Where:

AI_q : the public transport accessibility index for the q^{th} kind of public transport modes around the building.

AI : the public transport accessibility index for the building.

T_{mi} : the walking time(minute) from the building to the public transport stop on the optimal route *i*.

T_{ni} : the average public transport waiting time(minute) on the optimal route *i*

T_{mj} : the walking time(minute) from the building to the public transport stop on the other route *j*.

T_{ni} : the average public transport waiting time(minute) on the other route *j*.

St : the distance(meter) between the building and the public transport stop.

V : the average walking speed(meter per minute)

k : the reliability coefficient, the railway is 1 and the bus is 2.

a : the average arrival rate(vehicle per hour) of transit vehicle

Usually the routes are bidirectional at the public transport stop. The direction with high travel efficiency is considered in the calculation model for the public transport accessibility index. The optimal route is generally the one with small accessibility time. Sometimes the travelers have to change the trip routes to the trip destination. This will increase the trip delay. So the Equivalent Doorstep Frequency (EDF) of other selected route value need a reduction by a weight coefficient which is 1/2 in this paper. The walking speed *V*, distance *St* and average arrival rate a are all obtained by the survey data. The average walking speed *V* is 65.79 meter per minute based on the on-site observation including thirty shopping traveler samples. It is close to the value of walking speed in traffic engineering which is 70 meter per minute (Ren, 2008). So the public transport accessibility of the commercial buildings in the survey can be calculated by the survey data and the above formulation.

4.2 The relation between the public transport accessibility and parking demand of commercial buildings

The public transport service level around the buildings has some effect on the trip mode choice on a certain extent and that further affect the parking demand attracted by the buildings. With the public transport accessibility and high hour parking demand obtained by the survey data, the relation analysis between the public transport accessibility and parking demand is as follows:

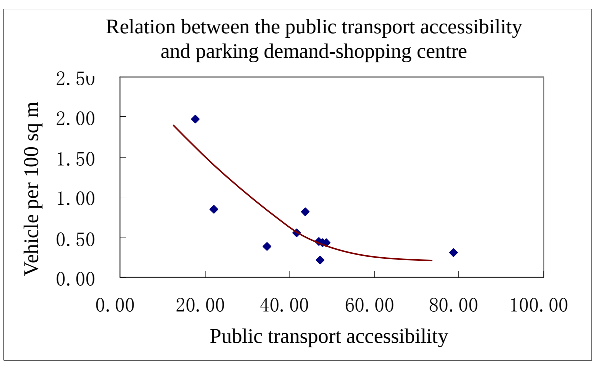

Figure 3. Relation between the Public Transport Accessibility and Parking Demand of the Shopping Centre

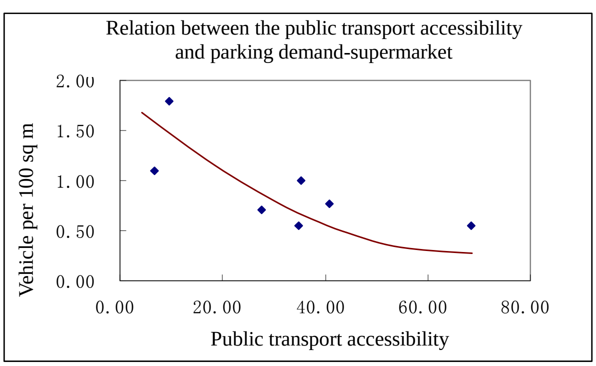

Figure 4. Relation between the Public Transport Accessibility and Parking Demand of the Supermarkets

From figure 3 and 4, we can see that it has strong relation between the public transport accessibility and parking demand of the shopping centre and supermarkets. On the whole, the parking demand decreases with the increase of the public transport accessibility. The public transport accessibility has effect on the parking demand of business buildings. When the public transport accessibility index is under 40, the parking demand decreases obviously with the increase of the accessibility. When the public transport accessibility index is above 60, the parking demand decreases little with the increase of the public transport accessibility. This shows that to increase the public transport accessibility in a certain range will greatly decrease the parking demand in a region.

Considering the practical maneuverability of parking index, this paper classifies the public transport accessibility into four levels for shopping centre and three levels for supermarkets. The higher level denotes the higher public transport service level and the accessibility and the lower parking demand rate. The parking demand rate under different public transport accessibility levels is shown in table 3 and 4. From these tables, we can see that the parking spaces supply can be reduced greatly in the area with high public transport accessibility. This will contribute to the establishment of the parking index of commercial buildings.

Table 3. Parking Demand Rate under Different Public Transport Accessibility Levels of the Shopping Centre

public transport accessibility of shopping centre	1	2	3	4
AI	20	20~40	40~60	60
parking demand rate per 100 sq m	1.97	0.62	0.48	0.31

Table 4. Parking Demand Rate under Different Public Transport Accessibility Levels of the Supermarkets

public transport accessibility of supermarkets	1	2	3
AI	20	20~60	60
parking demand rate per 100 sq m	1.45	0.76	0.56

In order to quantify the relation between the parking demand rate and the public transport accessibility, the relation formula is obtained by the mathematics analysis software. R^2 is the correlation coefficient. The values of R^2 for shopping centre and supermarkets are all bigger than 0.6. This proves that the accuracy of the model is high.

$$\alpha_{shoppingcentre} = 28.61 * AI^{-0.53} \quad R^2=0.625 \qquad (6)$$

$$\alpha_{supermarkets} = 3.11 * AI^{-0.40} \quad R^2=0.612 \qquad (7)$$

5. Conclusions

This paper analyzes the parking demand of the shopping centre and supermarkets in the commercial buildings based on the parking survey data in Beijing. Further it analyzes the relation between the parking demand and the public transport accessibility. The conclusions are that the parking demand decreases with the increase of the public transport accessibility. When the public transport accessibility index is under 40, the parking demand decreases obviously with the increase of the accessibility. When the public transport accessibility index is above 60, the parking demand decreases little with the increase of the public transport accessibility. This paper also gives the parking demand rate under different accessibility levels and the relation model. The conclusions will give some important references for the parking demand analysis of urban commercial buildings and the establishment of the parking index of buildings.

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Correspondence to:
Huanmei Qin
PhD candidate, assistant
Beijing Key Laboratory of Traffic Engineering, Beijing University of Technology,
Beijing 100124, China
Telephone: 01186-10-6739-6062
Cellular phone: 01186-136-8325-3263
Emails: hmqin@bjut.edu.cn

References:

[1] 周鹤龙，周志华，王波．大城市停车配建指标之用地分类(级)研究[J]．公路交通科技，2004, 21(4): 80-83
Zhou HL, Zhou ZH, Wang B. The land use classification for parking lot planning in metropolitan area [J]. Journal of Highway and Transportation Research and Development, 2004; 21(4): 80-83. (in Chinese)

[2] 南京市交通规划研究所，中规院中城联通公司．北京市建筑物配建停车设施标准与准则研究[R]. 2005
Nanjing institute of city transport planning, Beijing CCUIT science & technology Co., Ltd. Research on the parking criterion and guideline of the buildings in Beijng [R]. 2005. (in Chinese)

[3] 关宏志，刘小明．停车场规划设计与管理[M]．人民交通出版社, 2003
Guan HZ, Liu XM. Planning and management of parking lots [M]. China Communications Press, China. 2003. (in Chinese)

[4] 李自林，张丽洁．城市停车需求预测模型的分析 [J]． 天 津 城 市 建 设 学 院 学 报 ． 2007 13(3):169-172
Li ZL, Zhang LJ. Analysis of forecasting model of urban parking demand [J]. Journal of Tianjin Institute of Urban Constuction. 2007; 13(3):169-172. (in Chinese)

[5] 赵淑芝，匡星，张树山，姜波．基于 TransCAD 的城市公交网络可达性指标及其应用．交通运输系统工程与信息. 2005,5(2): 55-58
Zhao SZ, Kuang X, Zhang SS, Jiang B. A Evaluating Index of Accessibility for Urban Public Transit network Based on TransCAD. Journal of Transportation Systems Engineering and Information Technology. 2005,5(2): 55-58. (in Chinese)

[6] Murray A T, Wu X L. Accessibility tradeoffs in public transit planning. Journal of Geographical Systems. 2003;5(1): 93-107

[7] Morris J. M., Dumble P. L. and Wigan M. R.. Accessibility indicators for transport planning. Transportation Research Part A: Policy and Practice,1979;13(2): 91-109

[8] 张小丽，陈峻，王炜，蒋大治．基于公交可达性的公交站距优化方法．东南大学学报（自然科学版. 2009;39(2): 384-388
Zhang XL, Chen J, Wang W, Jiang DZ, Bus-stop spacing optimization based on bus accessibility, Journal of Southeast University (natural science edition). 2009;39(2): 384-388. (in Chinese)

[9] Simon C. Sub Matter 5b Parking Strategy.

Transport for London. 2003
[10] 任福田，刘小明，荣建等．交通工程学[M], 人民交通出版社. 2008
Ren FT, Liu XM, Rong J, et al. Traffic engineering [M]. China Communications Press, China. 2008. (in Chinese)

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