


Investigating the interaction between the parking choice and holiday travel behavior

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Bobin Wang¹, Chunfu Shao¹, Juan Li¹, Dan Zhao² and Meng Meng³

Abstract

Parking is one of the key links between the urban planning and transportation operation. However, most studies in this field focus on the parking behavior on workdays, and the holiday parking is seldom investigated. This study analyzes the interaction between the parking choice and travel behavior in the holidays. Data were collected at Fragrant Hills and Beijing Botanical Garden during the Qingming Festival (Tomb-sweeping Days) in 2013. The structural equation modeling was applied to examine the causal effects and quantitative relationships between the parking choice and holiday travel behavior and identify the main influencing factors based on the activity analysis. The results show that the parking choice has a close relationship with holiday travel behavior, which is more than an explanatory variable for the travel behavior. Moreover, the parking space availability, parking charge, and walking distance have significant effects on holiday parking choice. In addition, the personal attributes and household characteristics are significant influencing factors for the parking choice and holiday travel behavior.

Keywords

Parking choice, holiday travel behavior, questionnaire survey, structural equation modeling

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Introduction

Metropolis parking difficulty has become a profound social problem in China. With the improvement in household income, holiday travel becomes inevitable, and holiday parking problem is getting serious at the same time. Taking the Fragrant Hills as an example, the number of daily tourists had reached to 100,000 during the Red Leaf Festival in 2013. There were about 2368 parking spaces in the 11 parking lots around Fragrant Hills, which were all occupied during the holidays.¹ The huge holiday parking demand exceeds the service capability of the infrastructure. Therefore, it is necessary to carry out intensive research in the field of holiday parking behavior.

Although parking choice is only a small link in the holiday travel tour, it plays an important role and has

an effect on the holiday travel behavior. First, parking spaces are sufficient or not can influence the traveler's travel decisions. For most of the car travelers, if there is no parking space, they will reconsider their destinations. Second, parking choice influences the traveler's travel time and travel distance.² If the car traveler

¹MOE Key Laboratory for Urban Transportation Complex Systems Theory and Technology, Beijing Jiaotong University, Beijing, China

²Department of Traffic Management Engineering, Chinese People's Public Security University, Beijing, China

³Centre for Infrastructure Systems, School of Civil and Environmental Engineering, Nanyang Technological University, Singapore

Corresponding author:

Juan Li, MOE Key Laboratory for Urban Transportation Complex Systems Theory and Technology, Beijing Jiaotong University, Beijing 100044, China. Email: juanli@bjtu.edu.cn



spends a lot of time to find or wait for a spare parking space, their travel time will increase. Similarly, if the parking lot is far from the scenic spot entrance, the travel distance increases with the longer walking distance. Third, parking charge influences the activity time to some extent.³ In general, the parking charge is calculated by the hour, which is decided by the activity duration in the scenic spot. Therefore, parking charge is also an important consideration for the car travelers to control their activity duration in the holidays.

Traditionally, parking has only been considered as an explanatory variable for the analysis of travel mode choice.⁴ However, the parking choice considering the availability of parking facilities may influence the activity–travel scheduling process, such as travel time, activity duration, and activity place.⁵ Moreover, there is a demonstrable link between parking availability, parking charge, and mode choice, and it is a critical issue for policy-makers to manage the parking space in a multi-modal transportation system.^{6,7} Therefore, the parking properties should be taken into account in the interaction analysis of the parking choice and holiday travel behavior.

Therefore, this study takes the car traveler as the study object and investigates the interaction between the parking choice and holiday travel behavior based on the activity analysis. Moreover, in order to analyze the influence of parking choice on holiday travel behavior comprehensively and practically, this study introduces three kinds of influencing factors, namely, personal attributes, household characteristics, and parking properties, and provides an insight into the causal effects and quantitative relationships between them.

This study is organized as follows: section “Literature review” briefly reviews the literature on parking in general and identifies their shortages. Section “Methodology” describes the modeling approach and variables used in this study. Section “Data and survey” contains the activity-based travel behavior survey and data, and a discussion of the model results is presented in section “Result analysis”. Section “Conclusion” summarizes the important findings and puts forward policy suggestions for the future study.

Literature review

Research on parking has mainly concentrated on three aspects: data collection, parking model analysis, and parking policy research. There are three kinds of data collection methods for parking: traffic simulation is an easy method which collects data from the situation program, while it is not accurate and difficult to reflect the real situation.⁸ Questionnaire survey is another method, and the data are collected through face-to-face

interview.⁹ In addition, the GPS tracking can accurately record personal travel behavior by the mobile, but it is difficult to implement in practice.¹⁰ Therefore, questionnaire survey is a better method with higher accuracy and easier implementation.

Moreover, many models are applied to solve parking problems from various aspects. Bagloee and Asadi¹¹ developed a Logit model for parking planning, which considered the parking capacities and parking rationing constraints explicitly. Waraich and Axhausen¹² implemented a simple parking model into an existing agent-based traffic simulation, which is able to capture the parking capacity and pricing. Lam et al.¹³ proposed a time-dependent network equilibrium model and found that parking behavior is significantly affected by travel demand, walking distance, parking capacity, and parking charge.

In addition, people applied the theoretical results into practice for policy guidance. Box¹⁴ summarized various operational and safety studies and pointed out that curb parking represents a potentially hazardous and congestion-causing factor. Albert and Mahalel compared the different attitudes toward congestion tolls and parking fees to explore their effects on travel time. They found that drivers are willing to change their journey time to avoid congestion tolls.¹⁵ Hess evaluated the effect of free parking on travel mode choice and parking demand for the work trip in Portland’s (Oregon) central business district (CBD). The results showed that raising the parking charge at work sites will reduce the mode split ratio of drive alone.¹⁶ Qian et al.¹⁷ investigated how to design the parking capacities, parking charge, and accessibility to reduce total social costs.

The research about the interaction between the parking choice and holiday travel behavior is relatively limited. Much attention has been paid on either the parking analysis itself or the parking influence on some single aspect of travel decision making, such as travel mode choice, activity choice, and travel efficiency.¹⁸ Few studies investigate how parking choice affects overall activity scheduling of the travel behavior in the holidays. In addition, holiday travel behavior has received more and more attention recently.^{19,20} However, most studies neglect the parking properties and parking choice.²¹ In reality, parking availability, parking charge, parking accessibility, and the type of parking lot may significantly influence the travel behavior in the holidays. Connecting the parking choice with holiday travel behavior into account is an innovative point of this study.

In light of above, this study investigates the interaction between the parking choice and holiday travel behavior from the perspective of activity analysis. The contribution of this study is as follows: (1) filling the gap of the research of parking choice in the holidays,

(2) taking the parking choice with holiday travel behavior into account is an innovative point of this study, and (3) providing a reference for policy-makers regarding the holiday parking demand management.

Methodology

Structural equation modeling

Parking choice and holiday travel behavior are influenced by many factors. In order to explore the causal effects and quantitative relationships between them, a structural equation modeling (SEM) is applied to identify the key factors. SEM is a combination of factor analysis and regression analysis with the advantages which other common statistical methods do not have.²² First, there are error terms in SEM equations, which make the results in line with the actual situation. Second, there is more than one dependent variable, and one variable can be the dependent variable in one equation and an independent variable in another equation. Third, the overall model can be estimated by the fitting degree indicators.^{23–25} Therefore, it is suitable to use SEM for this study.

In general, a full SEM consists of two sub-models: a measurement model for observed variables and a structural model for latent variables. The measurement model contains two equations: one is the measurement model for the endogenous variables and the other is for the exogenous variables.²⁶ In the measurement model, the endogenous and exogenous latent variables are explained by their observed variables. In the structural model, the causal effects and quantitative relationships between the latent variables can be modeled. The structural model not only considers the regression effects of exogenous variables on endogenous variables but also considers the regression effects of endogenous variables between each other.²⁷ This study uses the full SEM model, which incorporates the measurement model along with the structural model. From the methodological point of view, it is recommended that the measurement model should be developed first, followed by the structural model.^{25,28,29}

The solution of SEM includes five steps: (1) specification—set up the initial hypothesis model, based on the mature theory or previous research results; (2) identification—this step decides whether the model can obtain the unique solution; (3) estimation—input the sample data into the initial model and estimate the eight parameter matrices; (4) evaluation—evaluate the effectiveness of the calculated model through the fitting indicators; and (5) modification. If the evaluation result is not satisfactory, modify the model and repeat the previous steps until obtaining the most reasonable and best-fitted model.^{30,31}

Initial hypothesis model

The initial hypothesis model is based on our previous study, which analyzes the influencing factor of the holiday trip chain's characteristics.³¹ Therefore, the main factors of the holiday parking choice model consist of five aspects: personal attributes, household characteristics, parking properties, holiday travel behavior, and parking choice. The five aspects are abstract concepts which can be measured by observable variables, so they are latent variables. Moreover, the personal attributes, household characteristics, and parking properties are influencing factors of holiday travel behavior and parking choice, so they are exogenous latent variables, and the holiday travel behavior and parking choice are endogenous latent variables. In addition, holiday travel behavior and parking choice interact with each other; thus, the path diagram of the initial structural equation model is shown in Figure 1.

The initial model was estimated and modified by the software Lisrel, and the Maximum Likelihood Estimation (MLE) was used for the estimation method.³² Moreover, the combined method of T-value minimum value correction and Modification Index (MI) maximum value correction was used to modify the model. T-value represents the interaction strength between the variables, and when the value is above 1.96 means that the influence is significant. MI reports the change in chi-square that results from freeing fixed parameters.³³

Furthermore, this study chose the ratio of chi-square value to the degrees of freedom (χ^2/df), the goodness of fit index (GFI), the root mean square error of approximation (RMSEA), the Bentler–Bonett normed fit index (NFI), and the comparative fit index (CFI) as five indicators to evaluate the model performance and measured how well one model is better than another. In practice, the recommended acceptance of a good model fit requires the obtained GFI, NFI, and CFI values should have a range from 0 to 1, with higher value indicating better model fit. A cutoff criterion of $CFI \geq 0.95$ is presently recognized as indicative of good fit,³⁴ while values of GFI and NFI greater than 0.90 are usually interpreted as indicating an acceptable fit.^{34–36} Moreover, the RMSEA values lower than 0.05 indicate a close fit of the model.³⁷ For the χ^2/df , the value below 2 indicates a good model fit.³⁸

Variables

The model variables are summarized in Table 1, and the questionnaire options are designed according to the specific circumstances of Beijing. The urban structure of Beijing is a radial-hoop network, and there are five ring roads in the urban area, so the starting point is divided into six options. In peak hours, some

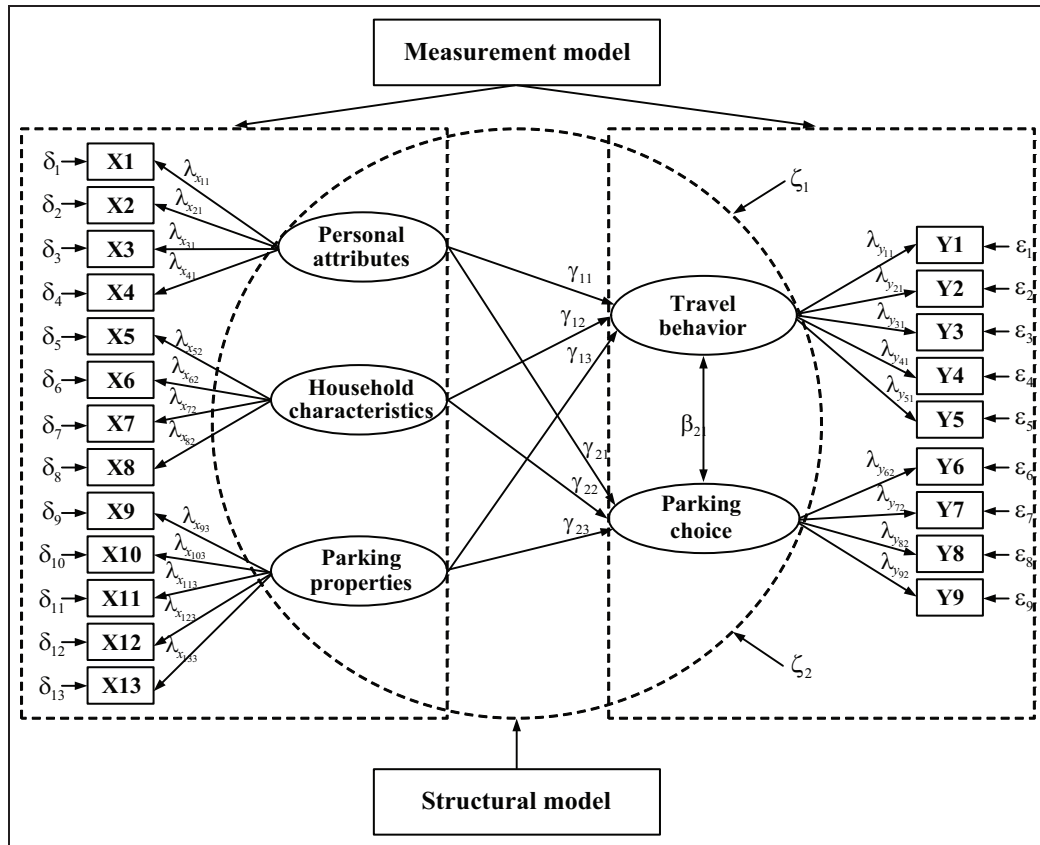


Figure 1. Path diagram of the initial structural equation model.

temporary parking lots are opened to relieve the parking space shortage in the holidays in Beijing. However, some travelers have to wait for the spare parking space. Moreover, it will take some time to escape from the parking lot when the car travelers decide to leave.

Data and survey

Sample

The data used in this study were collected at Fragrant Hills and Beijing Botanical Garden during the Qingming festival (Tomb-sweeping Days) in 2013. Fragrant Hills and Beijing Botanical Garden are popular scenic spots which lie in the 5th–6th ring road in Beijing. There are many tourists in the holidays, and the parking demand is great. The survey was conducted via a field investigation and combined with face-to-face interview, for a random sample of 980 responds. There were 15 parking lots opened to the public (see Figure 2), and the survey location included nine parking lots (P0, P1, P2, P3, P5, P6, P8, P9, and P10), considering the actual traffic conditions of the survey area. The survey time was 7:00–17:00 every day, and the survey lasted for 2 weeks.

The questionnaire includes three parts: one is the investigation of parking lots. The second section includes the information regarding personal attributes, household characteristics, parking properties, travel behavior, and parking choice. Moreover, in order to compare the travel behavior between the car traveler and other tourists, a third section is designed. A total of 980 questionnaires were distributed, and 773 effective samples were obtained.

Data analysis

The survey focuses on the 1-day travel and activity in the holidays, and the traveler's characteristics and parking properties are key factors. Therefore, the statistical analysis of the total sample is as follows:

Parking lot. The number of the occupied parking space was recorded every 15 min, which lasted for 8 h. P1 and P5 had the most parking spaces and the biggest volatility, which indicates that the larger the parking lot size, the greater the vehicle turnover. In addition, the peak utilization rate was reached at around 10 o'clock in the morning, which began to drop at around 4 o'clock in

Table 1. Summary of variables.

Exogenous latent variable	Variable name	Exogenous observed variable	Variable name (unit)	Explanation
ξ_1	Personal attributes	X1	Gender	1 = male; 2 = female
		X2	Age (years)	1 = 18–20; 2 = 21–30; 3 = 31–40; 4 = 41–50; 5 = 51–60; 6 = 61–70
		X3	Occupation	1 = manager; 2 = staff; 3 = migrant worker; 4 = civil servant; 5 = student; 6 = freelance; 7 = retired or unemployed; 8 = other
ξ_2	Household characteristics	X4	Type of residence	1 = local resident; 2 = nonlocal resident
		X5	Family size	≥ 0 integers
		X6	Family monthly income (RMB)	1 = 0–4000; 2 = 4001–10,000; 3 = 10001–30,000; 4 = above 30,000
		X7	Number of family cars	≥ 0 integers
ξ_3	Parking properties	X8	Number of the elderly and children	≥ 0 integers
		X9	Parking space availability	1 = no parking space; 2 = parking space needed to wait; 3 = spare parking space
		X10	Parking charge (RMB at a time)	1 = 0–10; 2 = 11–20; 3 = 21–30; 4 = above 30
		X11	Walking distance (m)	1 = 0–100; 2 = 101–200; 3 = 201–300; 4 = above 300
		X12	Type of parking lot	1 = on-street; 2 = private; 3 = temporary opened; 4 = public
		X13	Waiting time for parking (min)	1 = 0–10; 2 = 11–30; 3 = 31–40; 4 = above 40
Endogenous latent variable	Variable name	Endogenous observed variable	Variable name	Explanation
η_1	Travel behavior	Y1	Starting point	1 = in the 2nd ring road; 2 = 2nd–3rd ring road; 3 = 3rd–4th ring road; 4 = 4th–5th ring road; 5 = outside the 5th ring road; 6 = other provinces
		Y2	Trip distance (km)	1 = 0–30; 2 = 31–60; 3 = 61–90; 4 = 91–120; 5 = above 120
		Y3	Departure time	1 = 7:00–7:59; 2 = 8:00–8:59; 3 = 9:00–9:59; 4 = 10:00–10:59; 5 = 11:00–11:59; 6 = 12:00–12:59; 7 = 13:00–13:59; 8 = 14:00–14:59; 9 = 15:00–15:59; 10 = 16:00–16:59
		Y4	Arrival time	1 = 7:00–7:59; 2 = 8:00–8:59; 3 = 9:00–9:59; 4 = 10:00–10:59; 5 = 11:00–11:59; 6 = 12:00–12:59; 7 = 13:00–13:59; 8 = 14:00–14:59; 9 = 15:00–15:59; 10 = 16:00–16:59
		Y5	Activity duration (h)	1 = 0–0.5; 2 = 0.5–2; 3 = 2–4; 4 = above 4; 5 = stay here
η_2	Parking choice	Y6	Parking or not	1 = no; 2 = yes
		Y7	Parking mode	1 = on-street parking; 2 = off-street parking
		Y8	Parking location	1 = P5; 2 = P8, P9, P0; 3 = P1, P2, P10; 4 = P6, P3
		Y9	Parking duration (h)	1 = 0–0.5; 2 = 0.5–2; 3 = 2–4; 4 = above 4; 5 = stay here

the afternoon. The attributes of the nine parking lots are shown in Table 2.

In Table 2, the average utilization rate of P3 was the highest and P2 and P6 came next. Although the utilization rates of P1 and P5 were full or even excessive in peak hours, their average utilization rates were lower than expected. For the parking charge, P2 and P9 were most expensive, but their average utilization rates were

not the lowest. It is worthy to note that the average utilization rate of P8 was lower than the others obviously, due to the connection of P8 and P9. Moreover, there were some temporal parking spaces opened during peak hours, so the peak utilization rate of P1, P5, and P6 was above 100%. Therefore, the huge parking demand exceeds the service capability of the infrastructure in the holidays.

Table 2. Attributes of parking lots around Fragrant Hills and Beijing Botanical Garden.

Parking lot	P1	P2	P3	P5	P6
Total number of parking spaces	800	470	160	700	130
Parking charge (RMB at a time)	10	20	10	10	10
Opening hours	6:00–18:00	8:00–22:00	7:00–19:00	All the time	5:00–19:00
Average utilization rate	87.75%	92.77%	100.00%	79.57%	90.00%
Peak utilization rate	102.50%	99.15%	100.00%	102.86%	103.08%
Parking lot	P8	P9	P10	P0	
Total number of parking spaces	200	260	150	160	
Parking charge (RMB at a time)	10	20	10	10	
Opening hours	7:00–20:00	7:00–19:00	All the time	8:00–21:00	
Average utilization rate	47.50%	63.85%	64.67%	87.50%	
Peak utilization rate	59.00%	97.31%	95.33%	97.50%	

Traveler's characteristics. Most of the tourists were local residents (92%) and half (50%) were under 30 years old. About two-thirds (67%) of the family monthly income were under 10,000 RMB, and about half (48%) of the families had no car. Comparatively, the car travelers were older and richer than the other tourists. For the car travelers, 73% were above 30 years old and about half (48%) of the family income were above 10,000 RMB per month. Moreover, 26% of the car travelers were managers, which was higher than the 12% of the other tourists.

Travel behavior. In total, 61% of tourists traveled with families or relatives. For the activity duration in the scenic spots, most people (51%) stayed there for about 2–4 h. The arrival time focused on 10:00–11:00 and departure time focused on 16:00–17:00, when the traffic congestion and parking difficulty usually happen and appear. Moreover, 65% of the travelers took the public transport (taxi 3%, bus 33%, and metro 29%) and 28% took private cars. However, 52% of the travelers had cars; thus, 24% of the travelers had cars but did not take it. This study investigated this part of people and found that the main reasons were traffic jams (40%) and parking space shortage (27%). In addition, 57% of the car travelers stayed in the destination for 2–4 h, which was the period of a shortage of parking spaces. Therefore, limiting the parking duration in the parking lot is a good way to control the number of cars and tourists.

Result analysis

SEM measurement model

The measurement model specified a set of five latent variables, namely, personal attributes, household characteristics, parking properties, travel behavior, and

parking choice, as linear functions of their observed variables. The path diagram is shown in Figure 3.

As shown in Figure 3, the personal attributes have stronger and positive correlation for gender, age, and occupation but weaker and negative correlation for the type of residence. This means that the personal attributes mainly describe the traveler's gender, age, and occupation. Similarly, the household characteristics describe the traveler's family structure and the economic strength (i.e. family size, family monthly income, and the number of the elderly and children). Moreover, the parking space availability, the type of parking lot, walking distance, and parking charge have stronger weight for the parking properties, which means these factors have strong measurement capabilities. However, the travel behavior gives more importance to the trip distance, starting point, and activity duration. Similarly, the parking choice gives more importance to parking or not and parking duration. It is important to note the strong and positive correlation between the travel behavior and parking choice. This means that there is a significant interaction between them.

SEM with latent variables

The initial model was estimated and modified by Lisrel with the observed variables as the input and the model parameters as the output.³² The final path diagram for the structural model is shown in Figure 4.

As shown in Figure 4, the standardized coefficient between the personal attributes and the travel behavior and parking choice is 0.42 and 0.08, which means that the personal attributes have greater direct effects on holiday travel behavior and weaker direct but greater indirect effects on parking choice. Similarly, the standardized coefficient between the household characteristics and two endogenous latent variables is 0.90 and 0.49, which means that the household characteristics have a significant impact on holiday travel behavior

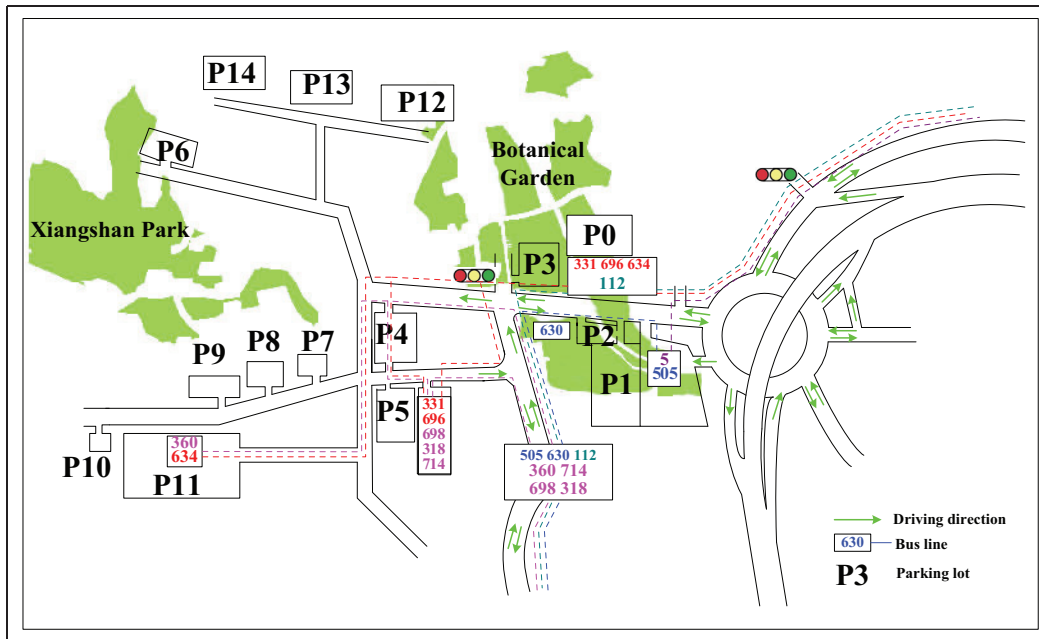


Figure 2. Parking lots overview of Fragrant Hills and Beijing Botanical Garden.

and a moderate impact on parking choice. Moreover, the standardized coefficient between the parking properties and parking choice is 0.52, which means that the parking properties have a positive effect on the parking choice.

In the results of the measurement model, the parking space availability, parking charge, and walking distance have strong weight for the parking properties. This means that these factors have significant effects on the parking choice. It is interesting to note the negative coefficient between the parking properties and the holiday travel behavior. This means that the parking properties, such as parking space availability, parking charge, and walking distance, have negative effects on holiday travel behavior.

In addition, the standardized coefficient between the two endogenous latent variables is 0.98, suggesting that the holiday travel behavior is closely related to the parking choice, that is, the more diverse the parking choice, the more complex the holiday travel behavior. Among the observed variables, the arrival time and activity duration have a strong measurement capability for the travel behavior, and the parking mode and parking duration have a stronger weight for the parking choice. Therefore, the key to solve the holiday parking problem is to shorten the activity duration and parking duration and change the traveler's arrival time.

Among the fitting indicators of the final model, the χ^2/df value is 1.59, the GFI value is 0.90, the RMSEA value is 0.053, the NFI value is 0.91, and the CFI value is 0.95. From the results, it can be seen that all of the

fitting indicators are within the recommended range except the slightly larger of the RMSEA value. Therefore, the model has a good fit.

Conclusion

The research about the interaction between the parking choice and holiday travel behavior is relatively limited. Traditionally, parking has only been considered implicitly as an explanatory variable on some single aspect of travel decision making. However, parking choice as an endogenous decision may have an interaction with the spatial-temporal characteristics of holiday travel behavior. Therefore, this study provides an insight into the interaction between the parking choice and holiday travel behavior based on the activity analysis.

The data were collected through the travel behavior survey at Fragrant Hills and Beijing Botanical Garden during the Qingming festival in 2013. Questionnaire was designed, and nine parking lots (P0, P1, P2, P3, P5, P6, P8, P9, and P10) were investigated. The conclusions can be summarized as follows:

1. The parking choice has a close relationship with the holiday travel behavior. This study investigates this correlation from spatial-temporal dimensions. The results show that the arrival time and activity duration has a strong measurement capability for the travel behavior. The parking mode and parking duration have significant effects on parking choice. Therefore, it is a

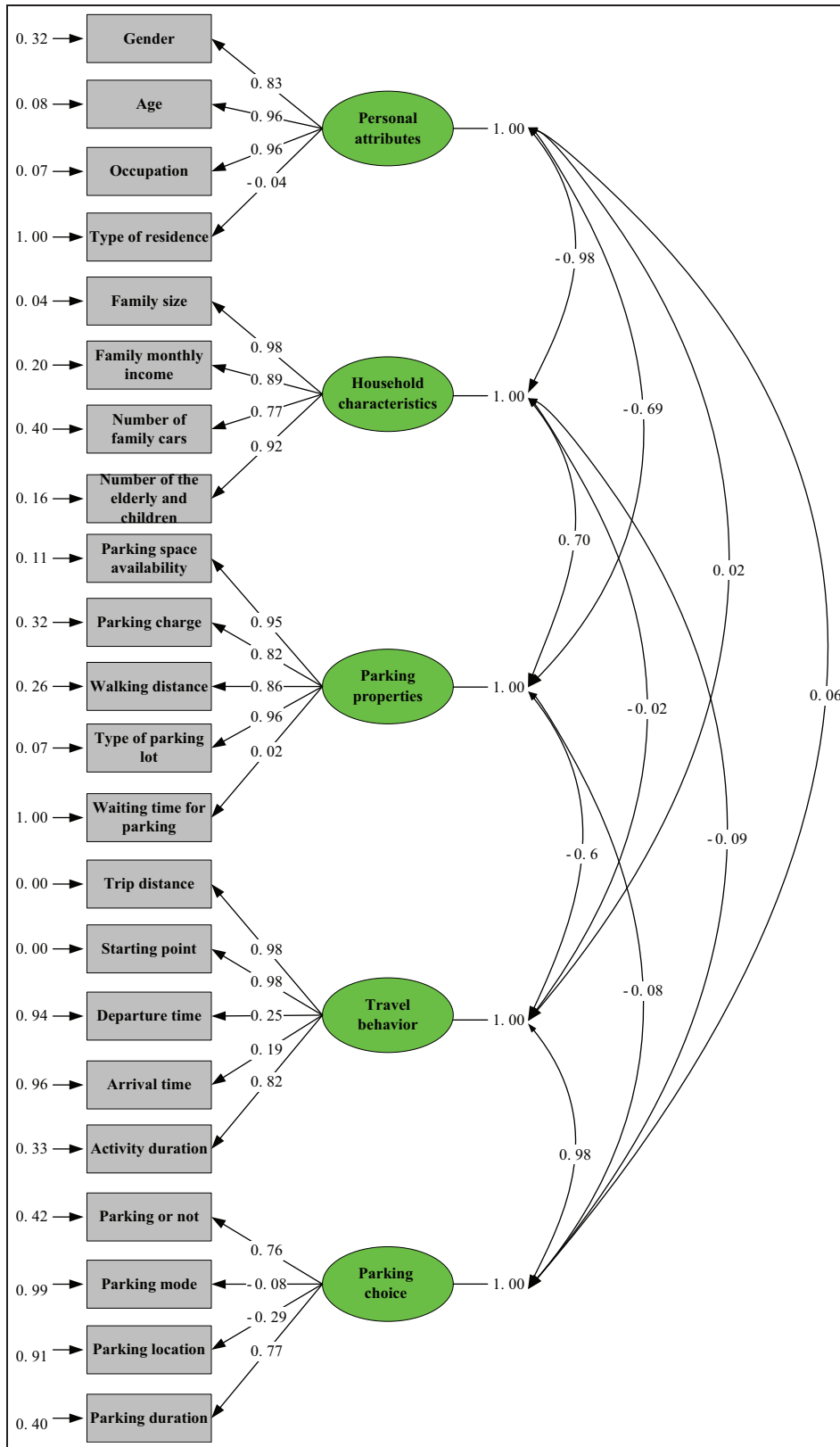


Figure 3. Finale path diagram of the measurement model.

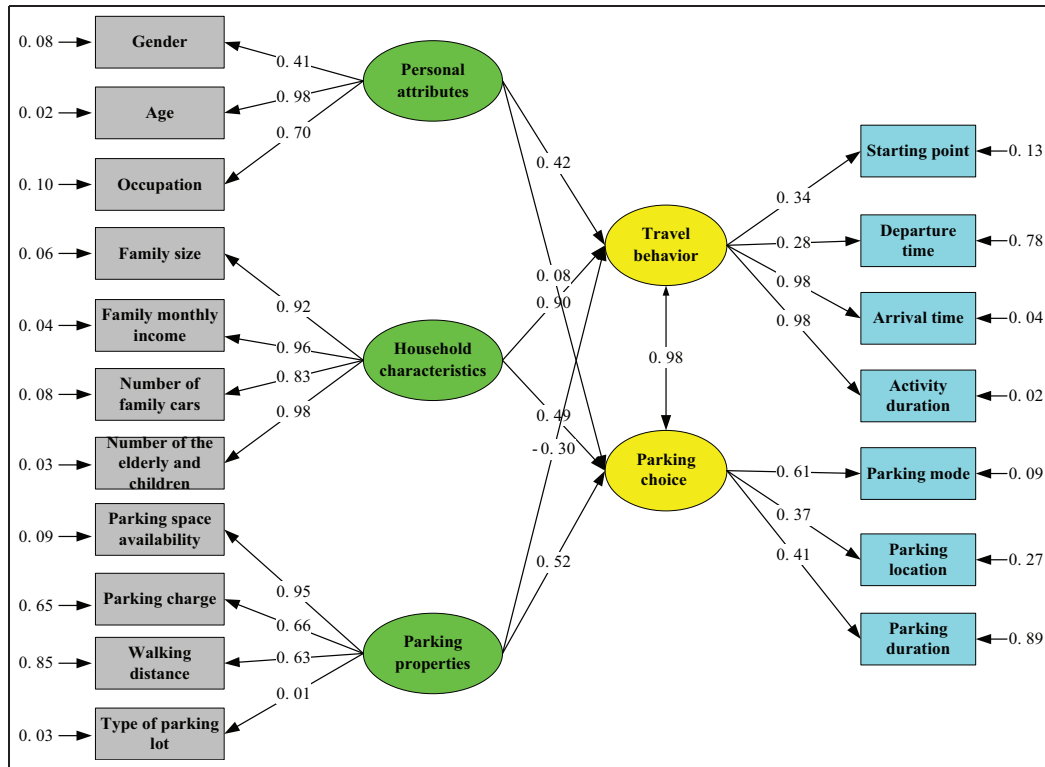


Figure 4. Final path diagram of the structural model.

good way to control the number of cars and tourists by shortening the traveler's activity duration (or parking duration) and adjusting the traveler's arrival time;

- The parking properties have significant effects on the parking choice and travel behavior in the holidays. Among these properties, the parking space availability, parking charge, and walking distance have stronger coefficients. Therefore, improving the utilization rate of parking lot, designing appropriate walking distance, and formulating reasonable parking charge can reduce the parking duration and adjust the arrival time;
- The household characteristics have significant effects on the parking choice and holiday travel behavior while the personal attributes have weaker direct but greater indirect effects on holiday parking choice. Therefore, the personal attributes and household characteristics should be considered comprehensively for the traffic management and operation.

The results of this study can provide a reference for policy-makers regarding the holiday parking demand management. There are some recommendations for effectively alleviating the holiday traffic congestion and

parking difficulty in China. First, policy-makers should improve the utilization rate of parking lots, design appropriate walking distance, and formulate reasonable parking charge. Second, they should put forward appropriate policies to shorten the traveler's activity duration (or parking duration) and adjust the traveler's arrival time, and the personal attributes and household characteristics should be considered comprehensively. Third, providing available information covering parking properties can alleviate holiday parking difficulties to some extent, such as parking space availability, parking charge, and walking distance.

This study focuses on the tourist travel and activities, and further study should extend to other leisure activities, such as shopping and dining. In addition, the study content can be extended to tour or trip chains.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

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