Research Article

Analysis of the Travel Intent for Park and Ride Based on Perception

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As a multimodal travel behavior, park and ride includes several trip modes such as car, walking, bus, or railway. And people's choice of park and ride is influenced by many factors. This paper, based on the park and ride behavior survey in Beijing, will analyze the relationship between the perception of the influencing factors and the behavior intent for park and ride by using structural equation modeling. The conclusions suggest that the park and ride choice for travelers is a passive behavior which means giving up driving the car is mainly caused by the serious traffic congestion. Furthermore, improving the service level of the park and ride facilities and the comfort for riding bus or railway will increase the utilization of park and ride facilities. The perceptions of the influencing factors have both direct and indirect effects on the travel intent for park and ride by the interaction among the influencing factors.

1. Introduction

Park and ride is a travel mode, in which the car travelers who are going to the city center (or congestion area) park in the peripheral area and then reach the destination by using public transportation. This mode is helpful to reduce the car flow in the city center, relieve the traffic pressure; and perfect the urban traffic structure. The factors affecting the park and ride choice for the car drivers include personal characteristics, service level of the transfer facilities, and policy factors.

Hole has used stated choice (SC) data to forecast the demand for an employee park and ride service. Four different Logit models have been established in the paper. The model estimations show that the drivers with low income, more cars, and parking spaces scarcity at travel destination would be more likely to use park and ride [1].

Bos et al. have conducted a stated choice experiment in Nijmegen, The Netherlands, using the hierarchical information integration method. The results indicate that social safety, quality of the connecting public transport, and relative travel times by transport modes are

key attributes to the success of park and ride facilities. Contextual variables seem to have only a minor impact [2].

Hess has developed the multinomial mode Logit model including driving alone, riding in a carpool, or transferring to transit for the trip to work in Portland's CBD. The results suggest that raising the cost of parking at work sites and decreasing the transit travel time (by improving service and decreasing headways) will reduce the driving alone mode share [3].

At present, the construction of park and ride facilities is just beginning in metropolitan cities of China. For example, Beijing and Shanghai have launched pilot program of park and ride and made the plan of park and ride facilities. Some related researches are shown as followes.

Hui and He have studied the influencing factors and the travel intent for park and ride choice behavior and used disaggregated model to analyze the importance of influencing factors. The paper brings forward the idea that the main factors affecting park and ride choice behavior are passive factors such as road traffic congestion and lack of parking spaces [4]. He et al. have established a binary Logit model using the stated preference survey data in Nanjing, China. The results show that income, driving experience, trip purpose, traffic congestion level, and parking fee have significant impacts on the use of park and ride facilities [5].

The previous researches mainly analyze the relations between the influencing factors and choice behaviors by using the investigations and models. The travelers may have different perceptions of the same influencing factors, and then they will produce different travel intents under the same traffic condition [6]. It can be said that the perception of the influencing factors is an important aspect for travel behavior analysis.

Sakano and Benjamin have studied the travel behavior for choosing the commuter rail or car between two cities using the structural equation analysis. The model is specified and estimated to test various policy factors such as changes in fares, headway and travel time of train service, and the congestion on the highway. It was found that travel time and explicitly expected extra travel time due to congestion are not significantly related to mode choice, and primary activities are significant predictors of mode choice [7].

Lin et al. have proposed an alternative model specification for better conceptualizing the customer perceived value construct and to discuss the theoretical justification of the model. The proposed model was elaborated based on theoretical contexts. Three models of different conceptualization specifications were estimated and compared with eTail service value survey data [8].

Rahaman et al. have used SERVQUAL to measure the quality of provided services and analyze the gaps between customer expectations and perceptions of the service organization. The research points out how the management of service improvement can become more logical and integrated to prioritize service quality dimensions and affect on increasing or decreasing service quality gaps [9].

Yüksel has used a structural equation modeling to explore the relationships between the perceived shopping environment and tourists' emotions and shopping values. The emotional state and shopping value created by the shopping environment were found to influence the enjoyment of shopping, revisiting intentions, and the tendency to spend more money and time than originally planned [10].

This paper takes the car park and ride travel behavior as the research object. Based on the park and ride behavior survey conducted in Beijing, China, it will analyze the relations between the perception of various influencing factors and the behavior intent for park and

ride by using the structural equation modeling. The results will provide some references for the park and ride behavior analysis and facilities planning and location.

2. Park and Ride Behavior Survey

In order to analyze the relationship between the perceptive factors and the park and ride behavior intent, it is necessary to understand the perception level of the related influencing factors for travelers by the survey. The influencing factors of this survey include personal characteristics such as age, sex, monthly income, car ownership, and household size and the perception of the traffic congestion, parking space and parking fee at destination, parking and riding at park and ride facility, travel time, and travel cost as well as comfort for riding public transit. The perceptive questions are constructed in terms of a five-point scale that measures the level of satisfaction with a statement. The scale categories are identified as "strongly satisfied," "relatively satisfied," "generically satisfied," "unsatisfied" and "strongly unsatisfied." It can also change the expressed optional contents according to different questions. For example, the perception levels of the traffic condition are "very congested," "relatively congested," "congested," "not congested," and "smooth traffic flow".

This paper used the combined survey methods with revealed preference (RP) and stated preference (SP). RP refers to situations where travelers are observed to make choices in real situations and is used to investigate the travel time, travel cost, and weekly trip times by using park and ride for the travelers. SP refers to situations where choices are observed in the hypothetical situations and is used to investigate the intent for using park and ride in the future [11–13]. The survey respondents are travelers who possess cars and have used the park and ride facilities once. The survey place is Tiantongyuan North park and ride facility which is the terminal station for Beijing subway line 5 with the straight line distance from the city centre of about 20 km. In the survey, the investigator inquires the interviewees at designated time and place and makes them fill in the questionnaires and then retrieves them. The survey was conducted from February to March in 2011. The retrieved sample is 112, and the effective sample is 99.

For the sex distribution, the proportion of interviewees for male and female is 52% and 48%, respectively. For the age distribution, the age of most interviewees is between 20 to 50 years, and the proportion is 78%. For the monthly income distribution, the proportion of interviewees with the monthly income less than or equal to 3000 yuan is 49%. The proportion of those with the monthly income between 3000 and 5000 is 31%. For the weekly days distribution for using park and ride, the proportion of interviewees with one day for using park and ride is 14%. The proportion of those with two days and three days is 18% and 17%, respectively. The proportion of those with the four days and five days is 10% and 24%, respectively. This indicates commuters often use the park and ride.

3. Park and Ride Behavior Survey Analysis

According to the survey data, this section will analyze the influencing factors.

3.1. Analysis of Personal Characteristics

It is shown by Figures 1 and 2 that the proportion of people who possess one car is 82%, two cars is 16%. The people who possess three cars is relatively less, and the proportion is only
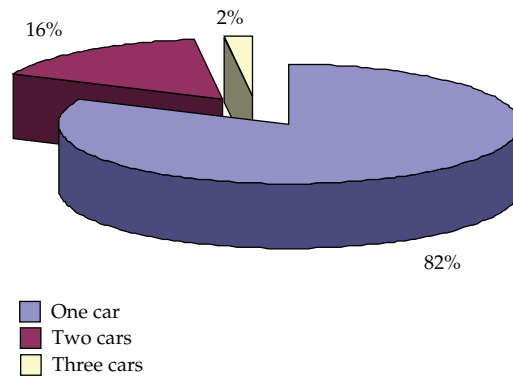
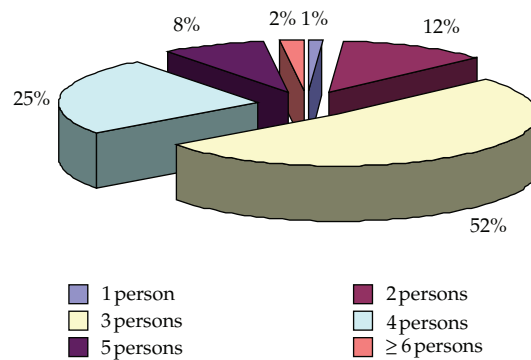**Figure 1:** Car ownership distribution.

Figure 2: Household size distribution.

2%. The household size is mostly 2, 3, and 4 persons which altogether share the proportion of 89%.

3.2. Perception of the Traffic Condition

Figure 3 shows that the perception of traffic condition is relatively poor for the interviewees. The proportion of the persons who perceive traffic condition as relatively congested and very congested is 81%. The proportion of the interviewees who perceive traffic condition as not congested and smooth is only 3%. This indicates that the traffic condition for driving is poor.

As can be seen from Figure 4, 44% of interviewees feel that the parking fee at destination is a little higher, and 32% of interviewees feel that the parking fee is reasonable and acceptable. Only 5% of interviewees think that the parking fee is cheap.

3.3. Perception on the Service Level of Park and Ride Facilities

As shown in Figures 5 and 6, among the two main factors influencing the service level of the park and ride facility, the proportions of interviewees who consider generally and relatively satisfied with the services are 44% and 33%, respectively, and only 8% of interviewees
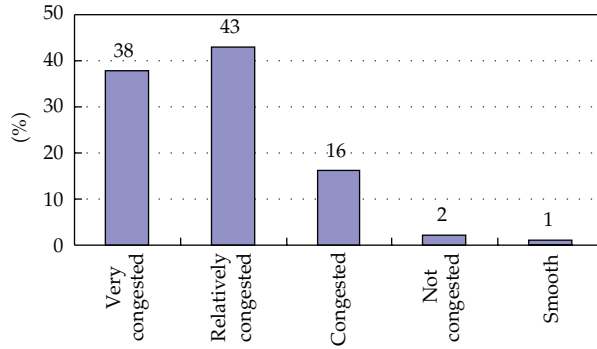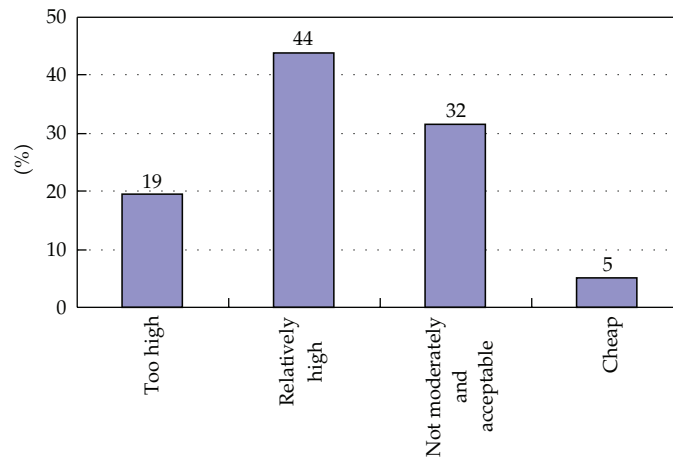
Figure 3: Traffic congestion.

Figure 4: Parking fee at destination.

are unsatisfied or strongly unsatisfied. For transferring at the park and ride facility, the proportions of interviewees who consider generally and relatively satisfied are 40% and 41%, respectively, and only 6% of interviewees are unsatisfied or strongly unsatisfied. This indicates that the service level of park and ride facility is rather good and the travelers are quite satisfied with it.

3.4. Perception of Travel Time and Cost

As shown in Figure 7, 45% of park and ride users feel comparatively satisfied, and 36% of those feel quite satisfied for the travel time. Only 11% of those feel unsatisfied and strongly unsatisfied for the travel time. Figure 8 shows that 16% of the interviewees are very satisfied for the travel cost, and 51% of those are relatively satisfied for the travel cost. Only 6% of those are unsatisfied and strongly unsatisfied for the travel cost. This indicates that the park and ride users are satisfied for the travel time and cost.

The perception of the comfort for riding bus or railway is shown in Figure 9. 23% of interviewees express that it is too crowded to be tolerated. While 38% of those consider that it is relatively crowded and a little unbearable. 34% of them consider that it is crowded but
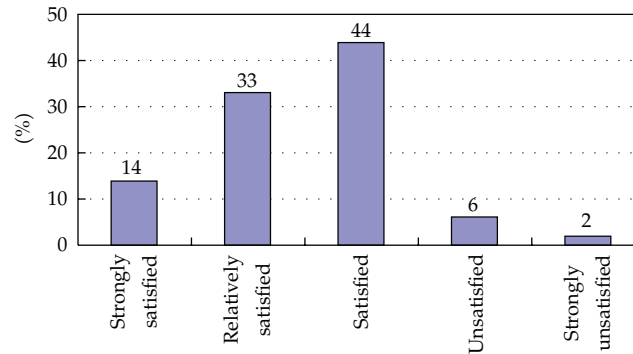
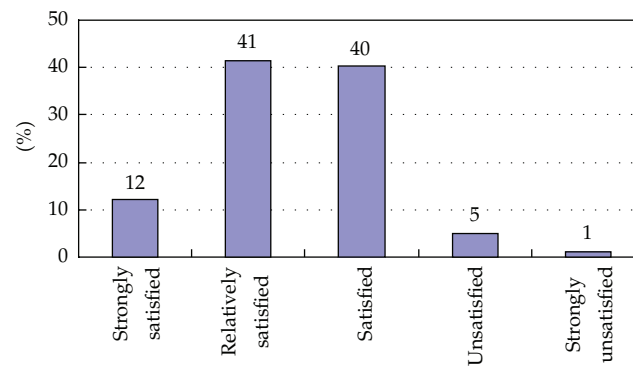**Figure 5:** Satisfaction for parking at park and ride facility.

Figure 6: Satisfaction for transferring at park and ride facility.

acceptable. Only 5% of them consider that it is comfortable. This indicates that service level for public transit need, to be improved.

3.5. Park and Ride Travel Intent

Park and ride travel intent is represented by the change of weekly travel times for using park and ride in the future as shown in Figure 10. 42% of interviewees do not change their weekly travel times for using park and ride. 36% of interviewees will increase their travel times for using park and ride. Among this group of travelers, 7% increase park and ride by three times, 16% by twice, and 13% by once. By contrast, 22% of users like to reduce their frequency of park and ride.

4. Analysis of the Park and Ride Travel Intent

Based on the previous analysis for the survey data, the structural equation is used to analyze the relationship between the influencing factors and park and ride intent. As a method to estimate and verify the causal relationship among variables, the structural equation is mainly used for analyzing and simulating the latent variable that cannot be directly observed. Recently, structural equation is gradually applied to the travel behavior researches [14–17].
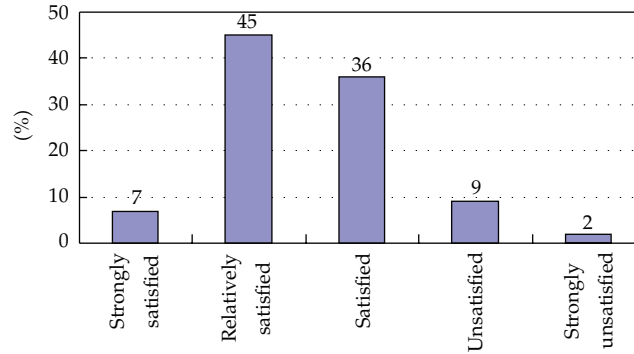
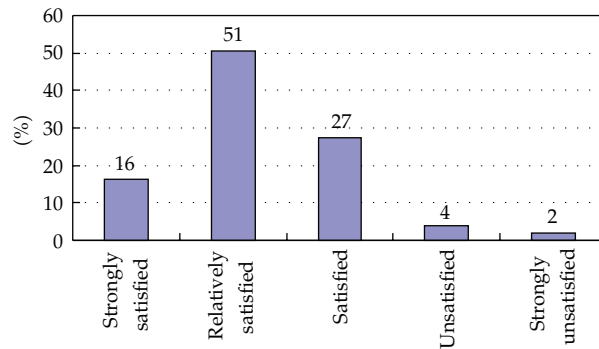**Figure 7:** Satisfaction for travel time.

Figure 8: Satisfaction for travel cost.

4.1. Structural Equation Modeling Theory

Structural equation modeling (SEM) is a statistic analysis method of the variables' relation based on the covariance matrix. The steps for applying the structural equation modeling include the model specification, quantification of variables, identification, estimation, and modification [18, 19].

Structural equation modeling (SEM) is composed of measurement model and structural model. A general structural equation includes three formulas as follows. Formula (4.1) is the structural model which analyzes the relation among latent variables. formulas (4.2) and (4.3) are measurement models which analyze the relation between the latent variables and the observed variables:

$$\eta = B\eta + \Gamma\xi + \zeta, \tag{4.1}$$

$$y = \wedge_y \eta + \varepsilon, \tag{4.2}$$

$$x = \wedge_x \xi + \delta, \tag{4.3}$$

where η is the vector of endogenous latent variables. B is the coefficient matrix of endogenous latent variables; Γ is the coefficient matrix of exogenous latent variables; ξ is the vector of exogenous latent variables; ζ is the vector of residual error of the structural model; y is
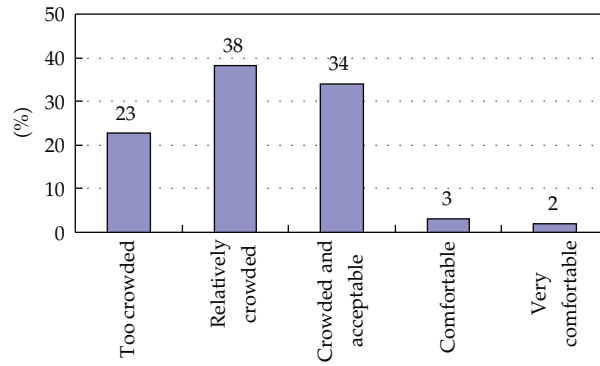
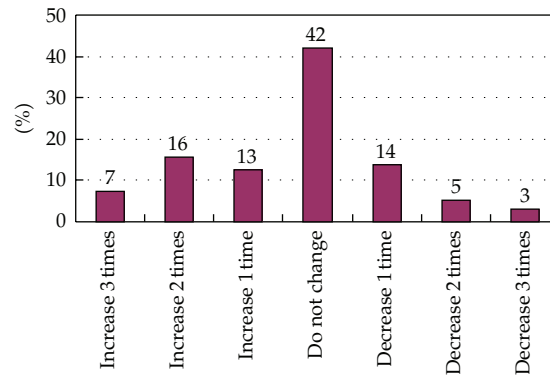**Figure 9:** Perception of the comfort for riding bus or railway.
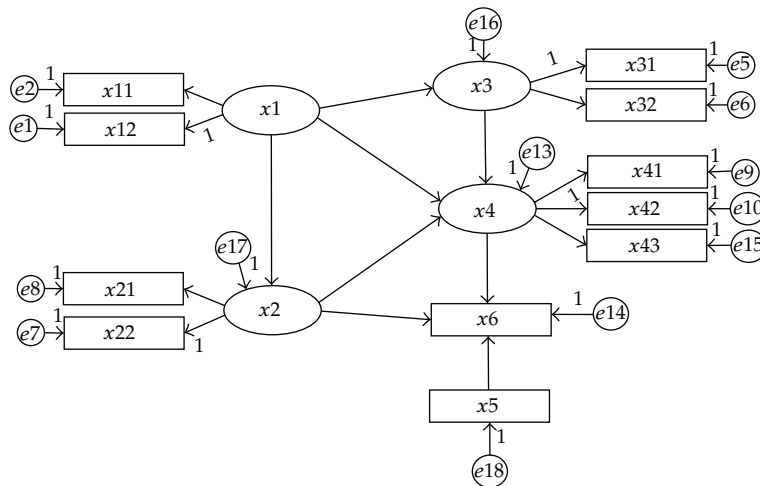

Figure 10: Park and ride travel intent.

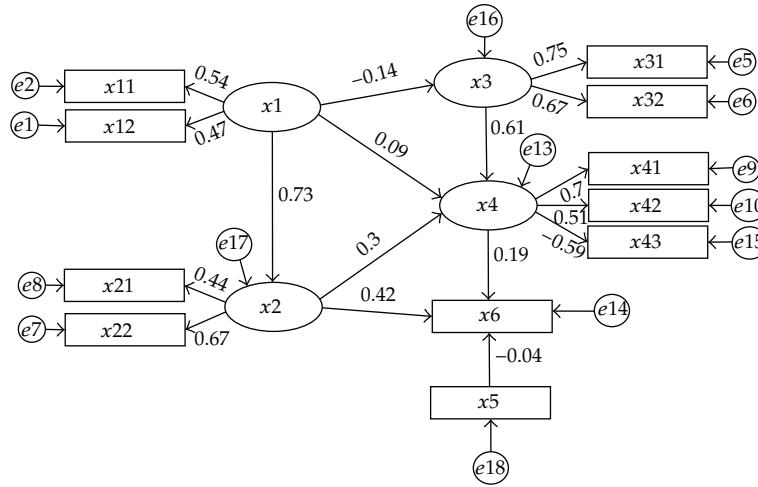**Figure 11:** The model specification diagram.

Figure 12: Standard output of model coefficients.

the vector of endogenous observed variables. $\wedge_y$ is the coefficient matrix of the endogenous observed variables y on endogenous latent variables η; ε is the vector of residual error of the endogenous observed variables; x is the vector of exogenous observed variables; $\wedge_x$ is the coefficient matrix for the exogenous observed variables x on exogenous latent variables ξ; and δ is the vector of residual error of the exogenous observed variables.

A whole structural equation modeling has eight coefficient matrixes. The model estimation methods include maximum likelihood (ML), generalized least squares (GLSs), and diagonally weighted least squares (DWLSs). The results of the model estimation are the relation among variables, errors in measure of variables and the portion that cannot be explained by the model, and so forth.

4.2. Selection of Model Variables

Eleven important influencing factors were chosen as the observed variables of structural equation by the correlation analysis. The influencing factors include car ownership, household size, perception of the traffic congestion, parking fee at destination, parking and transferring at park and ride facility, travel time, travel cost, and comfort for riding bus or railway. In order to analyze the effect of past travel behavior on the park and ride intent, the researcher adds another variable, the weekly travel days, for using park and ride. The latent variables are personal information, perception for using park and ride facility, perception of the traffic condition, and perception of the travel.

4.3. Estimation and Analysis of the Model

Amos software is used to establish the structural equation [20]. Figure 11 illustrates the hypothetic relation model for park and ride travel intent by repeatedly estimating parameters and modifying correlations of the models.

Since Amos software is used to denote the error, the residual error symbol in Structure Equation model formulas cannot be expressed by ζ, ε, δ, e. The maximum likelihood

method is used to obtain the goodness-of-fit indices and the standard coefficients for the model (Table 1).

Table 2 shows that the degrees of freedom of the model is 38 and the χ^2 of the model fit index is 26.550. The probability of significance level is 0.919 which refuses the null hypothesis. The statistic indices meet the requirements of relevant standards or critical values except for the normed fit index which is only 0.647. This indicates that the model is fitted to the sample data on the whole.

The standard direct influencing coefficients reflect to what extent the exogenous variables influence the endogenous variables. Their values are denoted by the standardized regression coefficients. Figure 12 shows that the personal information has a significant influence on the perception of the traffic condition with the standard coefficient of 0.73. This indicates that travelers who have fewer cars and household persons will consider that the traffic condition is more congested and parking fee is higher. Personal information has a little effect on the perception of the travel and using park and ride facility. The standard coefficient of the perception of traffic condition on the travel is 0.30. This shows that the poorer the perceptive traffic condition is, the more satisfied the perception for the travel time and cost and comfort for using park and ride is. The standard parameter for the perception of park and ride facility is 0.61. This indicates that the more satisfied the perception of parking and transferring at the facility is, the more satisfied the perceptive travel time and cost for using park and ride is. The standard parameter that the perception of traffic condition influences the travel intent is 0.42. This implies that the more congested the perception of traffic condition is and the higher the perceptive parking fee at destination is, the more inclined the travelers are to choose park and ride and increase the travel times for using park and ride. The standard parameter is 0.19 for the perception of travel of the travel intent which indicates that the more satisfied the travelers are with the perception of travel time, travel cost, and comfort for using park and ride, the more likely they are to choose park and ride and increase the travel times for using park and ride. The standard parameter for the past weekly travel days for using park and ride on the travel intent is −0.04. This indicates that the past travel behavior has a little effect on travel intent. The previous conclusions show that the poor traffic condition is the main factor that promotes car travelers' usage of park and ride. Improving the service level of park and ride facility and comfort for riding bus or railway will increase the utilization rate of park and ride facilities.

Table 3 shows the indirect influencing relationship among the variables which is caused by the effect of the exogenous observed variables on the other variables via the latent variables or endogenous observed variables. The indirect influencing standard coefficient can be obtained by multiplying the direct influencing standard coefficients. The indirect influencing standard coefficient for the personal information on the park and ride travel intent via the perception of using park and ride facility and travel is −0.016, and via the perception of travel is 0.017. The indirect influencing standard coefficient for the personal information on the park and ride travel intent via the perception of traffic condition is 0.307, and via the perception of traffic condition and travel is 0.042. Among these indirect relationships, the indirect effect for the personal information via the perception of traffic condition is the biggest. The total indirect influencing effect for the personal information on the travel intent via other variables is 0.35.

The perception of using park and ride facility has an effect of the perception on travel which further affects the park and ride travel intent with the indirect standard coefficient of

Table 1: Variables in structure equation.

Latent variables and variable symbols	Observed variables and variable symbols	Description and coding input values
Personal information X1	Car ownership X11	One car: 1 Two cars: 2 Three cars: 3
	Household size X12	One person: 1 Two persons: 2 Three persons: 3 Four persons: 4 Five persons: 5 Equal to or more than six persons: 6
Perception of traffic condition X2	Traffic congestion X21	Very congested: 1 Relatively congested: 2 Congested: 3 Not congested: 4 Smooth traffic flow: 5
	Parking fee at destination X22	Too high to be tolerated: 1 A little higher: 2 Moderately and acceptable: 3 Cheap: 4
Perception of park and ride facility X3	Perception of parking X31	Strongly satisfied: 1 Relatively satisfied: 2 Satisfied: 3 Unsatisfied: 4 Strongly unsatisfied: 5
	Perception of transferring X32	Strongly satisfied: 1 Relatively satisfied: 2 Satisfied: 3 Unsatisfied: 4 Strongly unsatisfied: 5
Perception of travel X4	Travel time X41	Strongly satisfied: 1 Relatively satisfied: 2 Satisfied: 3 Unsatisfied: 4 Strongly unsatisfied: 5
	Travel cost X42	Strongly satisfied: 1 Relatively satisfied: 2 Satisfied: 3 Unsatisfied: 4 Strongly unsatisfied: 5
	Comfort X43	Too crowded to be tolerated: 1 Relatively crowded: 2 Crowded and acceptable: 3 Comfortable: 4 Very comfortable and enough room: 5
Past weekly travel times for park and ride X5		One day: 1 Two days: 2 Three days: 3 Four days: 4 Five days: 5 Six days: 6 Seven days: 7

Table 1: Continued.

Latent variables and variable symbols	Observed variables and variable symbols	Description and coding input values
Travel intent for park and ride X6		Increase three times: 1 Increase two times: 2 Increase one time: 3 Do not change: 4 Decrease one time: 5 Decrease two times: 6 Decrease three times: 7

Table 2: Goodness-of-fit measures.

Measure	Meaning	Model results	Standards or critical values
x^2	x^2	26.550/38 ($P = 0.919$)	$P > 0.05$
CMIN/DF	x^2/degrees of freedom	0.699	<3.00
GFI	Goodness-of-fit index	0.949	>0.90
AGFI	Adjusted goodness-of-fit index	0.912	>0.90
NFI	Normed fit index	0.647	>0.90
RMSEA	Root mean square error of approximation	0.000	<0.08
CFI	Comparative fit index	1.000	>0.90
PGFI	Parsimony goodness-of-fit index	0.547	>0.50

0.12. The indirect influencing coefficient of the perception of traffic condition on park and ride travel intent via the perception of travel is 0.06 (Table 4).

These show that various influencing factors have a direct and indirect effect on travel intent based on the interaction among variables. The perception of traffic condition and travel has direct effect on the park and ride travel intent. Personal information has indirect effect on the park and ride travel intent via perception of using park and ride facility, traffic condition, and travel. The perceptions of using park and ride facility and traffic condition have indirect effect on the park and ride travel intent via the perception of travel.

5. Conclusions

Many influencing factors impact the multimodal modes choice for travelers. Park and ride is a multimodal travel behavior. The past researches mainly focused on the relationship between the influencing factors and travel mode choice based on the behavior survey and the disaggregated model. This paper, based on the park and ride survey conducted in Beijing, China, has studied the influence of perception of various factors on the park and ride behavior intent and analyzed the relationship between the perception of the factors and travel intent for park and ride by using the structural equation modeling. The research findings suggest that park and ride is a passive travel behavior which mainly caused by the poor traffic condition. Meanwhile, improving the service level of the park and ride facility and comfort for riding bus or railway will increase the utilization rate for park and ride. All these factors interact with each other. The research also indicates that the perception of various factors has

Table 3: The standard direct relationship.

	Personal information $X1$	Perception of park and ride facility $X3$	Perception of traffic condition $X2$	Perception of travel $X4$
Perception of park and ride facility $X3$	−0.14	0.00	0.00	0.00
Perception of traffic condition $X2$	0.73	0.00	0.00	0.00
Perception of travel $X4$	0.09	0.61	0.30	0.00
Travel intent $X6$	0.00	0.00	0.42	0.19

Table 4: The standard indirect relationship.

	Personal information $X1$	Perception of park and ride facility $X3$	Perception of traffic condition $X2$
Perception of transferring $X32$	−0.09	0.00	0.00
Perception of parking $X31$	−0.10	0.00	0.00
Comfort $X43$	−0.13	−0.36	−0.18
Travel intent $X6$	0.35	0.12	0.06
Travel cost $X42$	0.12	0.31	0.16
Travel time $X41$	0.16	0.42	0.21
Traffic congestion $X21$	0.32	0.00	0.00
Parking fee $X22$	0.49	0.00	0.00

both direct and indirect effects on travel intent. This research is conducive to the behavior analysis and policy making for park and ride.

Acknowledgments

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