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Modeling customer satisfaction for bus rapid transit in Changzhou, China

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Abstract: This paper aims to develop a customer satisfaction model for bus rapid transit (BRT). Both the socio-economic and travel characteristics of passengers were considered to be independent variables. Changzhou BRT was taken as an example and on which on-board surveys were conducted to collect data. Ordinal logistic regression (OLR) was used as the modeling approach. The general OLR-based procedure for modeling customer satisfaction is proposed and based on which the customer satisfaction model of Changzhou BRT is developed. Some important findings are concluded: Waiting sub-journey affects customer satisfaction the most, riding sub-journey comes second and arriving station sub-journey has relatively fewer effects. The availability of shelter and benches at stations imposes heavy influence on customer satisfaction. Passengers' socio-economic characteristics have heavy impact on customer satisfaction.

Key words: customer satisfaction; bus rapid transit; modeling; socio-economic characteristics; trip characteristics
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More and more cities are turning to bus rapid transit (BRT) as a way of cost-effectively expanding public transit services to relieve traffic congestion, reduce fuel consumption and carbon emissions, and increase mobility options for the poor[1]. In China, BRT has expanded faster than in any other regions around the world over the last five years[2]. By the end of 2015, BRT has been implemented in 22 cities in China[3].

Customer satisfaction is an aspect markedly influencing travel mode choices. In order to keep and attract more passengers, BRT services must have a high service quality to satisfy and fulfill a more wide range of different customers' needs[4]. That is, the increase in customer satisfaction for BRT services can translate into retained riders, newly attracted customers and a more positive public image. To accomplish these goals, it is important to explore effective methods for measuring customer satisfaction and summarize knowledge about what drives customer satisfaction for BRT services.

So far many methods have been developed to measure customer satisfaction. These methods involve Bivariate (Pearson) correlation, multiple regression analysis, factor analysis, combining factor analysis and multiple regression analysis, quadrant analysis and impact score method[5]. Another type of method is the Swedish customer satisfaction barometer (SCSB) and the American customer satisfaction index (ACSI)[6]. The ACSI model measures the cause-and-effect relationship that runs from the antecedents of customer satisfaction level (customer expectations, perceived service quality and perceived value) to its consequences (customer complaints and customer loyalty). The ACSI is the most widely applied method in studying transit customer satisfaction in China[7-9]. A more direct method for measuring customer satisfaction is the customer satisfaction index (CSI). The CSI represents a measure of service quality on the basis of the customer perceptions of service attributes expressed in terms of satisfaction rates, compared with customer expectations expressed in terms of importance rates[10]. CSI does not take into account the heterogeneities among user judgments. To overcome this lack, a new index, called the heterogeneous customer satisfaction index (HCSI), is proposed by introducing the dispersion of the importance and satisfaction rates among users[11].

The existing methods mainly take analytical perspective to study customer satisfaction, while this article attempts to address it by modeling. The objective of this article is to develop a customer satisfaction model for BRT service in China and obtain some useful conclusions from the model.

1 Methodology

1.1 Definition and effect factors of customer satisfaction

Customer satisfaction in this article is defined as a subjective feeling (very satisfied, satisfied, dissatisfied and very dissatisfied) rated by passengers resulting from comparing his or her perception with expectations for BRT services.

Customer satisfaction is affected by travel situations

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that passengers encounter during the entire bus journey. For the sub-journeys that are from origin to boarding stations and from alighting station to destination, arrival time or departure time, physical conditions and cleanliness of sidewalks have effects on customer satisfaction. When waiting at stations, customer satisfaction is influenced by such factors as waiting time, availability of shelter and benches, physical conditions, cleanliness and availability of maps. For the sub-journey riding on the bus, the factors, such as in-vehicle time, crowding, cleanliness, comfort of seats and driver attitudes, have impacts on customer satisfaction. Besides, customer satisfaction is affected by passengers' socio-economic characteristics in addition, such as gender, age, education, occupation, travel purpose, the presence of private cars and income.

For the factors mentioned above, some are difficult to quantify (such as cleanliness of sidewalks and stations, comfort of seats and driver attitudes), some have data that is difficult to obtain (such as physical condition and income). Therefore, we select the factors the data of which is available to establish customer satisfaction model. The selected factors include two types: 1) Trip characteristicssuch as arrival time, potential waiting time, availability of shelter and benches, in-vehicle time, in-vehicle crowding and travel purpose; 2) Socio-economic characteristics such as gender, age, education, occupation and car ownership.

1.2 Data collection

Questionnaire design is the first step for data collection. The questionnaire contains three parts: 1) Socio-economic characteristics of passengers; 2) Trip characteristics of passengers; 3) Personal satisfaction for BRT service, i. e., passengers need to select one from very satisfied, satisfied, dissatisfied and very dissatisfied based on their travel perceptions.

The on-board surveys were conducted on Changzhou BRT in China. Specifically, Route B1 and Route B11 were the main routes on which surveys were carried out. The surveys were implemented 7:30—18:00 on December 12th, 2012. In order to collect reliable data, the investigators interviewed passengers face-to-face onboard and inquired about items in the questionnaire. We randomly selected passengers to interview, and 300 passengers were interviewed in total. Finally, 251 questionnaires were selected for modeling after eliminating unreliable data.

1.3 Ordinal logistic regression

When modeling customer satisfaction, customer satisfaction is the dependent variable. Customer satisfaction is classified into four categories (very satisfied, satisfied, dissatisfied and very dissatisfied) in this article. Since "very satisfied" is better than "satisfied", "satisfied" is better than "dissatisfied" and so on, customer satisfaction is a discrete and ordinal dependent variable. Ordinal logistic regression (OLR) is a regression model suitable for dealing with discrete and ordinal dependent variables. Therefore, to account for both the discrete and ordered nature of data, OLR is used to establish the customer satisfaction model.

OLR can be considered as a generalization of multiple linear regression or binomial logistic regression. The model form for OLR is[12-13]

$$\ln \frac{P(y \leqslant j)}{1 - P(y \leqslant j)} = \beta_{0j} - \sum_{k=1}^{K} \beta_k x_k \tag{1}$$

where y represents the dependent variable and it is divided into J categories; x_k represents the k-th independent variable; β_k represents the coefficient of x_k; β_{0j} represents the j-th intercept; K represents the number of independent variables. $j = 1, 2, \ldots, J-1$; that is, the number of equations (logit) equals the number of categories in the dependent variable minus one.

1.4 Analysis for independent variables

Among all the factors selected for modeling customer satisfaction, arrival time, potential waiting time, in-vehicle time and in-vehicle crowding are continuous variables. Availability of shelter and benches, travel purpose, gender and car ownership are binary variables. Age, education and occupation are categorical variables.

Generally, the method for dealing with categorical variables is to create dummy variables for them. $m-1$ dummy variables need to be created if the categorical variable has m classes. The class omitted is reference category[13]. The dummy variables for age are age1, age2 and age3 and the reference category is the passengers whose ages are 6 to 29 years old. The dummy variables for education are edu1, edu2 and edu3 and the reference category is the passengers who hold a bachelor degree. The dummy variables for occupation are occ1, occ2, occ3 and occ4 and the reference category is the passengers who are company clerks.

The definitions, values and corresponding numerical marks for all the independent variables (18 in total) are shown in Tab. 1.

2 Process for Modeling Customer Satisfaction

We summarize the general procedure for modeling customer satisfaction using OLR (see Fig. 1). First, the model of customer satisfaction with all the considered independent variables is established. Then, gradually eliminate the independent variables that are not significantly associated with customer satisfaction and model it with the remaining independent variables. Iteration is terminated until the independent variables included in the model are all significantly related to customer satisfaction.

Tab. 1 The descriptions of variables

Variable		Definition	Value and mark		Variable type
Customer satisfaction		Subjective feeling given by passengers resulting from comparing his or her perception with expectations for BRT.	Very satisfied	1	Ordinal
			Satisfied	2	
			Dissatisfied	3	
			Very dissatisfied	4	
Arrival time		The time a passenger spends from origin to the boarding station.	It is obtained by interviewing passengers.		Continuous
Potential waiting time		It is the difference between budgeted waiting time and mean waiting time.	It is obtained by inquiring passengers about budgeted and mean waiting time.		Continuous
In-vehicle time		The time a passenger spends on the bus.	It is obtained by interviewing passengers.		Continuous
In-vehicle crowding		It is defined as passenger numbers on the bus divided by bus area.	It is calculated by recording bus area and passenger numbers on the bus when each respondent is interviewed.		Continuous
Availability of shelter and benches		There are shelter and benches available at boarding stations.	Yes	1	Binary
			No	0	
Travel purpose			Entertainment	1	Binary
			Commuting	0	
Gender			Female	1	Binary
			Male	0	
Car owning		There is (are) a car (cars) for a passenger.	Yes	1	Binary
			No	0	
Age	age1	The age of a passenger is 30-39.	Yes	1	Categorical (6 to 29 years old is reference category)
			No	0	
	age2	The age of a passenger is 40-59.	Yes	1	
			No	0	
	age3	The age of a passenger is more than 60.	Yes	1	
			No	0	
Education	edu1	A passenger has completed high school or a low-level education.	Yes	1	Categorical (Bachelor is a reference category)
			No	0	
	edu2	A passenger has completed vocational school.	Yes	1	
			No	0	
	edu3	The education level for a passenger is Master or above.	Yes	1	
			No	0	
Occupation	occ1	The passenger is a teacher or government officer.	Yes	1	Categorical (Company clerk is a reference category)
			No	0	
	occ2	The passenger is a student.	Yes	1	
			No	0	
	occ3	The passenger is self-employed.	Yes	1	
			No	0	
	occ4	Others	Yes	1	
			No	0	

As illustrated in Fig. 1, we delete the independent variables that are not statistically significant one by one, rather than deleting all of them simultaneously. We do this because some variables may change to become statistically significant after a variable is deleted from the data sample. Which should be eliminated first is determined according to the test of significance of coefficients (Wald χ^2). The independent variable with the largest p-value of Wald χ^2 should be eliminated first.

As described in Fig. 1, we first establish the model of customer satisfaction considering all the independent variables, which is called Model 1. The output for Model 1 using OLR is in Tab. 2. The p-value of 0.813 1 for the proportional odds assumption test is greater than 0.05, which indicates that this assumption cannot be refused and OLR is suitable for the sample data. The p-value of 0.000 1 for the overall model test is less than 0.05, that is, the variables included in Model 1 can interpret customer satisfaction and Model 1 is better than the model corresponding to null hypothesis. Wald χ^2 reflects testing for significance of coefficients. Based on the p-values for Wald χ^2, we find that arrival time, potential waiting time, in-vehicle time and edu2 are significantly related to customer satisfaction with the confidence level of 0.05. In-vehicle crowding, availability of shelter and benches, car owning and age2 are statistically significant with the confidence level of 0.1. However, gender, travel purpose, occ1, occ2, occ3 and occ4 do not have statistically significant impacts on customer satisfaction and may be gradually deleted from Model 1.

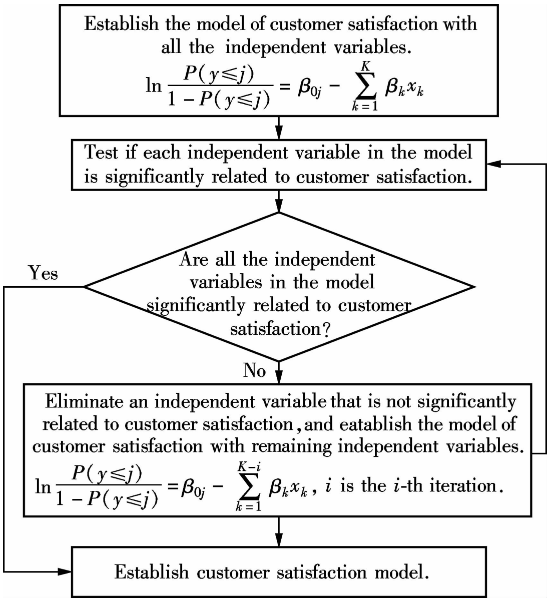

Fig. 1 The general procedure for modeling customer satisfaction using OLR

The coefficient of gender is positive (0.020 8) and male is a reference category, which means that females are more likely to be satisfied with BRT service in China than males when controlling other variables. The travel purpose coefficient is negative (−0.102 9), so the passengers who travel for entertainment have lower satisfaction on BRT service compared to those commuting (commuting is a reference category). The coefficients of occ1, occ2 and occ3 are −1.053 4, −0.083 6 and 0.738 1, respectively. Teachers or government officers (occ1) have the worst satisfaction on BRT service among all the types of occupations. An interesting finding is that the student's (occ2) satisfaction is lower than the company clerk's, which may be related to the one-child policy in China. Most students interviewed are from one-child families and they grew up in wealthy condition and thus they tend to enjoy higher service quality of transit. Self-employed passengers (occ3) display higher satisfaction than company clerks.

We delete gender, occupation and travel purpose one by one from the independent variable set and consequently build a customer satisfaction model with the remaining

Tab. 2 The model of customer satisfaction with all the independent variables using OLR (Model 1)

Independent variable		Coefficient	Wald χ^2	p-value
Intercept 1		9.080 5	43.249 2	0.000 1
Intercept 2		19.118 3	68.360 0	0.000 1
Intercept 3		26.476 6	75.015 7	0.000 1
Arrival time		−0.330 7**	60.786 0	0.000 1
Potential waiting time		−0.622 6**	31.802 3	0.000 1
In-vehicle time		−0.402 5**	76.641 2	0.000 1
In-vehicle crowding		−0.429 2*	2.596 0	0.100 0
Availability of shelter and benches	Yes	0.781 8*	2.708 5	0.099 8
	No (reference)			
Gender	Female	0.020 8	0.002 8	0.958 1
	Male (reference)			
Car ownership	Yes	−0.846 7*	2.441 1	0.098 2
	No (reference)			
Travel purpose	Entertainment	−0.102 9	0.054 3	0.815 8
	Commuting (reference)			
Age	age1 (30-39 years)	0.399 4	0.471 2	0.492 4
	age2 (40-59 years)	1.142 5*	3.601 0	0.057 7
	age3 (>60 years)	2.106 1	1.720 4	0.189 6
	6 to 29 years (reference)			
Education	edu1 (high school or lower)	0.659 5	1.294 8	0.255 2
	edu2 (vocational school)	1.104 6**	4.493 3	0.034 0
	edu3 (master or above)	0.802 1	1.587 8	0.207 6
	bachelor (reference)			
Occupation	occ1 (teacher or officer)	−1.053 4	0.511 6	0.474 4
	occ2 (student)	−0.083 6	0.025 4	0.873 3
	occ3 (self-employed)	0.738 1	0.926 9	0.335 7
	occ4 (other)	0.283 7	0.194 8	0.659 0
	Company clerk (reference)			
Proportional odds assumption test		$\chi^2=28.387\ 8$, DF = 36, $p=0.813\ 1$		
Overall model test		$\chi^2=470.977$, DF = 18, $p=0.000\ 1$		
Goodness-of-fit (AIC, SC)		219.911, 293.862		

Note: * means $p<0.1$; ** means $p<0.05$.

independent variables. Based on the tests for the significance of coefficients (p-values for Wald χ^2), all the independent variables become statistically significant when associated with customer satisfaction only after all three variables are removed.

After eliminating gender, occupation and travel purpose, the model of customer satisfaction with the remaining independent variables is called Model 2 and it is shown in Tab. 3. The p-value of 0.445 8 for the proportional odds assumption test of Model 2 is greater than 0.05, so this assumption cannot be rejected and OLR is suitable for the data set deleting these three variables. The p-value of 0.000 1 for the overall model test of Model 2 is less than 0.05, which enables Model 2 to be used to predict customer satisfaction. In Model 2, age1, age3, edu1 and edu3 are not statistically significant, but we cannot continue to remove them according to the principle that dummy variables must be simultaneously entered or deleted from a model.

Tab. 3 Model of customer satisfaction with independent variables left after eliminating gender, occupation and travel purpose using OLR (Model 2)

Independent variable		Coefficient	Wald χ^2	p-value
Intercept 1		8.962 3	45.885 8	0.000 1
Intercept 2		18.916 4	71.445 8	0.000 1
Intercept 3		26.299 6	77.603 7	0.000 1
Arrival time		−0.328 3**	61.940 0	0.000 1
Potential waiting time		−0.610 3**	31.881 6	0.000 1
In-vehicle time		−0.401 7**	78.415 2	0.000 1
In-vehicle crowding		−0.390 2*	2.248 2	0.093 8
Availability of shelter and benches	Yes	0.786 7*	2.919 8	0.087 5
	No (reference)			
Car ownership	Yes	−0.890 3*	2.811 3	0.093 6
	No (reference)			
Age	age1 (30-39 years)	0.502 8	0.871 6	0.350 5
	age2 (40-59 years)	1.207 8**	4.586 2	0.032 2
	age3 (>60 years)	2.274 8	2.231 2	0.165 2
	6-29 years (reference)			
Education	edu1 (high school or lower)	0.655 2	1.327 4	0.249 3
	edu2 (vocational school)	1.174 6**	5.302 9	0.021 3
	edu3 (master or above)	0.788 3	1.612 8	0.204 1
	Bachelor (reference)			
Proportional odds assumption test		$\chi^2=24.278\ 2$, DF = 24, $p=0.445\ 8$		
Overall model test		$\chi^2=470.592$, DF = 12, $p=0.000\ 1$		
Goodness-of-fit (AIC, SC)		210.025, 262.907		

Note: * means $p<0.1$, ** means $p<0.05$

3 Customer Satisfaction Model

According to the general procedure for modeling customer satisfaction in Fig. 1, Model 2, in which all the independent variables are statistically significant associated with customer satisfaction, is the right model desired.

On the basis of the output of Model 2 in Tab. 3, we establish the customer satisfaction model for BRT service in Changzhou, China:

$$\left.\begin{aligned}\ln\frac{P_1}{P_2+P_3+P_4}&=8.96-0.33\text{arr}-0.61\text{pwt}-0.4\text{ivt}-0.39\text{ivc}+0.79\text{asb}-0.89\text{car}+1.21\text{age2}+1.17\text{edu2}\\ \ln\frac{P_1+P_2}{P_3+P_4}&=18.92-0.33\text{arr}-0.61\text{pwt}-0.4\text{ivt}-0.39\text{ivc}+0.79\text{asb}-0.89\text{car}+1.21\text{age2}+1.17\text{edu2}\\ \ln\frac{P_1+P_2+P_3}{P_4}&=26.3-0.33\text{arr}-0.61\text{pwt}-0.4\text{ivt}-0.39\text{ivc}+0.79\text{asb}-0.89\text{car}+1.21\text{age2}+1.17\text{edu2}\end{aligned}\right\}$$

where P_1 represents the probability of customer satisfaction being very satisfied; P_2 represents the probability of customer satisfaction being satisfied; P_3 represents the probability of customer satisfaction being dissatisfied; P_4 represents the probability of customer satisfaction being very dissatisfied; $P_1+P_2+P_3+P_4=1$; arr represents arrival time, min; pwt represents potential waiting time. min; ivt represents in-vehicle time, min; ivc represents in-vehicle crowding, passengers/m^2; asb represents availability of shelter and benches (yes, asb = 1; otherwise, asb = 0); car represents car ownership (yes, car = 1; otherwise, car = 0); age2 indicates that the age of a passenger is 40-59 (yes, age2 = 1; otherwise, age2 = 0); edu2 indicates that a passenger completes vocational school (yes, edu2 = 1; otherwise, edu2 = 0).

For certain independent variable combinations, we can calculate the values for P_1, P_2, P_3 and P_4 based on the model above, and the specific customer satisfaction is the corresponding category of the largest value across P_1, P_2, P_3 and P_4.

4 Analysis on Customer Satisfaction Model

4.1 Analysis based on the positives and negatives of coefficients

Customer satisfaction is classified into very satisfied (1), satisfied (2), dissatisfied (3) and very dissatisfied (4). Therefore, the positive coefficients increase the likelihood of being the lower-numbered category (i. e., the higher-level satisfaction). On the contrary, the negative coefficients decrease the likelihood of being the lower-numbered category.

The coefficients estimated for arrival time, potential waiting time, in-vehicle time and in-vehicle crowding are negative, which means that the increase in them will reduce the likelihood of being a higher-level satisfaction (i. e., the larger their values are, the smaller the possibility of passengers being satisfied is). The parameter estimated for availability of shelter and benches is positive, which implies that the stations equipped with shelter and benches will enhance the possibility of passengers being satisfied. The negative coefficient for car ownership indicates that the passengers who own a car are less likely to feel satisfied with BRT service than those without a car. The positive coefficient for age2 implies that the passengers whose ages are 40-59 are more likely to feel satisfied with BRT service compared to the 6-29 years passengers. This finding is somewhat surprising and the reason may be that passengers aged 40-59 years have suffered the hardships of life and become more tolerant. The coefficient for edu2 is also positive, which tells us that the passengers who complete vocational school have a higher likelihood of having a higher-level satisfaction compared to those with a bachelor degree.

4.2 Analysis based on values of coefficients

By analyzing the absolute values of variable coefficients in the customer satisfaction model, we can obtain impact ranks of factors on customer satisfaction, which are summarized in Tab. 4. The interpretations for each finding are below.

Tab. 4 Findings concluded from customer satisfaction model

Analysis perspectives	Rank of impact on customer satisfaction (descending order)
Trip time-related characteristics	Potential waiting time, in-vehicle time, arrival time
From journey perspective	Waiting sub-journey, riding sub-journey, arriving station sub-journey
Trip characteristics	Availability of shelter and benches, potential waiting time, in-vehicle time, in-vehicle crowding, arrival time
Socio-economic and trip characteristics	Socio-economic characteristics, trip characteristics

Among the independent variables in the customer satisfaction model, arrival time, potential waiting time and in-vehicle time are trip time-related variables. Their coefficients are −0.33, −0.61 and −0.40, respectively. Rank them according to the absolute values of coefficients: potential waiting time, in-vehicle time and arrival time. Thus, potential waiting time has the greatest impact on customer satisfaction, while arrival time has the relatively smallest impact.

Potential waiting time, in-vehicle time and arrival time can be regarded as the representatives for waiting sub-journey, riding sub-journey and arriving station sub-journey, respectively. It is inferred from this perspective that waiting sub-journey affects customer satisfaction the most, riding sub-journey comes second and arriving station sub-journey affects it the least. In-vehicle crowding is also an attribute for riding sub-journey and its coefficient (−0.39) is quite close to in-vehicle time's. Therefore, in-vehicle crowding supports the inference above as well.

Arrival time, potential waiting time, in-vehicle time, in-vehicle crowding and availability of shelter and benches are trip characteristics. Availability of shelter and benches has the biggest coefficient (0.79) among them. It indicates that the equipment level at stations influences passengers' perception quite heavily, even more greatly than travel time. This statement makes sense due to passengers placing more emphasis on comfort and enjoyment with improvement in life quality in China. This also implies that transit agencies should provide higher-quality amenities at stations to enhance transit service quality.

We rank all the independent variables according to the absolute values of coefficients: age2 (1.21), edu2 (1.17), car ownership (0.89), availability of shelter and benches (0.79), potential waiting time (0.61), in-vehicle time (0.40), in-vehicle crowding (0.39) and arrival time (0.33). The first three (age2, edu2 and car ownership) are socio-economic characteristics and the final five are trip characteristics. It can be concluded from the coefficient magnitude that socio-economic characteristics have much heavier impact on customer satisfaction for BRT service than trip characteristics in Changzhou. That is, passengers mainly rely on their intrinsic characteristics to rate satisfaction or service quality.

5 Conclusion

Based on the data collected from on-board surveys in Changzhou BRT, the customer satisfaction model for BRT service is established using OLR.

The existing methods examine customer satisfaction from an analytical perspective, while this paper investigates it in terms of modeling. The existing methods rely on passengers' ratings of importance and satisfaction about service quality attributes on a Likert-type scale to study customer satisfaction, while this paper is based on identifying independent variables and inquiring their actual values. Another highlight is that the socio-economic characteristics are used as independent variables to model customer satisfaction, which can reflect individual differences because different passengers have different perceptions, even for the same bus experience.

We can calculate customer satisfaction with the established model as long as the socio-economic and trip characteristics of passengers are given, which is the useful feature of this model. It is somewhat difficult to obtain accurate satisfaction ratings on a Likert-type scale because passengers find it difficult to distinguish between their perception and expectation. On the contrary, it is relatively easy to survey objective characteristics (socio-economic and trip characteristics). Therefore, we can probably shift the way of surveying satisfaction ratings to a method of surveying objective characteristics and then calculating satisfaction based on them. Besides, the established model can also be applied when comparing satisfaction for BRT services across different passenger groups.

Some important findings from the customer satisfaction model are summarized as follows: 1) Waiting sub-journey affects customer satisfaction the most, riding sub-journey comes second and arriving station sub-journey has relatively less effect. 2) Equipment level at stations influences customer satisfaction quite heavily. Amenities construction is an efficient tool for improving BRT service quality. 3) Socio-economic characteristics have heavy impacts on customer satisfaction.

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快速公交乘客满意度建模研究——以常州快速公交为例

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摘要: 为了建立快速公交的乘客满意度模型,以乘客的社会经济特性和出行特征作为自变量,选取常州快速公交作为案例开展车内问卷调查以获取建模所需数据,采用有序 Logistic 回归作为建模方法. 提出了基于有序 Logistic 回归建模乘客满意度的一般性方法,并在此基础上建立了常州快速公交的乘客满意度模型. 通过对所建模型的分析发现:等车过程对乘客满意度的影响最大,其次是乘车过程,到站过程的影响相对最小;站点设施,如是否配备遮挡物和座椅等,对乘客满意度有较大影响;乘客的社会经济特性对乘客满意度有很大影响.

关键词: 乘客满意度;快速公交;建模;社会经济特性;出行特征

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