AN EMPIRICAL ANALYSIS OF BEIJING PUBLIC TRANSPORT USERS' SATISFACTION LEVEL

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Abstract: Assessing the level of public transport users' satisfaction is important not only to implication of public transport priority policy, but also to improvement of public transport service level. In this paper, evaluation index system of pubic transport passengers' satisfaction is established according to basic requirement of passengers. Then, based on matter element theory, evaluation model which uses coefficient of variation method to calculate the weight of the evaluation indices is developed. Finally, the model is applied to Beijing based on data surveyed by questionnare. The research indicates that public transport user satisfaction degree in Beijing is 'medium'.

1 INTRODUCTION

Along with the too rapid growth of motor vehicles, congestion in Beijing has long been an increasingly serious problem which brings negative effect to urban development and daily life of residents. Because of the limit in land resources, congestion in Beijing can not be solved by increasing the area of road substantially. As a result, transportation demand management (TDM) emerged as a useful tool. Improving public transport is one of the main TDM measures. Preferential development of urban public transport is an important measure to raise the utilization rate of transport resources and reduce traffic congestion. A convenient, fast and comfortable public transport system can attract more residents and thus improve the urban transport structure. Whether residents choose public transport mainly depends on its performance. The public transport system should be improved according to the requirements of the passengers. In that way public transport can be more attractive to the residents, so the congestion can be relieved effetely.

Assessing the level of public transport user satisfaction is not only important to the implication of public transport priority policy, but also of great significance to the improvement of the public transport service level. For the above reasons, this paper focuses on the evaluation of public transport user satisfaction.

2 LITERATURE REVIEW

Evaluation of public transport is worldwidely academic concerned due to practical significance. Foreign scholars have a preference for questionnaire-based survey and statistics to analyze factors affected to public transport user satisfaction. Based on data of SP survey, Hensher & Stopher (2003) did a research on 13 factors' influence on passengers' satisfaction; the 13 factors include bus travel time, seat availability on bus, driver attitude and general cleanliness on board etc. Tyrinopoulos& Antonio (2008) and Olio et al (2010) did similar analyses on influencial factors.

Some scholars focus on evaluating methods of public transport performance. Yeh et al (2000) developed a fuzzy multicriteria analysis model to assess the performance of bus companies; the model was then applied to evaluate ten bus companies' perfrmance in Taiwan. Cheng & Wang (2009) established an evaluation system based on government, transit operators and passengers, city of Zhengzhou was selected for the empirical study.

Some scholars assessed public transport performance by grey theory method. Li & Hu (2006) presents 23 evaluation indices involve infrastructure,

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service and benefit; and the city of Qingdao was studied by means of grey clustering method. Chen & Zhang (2009), Li & Sun (2010) did similar research on Lanzhou and Jinan. Shao et al (2009) established a comprehensive evaluation system based on analytic hierarchy process (AHP) and grey relational analysis in evaluation of public transport of Yinchuan. Based on questionaire surveyed data, Yang & Chen (2005) analyzed the influence degree of attributes like road density, average speed, departure intervals and accident rate on users' satisfaction.

In the model built by Shao (2005), indices involved five aspects including public transport infrastructure, investment of bus companies, public transit capacity and service quality. After the indices are weighted by means of analytic hierarchy process (AHP), evaluation was realized by an improved BP neural network model.

Overview of literature above indicates that evaluation criteria established in most of the recent research mainly used data related to public transport system instead of passengers' subjective feeling. Furthermore, fuzzy multicriteria analysis, grey theory method and BP neural network model is widely used to evaluate the service quality of public transport. However, fuzzy multicriteria analysis and grey theory method is often criticized for the definition of membership function and whitenization function is arbitrary. BP neural network model is only effective when mass typical data is available. So, in this paper, the authors will promote public transport users' satisfaction evaluation criteria from the perspective of passengers. In addition, comprehensive evaluation model is established based on the theory of matter element.

3 EVALUATION MODEL OF PUBLIC TRANSPORT USERS' SATISFACTION LEVEL

Matter element analysis is an appropriate tool in solving complex and incompatible problems. Multicriteria evaluation model is established based on matter element theory and it can be applied to evaluate the public transport user satisfaction.

A set of *n* indices $C_1, C_2, \cdots, C_n$ are chosen to evaluate public transport user satisfaction and the corresponding numerical values of indices are $X_1, X_2, \cdots, X_n$. The public transport user satisfaction can be expressed as a matter-element:

$$R = (N, C, X) = \begin{vmatrix} N & C_1 & X_1 \\ & \vdots & \vdots \\ & C_n & X_n \end{vmatrix}$$

R_j represents matter-element of classic domain while N_j is the *j*th grade of satisfaction and $x_{ji} = [a_{ji}, b_{ji}]$ is the value range of *j*th grade of satisfaction on the *i*th index. R_P is matter-element of section domain while P is whole grades of satisfaction and $x_{Pi} = [a_{Pi}, b_{Pi}]$ represents the value range of C_i.

$$R_j = \begin{vmatrix} N_j & C_1 & [a_{j1}, b_{j1}] \\ & C_2 & [a_{j2}, b_{j2}] \\ & \vdots & \vdots \\ & C_3 & [a_{jn}, b_{jn}] \end{vmatrix} \quad R_P = \begin{vmatrix} P & C_1 & [a_{P1}, b_{P1}] \\ & C_2 & [a_{P2}, b_{P2}] \\ & \vdots & \vdots \\ & C_n & [a_{Pn}, b_{Pn}] \end{vmatrix}$$

Correlation degree is defined as the membership between the index and the grade. In extenics, correlation degree can be calculated by the correlation function bellow:

$$k_j(x_i) = \begin{cases} -\dfrac{\rho(x_i, x_{ji})}{|x_{ji}|} & x \in x_0 \\ \dfrac{\rho(x_i, x_{ji})}{\rho(x_i, x_{pi}) - \rho(x_i, x_{ji})} & x \notin x_0 \end{cases}$$

$$\rho(x_i, x_{ji}) = \left| x_i - \frac{a_{ji} + b_{ji}}{2} \right| - \frac{b_{ji} - a_{ji}}{2}$$

where $|x_{ji}| = |a_{ji} - b_{ji}|$ and $k_j(x_i)$ is the correlation degree between the *i*th index and the *j*th grade. The correlation degree of the evaluation object matter-element and the *j*th grade can be calculated as:

$$L_j(x) = \sum_{i=1}^{n} k_j(x_i) w(x_i)$$

where $w(x_i)$ is the weight of the *i*th criterion.

4 EVALUATION SYSTEM OF MUNICIPAL PUBLIC TRANSPORT USERS' SATISFACTION

The evaluation index system is established follow the principles of systematicity, multi-levels,

Table 1: Evaluation indices, values and weights of Beijing public transport users' satisfaction level.

	Criteria	Sub-criteria and their Weights	Mean value of Indices	Weights of Indices
Satisfaction level	Efficiency 0.283	Waiting time at offpeak hours 0.156	7.41	0.044
		Waiting time at peak hours 0.166	7.07	0.047
		Transfer time 0.158	7.37	0.045
		Travel time 0.275	3.74	0.078
		Traffic information 0.245	4.57	0.070
	Convenience 0.263	Transfer times 0.220	5.96	0.058
		Walking time from station to destination 0.396	4.58	0.105
		Station information by broadcast 0.174	6.23	0.046
		Convenience during transferring 0.209	5.79	0.055
	Comfort 0.361	Waiting order 0.169	5.12	0.061
		Vehicle cleanliness 0.112	5.87	0.040
		Vehicle temperature and air condition 0.148	5.15	0.053
		Degree of crowding in the vehicle 0.241	3.23	0.086
		Running stability of vehicle 0.200	4.77	0.072
		Seat comfort 0.130	5.95	0.046
	Service quality 0.093	Staff friendliness 0.486	5.85	0.045
		Offering seats to other person 0.514	6.28	0.048

scientificity and feasibility. Finally, a three-level evaluation index system was established. In this system, municipal public transport user satisfaction is the evaluation objective; five attributes including efficiency, convenience, comfort and service are considered as criteria; 17 sub-criteria are selected in the third level (see table 1).

5 EMPIRICAL ANALYSIS OF BEIJING PUBLIC TRANSPORT USERS' SATISFACTION

In this part, we will evaluate the satisfactory level of Beijing public transport users based on the above questionaire surveyed data.

5.1 The Questionaire Survey

A questionnaire survey was conducted at bus station, urban rail and subway station, public transit hub, shopping center, parks and schools etc. in Beijing in January 2010 to obtain data of indices. The questionnaire was designed based on the evaluation index system. Indices were translated into questions according to the actual situation to get information from the passengers. We sent out 700 questionnaires and 527 of them were collected. Of the 527 correspondents, 252 persons are female while 257 of them are male; 182 (34.5%) correspondents' families have at least one private car; as to age structure, 443 (84%) of them are 18-45 years old, while senior persons (elder than 60 years old) only occupied 0.9%.

Passenger's judgment about public transport is described as five grades, 'very poor', 'poor', 'fair', 'good' and 'very good' and the corresponding numerical values are 1, 3, 5, 7 and 9 when recording the data. The statistical data is presented in Table 1 (see column 'mean value of the indices').

5.2 Weights of Indices

Coefficient of variation method can be used to calculate the weighs of indices objectively. It is adopted in this paper to avoid the defect of subjective methods such as AHP and Delphi method. The weight can be calculated as follows:

$$\delta_j = \frac{D_j}{\bar{x}_j} \quad (1)$$

Table 2: Relational degrees in Beijing public transport evaluation system.

Relational degree	Very good	Good	Medium	Poor	Very poor	Grade
Efficiency	-0.4276	0.021	-0.159	-0.313	-0.571	Good
Convenience	-0.435	-0.108	0.128	-0.294	-0.509	Medium
Comfort	-0.489	-0.247	0.163	-0.105	-0.448	Medium
Service quality	-0.396	0.050	-0.011	-0.414	-0.582	Good
Synthetically relational degree	-0.449	-0.119	0.046	-0.242	-0.511	Medium

$$w_j = \frac{\delta_j}{\sum_{j=1}^{n} \delta_j} \quad (2)$$

Where $\bar{x}_j$ is the mean value of jth index, D_j is the standard deviation of the jth index, δ_j is the coefficient of variation and w_j is the weight of the jth index.

Weights calculated by means of coefficient of variation method are presented in Table 1 (see column 'weights of indices').

5.3 Evaluation of Public Transport users Satisfaction Level

Mean value of the satisfaction degree obtained by the survey is taken as the value of corresponding index. Public transport user satisfaction degree can be described as five grades, 'very good' (the value range is 8-9), 'good' (6-8), 'medium' (4-6), 'poor' (2-4) and 'very poor' (1-2). According to the model built in part 2, matter-element of evaluation object, matter-element of classic domain and matter-element of section domain can be defined and relational degree between the indices and five grades can be calculated. Synthetically relational degree between public transport user satisfaction and five grades is obtained by weight sum. According to the definition of relational degree, the grade of public transport user satisfaction is given by $k_j = \max_{j=1,2,...n} L_j(x)$. The relational degrees are presented in Table 2.

Data in Table 2 indicates that public transport passenger satisfaction degree in Beijing is 'medium'. Furthermore, synthetically relational degree about 'good' is larger than it of 'poor'. According to the definition of relational degree in extenics, it is more likely to translate into grade of 'good' from 'medium'.

6 CONCLUSIONS

By improving public transport service quality to satisfy passengers, more residents will be appealed to use public transport instead, so that the congestion could be relieved. In order to evaluate the public transport user satisfaction, this paper proposed an evaluation model based on matter-element analysis theory. Based on the data obtained by questionnaire survey, the public transport user satisfaction is assessed from the perspective of passengers. Coefficient of variation method is adopted to calculate the weights of indices to overcome the shortcoming of subjective methods used in previous research. The research indicates that public transport user satisfaction degree in Beijing is 'medium' and close to 'good'. Poor user satisfaction about convenience and comfort affect the overall satisfaction of public transport service. While striving to construct public transport infrastructure, the government should pay more attention to improve the service quality of public transport to make public transport more attractive.

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