Evaluation of Cloud Model for Public Transport Service Quality

Meng Zhang1, Yi Zhang2*, Jinhui Li3, Xiaomin Wang4 and Zhixin Wang5

1,2*,3,4,5 Department of vehicle and traffic engineering, Henan University of Science and Technology, Luoyang, Henan, 471003, China

*Corresponding author’s e-mail: hkdjtszy@haust.edu.cn

Abstract. In order to practice bus city planning, it is of great significance to construct a reasonable urban bus service system. At present, there are various research models and methods, and a city bus service quality evaluation model is established based on the advantages and disadvantages of various methods. Analytic hierarchy process and coefficient of variation method were combined to form subjective and objective weights, and cloud model was established for comprehensive quality evaluation. The feasibility of the model is verified by the measured indexes of public transportation in Luoyang City, which proves the rationality of the evaluation method and provides reference for other cities.

1. Introduction

With the development of national economy, the car ownership is increasing rapidly, which not only brings serious environmental pollution, but also aggravates the traffic burden. The problem of urban traffic congestion has met an unprecedented test. In response to these problems, the state has issued a document on bus priority in 2012, emphasizing the importance of bus service quality. In order to practice the planning of public transportation city, it is necessary to improve the willingness of residents to choose public transportation in priority in the face of numerous transportation modes.

There are a large number of evaluation targets in the study of public transportation service quality, and the evaluation process is fuzzy and random[1]. The author uses the analytic hierarchy process and the variation coefficient method combining subjective and objective weighting [2] guaranteeing the rationality and scientific nature, the cloud model is set up, implementing effective transformation between qualitative and quantitative language data, to better reflect the fuzziness and relevance evaluation, so the comprehensive evaluation is made on the evaluation results [3]. Combined with the survey data of public transport quality in Luoyang, this paper evaluates the public transport quality in Luoyang and verifies the scientific and feasible method.

2. Evaluation Index System of Public Transportation Service Quality

2.1. Establishment of Indicators

By referring to the American satisfaction index model and combining with domestic scholars' research on bus service quality[4], starting from travelers' needs, the evaluation index system is constructed from five aspects of comfort, safety, convenience, efficiency and economy [5]. According to the principles of comprehensive evaluation and index design, the bus service quality index system is divided into levels, as shown in figure 1 [6,7].
2.2. Indicator determination and empowerment

The evaluation is in the form of a 5-level Likert scale[8]. The evaluation criteria used are: great satisfaction, satisfaction, general, dissatisfaction, great dissatisfaction. The evaluation values are 5, 4, 3, 2, 1.

Analytic hierarchy process has strong subjectivity. According to the expert's evaluation of each index, the judgment matrix is constructed to calculate the weight. Finally, the consistency test is carried out.

The coefficient of variation method measures the variation degree of a group of data. If the variation degree of an index is large, it means that it has the significance of evaluation, and the corresponding weight will be larger.

In order to fully consider the intention of the valuator and ensure the validity of the data, the subjective and objective 1:1 methods are used to weight the data, and the final weight result is obtained.

2.3. Comprehensive Evaluation Cloud Model

Cloud model [9] is a model based on fuzzy set and probability theory, which realizes the conversion of qualitative language and quantitative language through specific algorithms, and can effectively solve the problems of fuzziness and relevance in the evaluation process.

2.3.1. Cloud theory

Let a universe Q, x be its quantitative value, and the qualitative concept K of universe Q have a corresponding stable random number μЄ[0,1] for any x, which indicates the certainty of x for K. The distribution of x in the domain constitutes a cloud. Every cloud drop of a cloud is x. Cloud droplets are the transformation and uncertainty mapping of quantitative data and qualitative concepts. Clouds composed of multiple cloud droplets can represent the overall characteristics.

The cloud model is represented by Ex, En and He, which are expectation, entropy and hyper-entropy respectively. Expectation is the distribution expectation of cloud droplets in the domain. Entropy represents the uncertainty that cloud droplets are expected to accept and the dispersion degree of cloud droplets distribution. Hyper-Entropy is the quantity value of uncertainty, which indicates the correlation between randomness and fuzziness of qualitative concepts. When the correlation degree is high, the hyper-Entropy value is small.

2.3.2. Cloud computing

The parameter calculation of cloud model is divided into two parts [10]. The reverse cloud generator method is used for ordinary cloud digital calculation, and the expected value, entropy value and super entropy value of the measured cloud model are calculated according to the data characteristics. The index approximation method is used in the cloud digital calculation of the evaluation standard to form the standard evaluation grade cloud.
The calculation steps of inverse cloud generator method are as follows:

Each cloud drop in the cloud model is \( x \). If the number of cloud droplets is \( d \), the digital characteristics are expressed as follows:

\[
E_x = \bar{x} = \frac{1}{d} \sum_{j=1}^{d} x_j. \quad (1)
\]

\[
S^2 = \frac{1}{d-1} \sum_{j=1}^{d} (x_j - \bar{x})^2. \quad (2)
\]

\[
E_n = \left( \frac{\pi}{2} \right)^{\frac{3}{2}} \times \frac{1}{d} \sum_{j=1}^{d} |x_j - E_x|. \quad (3)
\]

\[
H_e = \left( S^2 - E_n^2 \right)^{\frac{1}{2}}. \quad (4)
\]

In the index approximation method, the value range of cloud droplets in each evaluation level is set as \([K_{\text{min}}, K_{\text{max}}]\), so the cloud expectation of evaluation level is one half of the sum of the maximum and minimum values in each evaluation level, and the cloud entropy of evaluation level is one sixth of the difference between the maximum and minimum values in each evaluation level. The cloud hyper-entropy of the evaluation grade is determined by the degree of fuzziness.

Cloud computing of each index is carried out by combining the survey results with equations (1), (2), (3) and (4) to generate a cloud parameter matrix of each index:

\[
R_i = r_{ij} (E_{x_i}, E_{n_i}, H_{e_i}).
\]

According to the determination of index weight, the evaluation results are calculated:

\[
B_i = W \cdot B
\]

Note: \( \cdot \) is the fuzzy operator \( M(., \Theta) \), \( B \) is the evaluation result.

Calculate the first-level index evaluation result:

\[
B_i(E_{x_i}, E_{n_i}, H_{e_i}) = W_i \times R_i. \quad (5)
\]

Calculate the service quality evaluation results:

\[
B_i(E_x, E_n, H_e) = W \times B_i. \quad (6)
\]

3. Case study

In order to verify the effectiveness of the method, an evaluation model of public transport service quality was established, and a random sampling survey was designed for residents of Luoyang City. The survey covered all public transport routes in Luoyang City. A total of 505 questionnaires and 472 valid questionnaires were distributed. The specific evaluation process is as follows:

3.1. Determining weight

According to expert evaluation, after calculation, the subjective weight of each level index was determined to be 0.134, 0.383, 0.107, 0.123, 0.253 respectively. And passed the consistency test.

The results of 472 questionnaires were collected and the mean and standard deviation of 21 influencing factors were calculated. According to the method of coefficient of variation, the secondary weights of each index were obtained as follows: 0.156, 0.182, 0.201, 0.172, 0.146, 0.143, 0.511, 0.489, 0.129, 0.165, 0.231, 0.206, 0.140, 0.128, 0.215, 0.209, 0.196, 0.186, 0.195, 0.443, 0.557. The weight of index relative to service quality is (0.040, 0.046, 0.051, 0.044, 0.037, 0.036, 0.042, 0.040, 0.043, 0.055, 0.078, 0.069, 0.047, 0.043, 0.054, 0.052, 0.049, 0.049, 0.035, 0.044).

According to the calculation results, the payment mode of indicator 11 has the largest weight relative to the quality of service, indicating that residents have a lower score on this index, and the public transport payment mode of Luoyang City is backward. Bus enterprises need to pay attention to this problem and improve it as soon as possible. Indicators such as the real-time information awareness of indicator 12, the departure frequency of indicator 15 and the punctuality rate of indicator 19 are weighted heavily because of their discreteness, which means that residents have different opinions on the two indicators.
In order to ensure fairness, subjective and objective use a ratio of 1:1 for joint weighting. After calculation, the first order weights of \(Z_1, Z_2, Z_3, Z_4\) and \(Z_5\) are 0.194, 0.233, 0.221, 0.186 and 0.166 respectively.

3.2. Comprehensive Evaluation of Cloud Model

3.2.1. Establishing Evaluation Cloud. Through sorting out the survey results of each index, cloud parameters of each secondary index are calculated, as shown in table 1.

| Secondary index | Ex   | En   | He   | Secondary index | Ex   | En   | He   | Secondary index | Ex   | En   | He   |
|-----------------|------|------|------|-----------------|------|------|------|-----------------|------|------|------|
| C1              | 3.715| 0.902| 0.104| C8              | 3.337| 0.827| 0.092| C15             | 3.128| 1.034| 0.049|
| C2              | 3.279| 0.935| 0.035| C9              | 3.814| 0.973| 0.307| C16             | 3.227| 1.035| 0.073|
| C3              | 3.233| 1.017| 0.103| C10             | 3.134| 1.070| 0.015| C17             | 3.250| 0.980| 0.002|
| C4              | 3.297| 0.885| 0.107| C11             | 2.227| 1.065| 0.036| C18             | 3.285| 0.936| 0.088|
| C5              | 3.733| 0.855| 0.060| C12             | 3.041| 1.288| 0.137| C19             | 3.192| 0.946| 0.146|
| C6              | 3.698| 0.830| 0.053| C13             | 3.314| 0.957| 0.055| C20             | 4.047| 0.862| 0.126|
| C7              | 3.297| 0.850| 0.117| C14             | 3.738| 0.963| 0.224| C21             | 3.733| 0.984| 0.220|

According to formula (5) and (6), the calculated service quality evaluation result is \(B(Ex, En, He) = (3.370, 0.947, 0.140)\).

3.2.2. Establishing Evaluation Grade Cloud. Combined with Likert scale, using index approximation method, cloud parameters of each evaluation grade are calculated. According to the evaluation grade cloud parameters, matlab is used to generate an evaluation grade cloud picture, as shown in figure 2.

3.2.3. Analysis of evaluation results. The result of service quality evaluation in Luoyang City is \(B(Ex, En, He) = B(3.370, 0.947, 0.140)\). In order to reduce the error, according to the cloud model theory, when the error is less than 0.01, the number of cloud droplets should be 2000. Combining with cloud parameters, the evaluation cloud should be generated and placed in the evaluation grade cloud for comparison, as shown in figure 3. The conclusion is drawn and the corresponding suggestions are put forward with the calculation process data.

Combining with the current situation of public transport in Luoyang City, through cloud analysis, the expected value of the evaluation cloud of public transport service quality in Luoyang City is \(Ex = 3.370\), which is between the general and basic satisfaction evaluation level cloud, and more inclined to the basic satisfaction level. It can be concluded that the evaluation result of public transport service quality in Luoyang City is basically satisfactory.
3.3. **Put forward the proposal**
Through the processing and analysis of cloud map of evaluation result and evaluation process data, this paper puts forward the corresponding suggestions for the public transportation from four aspects in Luoyang City. 1) Bus enterprises should learn from other small and medium-sized cities in the development of bus enterprises. In terms of payment methods, Luoyang city has lagged behind other cities. 2) Bus enterprises should pay attention to the construction of real-time operation information. 3) Both bus companies and drivers should pay attention to punctuality, make punctual departure, try their best to ensure time and save time cost for passengers as much as possible.

4. **Conclusion**
Aimed at the evaluation of public transportation service quality, a cloud model comprehensive evaluation method combining analytic hierarchy process and coefficient of variation method is proposed to avoid subjective or objective oneness. Through the calculation of cloud model parameters, the randomness and fuzziness of evaluation are ensured, and the final evaluation result cloud is obtained by using normal cloud combined with weight. Taking Luoyang city as an example, the method is verified to be scientific and feasible, and it also provides reference for other cities' related research.

**Acknowledgments**
This research was financially supported by the General Project of the National Social Science Foundation of China (Grant NO.16BJY070) and the Doctoral Research Start-up Funds for Henan University of Science and Technology (Grant NO.13480037).

**References**

[1] Zhou Xuemei, Shi Yunlin, Liu Mei, et al. (2015) Evaluation methods of urban and rural bus service quality. Journal of Tongji University(Natural Science Edition), 43(7): 1031-1038.

[2] Chang Fenghua, Fan Lili. (2014) Fuzzy comprehensive evaluation of green bus service quality from the perspective of passengers-based on the questionnaire survey of Pingdingshan City. Journal of Southwest Jiaotong University (Social Science Edition), 15(2): 57-63.

[3] Li Wanyu, Huang Xianfeng, Yan Wei, et al. (2018) Flood resource utilization risk assessment of water transfer project based on combined weight cloud model. South-to-North Water Transfer and Water Conservancy Technology, 16(05): 61-69.

[4] Zhang Bing, Zeng Minghua, Chen Qiuyan, et al. (2016) SEM-based research on urban bus service quality-satisfaction-loyalty. Mathematical Statistics and Management, 35(2): 198-205.

[5] Wu Huirong, Cui Shuhua, Zhang Haisong. (2012) Research on evaluation of urban bus service quality based on passenger perception. Journal of Chongqing Jiaotong University (Natural Science Edition), 31(5).

[6] Castillo, J.M.D., Benitez, F.G. (2012) A methodology for modeling and identifying users satisfaction issues in public transport systems based on users surveys. Procedia - Social and Behavioral Sciences, 54(2290): 1104-1114.

[7] Lai, W.T., Chen, C.F. (2011) Behavioral intentions of public transit passengers-the roles of service quality, perceived value, satisfaction and involvement. Transport Policy, 18(2): 0-325.

[8] Li Jinhui, Zhang Keke, Liu Yongbin. (2017) Service Quality Evaluation of Urban Taxicab Based on Customer Satisfaction Degree.In: Lecture Notes in Management Science. Philippine. pp. 251-257.

[9] Yang Jing. (2015) Research on Passenger Satisfaction Evaluation of Highway Passenger Transport Service Based on Cloud Theory. Chang’an University, Xi’an.

[10] Guo Xiaofan, Li Linbo, Wang Yanli, et al.(2018) Evaluation of public transport service satisfaction based on entropy weight-cloud model. Journal of Chongqing Jiaotong University (Natural Science Edition), 37 (09): 104-109.