Computing, Performance and Communication Systems (2022)
Clausius Scientific Press, Canada

DOI: 10.23977/cpcs.2022.060206
ISSN 2371-8889 Vol. 6 Num. 2

Research on Satisfaction Evaluation of Shared Motorcycle Service Based on Combinatorial Weight Matter-Element Analysis Method

Shixing Han[1], Chao Liu[1,*], Bin Hong[1], Qiyan Yao[1], Shixuan Han[2]

[1]College of Engineering, Tibet University, Lhasa, 850000, China
[2]Leicester International College, Dalian University of Technology, Panjin, Liaoning, 124221, China
**Corresponding author*

Keywords: Shared motorcycles, Satisfaction evaluation, Combined weights, Matter-element analysis, Service satisfaction

Abstract: The improvement of shared motorcycle service satisfaction is closely related to the population of short-distance travel, so on the basis of constructing the shared motorcycle service satisfaction evaluation system, this paper constructs a combined weight material element analysis shared motorcycle service satisfaction evaluation model, analyzes the weight of each evaluation index through the AHP-entropy weight combination weight method, combines the weight results to determine the classic domain, section domain and comprehensive correlation degree of each evaluation index, and determines the satisfaction evaluation results according to the index evaluation level. Therefore, the specific implementation methods to improve the satisfaction of shared motorcycle services are analyzed.

1. Introduction

In recent years, shared motorcycles have developed rapidly due to the advantages of convenient operation, efficient use, low-carbon and environmental protection, and the “last mile” travel problem has been well solved, meeting the needs of users for short-distance travel[0]. At the same time, due to factors such as the appearance, vehicle performance, vehicle comfort, charging standard, return of the vehicle, vehicle maintenance and other factors, the user's short-distance travel experience is affected and the satisfaction is reduced.

Through reference analysis, it is found that the research on the satisfaction evaluation of shared motorcycle service by domestic scholars can be divided into two aspects: (1) the establishment of shared motorcycle service satisfaction evaluation index. According to the influencing factors and measurement indicators of customer satisfaction, Wu Ying constructed a model between the overall satisfaction of shared bicycles and product factors, service factors, green factors and cost factors, and concluded that the product value, service value, green value and satisfaction of shared bicycles were positively correlated. The research conclusion that the cost perception of shared bicycles is negatively correlated with satisfaction[0]. (2) Research on the satisfaction evaluation model of shared motorcycle service. Xu Jiahong et al. constructed a binary ordered probability model to analyze the

influencing factors of shared bicycle satisfaction, and the results showed that gender, age, education level, etc. were significant factors affecting the satisfaction of urban shared bicycle service[0]. Feng Yan analyzed the differences between user shared bicycle satisfaction and different types of people by constructing a fuzzy comprehensive evaluation model and an ordered logistic regression model, and the results showed that the overall satisfaction of users was average and there were significant differences in the satisfaction of different types of people[0].

Based on the above analysis, this paper constructs a combined weight-matter-element analysis evaluation model to evaluate the satisfaction of shared motorcycle services. The material-element analysis model applied to the satisfaction evaluation of shared motorcycle services can measure the correlation between evaluation indicators and satisfaction levels, and can more intuitively analyze the influence of evaluation indicators on shared motorcycle service satisfaction. This study can provide a reference for the government to formulate policies related to shared motorcycles and the development of sharing enterprises in the forecast of urban shared motorcycles.

2. Satisfaction Evaluation of Shared Motorcycle Service Based on Combined Weight Matter-Element Analysis Method

2.1 Combined Weight Method

2.1.1 Determine Subjective Weights

Ordered weighted vector v_t:

$$v_s = \frac{C_{s-1}^t}{\sum_{t=0}^{s-1} C_{s-1}^t} = \frac{C_{s-1}^t}{2^{s-1}} \tag{1}$$

Absolute weight of the *j*th shared motorcycle service satisfaction rating index ($\overline{w_j}$) :

$$\overline{w_j} = \sum_{t=0}^{s-1} v_t \, p_t \tag{2}$$

The w_j of subjective weight weights after the correction of the OWA operator:

$$w_j = \frac{\overline{w_j}}{\sum_{j=1}^{n} \overline{w_j}}, j = 1,2, \dots, n \tag{3}$$

2.1.2 Determine Objective Weights

First, normalize the data (positive indicator):

$$x_{ij} = 0.998 \frac{x_{ij} - \min\{x_{1j}, \dots x_{nj}\}}{\max\{x_{1j}, \dots x_{nj}\} - \min\{x_{1j}, \dots x_{nj}\}} + 0.002 \tag{4}$$

Calculate the proportion of the value of item j shared motorcycle service satisfaction rating index p_{ij}:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} (j = 1,2, \dots, m) \tag{5}$$

Calculate the information entropy value of item j: Shared motorcycle service satisfaction rating indicator e_j:

$$e_j = -k\sum_{i=1}^{n} p_{ij}\ln p_{ij} \tag{6}$$

Thereinto:

$$k = \frac{1}{\ln(n)}, e > 0 \tag{7}$$

Calculate the entropy redundancy g_j:

$$g_j = 1 - e_j \tag{8}$$

Calculate the weights of each evaluation index h_j:

$$h_j = \frac{g_j}{\sum_{j=1}^{m} g_j} \tag{9}$$

2.1.3 Determine the Combined Weight

AHP is used to determine the subjective weight of the shared motorcycle service satisfaction evaluation index, and the weight is corrected by the OWA operator, at the same time, the index is objectively weighted by the entropy weight method, and finally, the combination weighting is carried out by the linear weighting method, which effectively solves the influence of subjective extreme value deviation on the weight accuracy, so that the calculated weight value has reliability.

Combined weight W:

$$W = \alpha w_j + \beta h_j \tag{10}$$

where $\alpha + \beta = 1$.

2.2 Matter-Element Analysis Method

2.2.1 Determine the Basic Matter Element

In this paper, the c_i of N, n evaluation indicators of shared motorcycle service satisfaction and the corresponding n magnitude values $v_i(i = 1,2,\ldots,n)$ are called ordered triples [0]. Shared motorcycle satisfaction evaluation:

$$R = (N, c, v)\begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_n \end{bmatrix} = \begin{bmatrix} N & c_1 & v_1 \\ & c_2 & v_2 \\ & \vdots & \vdots \\ & c_n & v_n \end{bmatrix} \tag{11}$$

N is the satisfaction of shared motorcycle service, c is the satisfaction evaluation index, and v is the characteristic value of N about c.

2.2.2 Determine the Classic Domain

The classic domain corresponds to the quantitative numerical range for each evaluation index of each satisfaction rating level, and the classic domain is:

$$R_{0j} = (N_{0j}, c_i, v_{0ji}) \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_n \end{bmatrix} = \begin{bmatrix} N_{0j} & c_1 & v_{0j1} \\ & c_2 & v_{0j2} \\ & \vdots & \vdots \\ & c_n & v_{0jn} \end{bmatrix} = \begin{bmatrix} N_{0j} & c_1 & [a_{0j1}, b_{0j1}] \\ & c_2 & [a_{0j2}, b_{0j2}] \\ & \vdots & \vdots \\ & c_n & [a_{0jn}, b_{0jn}] \end{bmatrix} \tag{12}$$

N_{0j} is the jth rating of shared motorcycle service satisfaction; v_{0j} is the value range of the satisfaction evaluation index c_i, that is, the classic domain R_{0j}.

2.2.3 Determine the Section Domain

The section domain is the range of values that can be taken for each index of each shared motorcycle service satisfaction rating C_i, then:

$$R_p = (P, C_i, v_{pi}) \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_n \end{bmatrix} = \begin{bmatrix} P & c_1 & v_{p1} \\ & c_2 & v_{p2} \\ & \vdots & \vdots \\ & c_n & v_{pn} \end{bmatrix} = \begin{bmatrix} P & c_1 & [a_{p1}, b_{p1}] \\ & c_2 & [a_{p2}, b_{p2}] \\ & \vdots & \vdots \\ & c_n & [a_{pn}, b_{pn}] \end{bmatrix} \tag{13}$$

P is the full evaluation level of shared motorcycle service satisfaction; The v_{pi} is the value range of the C_i, that is, the v_{pi} of the section domain.

2.2.4 Determine the Matter Element Matrix

For the shared motorcycle service satisfaction N to be evaluated, construct the material element matrix, then:

$$R_0 = (N, c_i, v_i) = \begin{bmatrix} N & c_1 & v_1 \\ & c_2 & v_2 \\ & \vdots & \vdots \\ & c_n & v_n \end{bmatrix} \tag{14}$$

v_1 is the range of N values that can be taken by the c_i, that is, the specific value of the evaluation index to be evaluated for the satisfaction of the shared motorcycle service.

2.2.5 Determine the Association Function

The association function is a function that indicates the degree of membership of the thing to be evaluated and a certain evaluation level, and its value indicates the degree to which the element meets the required value range when the value of the substance element is a certain point on the axis, which can quantify the incompatibility problem [0]. Then the correlation function can be expressed as follows:

$$k_j(v_i) = \begin{cases} \dfrac{\rho(v_i, v_{0ji})}{\rho(v_i, v_{pi}) - \rho(v_j, v_{ji})} (v_i \notin v_{0ji}) \\ -\dfrac{\rho(v_i, v_{ji})}{|a_{0j} - b_{01}|} (v_i \in v_{0ji}) \end{cases} \tag{15}$$

$$\rho(v_i, v_{0ji}) = \left| v_i - \frac{(a_{ij} - b_{ij})}{2} \right| - \frac{b_{ij} - a_{ij}}{2} \tag{16}$$

$$\rho(v_i, v_{pi}) = \left| v_i - \frac{(a_{pi} + b_{pi})}{2} \right| - \frac{b_{pi} - a_{pi}}{2} \tag{17}$$

2.2.6 Determine the Comprehensive Correlation Coefficient

The comprehensive correlation degree of shared motorcycle service satisfaction material element N_i is:

$$K_i(N_i) = \sum_{i=1}^{m} \omega_i K_j(v_i) \tag{18}$$

The comprehensive correlation coefficient of the evaluation index obtained by formula (18) is an n-dimensional row vector, and according to the principle of maximum correlation recognition, the grade corresponding to the maximum correlation coefficient is the evaluation result of the item to be evaluated ^{0}. Namely:

$$K_{it0} = \max\{K_{ij}(N_i)\}, j = 1,2,\cdots,n \tag{19}$$

3. Case Analysis of Shared Motorcycle Service Satisfaction Based on Combined Weight Material Element Analysis Method

3.1 Build a Service Satisfaction Evaluation Index System

Combined with the components, scope and definition of service satisfaction, analyzing the satisfaction research model, the influencing factors of shared motorcycle service and the characteristics of shared motorcycle service, and soliciting relevant expert opinions, this paper constructs a shared motorcycle service satisfaction evaluation system with 5 first-level indicators and 15 second-level indicators. Due to the special management mechanism of plateau cities, special attention has been paid to vehicle performance, sanitize epidemic prevention and supporting protection, which constitute the overall factors, and the rating system is shown in Table 1.

Table 1: Shared Motorcycle Service Satisfaction Evaluation Index System

Basic matter elements	Level 1 indicators	Secondary indicators
Shared motorcycle service satisfaction Q	Product Factor A	Vehicle exteriorA_1
		How to unlockA_2
		Vehicle comfortA_3
	Safety Factor B	The deposit is secureB_1
		Riding safetyB_2
		Information securityB_3
	Service Factor C	Find a vehicleC_1
		Unlock and return the carC_2
		ChargesC_3
	Management factor D	The information is accurateD_1
		Vehicle maintenanceD_2
		Complaint handlingD_3
	Overall factor E	Vehicle performanceE_1
		Sanitize epidemic preventionE_2
		Supporting protectionE_3

3.2 Determine the Classical Domain and Node Domain Elements of Each Index

According to the actual situation of the use of shared motorcycles in Lhasa and soliciting the

opinions of experts in transportation, this paper divides the evaluation indicators of shared motorcycle service satisfaction into four levels: poor, average, good and good, and determines the classic domain elements and saving domain elements of each evaluation index of shared motorcycle service satisfaction.

3.2.1 Classical Domain Matter

$$R_{10} = \begin{bmatrix} N_{01} & N_{02} & N_{03} & N_{04} \\ [0,0.4) & [0.4,0.6) & [0.6,0.8) & [0.8,1] \\ [0,0.2) & [0.2,0.4) & [0.4,0.6) & [0.6,1] \\ [0,0.5) & [0.5,0.6) & [0.6,0.8) & [0.8,1] \end{bmatrix}$$

$$R_{20} = \begin{bmatrix} [0,0.4) & [0.4,0.6) & [0.6,0.8) & [0.8,1] \\ [0,0.5) & [0.5,0.7) & [0.7,0.9) & [0.9,1] \\ [0,0.4) & [0.4,0.5) & [0.5,0.7) & [0.7,1] \end{bmatrix}$$

$$R_{30} = \begin{bmatrix} [0,0.2) & [0.2,0.4) & [0.4,0.6) & [0.6,1] \\ [0,0.3) & [0.3,0.5) & [0.5,0.7) & [0.7,1] \\ [0,0.4) & [0.4,0.6) & [0.6,0.7) & [0.7,1] \end{bmatrix}$$

$$R_{40} = \begin{bmatrix} [0,0.3) & [0.3,0.6) & [0.6,0.8) & [0.8,1] \\ [0,0.4) & [0.4,0.7) & [0.7,0.9) & [0.9,1] \\ [0,0.3) & [0.3,0.5) & [0.5,0.7) & [0.7,1] \end{bmatrix}$$

$$R_{50} = \begin{bmatrix} [0,0.2) & [0.2,0.4) & [0.4,0.6) & [0.6,1] \\ [0,0.4) & [0.4,0.6) & [0.6,0.8) & [0.8,1] \\ [0,0.4) & [0.4,0.7) & [0.5,0.9) & [0.9,1] \end{bmatrix}$$

3.2.2 Section Domain Matter

$$R_{1p} = \begin{bmatrix} \mathrm{P} & \mathrm{c}_1 & [0,1] \\ & \mathrm{c}_2 & [0,1] \\ & \mathrm{c}_3 & [0,1] \end{bmatrix} R_{2p} = \begin{bmatrix} \mathrm{P} & \mathrm{c}_1 & [0,1] \\ & \mathrm{c}_2 & [0,1] \\ & \mathrm{c}_3 & [0,1] \end{bmatrix} R_{3p} = \begin{bmatrix} \mathrm{P} & \mathrm{c}_1 & [0,1] \\ & \mathrm{c}_2 & [0,1] \\ & \mathrm{c}_3 & [0,1] \end{bmatrix}$$

$$R_{4p} = \begin{bmatrix} \mathrm{P} & \mathrm{c}_1 & [0,1] \\ & \mathrm{c}_2 & [0,1] \\ & \mathrm{c}_3 & [0,1] \end{bmatrix} R_{5p} = \begin{bmatrix} \mathrm{P} & \mathrm{c}_1 & [0,1] \\ & \mathrm{c}_2 & [0,1] \\ & \mathrm{c}_3 & [0,1] \end{bmatrix}$$

3.3 Determine the Combined Weight Results of Each Evaluation Index

In this paper, five plateau transportation experts analyzed the evaluation index system of shared motorcycle service satisfaction, calculated the subjective weight, and used the consistency test to prove the correctness of the obtained matrix. At the same time, according to the entropy weight method, the index entropy weight of the evaluation index is calculated, and then the objective weight of the line is obtained. Finally, the index weight is determined according to the combined weight formula, where $\alpha = 0.7$, and the results are shown in Table 2.

Table 2: Combined Weight Results of Shared Motorcycle Service Satisfaction Evaluation Indicators

Evaluation indicators	Subjective weights	Objective weighting	Combined weights	Standardization
A_1	7.0080	7.1520	7.100708	0.0491
A_2	7.1860	7.4490	7.426955	0.2352
A_3	6.9780	7.3100	7.642858	0.3583
B_1	7.6930	7.4630	7.517703	0.2869
B_2	7.2160	6.8250	7.018038	0.0020
B_3	7.7090	7.0240	7.546997	0.3036
C_1	5.7070	6.1280	8.158018	0.6521
C_2	5.3670	5.7800	8.768181	1.0000
C_3	6.4540	6.6130	8.144686	0.6445
D_1	5.9430	5.8090	8.086533	0.6113
D_2	4.9770	4.9610	8.105225	0.6220
D_3	6.0770	6.4290	8.346102	0.7593
E_1	6.7310	6.3320	8.10611	0.6225
E_2	7.9450	7.8410	8.444788	0.8156
E_3	7.0090	7.6910	8.325749	0.7477

3.4 Determine and Analyze the Evaluation Results of Satisfaction

3.4.1 Substance Element Results to Be Evaluated

From the standardized data in Table 2, it can be seen that the objects to be evaluated for shared motorcycle service satisfaction are:

$$R_1 = \begin{bmatrix} 0.7378 \\ 0.8275 \\ 0.7728 \end{bmatrix}, R_2 = \begin{bmatrix} 0.8831 \\ 0.6807 \\ 0.7793 \end{bmatrix}, R_3 = \begin{bmatrix} 0.3577 \\ 0.2390 \\ 0.5512 \end{bmatrix}, R_4 = \begin{bmatrix} 0.3053 \\ 0.0020 \\ 0.4682 \end{bmatrix}, R_5 = \begin{bmatrix} 0.5123 \\ 1.0000 \\ 0.8676 \end{bmatrix}$$

3.4.2 Correlation Results

The formula (15-17) calculates the level correlation degree of shared motorcycle service satisfaction evaluation index, and the results are shown in Table 3.

Table 3: Results of Level Correlation Degree of Shared Motorcycle Service Satisfaction Evaluation Index

Evaluation indicators	Difference	Medium	Good	Outstanding	Grade
A_1	-0.7233	-0.5850	-0.1700	0.1700	Outstanding
A_2	-0.4888	-0.3183	0.0450	-0.0215	Good
A_3	-0.6920	-0.6150	-0.2300	0.2300	Outstanding
B_1	-0.7150	-0.5725	-0.1450	0.1450	Outstanding
B_2	-0.7420	-0.5700	0.1450	-0.1835	Good
B_3	-0.5667	-0.4800	-0.1333	0.1333	Outstanding
C_1	-0.2758	0.3850	-0.1925	-0.4617	Medium
C_2	-0.2036	0.4850	-0.1940	-0.4243	Medium
C_3	-0.1063	0.2700	-0.2433	-0.3514	Medium
D_1	-0.5543	-0.2200	0.4400	-0.2642	Good
D_2	0.1750	-0.1750	-0.5286	-0.6333	Difference
D_3	-0.2263	0.3800	-0.1520	-0.3943	Medium
E_1	-0.7888	-0.7183	-0.5775	0.4225	Outstanding
E_2	-0.6767	-0.5150	-0.0300	0.0300	Outstanding
E_3	-0.8067	-0.6133	0.0800	-0.1212	Good

As can be seen from Table 3, there are 6 excellent indicators, 4 good indicators, 4 general indicators, and 1 poor index in the evaluation results of shared motorcycle service satisfaction Q.

Using Formula (9) to calculate the comprehensive correlation degree of the five first-level indicators in the shared motorcycle service satisfaction Q evaluation system, the results are shown in Table 4.

Table 4: Evaluation Results of Service Quality of Subject Librarians

Level 1 indicators	Weight	Difference	Medium	Good	Outstanding	Grade
A	0.08335	-0.15870	-0.12654	-0.02959	0.03155	Outstanding
B	0.07685	-0.15552	-0.12468	-0.01024	0.00729	Outstanding
C	0.29787	-0.17446	0.33957	-0.18760	-0.36858	Medium
D	0.25844	-0.15651	-0.00388	-0.06218	-0.33385	Medium
E	0.28350	-0.64416	-0.52351	-0.14955	0.09392	Outstanding
Comprehensive relevance		-0.25787	-0.08781	-0.08783	-0.11394	Medium

As can be seen from Table 4, the evaluation result of the shared motorcycle service satisfaction Q is average. Among them, the product factors, safety factors and overall factors were evaluated as excellent, and the service factors and management factors were evaluated as good. The evaluation results show that the satisfaction Q of shared motorcycle service is generally average, and there are shortcomings and areas for improvement: there is still room for improvement in unlocking methods, riding safety, accurate information, and supporting protection. Vehicle maintenance, vehicle finding, unlocking and returning, charging standards, complaint handling need to be improved.

According to the evaluation results, shared motorcycle companies can carry out rectification for the vehicles currently put on: (1) Improve safety supporting equipment. Enterprises need to purchase matching safety helmets, regularly overhaul shared motorcycles, and add speed limit functions to ensure the safety of users. (2) Actively respond to the requirements of epidemic prevention and control, disinfect and sterilize operating vehicles every day to ensure the safe use of vehicles; (3) Avoid the uneven distribution of bicycles in time and space, improve the convenience of users to return the car and the satisfaction of the delivery area.

4. Conclusion

In this paper, multi-index and multi-level comprehensive evaluation of shared motorcycle service satisfaction is carried out, a matter element analysis model is introduced for comprehensive evaluation, and the combined weight method is used for combined weighting, which effectively solves the influence of subjective extreme value deviation on weight accuracy, and obtains more scientific evaluation results. Through the empirical analysis of shared motorcycle service satisfaction in Lhasa, it is shown that the combined weight material element analysis model is feasible and operable when applied to shared motorcycle service satisfaction.

References

[1] HAN Shixing, GAO Yu, NIU Ruiqi, CHENG Gang, HONG Bin. Research on macro launch scale of shared motorcycles [J].Times Auto, 2022(11):10-12.

[2] WU Ying. Research on shared bicycle satisfaction based on customer perceived value [D].Sichuan Normal University, 2018.

[3] XU Jiahong, ZHOU Jibiao, MA Changxi, WAN Yan, SHEN Ying. Satisfaction evaluation method of shared bicycle based on binary ordered probability [J].Traffic Information and Safety, 2021, 39(03):136-141+151.

[4] FENG Yan. Survey on the satisfaction of urban residents with shared bicycles--Based on the survey data of Nanchang in 2017[J].Research World, 2018(07):13-18.DOI:10.13778/j.cnki.11-3705/c.2018.07.003.

[5] Cai Wen. Extenics and its application [J]. Chinese Science Bulletin, 1999(07):673-682.

[6] Zhang Jiajia, Zhang Fangfan, Huang Yu. Risk assessment of geological disasters in a reservoir area based on material element extension method[J].Journal of Heilongjiang University of Science and Technology,2013,23(05):491-495.

[7] CHEN Zhenbiao, LIU Minrong, CHEN Huiqi. Service Quality Evaluation of Librarians Based on Entropy Weight

Matter-Element Analysis Model: A Case Study of Fuzhou University Library [J].Information Exploration, 2017(05):1-5.