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Evaluation Studies on Client Satisfaction Degree of Railway Statistic Information System

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Abstract

To increase the accuracy and the efficacy of client satisfaction degree of railway statistic information system, we give an AHP-based comprehensive assessment about satisfaction degree of information system, hoping to solve problems about evaluation difficulties of multi-index, multi-criteria and multi-level. Since the conventional AHP-based method is affected by subjective factors, we develop an enhanced AHP method to decrease limitations of conventional methods. Our method, still based on expert scoring, perform cluster analysis of scoring data, apply the clustering method of Euclid Distance with Weight to eliminate scores with the largest divergence, and utilize the AHP method and Function of Weight Average to obtain weight of evaluation index, which is useful to improve the accuracy and efficacy and can enhance effects of the more pivotal evaluation index on results. Finally, we prove its rationality and reliability in an evaluation of client satisfaction degree of railway statistic information system.

Keywords: *Railway Statistical Information System, AHP, Users' Satisfaction, Cluster Analysis*

1. Introduction

With advancement of railway informationization, more and more information system associated with railway statistics are present, so how to evaluate these system and client satisfaction degree of them are hot for many railway related studies. The core of evaluation of client satisfaction degree is determination of weights of evaluation index. Here, we studied weights of index about railway statistic information system and analyzed the client satisfaction degree.

A large amounts of methods have been used by researchers to investigate the weight of index, including Analytic Hierarchy Process(AHP), Fuzzy Synthetic Evaluation Method, Data Envelopment Analysis(DEA), Multi-level Extension Method, BP Neutral Network etc. Wang et al. [1] took AHP method to analyze factors, determined the hierarchical structure of index and the judgment matrix, gave the single ranking weight and overall ranking weight of the elements in all layers, and analyzed factors qualitatively and quantitatively. Shao et al. [2] set up a factor set, established the evaluation set and weight set based on the Delphi Method, determined subject functions of every factor, constructed the single factor judging matrix and finally conducted the fuzzy comprehensive evaluation. Zhu et al. [3] introduced a improved DEA method, which avoided the shortcomings of the traditional DEA method that could not determine the sequence of efficient DMU. Shao et al. [4] developed the multi-level extensible evaluation model with the extension method as the core, in which the risk degrees of the line and its subsystems are determined and a new method for comprehensive evaluation is put forward. Wang et al. [5] applied an improved BP Neutral Network Method to evaluate index, in which comprehensive evaluation based on S-Type Function was performed to solve problems of conventional BP Neutral Network with long training time, high sensitivity to initial weight, liability to converge to local minimum.

Here, based on expert scoring, we perform cluster analysis of scoring data, apply the clustering method of Euclid Distance with Weight to eliminate scores with the largest

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divergence, combine the AHP method and Function of Weight Average to obtain weight of evaluation index, which is useful to improve the accuracy and efficacy and can enhance effects of pivotal evaluation index on results.

2. Evaluation System on Client Satisfaction Degree of Railway Statistic Information System

With advancement of railway informationization, more and more information system associated with railway statistics are present, so how to evaluate these system and client satisfaction degree of them are hot for many railway related studies. The core of evaluation of client satisfaction degree is determination of weights of evaluation index. Here, we studied weights of index about railway statistic information system and analyzed the client satisfaction degree.

2.1. Subheadings Constitution of Railway Statistic Information System

Railway statistic information system is guided by complete and intact institution, scientific and rational index, advanced investigation technology, rapid and prompt data treatment, accuracy and reliability of statistics information, legal management, standard and sequential infrastructure and superior consulting service. Decision support and analysis is at the core, and construction of information resource database and realizing resource sharing and automation of statistic work is aim to provide high quality and efficient statistic service to railway reform, development and management [6].

Railway statistic system contains all parts of railway-related activities, including Cargo Transportation sub-system, Passenger Transportation Statistics sub-system, Locomotive Statistics Sub-system, Luggage and Parcel Statistics Sub-system, Labor Statistics Sub-system, Investment in fixed Assets Statistics sub-system, Transportation Equipment Statistics Sub-system, Energy Saving Statistics Sub-system, Environmental Protection Statistics Sub-system, Integrated Inquire about Transportation Statistics Sub-system, as shown in Figure 1.

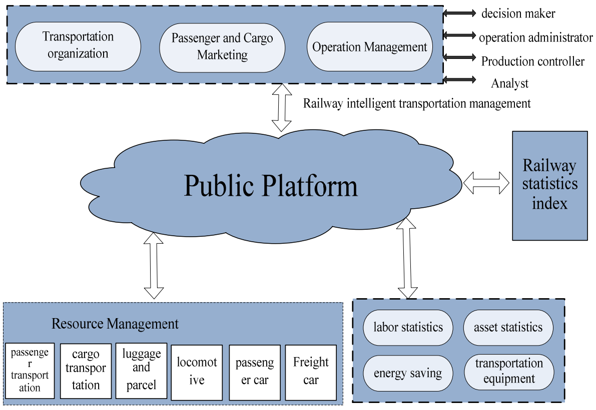

Figure 1. Structures of Railway statistic information system.

Railway statistic system is an important part of Railway intelligent transportation management, and Railway statistic informationization is based on public platform construction, which consist of communication network platform, Railway statistic information sharing platform, information security assurance platform and public platform of new Railway statistic information etc.

2.2. Evaluation Index of Client Satisfaction Degree of Railway Statistic Information System

The evaluation index of railway statistic information system reflects situations of transportation, production, and manipulation in the railway, including many aspects, such as passenger transportation, cargo transportation, passenger cars, freight cars, locomotive, dispatching, transportation security and operation income etc. According to these factors, we constructed Evaluation Index of Client Satisfaction Degree. These factor sets are shown in Table 1.

Table 1. Evaluation Indices of Client Satisfaction Degree

Systematic layer	Element layer	Index layer
Evaluation Index System of Client Satisfaction Degree	System Controlling Element U_1	Functionality r_{11}
		Realiability r_{12}
		Practicability r_{13}
		Efficiency r_{14}
	Staff Controlling Element U_2	Proficiency r_{21}
		Occupational Capability r_{22}
		Cooperation Capability r_{23}
		Consciousness r_{24}
	Environmental Equipment Elements U_3	Equipment r_{31}
		Network Bandwidth and Environment r_{32}
		Working Environment r_{33}

2.3. Scoring Standard

Using scores performed by experts to establish a pairwise comparison matrix U=[uij], in which the importance of the comparative values of ui to uj is represented by uij, and i and j is the index described above. Scoring standard is shown in table 2.

Table 2. Scoring Standard

Score	Meaning
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very Importance
9	Extreme Importance
2,4,6,8	Compromise Value
Inverse	uij=1/uji

3. Fuzzy Comprehensive Evaluation Based on Cluster Analysis

With the advancement in networking and multimedia technologies enables the distribution and sharing of multimedia content widely. In the meantime, piracy becomes increasingly rampant as the customers can easily duplicate and redistribute the received multimedia content to a large audience. Insuring the copyrighted multimedia content is appropriately used has become increasingly critical.

3.1. Normalization of Scores

Since the eigenvalue of xi(xi∈X) is not in the close interval [0,1], it is essential to normalize raw data [7]. as shown in equations 1-4:

Average Value $\bar{x}_j$: $\bar{x}_j = \frac{1}{n}\sum_{i=1}^{n} x_{ij}$; (1)

Standard deviation S_j: $S_j = (\frac{1}{n}\sum_{i=1}^{n}(x_{ij} - \bar{x}_j)^2)^{1/2}$; (2)

Standard value of raw data: $x'_{ij} = \frac{(x_{ij} - \bar{x}_j)}{S_j}$; (3)

Extreme value standardization: $x''_{ij} = \frac{x'_{ij} - \min(x'_{ij})}{\max(x'_{ij}) - \min(x'_{ij})}$; (4)

When $x'_{ij} = \min(x'_{ij})$, x=0; when $x'_{ij} = \max(x'_{ij})$, x=1. So standardization values of raw data is situated at [0,1].

3.2. Cluster Analysis

Here, cluster analysis is based on weighted Euclid distance, in which the relative distance but not absolute distance is more accurately response to data distribution, when we have no any domain knowledge about the data objects[8].

$$d(x_i, x_j) = \left[\sum_{k=1}^{p} w_k \left|x_{ik} - x_{jk}\right|^2\right]^{1/2} \tag{5}$$

(Where $w_k (k = 1, 2, \cdots, q)$ represents weight values of variables.)

Input: k--number of clusters, dataset U containing n data.

Output: numbers of clusters which have minimum variance.

Steps:

(1) Select k samples from n samples as initial cluster;

(2)Based on the average value of overall samples, obtain Euclid distance of all samples, and cluster all samples from minimum weight Euclid distance.

(3)Calculate the average value of all samples.

(4)Reture to (2) and (3) until there is no change of any cluster.

3.3. Weight Determination

This paper applies AHP method to establish a matrix[9,10], as shown in equations 6-12:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \tag{6}$$

(Where $a_{ij} = 1/a_{ji} (i \neq j)$, $a_{ij} = 1 (i = j)$ and value is determined according to Table 2.)

Sum-Product Method in AHP:

(1) Normalization of every line of all variables in matrix $A = (a_{ij})_{n*n}$:

$$\overline{a_{ij}} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} (i, j = 1, 2, 3, \cdots n) \tag{7}$$

(2)Sum of every row of all variables in matrix $A = (a_{ij})_{n*n}$ after normalization:

$$\overline{W}i = \sum_{j=1}^{n} \overline{a_{ij}} (i, j = 1, 2, 3, \cdots, n) \tag{8}$$

(3) Normalization of normalized $\overline{W} = [\overline{W}1, \overline{W}2, \overline{W}3, \cdots, \overline{W}n]$:

$$W = \frac{\overline{W}i}{\sum_{j=1}^{n} \overline{W}i} (i = 1,2,3,\cdots,n) \quad (9)$$

(Where $W = [W_1, W_2, W_3, \cdots, W_n]^T$ are needed weight vectors.)
(4) Maximum characterized roots from Matrix Theory:

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i} = \frac{1}{n} \sum_{i=1}^{n} \frac{\sum_{j=1}^{n} a_{ij} W_j}{W_i} \quad (10)$$

(5) Consistency Test:

$$CI = \frac{\lambda_{\max} - n}{n-1} \quad (11)$$

$$CR = \frac{CI}{RI} \quad (12)$$

(Where CI is Consistency Index, CR is Consistency Ratio, and RI is Average Random Consistency Index.)

4. Example
4.1. Scoring by Experts

For example, we invited 6 experts to evaluate railway statistic information system, which includes Systematic Controlling Layer containing Functionality, Reliability, Practicability and Efficiency, Staff Controlling Layer containing Proficiency, Occupational capability, Cooperation capability and Consciousness, and Environmental Equipment Layer containing equipment, network bandwidth and environment and working Environment. As mentioned above, pairwise comparison is used to score[11,12].First, Element layers were scored, which is shown in Table 3.

Table 3. Scores of Element Layers

Expert	Pairwise Comparison Among 3 Element Layers		
	U1-U2	U1-U3	U2-U3
1	3	3	2
2	4	3	2
3	4	4	2
4	5	2	3
5	2	3	2
6	4	3	2
Average	3.7	3.0	2.2

4.2. Data Clustering

Firstly, we made a clustering analysis of Systematic Controlling Elements U1 to eliminate the value with the largest deviation applying Euclid Distance Theory. Since processes of Fuzzy Clustering Method are complicated and the computation power huge, so we relied on SPSS17.0 to treat matrix through a computer aided way according to steps mentioned above[13].

Figure 2 showed results of data treatment and we can know that all 6 samples are in the clustering analysis. Figure 3 showed steps of treatment and we can find that relationship between clusters varied, and coefficient was larger during proceeding of clustering, indicating their correlation become less and deviation become large. In Figure 3, the left half part showed the experts were clustered in every step, and we could find the expert 2 and 5 were firstly clustered. The right half part showed the firstly clustered step number.

Treatment Collectiona,b					
Example					
Efficient		Defficient		Total	
N	percent	N	percent	N	percent
6	100.0	0	.0	6	100.0

a. Euclidean Distance had been used
b. average link(between groups)

Figure 2. Data Treatment Collection

Rank	Cluster Group		Coefficient	First Cluster		Next Rank
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	2	5	1.000	0	0	4
2	1	4	1.000	0	0	3
3	1	3	1.584	2	0	4
4	1	2	2.183	3	1	5
5	1	6	3.742	4	0	0

Figure 3. Steps of Fuzzy Treatment

From above analysis, we could know that scores by the expert 6 showed the largest deviation, which may be the results of subjective factors, so scores from him were eliminated from overall data. With a similar method, results from the expert 4 were also eliminated. During the clustering analysis of Staff Controlling Element U2 and Environment Equipment U3, scores from the expert 4 and 5 showed the largest deviation and eliminated respectively. After these treatments, new scoring tables were obtained, and Table 4 showed Element Layer scoring and Index Layer scoring respectively.

Table 4. Scores of Index Layers

experts	U1					
	r11-r12	r11-r13	r11-r14	r12-r13	r12-r14	r13-r14
1	6	4	3	1	1/2	1/4
2	5	5	4	2	1/3	1/3
3	6	5	2	1	1/3	1/3
4	7	4	3	1	1/2	1/4
5	6	5	4	2	1/3	1/3
Average	6.0	4.6	3.2	1.4	0.4	0.3

experts	U2					
	r21-r22	r21-r22	r21-r22	r21-r22	r21-r22	r21-r22
1	1/4	2	2	5	5	1
2	1/3	3	1	4	6	1
3	1/3	2	2	5	4	2
4	1/4	3	2	4	5	1
5	1/3	3	1	4	5	2
Average	0.3	2.6	1.6	4.4	5	1.4

experts	U3		
	r31-r32	r31-r32	r31-r32
1	2	2	2/5
2	2	3	1/2
3	3	4	3/4
4	3	4	1/2
5	2	2	1/2
Average	2.4	3	0.5

4.3. Comprehensive Fuzzy Analysis

After analysis with AHP-based method as described above, weights of U1, U2 and U3 were obtained. RI is determined by large amounts of experiment data, which were shown in Table 5.

Table 5. Value of RI

n	1	2	3	4	5	6
RI	0.00	0.00	0.58	0.90	1.12	1.24
n	7	8	9	10	11	7
RI	1.32	1.41	1.45	1.49	1.51	1.32

All weight data after scoring:

(1) Weight of Elements Layer U1,U2 and U3 is $A=[0.604,0.268,0.128]^T$, $\lambda_{max}=3.08$; Consistency Test: $CI=0.04$, $CR=0.069$.

(2)Weight of Index Layer in Elements Layer U1, including Functionality, Reliability, Practicability and Efficiency, were $W_{U1}=[0.589,0.112,0.082,0.217]^T$ respectively, $\lambda_{u1max}=4.08$; Consistency Test: $CI_{u1}=0.027$, $CR_{u1}=0.030$

(3) Weight of Index Layer in Elements Layer U2, including Proficiency, Occupational capability, Cooperation capability and Consciousness, were $W_{U2}=[0.209,0.560,0.126,0.105]^T$ respectively, $\lambda_{u2max}=4.14$; Consistency Test: $CI_{u2}=0.047$, $CR_{u2}=0.052$

(4) Weight of Index Layer in Elements Layer U3, including Equipment, Network Bandwidth and Environment and Working Environment were $W_{U3}=[0.591,0.178,0.231]^T$ respectively, $\lambda_{u3max}=3.08$; Consistency Test: $CI_{u3}=0.04$, $CR_{u3}=0.069$.

After eliminating scores by experts with the largest deviation:

(1) eight of Elements Layer U1,U2 and U3 is $A=[0.609,0.259,0.132]^T$, $\lambda_{max}=3.06$; Consistency Test: $CI=0.03$, $CR=0.052$ 。

(2) Weight of Index Layer in Elements Layer U1, including Functionality, Reliability, Practicability and Efficiency, were $W_{U1}=[0.569,0.103,0.089,0.239]^T$ respectively, $\lambda_{u1max}=4.07$; Consistency Test: $CI_{u1}=0.023$, $CR_{u1}=0.026$

(3) Weight of Index Layer in Elements Layer U2, including Proficiency, Occupational capability, Cooperation capability and Consciousness, were $W_{U2}=[0.209,0.567,0.118,0.106]^T$ respectively, $\lambda_{u2max}=4.08$; Consistency Test: $CI_{u2}=0.027$, $CR_{u2}=0.030$

(4) Weight of Index Layer in Elements Layer U3, including Equipment, Network Bandwidth and Environment and Working Environment were $W_{U3}=[0.574,0.184,0.242]^T$ respectively, $\lambda_{u3max}=3.01$, Consistency Test: $CI_{u3}=0.005$, $CR_{u3}=0.0086$.

4.4. Consistency Test of Weight

CI was index of consistency, and CI=0 indicated full consistency. When approaching to 0, CI showed more satisfied consistency, and, in contrast, larger CI indicated lower consistency. Comparison of data from this example was showed here:

Weight of Element Layer: CIBefore=0.04＞CIafter=0.03＞0；
Weight of Systematic Controlling ElementsU1: CIU1Before=0.027＞CIU1after=0.023＞0;
Weight of Systematic Controlling ElementsU2: CIU2Before=0.047＞CIU2after=0.027＞0;
Weight of Systematic Controlling ElementsU3: CIU3Before=0.04＞CIU3after=0.005＞0;

Here, CI Before indicated weight of all data before clustering analysis and CIafter indicated weight of data after clustering analysis following eliminating data with the largest deviation. From these results we could know that eliminating data with the largest deviation can improve consistency.

When CR<0.1, weight of matrix is admitted, and satisfaction consistency is accepted. Comparison of data from this example was showed here:

Weight of Element Layer: CRafter=0.052<CRbefore =0.069<0.1

Weight of Systematic Controlling ElementsU1: CRu1after =0.026<CRu1 before =0.030<0.1

Weight of Systematic Controlling ElementsU2: CRu2after =0.030<CRu2 before =0.052<0.1

Weight of Systematic Controlling ElementsU3: CRu3after =0.0086<CRu3 before =0.069<0.1

After test with CI and CR, we can find that eliminating scores with largest deviation and calculating the weight would improve satisfaction consistency.

4.5. Consistency Test of Weight

Integration of above weight values after clustering, applying weighted average comprehensive function, we could obtain weights of all indices, as showed in Table 6.

Table 6. Index of Railway Statistic Information System

	Functionality	0.347
U1	Reliability	0.063
	Practicability	0.054
	Efficiency	0.146
	Proficiency	0.054
U2	Occupational Capability	0.147
	Cooperation Capability	0.031
	Consciousness	0.027
	Equipment	0.076
U3	Network Bandwidth and Environment	0.024
	Working Environment	0.032

5. Conclusion

This study applies Clustering Analysis to AHP Method, analyzes the client satisfaction degree of railway statistic information system, and assesses the weight of all indices, resulting into some meaningful data.

Using Clustering Analysis-based AHP method is objective and scientific to evaluate indices of railway statistic information system, which is useful to improve available methods and decrease problems of directly scoring by experts. In addition, this method increases the accuracy and validity of data evaluation, reducing the difficulty and raising the efficiency. Similar methods can also be used in other fields and have good application value.

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