Study on Evaluation of Logistics Enterprise Informationization Performance Based on the Theory of Fuzzy AHP

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***Abstract*—This paper constructed an evaluation model for the logistics enterprise informationization of their own, based on the study of status and evaluation of logistics enterprise informationization performance. Comprehensively evaluated the model by AHP and Fuzzy and then proved the model's availability with a certain example. In the practical application in order to reduce the subjectivity of the evaluation results, the authority of experts should be selected.**

Keywords-logistics enterprise; informationization performance; AHP; fuzzy comprehensive evaluation

I. Introduction

The world information wave is everywhere with the coming of the information age. Logistics enterprise information as the important circulation in the information process is inevitable pushed to the information outlet wave. A scientific and practical logistics enterprise information performance evaluation system should be made to realize the construction and prefect of the logistics enterprise information because of the capital investment and time are large and long. This is great significance for logistics enterprise to promote the industry competitiveness.

HuangFuhua believes that the logistics enterprise information is actually a kind of related properties which is dependent on the determined purpose to define the logistics enterprise information, and is a kind of behaviours that turn all kinds of attribute into objective quantitative criteria or subjective utility. That is the logistics enterprise information performance is a process, which purpose is effectively meet the performance of the logistics enterprise information, determinates the logistics enterprise information performance with the objective quantitative criteria or subjective utility behaviours. Analysing, controlling and correcting the disadvantage of the process rely on modern information technology and tools [1].

The analysis and judgment process of performance evaluation is complex, it involves many influencing factors [2]. There are many evaluation method of mainstream.In these years, the foreign scholars put their focus on a mixture use of the AHP method, the DEA method and the BSC. Amy H.l.Lee combined the fuzzy analytic hierarchy process (AHP) and the balanced scorecard method to evaluate the performance of IT department of Taiwan. [3] Y.T.Jou diagnosis enterprise ego performance used six sigma method, the combination of control chart method and the analytical hierarchy process mothed in order to improve enterprise performance [4]. Vincent F.Yu evaluated the performance of multiple factories in a fuzzy environment by combining the vote method and the fuzzy TOPSIS method [5]. Desheng Dash Wu extended the DEA and efficiency analysis method to develop a random performance analysis model to evaluate the system stability in different son model and different environment [6]. Chinese scholars such as Yan-Xiuxia combined the analytic hierarchy process (AHP) method and entropy technology to evaluate the performance. This combination makes full use of the advantages of the objective evaluation (entropy method) and subjective evaluation (AHP). ShenYuan used the DEA methods such as the C^2R model and C^2GS^2 model, the former can be used to evaluate the whole effectiveness of the decision making units and the latter can be used to evaluate the pure technical efficiency of the decision making units. LiuHui supports the principal component analysis for finding reasonable and comprehensive performance index [9]. WangShengfeng established logistics performance evaluation model with the grey relational analysis method. She attributed the logistics performance evaluation problem to grey relational question and researched the logistics enterprise performance problem by comparing the sequences and reference sequences [10].ChenZhiYa used analytical hierarchy process (AHP) to quantify the qualitative indexes and determine the quantitative indexes weights besides the balanced scorecard and comprehensive method. This mixture of the two methods can keep balance among all, and it can reflect the logistics enterprise performance situation realistically [11].

This paper introduced the theory of fuzzy mathematics based on the analytic hierarchy process (AHP). It evaluated the logistics enterprise information performance with the fuzzy comprehensive evaluation method. It combined the qualitative and quantitative method to make up for the lack of a single use of analytic hierarchy process to improve the reliability, accuracy and objectivity of the comprehensive evaluation.

II. The Basic Idea of The Model

In fact, the full name of FAHP is Fuzzy Analytic Hierarchy Process. It can be broken down into two parts, one is a kind of decision analysis method named AHP proposed by American operations A.L.Saaty in the mid 1970[12]. This method sorts the prepare quality plan on the pros and cons by making structure Hierarchy model, then getting the total goal weight by quantifying and handling the quantifies of each layer of the subjective judgment. The other is evaluation method, is a kind of fuzzy

comprehensive evaluation method based on the fuzzy mathematics and statistics. It turns the qualitative evaluation into a quantitative evaluation according to the membership of fuzzy mathematics and quantitative evaluates the things or object restricted by various factors [13]. First of all, FAHP uses the AHP to establish the logistics enterprise information performance evaluation model. Secondly, determine the weight of each index in the model. And then fuzzily evaluate the logistics enterprise performance using the AHP. Finally, determine the rating of the evaluation system.

The implementing steps of the model are as the following:

Step1: establish the evaluation model

This paper establishes a logistics enterprise information performance model using AHP. The model sets up three ratings: the target layer, criterion layer and index layer. The corresponding index sets A and $B=\{B_1,\ B_2,\ B_3,\ B_4\}$, $B_i=\{C_{i1},\ C_{i2}\ \cdots\ C_{i4}\}$, of which $i=1,2\cdots 4$.

Step2: construct the judgment matrix and identify the weight vector

a. According to the assignment standards of the judgment matrix quantitative the evaluation index and construct judgment matrix $A(a_{ij})_{4\times 4}$ according to the quantitative results.

b. Determine the weight vector $W=\{w_1,w_2\cdots w_4\}^T$ of the evaluation matrix.

Step3: consistency check

For the AHP to maintain the consistency of the judgment is very important. Although when construct the judgment matrix A is not required consistency the judgment consistency is far away from the standard is also not allowed [14]. So need to examine the consistency of judgment matrix A.

a. Calculate the consistency index $CI=\frac{\lambda_{\max}-n}{n-1}$,n is the order number of the judgment matrix, $\lambda_{\max}$ is the biggest characteristic root for the judgment matrix;

b. Calculate the relative consistency index $CR=\frac{CI}{RI}$, in this paper RI is 0.89. Usually when $CR<0.1$, the consistency check passed; otherwise, the judgment matrix needs to be reconstructed [15].

Step4: determine the evaluation rating

The evaluation rating is the gather of all evaluation result. We divided the result of logistics enterprise information performance evaluation into five ratings: perfect, very good, good, medium, bad. These five ratings fit for the evaluation factors $U=\{U_1,U_2,U_3,U_4,U_5\}$. Then determine the membership of the various evaluation results using the fuzzy statistic method to make $U_i=\{5\ \ 4\ \ 3\ \ 2\ \ 1\}$, of which $i=1,2\cdots 5$. Then get the fuzzy relation matrix according to the mapping of the evaluation standards to limited factor gather, called $R_i=\{R_1,R_2,R_3,R_4\}$.

Step5: the fuzzy comprehensive evaluation

Determine the various evaluation indexes weight $W=[w_1,w_2\ldots w_4]$ and the fuzzy matrix of the evaluation rating gather using the above calculation results. We can get the evaluation vector B, $B=W\times R$. Fuzzy evaluate B according to the rule of maximum membership principle.

III. Establish The Evaluation System

A choose the indexes

Design the logistics enterprise information performance model according to the financial-the property's point of view followed the principles of purpose, comprehensive, scientific, objective, conciseness and operability [16]. Financial perspective includes information infrastructure dimension, network business operation dimension, customer service dimension and cost and profit dimension. And the non-financial perspective includes the cost dimension and profitability dimension. Index selection as follows:

1) information infrastructure dimension

Information technology equipment interconnection rate. The extent is the information technology equipment and the network connection, is the proportion of the networking equipment in all equipment.

Quality of the information person. The support form the quality of the information person is an important part in the implementation process of the enterprise information, is an important of the dimension information technology performance indicators, and is also the indispensable index in the process of the enterprise information performance evaluation.

Information utilization. It is the combination of the information technology, the corporate culture and the management systems; it is the extent of effective knowledge transfer in the enterprise information implementation process. It is also can be understood as the utilization of information obtained from information technology equipment or the proportion that the available information accounted for the all.

The actual performance of equipment. It means the operation, wear and tear depreciation, life circumstances and customer requirements consistent with the degree in the using process.

2) network business operation dimension

Online order processing accuracy. It means the accuracy of correctly handle the users' order. Handle here contains delivery according to the order or mention the user to correct the wrong order.

IT contribution. The influence extent that the repeat use of the large capacity of the information store and the operation simplification affect the growth of the enterprise.

Website praise rate. The satisfaction extent that users feel to the service website provided. Including friendly interface sex, website speed and online service attitude of server.

Completion rate of online business. It means the proportion successful completion of total online business.

3) customer service dimension

The customer service dimension is more likely a kind of enterprise strategic planning. The enterprise internal members' attitude to the customers decided the service quality.

Service accuracy. It includes the accuracy rate of correctly delivery or inventory, etc.

On time delivery. Reflect the on time extent of logistics services, including delivery timely rate, import and export business of the prompt submission rate, etc.

The customer communication rate. Mainly refers to the communication between the logistics enterprise and customers in the service process. The attitude of the logistics service person to the customers plays a decisive role in retention rate. Effective communication could improve the understanding between the servers and the customers, and improve the customer's satisfaction.

Customer satisfaction. It is the extent of the customers' satisfaction to the enterprise service. Include customer complaints and complaint handling, etc. This can be obtaining by using the Internet or investigating. And it is the key index in the enterprise information performance evaluation process. The index can also be reflected through the customer retention rate and growth rate.

4) cost and profit dimension

Logistics information cost investment proportion. It is the proportion that logistics information cost in the information process account to the all.

Logistics risk control costs. The market itself unpredictable the logistics enterprise should prepare for every change occurred any time. The coat of the preparing can be an index in the evaluation system.

Unit logistics cost. It refers the unit product logistics cost and doesn't effected by the change of the product price and trading condition. We choose the logistics risk control costs as the evaluation index because through analyzing its history data can easier reflect the logistics cost of actual changes.

The information gain. The benefit added after the information implementation.

B Establish the Evaluation System

target layer	Maximization of enterprise value A			
criterion layer	information infrastructure dimension B_1	network business operation dimension B_2	customer service dimension B_3	cost and profit dimension B_4
index layer	information technology equipment interconnection rate (C_{11})	online order processing accuracy (C_{21})	Service accuracy (C_{31})	logistics information cost investment proportion (C_{41})
	quality of the information person (C_{12})	IT contribution (C_{22})	On time delivery (C_{32})	Logistics risk control costs (C_{42})
	information utilization (C_{13})	website praise rate (C_{23})	The customer communication rate (C_{33})	Unit logistics cost (C_{43})
	the actual performance of equipment (C_{14})	completion rate of online business (C_{24})	Customer satisfaction (C_{34})	The information gain (C_{44})

IV. A Simple Application

For validating the method's applicability and feasibility this paper choose a logistics enterprise in Heilongjiang province which has just completed preliminary. For the information performance evaluation problem we use the FAHP to evaluate the logistics enterprise information performance.

A establish the evaluation matrix according to the evaluation model

① the evaluation matrix A -B

$$\begin{bmatrix} A & B_1 & B_2 & B_3 & B_4 & W \\ B_1 & 1 & 1/3 & 1/5 & 1/7 & 0.059 \\ B_2 & 3 & 1 & 1/2 & 1/4 & 0.147 \\ B_3 & 5 & 2 & 1 & 1/2 & 0.281 \\ B_4 & 7 & 4 & 2 & 1 & 0.514 \end{bmatrix}$$

$\lambda_{\max} = 4.028,\ CI = 0.009,\ RI = 0.89,\ CR = 0.11 < 0.1$, so the matrix meets the consistency.

② the evaluation matrix B_1-C

$$\begin{bmatrix} B_1 & C_{11} & C_{22} & C_{33} & C_{44} & W_1 \\ C_{11} & 1 & 1/4 & 1/3 & 1/5 & 0.068 \\ C_{22} & 4 & 1 & 2 & 1/3 & 0.240 \\ C_{33} & 3 & 1/2 & 1 & 1/5 & 0.139 \\ C_{44} & 5 & 3 & 5 & 1 & 0.553 \end{bmatrix}$$

$\lambda_{\max} = 4.138,\ CI = 0.046,\ RI = 0.89,\ CR = 0.052 < 0.1$, so the matrix meets the consistency.

③ the evaluation matrix B_2-C

$$\begin{bmatrix} B_2 & C_{21} & C_{22} & C_{23} & C_{24} & W_2 \\ C_{21} & 1 & 2 & 3 & 1/2 & 0.286 \\ C_{22} & 1/2 & 1 & 1/3 & 1/4 & 0.098 \\ C_{23} & 1/3 & 3 & 1 & 1/2 & 0.182 \\ C_{24} & 2 & 4 & 2 & 1 & 0.434 \end{bmatrix}$$

$\lambda_{\max} = 4.121,\ CI = 0.040,\ RI = 0.89,\ CR = 0.045 < 0.1$, so the matrix meets the consistency.

④ the evaluation matrix B_3-C

$$\begin{bmatrix} B_3 & C_{31} & C_{32} & C_{33} & C_{34} & W_3 \\ C_{31} & 1 & 2 & 3 & 1/3 & 0.239 \\ C_{32} & 1/2 & 1 & 2 & 1/3 & 0.153 \\ C_{33} & 1/3 & 1/2 & 1 & 1/5 & 0.086 \\ C_{34} & 3 & 3 & 5 & 1 & 0.522 \end{bmatrix}$$

$\lambda_{\max} = 4.059,\ CI = 0.020,\ RI = 0.89,\ CR = 0.022 < 0.1$, so the matrix meets the consistency.

⑤ the evaluation matrix B_4-C

$$\begin{bmatrix} B_4 & C_{41} & C_{42} & C_{43} & C_{44} & W_4 \\ C_{41} & 1 & 1/5 & 1/3 & 1/7 & 0.053 \\ C_{42} & 5 & 1 & 5 & 1/2 & 0.320 \\ C_{43} & 3 & 1/5 & 1 & 1/7 & 0.092 \\ C_{44} & 7 & 2 & 7 & 1 & 0.535 \end{bmatrix}$$

$\lambda_{\max} = 4.170,\ CI = 0.056,\ RI = 0.89,\ CR = 0.063 < 0.1$, so the matrix meets the consistency.

B determine the judgment matrix

We use the expert evaluation method to determine the judgment matrix. Invite related experts to the logistics enterprise information performance evaluation to give score to the qualitative indexes. And get the judgment matrix R_{11} R_{22} R_{33} R_{44}, the results are as the follow:

$$R_{11} = \begin{bmatrix} 3 & 4 & 3 & 4 \\ 4 & 3 & 3 & 3 \\ 2 & 4 & 2 & 4 \\ 4 & 3 & 5 & 4 \end{bmatrix}, \quad R_{22} = \begin{bmatrix} 2 & 3 & 3 & 4 \\ 4 & 3 & 3 & 4 \\ 3 & 2 & 3 & 2 \\ 3 & 3 & 4 & 3 \end{bmatrix},$$

$$R_{33} = \begin{bmatrix} 4 & 2 & 2 & 3 \\ 3 & 4 & 3 & 3 \\ 2 & 3 & 3 & 4 \\ 4 & 3 & 3 & 4 \end{bmatrix}, \quad R_{44} = \begin{bmatrix} 2 & 3 & 3 & 3 \\ 3 & 3 & 2 & 5 \\ 3 & 4 & 3 & 4 \\ 2 & 3 & 2 & 5 \end{bmatrix}.$$

C fuzzy comprehensive evaluation

a. rating 1 evaluation

Be weighted to R and make it fuzzy conversion.

information infrastructure dimension:

$$R_1 = W_1 \times R_{11} = [3.654 \quad 3.207 \quad 3.967 \quad 3.76]$$

network business operation dimension:

$$R_2 = W_2 \times R_{22} = [2.812 \quad 2.818 \quad 3.434 \quad 3.202]$$

customer service dimension:

$$R_3 = W_3 \times R_{33} = [3.675 \quad 2.914 \quad 2.761 \quad 3.608]$$

cost and profit dimension:

$$R_4 = W_4 \times R_{44} = [2.412 \quad 3.092 \quad 2.145 \quad 4.908]$$

b. rating 2 comprehensive evaluation B

$$B = W \times R = [0.059 \quad 0.147 \quad 0.281 \quad 0.514] \times \begin{bmatrix} 3.654 & 3.207 & 3.967 & 3.76 \\ 2.812 & 2.818 & 3.434 & 3.202 \\ 3.675 & 2.914 & 2.761 & 3.608 \\ 2.412 & 3.092 & 2.145 & 4.908 \end{bmatrix}$$

$$= [2.901 \quad 3.012 \quad 2.617 \quad 4.230]。$$

According to the maximum membership principle the rating result is 4.230 which correspond between prefect and very good means the rating of the information performance of this logistics enterprise is perfect.

V. Conclusion

First of all, based on the analysis of the fuzzy matrix B we can found that in the logistics enterprise information performance evaluation system the network business operation dimension and cost and profit dimension take a large proportion. This shows that the information construction process in this enterprise paid more attention in network business operation dimension and cost and profit dimension than information infrastructure dimension and customer service dimension. But in today's society, along with the national "people-oriented" concept of development appear people pay more and more attention to infrastructure and the customer service. For the logistics enterprises, it will become the mainstream trend that follow the time, response country policies, strengthen the information infrastructure and provide good customer service. So we suggested that enterprise should strengthen information infrastructure and improve customer service rating.

In addition, this paper using FAHP evaluated the information performance of logistics enterprise, because the limited of the study conditions when used the expert evaluation method in which the experts may not so authoritative which might affect the result a little. But this paper can still improve that FAHP can evaluate the information performance from the both views of qualitative and quantitative. This method has a simple principle. Its evaluation result is more objective and it also beneficial to promote and apply.

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