Research on performance evaluation in logistics service supply chain based unascertained measure

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Abstract

The comprehensive model on performance evaluation of logistics service supply chain was established based on unascertained measure. On the basic of considering the factors influencing logistics service supply chain, the comprehensive evaluation index system were determined from four aspects, which includes logistics service capacity, logistics service quality, collaborative development ability and social influence. In view of different influencing factors of logistics service supply chain, the index weight was calculated through entropy weight coefficient method. Then, the grade division was finished by credible degree recognition criterion. Finally, the comprehensive evaluation model was used in engineering example. The test result through the application practice showed that the model proposed can carry on reasonably and effectively comprehensive assessment for the performance evaluation of logistics service supply chain.

Keywords: logistics service supply chain, unascertained measure, credible degree recognition, evaluation

1 Introduction

With the rapid development of global economy, the logistics service industry has been developing rapidly. The service supply chain is one of the new trends on the study of supply chain. And the logistics service supply chain is an important branch of supply chain research. It is also an important trend of modern logistics industry development[1-3].

The logistics service supply chain is to take logistics service integrators as the core. Its basic structure includes functional logistics service providers, logistics service integrators and customers. It is a new supply chain to ensure logistics operation of industry supply chain by supplying flexible logistics services[4-5]. Under the increasingly vigorous competition environment, the business management and policymaking can acquire reliable basis to make enterprise resources and social resources dispose reasonably and help enterprise executive strategies to achieve competitive advantages[6-9]. During logistics service supply chain operation, the establishment and operation of supply chain have their characteristics. And the performance level is restricted by many factors. So it has to be analyzed by the systematic and overall viewpoint. Although the study of the establishment on the supply chain performance evaluation index system is enough, the most evaluation index systems are not scientific and overall enough. They only consider the factors of supply chain itself and neglect the effect of the customs to evaluation. So a kind of scientific and effective evaluation method should be found and used in the performance evaluation of logistics service supply chain.

Here, the unascertained measure model and Shannon information entropy are used in performance evaluation of logistics supply chain. The unascertained measure is an objective evaluation method. And the Shannon information entropy is a kind of objective weight defining. So the evaluation results will be much more reasonable and accurate by using the unascertained measure and Shannon information model because the rigour of model itself.

The structure of this paper is as follows: we first establish the comprehensive assessment index system of logistics service supply chain by analyzing the characteristics of logistics service industry. Then the comprehensive assessment model of the performance evaluation in logistics service supply chain based on the unascertained measure and entropy method are introduced. In the following part, we focus on the application of the model in practice. Finally, through the application in the assessment of performance evaluation in logistics service supply chain, the effectiveness and feasibility of method was shown.

1 Establishment of performance evaluation index system

2.1 STRUCTURE OF LOGISTICS SERVICE SUPPLY CHAIN

Logistics service supply chain is around the core logistics enterprises, and use modern information technology to integrate functional logistics service providers of value-added service, then form a whole function net chain structure which includes logistics procurement, transportation, warehousing, packing, processing and distribution to supply individuation, integration and networking logistics service for industry supply chain[10-14]. And the structure of logistics service supply chain is shown in Figure 1.

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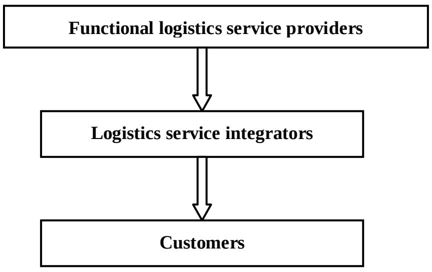

FIGURE 1 The structure of logistics service supply chain

2.2 ESTABLISHMENT OF PERFORMANCE EVALUATION INDEX SYSTEM

Dynamic performance evaluation of logistics service supply chain is a comprehensive evaluation process, which is consist of many kinds of causality and layer structure. So, how to select reasonable performance evaluation indicators is the key to establish a scientific and reasonable evaluation system.

The existing supply chain performance evaluation indexes selected are based on manufacturing enterprise. And logistics service supply chain is dominated by core logistics providers. Its performance level depends on the cooperation relationship of logistics service providers and the fitness degree between logistics capability and environment. Here the performance evaluation index system of logistics service supply chain is proposed from four aspects, which includes logistics service capacity, logistics service quality, collaborative development ability and social influence[15]. And the evaluation index system of logistics service supply chain is shown in Table 1.

3 Unascertained measure model

Suppose $x_i\,(i=1,\cdots,n)$ is the development status of logistics service supply chain of i^{th} month in an automobile enterprise. $X=(x_1,\cdots,x_n)$ is named as an universe.

Appraisal object $x_i\,(x_i \in X)$ has m evaluation indexes. $I=(I_1,\cdots,I_m)$ is called as an index set. x_{ij} is an observation value of appraisal object x_i under index I_j. $C_k\,(1\le k\le K)$ is k^{th} comment grade.

And $C_k=(c_1,\cdots,c_k)$ is a comment set. Suppose A is a standard matrix. So the standard matrix A can be showed:

$$A=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1k} \\ a_{21} & a_{22} & \cdots & a_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mk} \end{bmatrix}. \tag{1}$$

And a_{jk} is a numerical under index $I_j\,(j=1,\cdots,m)$ and comment grade $C_k\,(k=1,\cdots,K)$. a_{jk}

Satisfies $a_{ji}>a_{j2}>\cdots>a_{jk}$ or $a_{ji}<a_{j2}<\cdots<a_{jk}$.

3.1 DETERMINATION OF SINGLE INDEX UNASCERTAINED MEASURE

Suppose x_{ij} is the value under j^{th} index for i^{th} appraisal object. $u_{ijk}=u(x_{ij}\in C_k)$ is unascertained measure of x_{ij} for grade C_k .

TABLE 1 The evaluation index system of logistics service supply chain

Target layer	Status layer	Index layer
Performance evaluation of logistics service supply chain A	Logistics service capacity B_1	Resource function ability C_1
		Fulfil service commitments ability C_2
		Service response ability C_3
		Supply chain profitability C_4
	Logistics service quality B_2	Logistics service reliability C_5
		Flexible logistics services C_6
		Personnel professional degree C_7
	Collaborative development ability B3	Service process control ability C_8
		Enterprise cooperation credibility C_9
		Logistics resource integration ability C_{10}
	Social influence B4	Service market occupation rate C_{11}
		Core enterprise influence C_{12}

$$(u_{ijk})_{m\times k}=\begin{bmatrix} u_{i11} & u_{i12} & \cdots & u_{i1k} \\ u_{i21} & u_{i22} & \cdots & u_{i2k} \\ \vdots & \vdots & \ddots & \vdots \\ u_{im1} & u_{im2} & \cdots & u_{imk} \end{bmatrix} ,(2)$$

$x_{ij}\in C_k$ denotes that x_{ij} is in the grade C_k conditions. Meanwhile, u should satisfy the principle of polarity and additivity.

Suppose that $a_{ji}<a_{j2}<\cdots<a_{jk}$, then

(1) When $x_{ij}<a_{j1}$

$$\begin{cases} u_{ijk}=1 \\ u_{ij1}=u_{ij2}=\cdots=u_{ijk-1}=0 \end{cases} \tag{3}$$

(2) When $x_{ij}>a_{jk}$

$$\begin{cases} u_{ijk}=1 \\ u_{ij1}=u_{ij2}=\cdots=u_{ijk-1}=0 \end{cases} \tag{4}$$

(3) When $a_{jk} \le x_{ij} \le a_{jk+1}$

$$\begin{cases} u_{ijk} = \dfrac{a_{jk+1} - x_{ij}}{a_{jk+1} - a_{jk}} \\ u_{ijk+1} = \dfrac{x_{ij} - a_{jk}}{a_{jk+1} - a_{jk}} \\ u_{ij1} = u_{ij2} = \cdots = u_{jik-1} = 0 \\ u_{ijk+2} = u_{ijk+3} = \cdots = u_{ijk} = 0 \end{cases} \tag{5}$$

3.2 DETERMINATION OF MULTI-INDEX UNASCERTAINED MEASURE

3.2.1 Determination of weight coefficient for appraisal index

Entropy which used to be a thermodynamic concept, it was introduced into information theory in 1948 by C. E. Shannon who put forward the concept of information entropy to measure the level of system chaos or disorder [16-17]. And Shannon information entropy, which is an objective and applicable method for the determination of weight value, was introduced into the comprehensive assessment.

Suppose that there are m appraisal objects and n appraisal indexes in a comprehensive assessment. The decision matrix $y_{m\times n}$ can be obtained:

$$y_{m\times n} = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ y_{m1} & y_{m2} & \cdots & y_{mn} \end{bmatrix}. \tag{6}$$

In the above formula, y_{ij} denotes that appraisal object x_i obtaining appraisal value under appraisal index I_j.

After the decision matrix was obtained, it need to be applied normalization processing. The normalization processing method is as follows:

For profitability indexes:

$$y_{ij}' = \frac{y_{ij} - \min y_j}{\max y_j - \min y_j} \tag{7}$$

(2) For cost indexes:

$$y_{ij}' = \frac{\max y_j - y_{ij}}{\max y_j - \min y_j} \tag{8}$$

In the formula (7) and (8), $\max y_j$, $\min y_j$ denote respectively the maximum value and minimum value under appraisal index I_j.

So, the degree of importance for appraisal index y_{ij} can be expressed as d_{ij} under appraisal index I_j:

$$d_{ij} = \frac{y_{ij}'}{\sum_{i=1}^{m} y_{ij}'} \tag{9}$$

The entropy value of appraisal index I_j is:

$$H_j = -k\sum_{i=1}^{m} d_{ij} \ln d_{ij} \tag{10}$$

And the entropy weight value of index I_j is:

$$w(I_j) = \frac{1 - H_j}{\sum_{j=1}^{n}(1 - H_j)} \tag{11}$$

3.2.2 Determination of multi-index unascertained measure

Suppose $u_{ik}(x_i \in C_k)$ is multi-index unascertained measure, and denotes the degree of appraisal object x_i for the grade C_k, so

$$u_{ik} = \sum_{j=1}^{m} w(I_j) u_{ijk}, (1 < i < n, 1 < k < K) \tag{12}$$

Then, the multi-index unascertained measure matrix is:

$$(u_{ik})_{n\times k} = \begin{bmatrix} u_{11} & u_{12} & \cdots & u_{1k} \\ u_{21} & u_{22} & \cdots & u_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ u_{n1} & u_{n2} & \cdots & u_{nk} \end{bmatrix} \tag{13}$$

2.3 CREDIBLE DEGREE RECOGNITION CRITERION AND SORT

Because of the arrangement for grade C_k is orderly, credible degree recognition criterion is used. The credible degree is selected $\lambda(0.5 < \lambda < 1)$, generally $\lambda = 0.6$ or $\lambda = 0.7$ [18]. Suppose:

$$k_i = \min\left[k : \sum_{i=1}^{k} u_{ik} \ge \lambda, 1 < k < K\right] \tag{14}$$

k_i denotes appraisal object x_i belong to appraisal grade C_k.

The score criterion method is applied to order for appraisal object x_i:

$$q(x_i) = \sum_{k=1}^{K} n_k u_{ik}\ , \tag{15}$$

where, n_k denotes the score of grade C_k.

Thus, the appraisal samples can be carried out quality order based on $q(x_i)$.

4 Application in performance evaluation of logistics service supply chain

Here, an automobile logistics service supply chain of the third-party logistics company, which was taken as an example to establish the performance evaluation index system and performance evaluation model. And the performance evaluation of logistics service and predictive parsing are finished by the comprehensive evaluation model established. Finally, the comprehensive evaluation results can be acquired. The index performance data of an automobile logistics service supply chain from January to June in 2013 is shown in Table 2. And the grading standard of supply chain performance is shown in Table

TABLE 2 The index performance data of an automobile logistics service supply chain

Time	Index status value											
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
January	68	90	6	15	85	63	18	59	59	58	16	53
February	75	82	2	15	94	67	44	65	73	73	13	63
March	85	92	4	16	92	82	17	64	72	72	17	60
April	75	75	3	14	85	56	26	62	63	63	14	64
May	82	94	3	9	95	80	30	74	62	64	15	64
June	65	90	4	15	96	85	21	68	71	72	18	66

TABLE 3 The grading standard of supply chain performance

Evaluation index	Grade division			
	A	B	C	D
C1	≤100	＜80	＜70	＜60
C2	≤100	＜90	＜80	＜70
C3	≤2	≤4	≤6	≤30
C4	≤100	≤15	≤13	≤11
C5	≤100	＜90	＜85	＜80
C6	≤100	＜80	＜70	＜60
C7	≤100	＜40	＜30	＜20
C8	≤100	＜70	＜65	＜60
C9	≤100	＜80	＜70	＜60
C10	≤100	＜80	＜70	＜60
C11	≤100	＜50	＜16	＜10
C12	≤100	＜70	＜65	＜60

4.1 Determination of single index unascertained measure

The single index unascertained measure matrix can be obtained based on the index performance data of an automobile logistics service supply chain by using the formula (3) to (5). So single index unascertained measure matrix of this logistics service supply chain in January is:

$$(u_{1jk})_{12\times 4}=\begin{bmatrix} 0 & 0 & 0.8 & 0.2 \\ 0.5 & 0.5 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 0.25 & 0.75 & 0 & 0 \\ 0 & 0 & 0.3 & 0.7 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Similarly, the single index unascertained measure matrix of the remaining five months can be obtained.

4.2 DETERMINATION OF MULTI-INDEX UNASCERTAINED MEASURE

4.2.1 Determination of index weight coefficient

The index performance data of logistics service supply chain is made normalization processing based on the formula (7) and (8). And the policy matrix after normalization processing is:

$$y'_{6\times 12}=\begin{bmatrix} 0.15 & 0.789 & 0 & 0.857 & 0 & 0.241 & 0.037 & 0 & 0 & 0 & 0.6 & 0 \\ 0.5 & 0.368 & 1 & 0.857 & 0.818 & 0.379 & 1 & 0.4 & 1 & 1 & 0 & 0.769 \\ 1 & 0.895 & 0.5 & 1 & 0.636 & 0.897 & 0 & 0.333 & 0.929 & 0.933 & 0.8 & 0.538 \\ 0.5 & 0 & 0.75 & 0.714 & 0 & 0 & 0.333 & 0.2 & 0.286 & 0.333 & 0.2 & 0.846 \\ 0.85 & 1 & 0.75 & 0 & 0.909 & 0.828 & 0.481 & 1 & 0.214 & 0.4 & 0.4 & 0.846 \\ 0 & 0.789 & 0.5 & 0.857 & 1 & 1 & 0.148 & 0.6 & 0.857 & 0.933 & 1 & 1 \end{bmatrix}$$

Then, the entropy weight of the evaluation indexes can be determined based on the formula (9) to (11). And the entropy weight vector is:

$$w(I_j)=(0.821,0.873,0.878,0.895,0.766,0.834,0.702,0.818,0.815,0.849,0.831,0.888)$$

4.2.2 Determination of multi-index unascertained measure

The multi-index unascertained measure can be determined based on the formula (12), and it is

$$(u_{ik})_{6\times 4} = \begin{bmatrix} 0.628 & 1.906 & 2.616 & 4.820 \\ 1.234 & 3.092 & 4.624 & 1.021 \\ 0.625 & 4.799 & 2.792 & 1.754 \\ 0.439 & 1.297 & 4.575 & 3.659 \\ 1.360 & 3.630 & 2.605 & 2.375 \\ 0.668 & 4.547 & 3.712 & 1.042 \end{bmatrix}$$

4.2.3 Recognition and sort

According to credible degree recognition criterion, credible degree is 0.7, $n_k = 5 - k$. Then the performance level of the logistics service supply chain and grade sort can be obtained based on the formula (14) and (15). The comprehensive evaluation results are shown in Figure 2 and Figure 3.

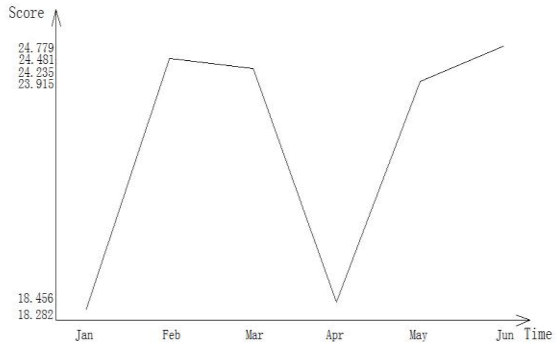

FIGURE 2 The score of performance evaluation

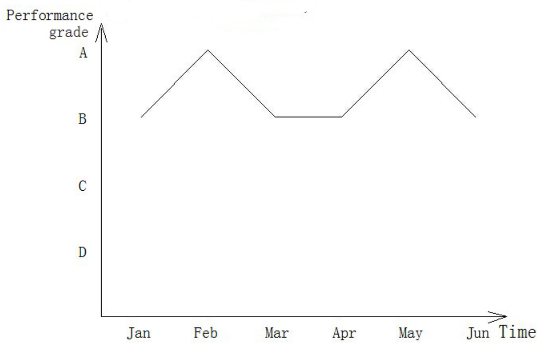

FIGURE 3 The performance grade of logistics service supply chain

Through the comprehensive performance evaluation results of logistics service supply chain, the decision makers can propose the improved measures according to the performance grade to help logistics service supply chain realize stable development. And the improved measures of different performance grades are as follows: if the performance grade is A, it shows an excellent operation state, then the existing supply chain can be kept and change with the direction of the market. If the performance grade is B, it shows a good operation state, then the existing logistics service supply chain should be improved by drawing lessons from related excellent supply chains. If the performance grade is C, it shows a medium operation state, then the key links should be selected to improved the logistics service supply chain after the market research. And if the performance grade is D, it shows a poor operation state, then the decision makers should examine fully the process of supply chain management and consult relevant experts according to the examination results to improve the logistics service supply chain.

5 Conclusions

The performance evaluation of the logistics service supply chain can measure the realization degree of supply chain target and provide the theoretical foundation for decision makers. Here, the comprehensive assessment model on the performance evaluation of logistics service supply chain was established based on entropy and unascertained measure. Weight coefficient of each index was determined through using entropy coefficient method. And credible degree recognition criterion was applied to analysis the comprehensive assessment results. Then, the model was used in the application. The feasibility and effectiveness of the model established were verified. And the comprehensive performance evaluation results of logistics service supply chain can guide the decision makers formulate the improved measures according to the performance grade to help logistics service supply chain realize stable development.

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