Research on Selection of Fresh Cold Chain Logistics Service Providers Based on AHP-TOPSIS

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Abstract

The fresh food industry has developed rapidly in recent years, and fresh cold chain logistics have high cost, timeliness and system complexity. This article first determines the evaluation index through the literature collection method, and secondly uses the analytic hierarchy process and the approximation positive and negative ideal solution method to evaluate the service provider. Finally, an example analysis is used to show that the evaluation index system is feasible and effective, and can provide a certain reference value for fresh cold chain enterprises.

Keywords

Logistics Service Provider; Analytic Hierarchy Process; TOPSIS.

1. Introduction

People attach great importance to improving the quality of life. Fresh, healthy, nutritious, convenient and safe high-quality low-temperature products have gradually become indispensable in people's lives. Due to the characteristics of perishable and spoilage of fresh products, the whole link of procurement, storage, processing, transportation and distribution requires that it be under a specific temperature, which requires a very sensitive and efficient system for cold chain engineering. At present, domestic cold chain system is relatively backward, and the loss rate is extremely high in the process of product circulation. In addition, in the entire cold chain logistics system, if any link fails, it may cause product problems for harmful substances. Therefore, a scientific and correct choice of evaluation method system is necessary. For example, Pan et al. (2017) [1] used green cold chain logistics process, green environmental protection, green development capability, green collaboration, financial factors and customer feedback to study the development model and evaluation system of green cold chain logistics in my country. Li et al. (2017) [2] Transform qualitative evaluation indicators such as comprehensive capabilities, service time, service cost, and enterprise strength of reactive enterprises into quantitative evaluation of specific data. Singh. et al. (2018) [3] constructed ten indicator systems including transportation and warehousing costs, logistics basis and warehousing facilities, customer service, etc. Yang Dequan and Pei (2012) [4] When evaluating the performance of logistics companies, the company's indicators are divided into four aspects: transportation efficiency, inventory management, and information technology level to evaluate the logistics system. According to the concept of green supply chain, Zhang (2015) established an index evaluation system for the performance of agricultural cold chain logistics companies. Similarly, the evaluation method selected by the service provider is also very important. Therefore, there are many methods for the evaluation of cold chain logistics service providers by scholars at home and abroad. Some methods can be used alone, while others are more than two methods. Research: Wang (2016) [6] introduced a quality function configuration method (QFD), discussed the service quality of cold chain logistics of fresh products, and provided a better way to meet customer needs. Singh (2018) et al. [3] constructed 10 indicator systems including transportation and warehousing costs, logistics infrastructure and warehousing facilities, customer service, etc., and used fuzzy AHP and TOPSIS to study Indian cold chain logistics service providers. Zhao et al. (2019) [7] evaluated the performance of food cold chain logistics companies by using AHP method and entropy weight method. With the in-depth study of the evaluation of cold chain logistics service providers, the previous single method can no longer be satisfied, so some scholars in our country have also conducted in-depth research on this issue and obtained rich research results: Deng etc. (2010) [8] Following the principles of simplicity, system,

effectiveness and scientifically, the third-party logistics service providers are evaluated using the extension evaluation method, and the indicators are constructed according to the complexity and high cost of cold chain logistics Evaluation System. Cao Ying (2011) [9] based on the unique nature of cold chain logistics, established a comprehensive evaluation system of cold chain logistics service provider index evaluation using AHP, and based on the balanced scorecard, built a The performance evaluation index system of agricultural cold chain logistics enterprises, such as facility technology level, cost and other indicators, has ensured its scientifically and operability through practical examples. This article combines the AHP method and TOPSISI method, through chromatographic analysis and comprehensive ranking of various indicators, to evaluate the fresh cold chain logistics service providers, comprehensively select the best service provider, and make a living Fresh enterprises provide reference. A large number of research results show that the AHP-TOPSIS method has a good applicability for the selection of logistics service providers.

2. Evaluation Index System and Model Construction of Fresh Cold Chain Logistics Service Providers

2.1 Evaluation index system of fresh cold chain logistics service providers

According to the characteristics of fresh cold chain logistics and the literature collection method, this paper follows the principles of systematic comprehensiveness, scientifically and operability to determine the evaluation indexes of service providers. This paper refers to the relevant research literature of previous scholars, combined with the data and questionnaires on the Internet, and comprehensively selects three indicators of logistics level, enterprise status and service level as the first-level indicators to build a fresh cold chain logistics service provider evaluation index system. The details are shown in Table 2.1:

Table 2.1 Evaluation Index System of Fresh Cold Chain Logistics Service Providers

First-level indicators	Secondary indicators
Logistics level	Refrigeration infrastructure
	Cold chain transportation efficiency
	Refrigerated truck utilization
Business status	Technique level
	Financial status
	Staff level
Service Level	Customer Experience
	On-time delivery
	product quality

2.2 AHP-TOPSIS evaluation method

Hierarchical analysis: this is a combination of quantitative and qualitative, hierarchical method of analysis, which combines multiple evaluation factors based on their relationship between correlations for hierarchical analysis, constructing a system of progressive layers: goal level, criterion level, decision level, approximating the ideal solution ordering method (TOPSIS). For multi-objective optimization problems, there are usually n evaluation goals, each of which has m evaluation indicators. The specific decision steps are as follows.

Step 1: Construct the judgment matrix

Assuming that the factor A_k in the layer A is related to the factor $B_1, B_2 \ldots$ in the next layer, the judgment matrix is constructed as $B = (b_{ij})_{n\times m}$ which has the following properties:

$$b_{ij} > 0, \quad b_{ji} = \frac{1}{b_{ij}}, \quad b_{ij} = 1 \ (i = 1, 2 \ldots n)$$

b_{ij} indicates the importance of element i compared to element j. The meaning of the scale is shown in Table 2.2:

Table 2.2 AHP scale table

Factor i VS Factor j	Quantized value
Equally important	1
Slightly important	3
Stronger important	5
Strongly important	7
Extremely important	9
The median value of the two adjacent judgments	2、4、6、8

Step 2: Hierarchical ordering and consistency check

Hierarchical single sorting can be briefly described as the problem of calculating the characteristic root and characteristic vector of the judgment matrix B, that is, for the judgment matrix, the calculation satisfies

$$BW = \lambda_{\max} w_i \tag{2.1}$$

In the formula, $\lambda_{\max}$ is the largest feature root of B; W is the corresponding normalized feature vector; and the component w_i of W is the weight of the single ranking of the factors in the current layer.

Perform consistency check on the judgment matrix in hierarchical ordering:

$$CI = \frac{\lambda_{\max} - 1}{n - 1} \tag{2.2}$$

Calculate the consistency ratio:

$$CR = \frac{CI}{RI} \tag{2.3}$$

The random consistency index is shown in Table 2.3:

Table 2.3 Average random consistency index of 1-9 matrix

Orders	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

When the calculated CR value is less than 0.1, it is considered to pass the consistency test, otherwise it fails, and the matrix needs to be modified to achieve a CR value of less than 0.1.

Step 3: Overall ranking and consistency check

The total ranking refers to the relative weight of each factor in the judgment matrix of the B layer against the target layer (the uppermost layer). This paper uses a top-down method to synthesize layers. The calculation method is the same as the above single sorting. When the total ranking consistency check value CR is less than 0.1, it indicates that the overall consistency of the judgment matrix is acceptable.

Step 4: Use the vector normalization method to obtain the normalized decision matrix Z_{ij}

$$Z_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{n} y_{ij}^2}} \tag{2.4}$$

Where y_{ij} represents the specific weight of each factor, where $i = 1,2,3...n$, $j = 1,2,3...m$,

Step 5: Determine positive ideal solution Z^+ and negative ideal solution Z^-

Positive ideal solution:

$$Z^+ = \left(\max Z_{ij} \middle| j \in J_1\right), \left(\min Z_{ij} \middle| j \in J_2\right), \middle| i = 1,2..., n = z_1^+ , z_2^+ .... z_j^+ \tag{2.5}$$

Negative ideal solution:

$$Z^- = \left(\min Z_{ij} \middle| j \in J_1\right), \left(\max Z_{ij} \middle| j \in J_2\right), \middle| i = 1,2..., n = z_1^- , z_2^- .... z_j^- \tag{2.6}$$

Where J_1 is the profitability index set, which represents the optimal value on the i-th index; J is the lossy index, which represents the worst value on the i-th index.

Step 6: Calculate the Euclidean distance from the evaluated object to the positive and negative ideal solutions

$$D_i^+ = \sqrt{\sum_{j=1}^{m} \left(Z_{ij} - Z_j^+\right)^2} \tag{2.7}$$

$$D_i^- = \sqrt{\sum_{j=1}^{m} \left(Z_{ij} - Z_j^-\right)^2} \tag{2.8}$$

Among them, z_j^+ and z_j^- represent the distance from the j-th target to the optimal value and the worst value, respectively, z_{ij} is the weight value of the i-th evaluation index of the j-th target.

Step 7: Calculate the relative closeness between each plan and the best plan

$$L_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{2.9}$$

Thus, the comparison of various schemes is completed, in which the value of *Li* is between 0-1, and the closer to 1, the closer to the optimal solution.

3. Example Analysis

In order to enhance the practicability and feasibility of the study, this paper selects a fresh food company in Chongqing as an enterprise case. At present, there is a fresh food company that needs to ensure product quality and transportation efficiency during the sales process. Four fresh cold chain logistics service providers A_1, A_2, A_3, A_4 are selected, and the best one among these four companies needs to be selected as a partner. Based on the AHP method, the evaluation index weights of fresh cold chain logistics service providers are determined, and the TOPSIS method is used to evaluate multiple candidate service providers. After in-depth investigation and interview, the specific data of the corresponding indicators of these four service providers were obtained. The specific data are as follows:

Table 3.1 Service provider original indicator data table

Index number	Indicator name	Raw data of alternative service provider indicators			
		A_1	A_2	A_3	A_4
$C1$	Refrigeration infrastructure	0.77	0.74	0.68	0.71
$C2$	Cold chain transportation efficiency	0.94	0.96	0.95	0.92
$C3$	Refrigerated truck utilization	0.65	0.58	0.63	0.57
$C4$	Techniques level	0.96	0.91	0.92	0.95
$C5$	Financial status	0.70	0.56	0.65	0.48
$C6$	Staff level	0.74	0.65	0.72	0.69
$C7$	Customer Experience	0.91	0.89	0.92	0.85
$C8$	On-time delivery	0.89	0.94	0.92	0.88
$C9$	product quality	0.78	0.86	0.85	0.76

(1). According to the established index system, establish the initial data matrix:

(2). Use AHP to calculate the evaluation index weight of fresh cold chain logistics service providers, in which the first-level index is expressed as B and the second-level index is expressed as C.

Layer i B ndex weight determination:

1) Establish a judgment matrix $A-B$

$$A-B=\begin{pmatrix} 1 & 3 & 4 \\ \frac{1}{3} & 1 & 2 \\ \frac{1}{4} & \frac{1}{2} & 1 \end{pmatrix}$$

2) Hierarchical ordering and consistency check

The weight vector of the judgment matrix obtained by the normalized summation method is:

$$W=\begin{pmatrix}0.627 & 0.228 & 0.145\end{pmatrix}^T, \lambda_{\max}=3.025, CI=\frac{3.025-3}{3-1}=0.013$$

If $n=3$, $RI=0.58, CR=\frac{CI}{RI}=\frac{0.013}{0.58}=0.02<0.1$

This shows that the judgment matrix meets the consistency requirements.

For the determination of the index weight of layer C, according to the above method, the calculation result of the index weight of layer C is as follows:

1) Logistics level $B1-C1$ judgment matrix

$$B1-C1=\begin{pmatrix} 1 & 3 & 5 \\ \frac{1}{3} & 1 & 4 \\ \frac{1}{5} & \frac{1}{4} & 1 \end{pmatrix}$$

$$W_1=\begin{pmatrix}0.661 & 0276 & 0.113\end{pmatrix}^T, \lambda_{\max}=3.115, CR=0.09<0.1$$

Therefore, the $B1-C1$ judgment matrix conforms to the consistency test.

2) Enterprise status $B2-C2$ judgment matrix

$$B2-C2=\begin{pmatrix} 1 & 4 & 5 \\ \frac{1}{4} & 1 & 2 \\ \frac{1}{5} & \frac{1}{2} & 1 \end{pmatrix}$$

$$W_2=\begin{pmatrix}0.681 & 0.201 & 0.118\end{pmatrix}^T, \lambda_{\max}=3.025, CR=0.02<0.1$$

Therefore, the $B2-C2$ judgment matrix meets the consistency test

3) Service level $B3-C3$ judgment matrix

$$B3-C3=\begin{pmatrix} 1 & 3 & 4 \\ \frac{1}{3} & 1 & 2 \\ \frac{1}{4} & \frac{1}{2} & 1 \end{pmatrix}$$

$$W_3=\begin{pmatrix}0.624 & 0.239 & 0.137\end{pmatrix}^T, \lambda_{\max}=3.018, CR=0.015<0.1$$

Table 3.2 Weights of indicators for each layer

A layer indicator	B layer indicators and weights	C layer index	C layer indicators and weights	Normalized C layer index weights
Evaluation of fresh cold chain logistics service providers	Logistics level 0.627	Refrigeration infrastructure	0.661	0.630
		Cold chain transportation efficiency	0.276	0.263
		Refrigerated truck utilization	0.113	0.107
	Business status 0.228	Techniques level	0.681	0.680
		Financial status	0.201	0.202
		Staff level	0.118	0.118
	Service Level 0.145	Customer experience	0.624	0.621
		On-time delivery	0.239	0.241

		Product quality	0.137	0.138

Therefore, the $B3-C3$ judgment matrix conforms to the consistency test.

The weights of the B layer indicators and the C layer indicators are comprehensively calculated, and the C layer indicators are integrated with weights and then normalized. The weight W is shown in Table 3.2:

(3). According to the AHP method, the weight W of each index is obtained, and the original data is weighted:

$$KW=\begin{pmatrix} 0.485 & 0.247 & 0.067 & 0.653 & 0.141 & 0.087 & 0.565 & 0.214 & 0.108 \\ 0.466 & 0.253 & 0.062 & 0.619 & 0.113 & 0.077 & 0.553 & 0.227 & 0.119 \\ 0.428 & 0.250 & 0.067 & 0.626 & 0.131 & 0.085 & 0.571 & 0.221 & 0.117 \\ 0.447 & 0.242 & 0.061 & 0.646 & 0.097 & 0.081 & 0.528 & 0.212 & 0.105 \end{pmatrix}$$

(4). Use the formula (2.4) to obtain the norm matrix:

$$Z=\begin{pmatrix} 0.530 & 0.499 & 0.534 & 0.513 & 0.580 & 0.528 & 0.510 & 0.490 & 0.479 \\ 0.510 & 0.509 & 0.477 & 0.487 & 0.464 & 0.468 & 0.498 & 0.518 & 0.528 \\ 0.468 & 0.504 & 0.518 & 0.492 & 0.539 & 0.514 & 0.515 & 0.506 & 0.522 \\ 0.489 & 0.488 & 0.468 & 0.508 & 0.398 & 0.492 & 0.476 & 0.485 & 0.467 \end{pmatrix}$$

(5). According to formulas (2.5) and (2.6), determine the positive ideal solution and the negative ideal solution of the index, and construct the positive ideal vector Z^+ and the negative ideal vector Z^-:

$$Z^-=(0.468 \quad 0.488 \quad 0.468 \quad 0.486 \quad 0.398 \quad 0.468 \quad 0.476 \quad 0.485 \quad 0.467)$$

$$Z^-=(0.468 \quad 0.488 \quad 0.468 \quad 0.486 \quad 0.398 \quad 0.468 \quad 0.476 \quad 0.485 \quad 0.467)$$

(6). According to formulas (2.7), (2.8) and (2.9), calculate the optimal value of the evaluation index of each program, the distance of the worst value, and the relative proximity of each program to the optimal program L_i. The calculation results are shown in Table 3.3. The pros and cons of the four schemes are ranked according to their proximity. The larger Li is, the better the comprehensive evaluation is, and the worse it is.

Table 3.3 Supplier comprehensive evaluation results and ranking table

Candidate Service Provider	D^+	D^-	L_i	Sort
A_1	0.086	0.021	0.196	4
A_2	0.075	0.053	0.414	2
A_3	0.058	0.036	0.383	3
A_4	0.067	0.149	0.690	1

It can be seen from Table 3.3 that the evaluation result is $A_4 > A_2 > A_3 > A_1$, so the best fresh cold chain logistics service provider is A_4, and it should be selected as a strategic partner.

4. Summary

The main content of this article is to construct the index evaluation model of fresh cold chain logistics service providers based on AHP-TOPSIS method, establish a hierarchical structure model according to the nature and principle of AHP method, and determine the weight of each index. This article uses the TOPSIS method to evaluate the four service providers, and uses the principles and advantages of

the TOPSIS method to process the original data to standardize it, eliminate the dimensional influence between the indicators, and reflect the actual situation in a true and objective manner. This article provides reference opinions for enterprises through comprehensive evaluation results of service providers, which has certain research significance.

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