Research on Regional Service capability Evaluation of Cold chain Logistics Enterprises based on WSR

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Abstract: The improvement of the regional service quality of cold chain logistics enterprises helps them to create a modern integrated logistics service system of market scale, thus expanding their business scope and enhancing their market competitiveness. WSR is an acronym for "Physical-Truth-Human Reasoning Methodology", and ANP-TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) is a multi-objective decision analysis method based on network analysis. This paper constructs an evaluation index system for regional service quality of cold chain logistics enterprises based on WSR system methodology, and builds an evaluation model based on ANP-TOPSIS method. Firstly, on the basis of considering the interrelationship of the elements in the evaluation system, ANP is applied to analyse the weights of each evaluation index, and then Enterprise A is used as the empirical research object to evaluate the service quality of the enterprise in different regions through the TOPSIS method and combine the index weights obtained by ANP to obtain the comprehensive ranking of the enterprise's regional logistics service quality. The results show that the service quality of enterprise A in the four regions varies greatly, showing the development characteristics of strong in the south and weak in the north, which is in line with the actual situation, thus verifying the validity of the model and providing corresponding solution suggestions for it according to the results obtained.

Keywords: WSR Analysis, ANP-TOPSIS, Cold chain logistics, Regional service capacity

1. Introduction

Cold chain logistics includes frozen storage of fresh products, refrigerated processing, refrigerated transportation and distribution, refrigerated sales, etc. With the progress of electronic information technology and the development of electronic commerce in recent years, the cold chain logistics has also been developed rapidly. Since 1990, China's milk-based dairy products have entered a period of rapid development, with an average growth rate of 12.1% from 1990 to 2009, ranking first in the world. Since 1995, the annual output of frozen food in China has been increasing at a rate of 20% year by year, with the annual output reaching more than 10 million tons. According to incomplete statistics, in recent years, there are about 2,000 manufacturers of various types of frozen food in China, with annual sales of more than 10 billion yuan[5]. 2017, China's meat production exceeded 16 million tons. Among them, the output of low-temperature meat products reached 10.72 million tons, accounting for 64.3% of the total output of meat products, and the total logistics of agricultural products in China reached 3.7 trillion yuan in the same year, an increase of 3.9% over the previous year[15]. According to the

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statistics of China Federation of Logistics Associations and Purchasing, since 2012, the annual growth of cold chain logistics in China has exceeded 20%, and the scale of cold chain logistics reached hundreds of millions of tons in 2014. The total potential logistics volume of cold chain food in China in 2015 is as high as 4.3 trillion yuan[13]. In this context, more and more cold chain enterprises have started to develop regional cold chain logistics in order to improve the service quality of cold chain logistics, expand the business scope and shorten the delivery cycle, in order to occupy a place in the increasingly competitive market. Therefore, the evaluation of the regional service quality of cold chain logistics enterprises can help enterprises adopt different development strategies for different regions in the decision-making process, and ultimately achieve the improvement of the overall service quality of cold chain logistics enterprises.

2. Literature review

2.1 Literature review

In terms of research on the construction of cold chain logistics service quality evaluation index system, scholars at home and abroad have conducted in-depth analysis from different aspects. Foreign scholars Perreault et al put forward the 7Rs theory, and on the basis of this theory, they evaluated the service quality of logistics enterprises from seven indicators: cargo accuracy, cargo completeness, commodity information accuracy, delivery punctuality, delivery accuracy, timeliness and price. Farasuraman and Berry, based on the theory of total quality management, evaluated the service quality of logistics enterprises from five perspectives: tangibility, reliability, assurance, responsiveness and care. Reliability, assurance, responsiveness and caring 5 perspectives 22 subdivision indicators, proposed SERVQAUL assessment scale, the assessment scale for subsequent scholars to study logistics service quality laid a solid foundation. Domestic scholars such as He Yaoyu[8] believe that logistics service quality affects customer loyalty and constructs a service quality influence factor system from five aspects: information capability, distribution capability, pre-sales and after-sales service capability, matching capability and innovation capability; Zhao Dawei et al [16] constructs an evaluation system of agricultural cold chain logistics service quality from five aspects: transportation capability, storage capability, customer service capability, distribution capability and information level Li Lin[9] constructed a set of evaluation index system for the service quality of fresh agricultural products cold chain logistics in the context of e-commerce by using SERVQUAL and LSQ service quality models in terms of reliability, timeliness, economy, information and service flexibility; Wang Yong et al [14] constructed a system of evaluation indexes for the service quality of fresh agricultural products cold chain logistics in the context of industrial In the context of industrial integration, Wang Yong et al [14] constructed a cold chain logistics service quality evaluation system from four aspects: cold storage capacity, operation capacity, personnel communication capacity and logistics information capacity, evaluated specific enterprises through fuzzy comprehensive evaluation method, and gave corresponding suggestions; Qiu Bin[12] studied three aspects of fresh cold chain logistics process service quality, information service quality and personnel communication quality from the perspective of customers and constructed a Chen Hongli[2] used Lean Six Sigma quality management tools and fuzzy hierarchical analysis to classify and quantify the key control factors in the cold chain logistics service process from the four aspects of procurement, loading and unloading, distribution and storage, providing a theoretical basis and methodological reference for the quality management of cold chain logistics enterprises.

In the research on the regional evaluation of cold chain logistics, most scholars compare the development level of logistics among regions from a geographical perspective. For example, Guo Mingde et al [6] calculated and analyzed the development level of agricultural cold chain logistics of 12 typical provinces and cities through factor analysis method, multi-layer perception and cluster analysis method on the basis of constructing the evaluation index system of the development level of agricultural cold chain logistics, and the results showed that the regional disparity of the development level of agricultural cold chain logistics in China was obvious; Chen Jiming[4] et al, through constructing the evaluation index system of cold chain logistics of dairy products By constructing an evaluation index system for dairy products, 14 dairy enterprises in Beijing, Tianjin and Hebei regions were used as samples to evaluate their logistics capacity and regional differences using the entropy value method; Cao Bingrue[1] et al. conducted an empirical study on the logistics development capacity of 13 cities in Jiangsu Province using the ANP-TOPSIS method. The results show that the level of logistics development in Jiangsu Province is roughly divided into three levels, and corresponding development suggestions are made according to the classified levels.

2.2 Summary of the literature review

(1) Most scholars have fully considered the functional elements affecting the service quality of cold chain logistics in the construction of the cold chain logistics service quality index system, but most of them have examined the factors affecting the service quality of cold chain logistics from a single dimension and neglected the problem of system selection of the factors affecting the service quality of cold chain logistics regions from a multi-dimensional perspective. Therefore, this paper will use the WSR system methodology to study the various influencing factors of regional service quality of cold chain logistics from three dimensions: physical - factual - human.

(2) Most scholars in the past have compared the differences in the level of logistics development between different regions from a geographical perspective, while existing researchers have failed to examine the differences in service quality between different regions of the same enterprise from an enterprise perspective. Therefore, this paper analyses the service differences of the same enterprise among different regions from the enterprise perspective, so as to obtain the ranking of the service capacity of enterprises among regions and provide a basis for specific enterprise decision-making.

(3) As a complex evaluation system, there is an interdependent relationship between the indicators. This paper can take into account the interrelationship between all the elements through the ANP method, and evaluate the regional service quality of cold chain logistics based on the evaluation model combining ANP method and TOPSIS, and the results will be more scientific and objective.

3. Regional service quality index system of cold chain logistics enterprises based on WSR

3.1 Main elements of WSR methodology

The WSR methodology was proposed by Zhu Zhichang and Gu Kifa et al. in 1994, aiming to deal with complex system engineering problems from the physical, matter and human dimensions [10-11, 17]. Its details are shown in Table 1.

Table 1 WSR Methodology Content

Category	Physical	Reasoning	Humanistic
Object and content	What are the laws and laws of the objective material world	Organisation, systems management and doing things right	People, groups, relationships and dealing with the world
Focus	What is it? Functional Analysis	How? Logical analysis	What's the best way to do it? Possibly? Humanities analysis
Principles	Honesty and the pursuit of truth	Coordination, the pursuit of efficiency	Talking about humanity and harmony in the pursuit of results
Required knowledge	Natural Sciences	Management Science, Systems Science	Humanistic knowledge, behavioural sciences

3.2 Regional service quality index system of cold chain logistics enterprises based on WSR

(1) Physical: The level of logistics facilities and equipment, the floor space of enterprise cold storage and the number of distribution points directly affect the quality of enterprise regional logistics services. Among them, enterprise logistics equipment includes enterprise logistics basic equipment (such as conveyor belts, forklifts, shelves, etc.), cold chain transportation equipment (such as refrigerated trucks, refrigeration railway sets, etc.), cold chain storage equipment (such as refrigerated cabinets, refrigerated containers, etc.), cold chain packaging equipment (such as insulated boxes, ice bags, etc.), and logistics information equipment (such as GPS, EDI, FID, etc.) covering transportation, storage, packaging, sales and distribution and information in the process of cold chain logistics. loading and unloading handling, sales distribution and information processing[3].

(2) Reasoning: The quality of logistics services is specifically reflected in the process of cold chain logistics services. The service quality of cold chain logistics enterprises is examined from the perspectives of cold chain transportation capability, storage temperature compliance, packaging integrity, on-time delivery rate, product loss rate, order processing capability, order renewal capability and enterprise innovation capability, which can reflect the service quality of the cold chain logistics service process in a more comprehensive manner[7].

(3) Human reasoning: Human reasoning is mainly reflected in the dynamic role of "human" in the service activities on logistics equipment, service process, and the handling of problems between the two sides. This includes the two aspects of the enterprise staff and customers. On the one hand, the image of the staff, professional quality, service attitude and customer communication ability will directly affect the customer's intuitive feeling of cold chain logistics services. On the other hand, the complaint rate of customers to the enterprise can also reflect the regional service capacity of the enterprise from the side.

4. Regional service quality evaluation methods for cold chain logistics enterprises

4.1 ANP model building

The Analytic Network Process (ANP) was developed in 1996 by T.L. Saaty, an American operations researcher. ANP consists of a control layer and a network layer. The control layer is governed by the target elements; the elements in the network layer interact with each other and are governed by the control layer .

In the cold chain enterprise regional service quality rating index system, the objective is the cold chain logistics enterprise regional service quality evaluation system, which contains 3 primary indicators:

$$B_i = (B_1, B_2, , B_3) \tag{1}$$

The physical, physical, and human indicators and 20 secondary indicators respectively.

$$B_i = \left(B_{i1}, B_{i2}, \cdots, B_{ij}\right) \tag{2}$$

Among themB_{ij} represents the first$i$ of the first level indicator.j The second level indicator. The network structure model of regional service quality evaluation of cold chain enterprises was constructed through random interviews with experts and combined with the actual operation situation of enterprises. The two-way loop arrows of the same cluster represent the interactions within the element group. The two-way straight arrows represent the mutual influence of the two element groups.

4.2 Determination of weights for each indicator based on ANP

(1) Constructing an unweighted supermatrix

Let there be a single criterion in the control layer$P$ thatB_i $(i = 1,2,3)$ be the set of network layer elements.b_{i1} ,b_{i2} , ...,b_{in} are the B_i the elements in the Using P as the criterion and B_i the elements in is the sub-criterion, and the B_i The elements in are compared two-by-two, and when the elements are unrelated h_{ij} = 0. The eigenvectors are normalised to create a supermatrix$H$.

$$H = \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1n} \\ h_{21} & h_{22} & \cdots & h_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ h_{n1} & h_{n2} & \cdots & h_{nn} \end{bmatrix} \tag{3}$$

followed by P as the main criterion and B_i The factors in the element group are scored according to their influence on the sub-criteria, and the normalized feature vectors are aggregated to the full matrix of the element group M The normalised feature vectors are aggregated into a full matrix of elements.

$$\mathrm{M} = \begin{bmatrix} m_{11} & m_{12} & \cdots & m_{1n} \\ m_{21} & m_{22} & \cdots & m_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ m_{n1} & m_{n2} & \cdots & m_{nn} \end{bmatrix} \tag{4}$$

(2) Constructing the weighted supermatrix

Combining the matrix H with the matrix M multiplying by the matrix to obtain the weighted supermatrix $\overline{w}$.

$$\overline{w} = \begin{bmatrix} \overline{w}_{11} & \overline{w}_{12} & \cdots & \overline{w}_{1n} \\ \overline{w}_{21} & \overline{w}_{22} & \cdots & \overline{w}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \overline{w}_{n1} & \overline{w}_{n2} & \cdots & \overline{w}_{nn} \end{bmatrix} \tag{5}$$

(3) Solving limit supermatrices

The weighted supermatrix $\overline{w}$ and self-multiply until each row of the weighted hypermatrix converges to give the limit hypermatrix K . Assume that the final vector of any row in the matrix is obtained as $\mathrm{K} = \left[k_1, \ k_2 \cdots k_{20}\right]^T$, K represents the indicator weights.

4.3 TOPSIS model construction

The C The judgment matrix determined by the 20 indicators for each region E_{c20} The matrix is normalised and then the elements are weighted to obtain the matrix F_{c20}.

$$F_{c20} = \begin{bmatrix} k_1 e_{11} & \cdots & k_{20} e_{120} \\ \vdots & \ddots & \vdots \\ k_1 e_{c1} & \cdots & k_{20} e_{c20} \end{bmatrix} = \begin{bmatrix} f_{11} & \cdots & f_{120} \\ \vdots & \ddots & \vdots \\ f_{c1} & \cdots & f_{c20} \end{bmatrix} \tag{6}$$

$$V^+ = \left\{\left(max y_{ij} | j \in J^+\right), \left(min y_{ij} | j \in J^- | i = 1,2,\cdots,m\right) = \left(V_1^+, V_2^+, \cdots, V_r^+\right\} \tag{7}$$

$$V^- = \left\{\left(max y_{ij} | j \in J^-\right), \left(min y_{ij} | j \in J^+ | i = 1,2,\cdots,m\right) = \left(V_1^-, V_2^-, \cdots, V_r^-\right\} \tag{8}$$

$$D_i^+ = \sqrt{\sum_{j=1}^{r} \left(y_{ij} - V_j^+\right)^2}, i = 1,2,\cdots,m \tag{9}$$

$$D_i^- = \sqrt{\sum_{j=1}^{r} \left(y_{ij} - V_j^-\right)^2}, i = 1,2,\cdots,m \tag{10}$$

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-}, i = 1,2,\cdots,m \tag{11}$$

Of which. V^+ is the set of benefit-based indicators. V^- is the set of cost-based indicators.D_i^+ , D_i^- are the distances between the region to be evaluated and the positive and negative ideal solutions, respectively C_i relative closeness.

5. Empirical analysis of regional service quality evaluation of cold chain logistics enterprises

Founded in the 1990s, Enterprise A has been developing regional cold chain logistics to meet the needs of the market in recent years in order to improve the quality of customer service. It has four logistics parks, which are located in the northern, central and southern regions of Shanxi Province and the southern region of Inner Mongolia.

Starting from the actual situation of the enterprise, according to the regional service quality evaluation model of the cold chain logistics enterprise constructed above, five project leaders of enterprise A and five experts and scholars in logistics and business management were invited to form a decision-making expert group and statistically analyse the various influencing factors and indicators affecting the logistics service quality of the cold chain enterprise to conduct an empirical study of the enterprise. The specific process is as follows.

5.1 Determining the relative weight of each indicator using ANP

(1) Constructing an unweighted overweight matrix." evaluation of regional service quality of cold chain logistics enterprises", so "evaluation of regional service quality of cold chain logistics enterprises" is the evaluation target and also the decision criterion. The indicator layer corresponds to the network layer of the ANP and contains three element groups, each of which includes a number of indicators. Because of the complexity of the ANP calculation process, this paper uses Super Decisions software to obtain the results.

In the main screen of Super Decisions 2.1.0, execute the menu command [New],Create the three element groups "Physical", "Matter" and "Human". In the created element group, execute the command "[Create nod in cluster]" to create each element under the element group. Then execute the "[Design]|[Node connexions from]" menu command to build the relationships between the element groups and the elements. The network diagram of regional service capacity evaluation indicators of cold chain logistics enterprises is obtained.

Enter the main interface of Super Decisions and execute the "[Assess/Compare]|[pairwise comparisons]" menu command to select the importance coefficients between the indicators based on the results of the questionnaire filled in by the expert scoring method. The menu command "[Assess/Compare]|[Unweighted super Matrix]" gives the unweighted super matrix H as follows (with three decimal places).

(2) Construction of the weighting matrix

Execute the "[Compuations]|[Cluster Matrix]" menu command to obtain the weighting matrix M as follows.

$$M = \begin{pmatrix} 0.333 & 0.333 & 0.196 \\ 0.333 & 0.333 & 0.493 \\ 0.333 & 0.333 & 0.311 \end{pmatrix} \quad (12)$$

(3) Construction of the weighted supermatrix.

Execute the "[Compuations]|[Weighted Matrix]" menu command to obtain the weighted supermatrix $\overline{w}$ (Figure 1).

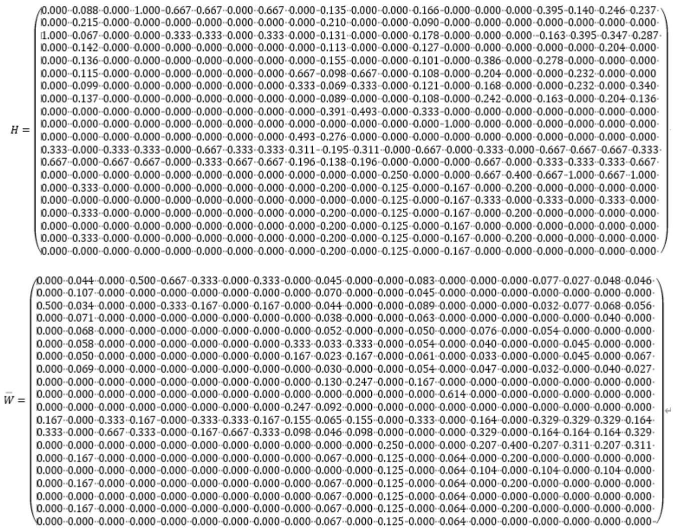

Figure 1: supermatrix H and $\overline{w}$

(4) Construct and solve the limiting supermatrix.

Each column of the matrix is the weight value of each indicator. After sorting, we get K:

$$K = [k_1, \ k_2 \cdots k_{20}]^T = [0.104, 0.040, 0.032, 0.032, 0.042, 0.042, 0.042, 0.042, 0.067, 0.057, 0.016, 0.017, 0.014, 0.024, 0.031, 0.012, 0.064, 0.015, 0.036, 0.146, 0.166] \tag{13}$$

From the above, we can conclude that from the perspective of the element group, from the perspective of the elements, the cold storage area, the number of distribution points, cold chain transport capacity, storage temperature compliance, and the image of the staff have a greater total impact on the regional service capacity of cold chain logistics enterprises. Combined with the theoretical basis of physical - physical - human interaction, we can see that the level of cold storage equipment and packaging equipment will directly affect the above-mentioned factors with greater impact.

5.2 Evaluation of regional service quality of cold chain logistics of enterprise A

Through the field survey of enterprise A, the data of each indicator of the enterprise's four logistics parks in Taiyuan, Inner Mongolia, Yuncheng and Jinbei were selected for 2018. Among them, 18 benefit-based indicators and 2 cost-based indicators. After normalising the raw data with Matlab software, the weighted normalisation matrix was calculated. The positive and negative ideal values were obtained V^+ , and V^- , after which the Euclidean distance between each city and the positive and negative ideal values was calculated D_i^+ and D_i^- .

$$V^{+}=[0.0776,0.0302,0.0210,0.0218,0.0255,0.0271,0.0230,0.0378,0.0067,0.0081,0.0087,0.0074,0.0122,0.0158,0.0114,0.0384,0.009,0.0235, 0.0219,0.0931] \quad (14)$$

$$V^{-}=[0.0342,0.0121,0.0010,0.0087,0.0162,0.0165,0.0189,0.0309,0.0400,0.0076,0.0083,0.0066,0.0119,0.0144,0,0.0252,0.0059,0.0147,0.1207, 0.0741] \quad (15)$$

$$D_i^{+}=[0.0003 ,0.0617 ,0.1182 ,0.0638] \quad (16)$$

$$D_i^{-}= [0.1199 ,0.0793 ,0.0066 ,0.0601] \quad (17)$$

$$C_i=[0.9978 ,0.5622 ,0.0530 ,0.4851] \quad (18)$$

From the above, it can be seen that the relative posting size of the regional logistics service quality of enterprise A is in the following order.$C_1 > C_2 > C_4 > C_3$ That is, Taiyuan logistics park has the strongest service quality, Yuncheng and Inner Mongolia logistics park is the second strongest, and Jinbei logistics park is the worst. This shows that the development of enterprise A is mainly focused on the central and southern regions of Jin, while the service quality of northern Jin and Inner Mongolia is insufficient.

In terms of the weight of each indicator, the factors affecting the quality of regional logistics services are mainly focused on customer complaint rate, customer loyalty, total corporate assets, on-time delivery rate, and product loss rate, so the company should increase its capital investment in the logistics centres in Taiyuan and Yuncheng, as well as in Jinbei and Inner Mongolia logistics parks, and continuously improve the logistics infrastructure, cold storage facilities and information equipment investment. At the same time, it should also widely absorb advanced logistics personnel, improve service awareness and communication quality to enhance the quality of enterprise logistics services.

6. Conclusions and recommendations

This paper constructs the regional service quality evaluation index system of cold chain logistics enterprises from the perspective of regional service quality evaluation of cold chain logistics enterprises through WSR system methodology from physical - factual - human reasoning. The evaluation indexes are assigned weights based on the interrelationship of the elements through the ANP-TOPSIS method, and then the evaluation of the strengths and weaknesses of the regions or cities in the region through the weighted TOPSIS method overcomes the subjectivity of expert scoring. Finally, it is proved that the method is objective and can be applied in real practice to provide reference for the decision making of cold chain logistics enterprises.

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