Research on Green Logistics Service Provider Selection Based on Combination Weights-TOPSIS

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Abstract

In order to comply with the "green" trend of agricultural product logistics industry under the background of China's e-commerce, this paper combines with the characteristics of agricultural products transportation, aims at the problem that the agricultural product green logistics service provider selection process exists fuzzy uncertainty, from the low-carbon perspective to construct the third-party green logistics service provider evaluation index system and proposes a TOPSIS logistics service quotient decision model based on intuitionistic fuzzy set and entropy weight combination weighting. Compared with the traditional logistics service provider selection model， this model can reduce the error of the single weight determination method on the result, reflecting the subjective weight of the expert experience and reflecting the objective weight of the indicator information. Through the analysis of the example, this paper verifies the practicability and scientific of the model to reduce the error caused by the hesitation and biased subjectivity of experts when judging the importance of indicators, and provides a theoretical reference for the selection of third-party green logistics service providers of agricultural products in the future.

Keywords

Agricultural products, Green logistics, Intuitionistic fuzzy set, Entropy.

1. Introduction

In recent years, rural e-commerce has been vigorously developing with the goal of revitalizing the countryside, promoting structural reforms in the supply side of agriculture, and cultivating new kinetic energy for rural development. As the carrier of agricultural product circulation, logistics is the key to ensuring the advancement of e-commerce precision poverty alleviation projects. Due to the backwardness of logistics technology, the current agricultural product logistics process is seriously depleted, seriously affecting the safety and quality of agricultural products, and causing great damage to the ecological environment. Therefore, the greening of farming products logistics has become the development direction of world agricultural trade. Under the situation that the concept of green production and consumption is deeply rooted in the hearts of the people, it is a real problem that China needs to solve urgently to make the best choice for the scientific evaluation of the third-party logistics service providers of agricultural products with different development levels.

In recent years, scholars at home and abroad have done a lot of work on Agricultural product green logistics. From the research content, most of the literature have qualitative research on the status quo, countermeasures and system construction of green logistics of agricultural products from a macro perspective and a small part is based on the quantitative analysis of the perspective of agricultural products green logistics service providers.

In 1987, the International Environment and Development Committee proposed “environmental symbiosis logistics” to integrate the sustainable development perspective into logistics activities, and “green logistics” was proposed [1]. Xiaolan Liu comprehensively considered the objectivity of logistics service providers data and the farmers' subjective preferences, constructed the DEA-AHP model for the evaluation and selection of agricultural product logistics service providers [2]. Xianjun Huang used fuzzy matter element and AHP method to determine the weight and constructed a logistics service provider selection model [3]. Sui et al. constructed a third-party logistics service provider evaluation index system for agricultural products and selected it by network analytic hierarchy process (ANP), this method has a strong dependence on experts and is subjective [4]. After that, Zhanhai Wang and others considered the scientific nature of the logistics service provider selection process, and proposed a third-party logistics service provider selection model based on AHP-TOPSIS [5]. Haoran Huang et al. based on the perspective of decision-maker's error loss, constructed a third-party logistics service provider selection model for agricultural products, this method is more complicated in practical application and has relatively low feasibility [6].

In summary, although agricultural product logistics service providers have many selection methods, most of them are based on qualitative methods such as AHP and ANP. When determining the weight of indicators, the hesitancy and biased subjectivity of experts on the importance evaluation of indicators are neglected, and the objectivity of evaluation basis is lowered. At the same time, the evaluation indicators of agricultural logistics service providers are not comprehensive, and the green development capability of service providers is not used as a measure. Therefore, this paper applies the combination weighting-TOPSIS decision model to comprehensively evaluate and select logistics service providers to reduce the error caused by the hesitation and biased subjectivity of experts when judging the importance of indicators, and provides a theoretical reference for the selection of third-party green logistics service providers of agricultural products in the future.

2. Construction of Evaluation Index System for Agricultural Products Green Logistics Service Providers

The construction of evaluation index system is the key to the selection of agricultural green service providers. In order to objectively reflect the development level of logistics service providers in multiple dimensions, the selection of indicators must follow the principles of systematic, simplicity, availability, independence, etc., while ensuring that the indicator system has high application value and operability.

Xiaolan Liu and others believed that the choice of agricultural logistics service providers involves economic, informational level and development potential [2]. Sui and others set the indicator system from five aspects: service, quality, development potential, information technology and enterprise strength [4]. When Xin Zhao used the AHP-GRAP method to evaluate fresh product logistics service providers, he believed that not only should he pay attention to the logistics operation and market economy, but also should consider the enterprise cooperation capability indicators [7]. Haoran Huang et al. constructed a third-party logistics service provider selection model for agricultural products based on the perspective of decision makers' error loss. This method is more complicated in practical application and has relatively low feasibility [6].

According to previous studies, through experts consultation, considering the short shelf life of agricultural products, strong seasonality, large loss of agricultural product transportation, strict requirements for packaging, storage, circulation processing, etc., this paper introduces green execution factors as evaluation criteria, establishing evaluation index system for green logistics service providers of agricultural products from six aspects: management, service cost, service quality, service competitiveness, cooperation ability and green execution, as shown in Table 1.

Table 1 Agricultural product green logistics service provider evaluation index system

Dimension layer	Indicator layer	Unit	Type	Nature
Management	Business hours（A1）	year	quantitative	positive
	Business coverage（A2）	10-point scale	qualitative	positive
	Asset-liability ratio（A3）	%	quantitative	negative
	Employee turnover rate（A4）	%	quantitative	negative
Service cost	Transport prices (B1)	10000RMB/year	quantitative	negative
Service quality	Punctual rate (C1)	%	quantitative	positive
	Damage rate (C2)	%	quantitative	negative
	Customer satisfaction (C3)	%	quantitative	positive
	Service response time (C4)	hour	quantitative	negative
Service competitiveness	Cold chain equipment net asset value（D1）	10000RMB	quantitative	positive
	GPS transport vehicle ratio（D2）	%	quantitative	positive
	Agricultural product packaging technology (D3)	10-point scale	qualitative	positive
	Path optimization level（D4）	10-point scale	qualitative	positive
	Service innovation level（D5）	10-point scale	qualitative	positive
Cooperation ability	Contract execution rate (E1)	%	quantitative	positive
	Industry reputation (E2)	10-point scale	qualitative	positive
Green execution	Environmentally friendly vehicle ratio (F1)	%	quantitative	positive
	Packaging recovery rate (F2)	%	quantitative	positive
	Environmental protection of packaging materials (F3)	10-point scale	qualitative	positive
	Green culture promotion (F4)	10-point scale	qualitative	positive

3. Combination Weights-TOPSIS Green Logistics Service Provider Selection Model Construction

3.1 Indicator data preprocessing

In the established indicator system, the dimensions, units of measurement, nature, and values of the indicators vary. Therefore, the decision matrix needs to be assimilated and normalized to eliminate the impact of the above differences.

Firstly, the established indicator system includes positive indicator data and negative indicator data, which are to be assimilated separately as shown in the follows.

For positive type indicators:

$$y_{ij} = \frac{\max\limits_{1\le i\le m}(x_{ij}) - x_{ij}}{\max\limits_{1\le i\le m}(x_{ij}) - \min\limits_{1\le i\le m}(x_{ij})} \quad (j = 1, 2, \ldots, n) \tag{1}$$

For negative type indicators:

$$y_{ij} = \frac{x_{ij} - \min\limits_{1 \le i \le m}(x_{ij})}{\max\limits_{1 \le i \le m}(x_{ij}) - \min\limits_{1 \le i \le m}(x_{ij})} \ (j = 1, 2, ..., n) \tag{2}$$

In the equation (1) and (2), $\max\limits_{1 \le i \le m}(x_{ij})$ is the maximum value of the jth indicator; $\min\limits_{1 \le i \le m}(x_{ij})$ is the minimum value of the jth indicator.

Then, the indicator data need to be normalized as shown in the follows.

$$z_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{m} y_{ij}^2}} \ (j = 1, 2, ..., n) \tag{3}$$

Therefore, the convergence normalization decision matrix $Z = (z_{ij})_{m \times n}$ is obtained.

3.2 Intuitionistic Fuzzy Set-Entropy Weight Combination Weight Model

After the indicator data is preprocessed, it is necessary to assign weights to each evaluation index. To reflect the scientific and rationality of index empowerment, and to reduce the uncertainty of the hesitation and bias subjectivity of the experts, and reflect the objectivity of the evaluation information, this paper uses the combination of intuitionistic fuzzy sets and entropy weights to empower. The method then uses the Lagrangian multiplication optimization method to comprehensively determine the weight of the evaluation index.

3.2.1 Determination of subjective weight based on intuitionistic fuzzy sets

The expansion of Intuitionistic Fuzzy Sets (IFS) as a traditional fuzzy set was first proposed by the Bulgarian scholar Atanassov in 1986 [8]. Intuitionistic fuzzy sets consider the three aspects of membership degree, non-subordinate degree and hesitation degree, which is more flexible and practical than traditional fuzzy sets in dealing with ambiguity and uncertainty. This method determines the subjective weights as follows:

$\mu_j \in [0,1] (j = 1, 2, ..., n)$ and $\sum_{j=1}^{n} \mu_j = 1$.

Let the set of subjective weights obtained from the intuitionistic fuzzy set be called $\mu_j = (\mu_1, \mu_2, ..., \mu_n)^T$, $\mu_j \in [0,1] (j = 1, 2, ..., n)$ and $\sum_{j=1}^{n} \mu_j = 1$

step1: The evaluation matrix M_k is constructed by a quantitative ranking table.

Considering the hesitation and bias of the experts in judging the importance of indicators, the intuitionistic fuzzy set of expert hesitation is introduced. First, based on the results of previous research, establish a quantitative importance scale for indicators. Secondly, based on the decision maker's evaluation of the importance of the indicator data, combined with the indicator importance quantitative rating table, the evaluation matrix M_k is constructed as follows.

$$M_k = \left(\langle \alpha_{ij}, \beta_{ij} \rangle_k\right)_{m \times n} = \begin{bmatrix} \langle \alpha_{11}, \beta_{11} \rangle_k & \langle \alpha_{12}, \beta_{12} \rangle_k & \cdots & \langle \alpha_{1n}, \beta_{1n} \rangle_k \\ \langle \alpha_{21}, \beta_{21} \rangle_k & \langle \alpha_{22}, \beta_{22} \rangle_k & \cdots & \langle \alpha_{2n}, \beta_{2n} \rangle_k \\ \cdots & \cdots & \cdots & \cdots \\ \langle \alpha_{m1}, \beta_{m1} \rangle_k & \langle \alpha_{m2}, \beta_{m2} \rangle_k & \cdots & \langle \alpha_{mn}, \beta_{mn} \rangle_k \end{bmatrix} \tag{4}$$

In the equation (4), $k = 1, 2, ..., p$; p is the number of decision makers; $\langle \alpha, \beta \rangle$ is the intuitionistic fuzzy number of the importance of the indicator; α is the membership degree and β is the non-membership degree, and satisfies $0 \le \alpha + \beta \le 1$.

step2: Building an aggregation matrix W with IFWA.

IFWA is an intuitionistic fuzzy weighted average operator. These fuzzy numbers of different weights could be weighted average by the IFWA. This paper uses IFWA to calculate the intuitionistic fuzzy numbers under different decision makers to construct an aggregate matrix W shown as follows.

$$W = \left(\left\langle \theta_{ij}, \sigma_{ij} \right\rangle\right)_{m\times n} = \begin{bmatrix} \langle \theta_{11}, \sigma_{11} \rangle & \langle \theta_{12}, \sigma_{12} \rangle & \dots & \langle \theta_{1n}, \sigma_{1n} \rangle \\ \langle \theta_{21}, \sigma_{21} \rangle & \langle \theta_{22}, \sigma_{22} \rangle & \dots & \langle \theta_{2n}, \sigma_{2n} \rangle \\ \dots & \dots & \dots & \dots \\ \langle \theta_{m1}, \sigma_{m1} \rangle & \langle \theta_{m2}, \sigma_{m2} \rangle & \dots & \langle \theta_{mn}, \sigma_{mn} \rangle \end{bmatrix} \tag{5}$$

In the equation (5),

$$\left\langle \theta_{ij}, \sigma_{ij} \right\rangle = \text{IFWA}_{\eta}\left(\left\langle \alpha_{ij}, \beta_{ij} \right\rangle_1, \left\langle \alpha_{ij}, \beta_{ij} \right\rangle_2, \dots, \left\langle \alpha_{ij}, \beta_{ij} \right\rangle_p\right)$$

$$= \eta_1 \left\langle \alpha_{ij}, \beta_{ij} \right\rangle_1 + \eta_2 \left\langle \alpha_{ij}, \beta_{ij} \right\rangle_2 + \dots + \eta_p \left\langle \alpha_{ij}, \beta_{ij} \right\rangle_p \tag{6}$$

step3: Calculate the fuzzy entropy of the jth indicator.

Assume that $\left\langle \theta_{ij}, \sigma_{ij} \right\rangle$ represents the intuitionistic fuzzy number of the service provider i for each index evaluation value j, θ_{ij} is the membership degree, σ_{ij} is the non-membership degree, and the hesitation degree $\pi_{ij} = 1 - \theta_{ij} - \sigma_{ij}$ is introduced, then the fuzzy entropy as shown:

$$E_j = -\frac{1}{\ln m}\sum_{i=1}^{m}\left(1-\pi_{ij}\right)\ln\left(1-\pi_{ij}\right) \left(j = 1,2,\dots,n\right) \tag{7}$$

step4: Calculate the subjective weight of the jth indicator.

$$\mu_j = \frac{1-E_j}{n-\sum_{j=1}^{n} E_j} \left(j = 1,2,\dots,n\right) \tag{8}$$

3.2.2 Determination of objective weight based on entropy weight method

The entropy weight method determines the weight according to the information entropy contained in the objective data of the index, which can avoid the influence of the decision maker's subjective judgment. As a thermodynamic concept, entropy was first introduced into information theory by Shannon. Information entropy is related to the degree of dispersion of information. The larger the information entropy, the more discrete the information, and the smaller the information entropy, the more concentrated the information [9]. This method determines the objective weight calculation steps as follows:

Assume that the objective weight set obtained by the entropy weight method is $\lambda_j = \left(\lambda_1, \lambda_2, \dots, \lambda_n\right)^T$, where $\lambda_j \in [0,1] \left(j = 1,2,\dots,n\right)$, $\sum_{j=1}^{n}\lambda_j = 1$.

step1: Calculate the information entropy of the jth indicator.

$$E_j' = -\frac{1}{\ln m}\sum_{i=1}^{m} p_{ij} \ln p_{ij} \left(j = 1,2,\dots,n\right) \tag{9}$$

In the equation (9),

$p_{ij} = \frac{z_{ij}}{\sum_{i=1}^{m} z_{ij}} \left(j = 1,2,\dots,n\right)$ and when $p_{ij} = 0$, define that $\lim_{p_{ij}\to 0} p_{ij} \ln p_{ij} = 0$.

step2: Calculate the objective weight of the jth indicator.

$$\lambda_j = \frac{1-E_j'}{n-\sum_{j=1}^{n} E_j'} \quad (j=1,2,...,n) \tag{10}$$

3.2.3 Calculate subjective and objective combination weight

Assume that the final indicator weight set is $\omega_j = (\omega_1, \omega_2, ..., \omega_n)^T$, $\omega_j \in [0,1](j=1,2,...,n)$ and $\sum_{j=1}^{n} \omega_j = 1$.

The Lagrangian multiplication optimization is performed on the weight of the indicators obtained by the intuitionistic fuzzy set and the entropy weight method respectively, and the final weight can be obtained as follows.

$$\omega_j = \frac{\sqrt{\mu_j \lambda_j}}{\sum_{j=1}^{n} \sqrt{\mu_j \lambda_j}} \quad (j=1,2,...,n) \tag{11}$$

3.3 TOPSIS decision model

The TOPSIS method (Technique for Order Preference by Similarity to an Ideal Solution), which approximates the ideal solution ranking method, was first proposed by C.L.HWANG et al. in 1981 [10]. As a method for multi-objective decision analysis of finite schemes, it is based on the convergence normalization matrix, solves the optimal and worst scheme, and ranks the evaluation targets by calculating the closeness of the evaluation target and the optimal worst-case solution distance. Make decisions. The specific solution steps are as follows:

3.3.1 Constructing a weighted normalized decision matrix S

$$S = (s_{ij})_{m\times n} = \omega_{ij} Z = \begin{bmatrix} \omega_1 z_{11} & \omega_2 z_{12} & \cdots & \omega_n z_{1n} \\ \omega_1 z_{21} & \omega_2 z_{22} & \cdots & \omega_n z_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \omega_1 z_{m1} & \omega_2 z_{m2} & \cdots & \omega_n z_{mn} \end{bmatrix}$$

3.3.2 Solving the optimal vector and the worst vector

$$S^+ = \max_{1\le i\le m}(s_{ij}) = \left(\max_{1\le i\le m}(s_{i1}), \max_{1\le i\le m}(s_{i2}), ..., \max_{1\le i\le m}(s_{in})\right) \tag{12}$$

$$S^- = \min_{1\le i\le m}(s_{ij}) = \left(\min_{1\le i\le m}(s_{i1}), \min_{1\le i\le m}(s_{i2}), ..., \min_{1\le i\le m}(s_{in})\right) \tag{13}$$

3.3.3 Solving the optimal vector S^+ and the worst vector S^- .

Calculate the Euclidean distance D_i^+ and D_i^- between the jth evaluation target and the optimal vector S^+ and the worst vector S^-:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left(\max_{1\le i\le m}(s_{ij}) - s_{ij}\right)^2} \tag{14}$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} \left(\min_{1\le i\le m}(s_{ij}) - s_{ij}\right)^2} \tag{15}$$

3.3.4 Calculating the closeness C_i of the ith evaluation target to the optimal vector S^+ is:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{16}$$

According to the TOPSIS principle, C_i is sorted in descending order. The larger C_i is, the closer the logistics service capability of the evaluation target is to the ideal solution, to determine the optimal solution of the decision set X .

4. Case analysis

Agricultural product e-commerce limited liability company is a specialized e-commerce service platform for agricultural products in the northwest region and is headquartered in Yan'an, Shaanxi Province, China. Under the support of the county government and various provincial and municipal departments, the company is engaged in the cultivation, acquisition, storage and sales of local kiwifruit and apples. Through industrialization, branding and quality of agricultural products, the company has effectively strengthened the production and marketing of agricultural products and played an active role in the precise poverty alleviation and rural revitalization of e-commerce.

In order to reduce transportation costs and concentrate on expanding the marketing business, the company wants to outsource its logistics business. The company has five decision makers $\left(M_1, M_2, M_3, M_4, M_5\right)$, with different decision weights $\left(0.3, 0.2, 0.2, 0.15, 0.15\right)$. Under the call of the national "green logistics", four candidate service providers $\left(R_1, R_2, R_3, R_4\right)$ were initially selected through market research by policymakers. The decision makers use the five first-level indicator evaluation systems in Table 1 and use the combined weighting-TOPSIS method to evaluate and rank the candidate service providers. The candidate service provider raw data is shown in Table 2.

4.1 Raw data processing

According to the data in Table 2, a decision matrix $X = \left(x_{ij}\right)_{4\times 20}$ of 4 rows and 20 columns is established. Where x_{ij} represents the value of the ith indicator of the jth service provider, $i = 1, 2, 3, 4$ and $j = 1, 2, ..., 20$.

Table 2 Raw data of four candidate service providers

	R1	R2	R3	R4
A1	4.00	6.00	4.00	3.00
A2	6.30	6.80	7.10	7.40
A3	49.68%	51.22%	47.49%	49.44%
A4	23.73%	21.83%	22.51%	20.32%
B1	130.00	170.00	110.00	190.00
C1	91.22%	93.39%	89.61%	90.74%
C2	3.76%	4.24%	4.77%	3.28%
C3	91.70%	95.92%	91.03%	94.15%
C4	1.50	1.70	1.40	1.20
D1	69.75	75.23	74.71	68.72
D2	90.69%	89.00%	89.95%	85.97%
D3	9.30	8.40	8.10	8.70
D4	6.70	8.30	6.60	7.10
D5	8.10	8.00	8.50	8.20
E1	93.78%	90.69%	92.18%	94.59%
E2	8.50	7.80	9.20	8.70
F1	31.57%	36.01%	27.48%	32.61%

F2	6.31%	1.74%	4.57%	3.17%
F3	6.10	7.80	6.90	6.30
F4	8.70	8.20	9.10	8.80

According to equations (1) and (2), the positive and negative property indicators in the decision matrix are processed separately, and the indicators are normalized in combination with equation (3) to obtain the convergence normalization matrix Z as follows.

$$Z=\begin{bmatrix} 0.4851 & 0 & 0.4851 & 0.7276 \\ 0.8538 & 0.4657 & 0.2328 & 0 \\ 0.4616 & 0.7862 & 0 & 0.4110 \\ 0.7885 & 0.3491 & 0.5064 & 0 \\ 0.1961 & 0.5883 & 0 & 0.7845 \\ 0.4254 & 0 & 0.7410 & 0.5195 \\ 0.2614 & 0.5228 & 0.8114 & 0 \\ 0.6301 & 0 & 0.7301 & 0.2643 \\ 0.4867 & 0.8111 & 0.3244 & 0 \\ 0.6428 & 0 & 0.0610 & 0.7636 \\ 0 & 0.3335 & 0.1460 & 0.9314 \\ 0 & 0.5571 & 0.7428 & 0.3714 \\ 0.6096 & 0 & 0.6476 & 0.4572 \\ 0.5657 & 0.7071 & 0 & 0.4243 \\ 0.1740 & 0.8377 & 0.5177 & 0 \\ 0.4260 & 0.8520 & 0 & 0.3043 \\ 0.4353 & 0 & 0.8363 & 0.3333 \\ 0 & 0.7864 & 0.2994 & 0.5403 \\ 0.6969 & 0 & 0.3690 & 0.6149 \\ 0.3885 & 0.8742 & 0 & 0.2914 \end{bmatrix}^T$$

4.2 Weight calculation

4.2.1 Subjective weight determination

Refer to the existing data and the previous literature, and establish a quantitative data level of the indicator data, as shown in Table 3:

Table 3 Indicator data importance quantization scale

Indicator data importance	Evaluation value intuitionistic fuzzy number
Extremely important	<0.90,0.10>
important	<0.70,0.25>
medium	<0.50,0.35>
unimportant	<0.30,0.60>
Extremely unimportant	<0.10,0.90>

The five decision makers $(M_1, M_2, M_3, M_4, M_5)$ evaluated the program data according to the actual situation, and obtained specific intuitionistic fuzzy numbers, and constructed the evaluation matrix of five decision makers according to the form of the formula. The five decision matrices are:

$$M_1=\left(\left\langle \alpha_{ij},\beta_{ij}\right\rangle_1\right)_{4\times 20},\ M_2=\left(\left\langle \alpha_{ij},\beta_{ij}\right\rangle_2\right)_{4\times 20},$$

$$M_3=\left(\left\langle \alpha_{ij},\beta_{ij}\right\rangle_3\right)_{4\times20},M_4=\left(\left\langle \alpha_{ij},\beta_{ij}\right\rangle_4\right)_{4\times20},M_5=\left(\left\langle \alpha_{ij},\beta_{ij}\right\rangle_5\right)_{4\times20}.$$

Since the decision weights of the five decision makers are different, the above five evaluation matrices are weighted and averaged according to equation (6) and the IFWA operator is used to obtain an aggregation matrix called W.

$$W=\left(\left\langle \theta_{ij},\sigma_{ij}\right\rangle\right)_{4\times20}=\begin{bmatrix}
\langle0.54,0.37\rangle & \langle0.58,0.35\rangle & \langle0.54,0.37\rangle & \langle0.58,0.35\rangle\\
\langle0.63,0.30\rangle & \langle0.80,0.18\rangle & \langle0.63,0.30\rangle & \langle0.57,0.35\rangle\\
\langle0.58,0.35\rangle & \langle0.51,0.39\rangle & \langle0.58,0.35\rangle & \langle0.58,0.35\rangle\\
\langle0.47,0.42\rangle & \langle0.67,0.28\rangle & \langle0.55,0.37\rangle & \langle0.69,0.26\rangle\\
\langle0.78,0.19\rangle & \langle0.75,0.22\rangle & \langle0.78,0.19\rangle & \langle0.82,0.17\rangle\\
\langle0.69,0.26\rangle & \langle0.80,0.18\rangle & \langle0.69,0.26\rangle & \langle0.81,0.17\rangle\\
\langle0.75,0.22\rangle & \langle0.80,0.18\rangle & \langle0.75,0.22\rangle & \langle0.76,0.21\rangle\\
\langle0.78,0.19\rangle & \langle0.83,0.16\rangle & \langle0.78,0.19\rangle & \langle0.78,0.20\rangle\\
\langle0.75,0.22\rangle & \langle0.81,0.17\rangle & \langle0.75,0.22\rangle & \langle0.80,0.18\rangle\\
\langle0.74,0.22\rangle & \langle0.85,0.14\rangle & \langle0.74,0.22\rangle & \langle0.62,0.31\rangle\\
\langle0.63,0.30\rangle & \langle0.83,0.16\rangle & \langle0.63,0.30\rangle & \langle0.60,0.32\rangle\\
\langle0.81,0.17\rangle & \langle0.74,0.22\rangle & \langle0.81,0.17\rangle & \langle0.71,0.24\rangle\\
\langle0.74,0.22\rangle & \langle0.78,0.20\rangle & \langle0.74,0.22\rangle & \langle0.72,0.24\rangle\\
\langle0.54,0.37\rangle & \langle0.71,0.25\rangle & \langle0.54,0.37\rangle & \langle0.74,0.22\rangle\\
\langle0.76,0.21\rangle & \langle0.78,0.20\rangle & \langle0.76,0.21\rangle & \langle0.88,0.12\rangle\\
\langle0.74,0.23\rangle & \langle0.78,0.20\rangle & \langle0.74,0.23\rangle & \langle0.67,0.27\rangle\\
\langle0.74,0.22\rangle & \langle0.86,0.13\rangle & \langle0.74,0.22\rangle & \langle0.77,0.20\rangle\\
\langle0.70,0.25\rangle & \langle0.74,0.23\rangle & \langle0.70,0.25\rangle & \langle0.70,0.25\rangle\\
\langle0.76,0.21\rangle & \langle0.77,0.20\rangle & \langle0.76,0.21\rangle & \langle0.77,0.20\rangle\\
\langle0.55,0.36\rangle & \langle0.70,0.25\rangle & \langle0.55,0.36\rangle & \langle0.53,0.39\rangle
\end{bmatrix}^T$$

According to equations (7) and (8), after obtaining the hesitation degree and the intuitionistic fuzzy entropy, the subjective weights of all indicators can be calculated.

$$\mu=(0.0439,0.0477,0.0441,0.0458,0.0528,0.0516,0.0519,0.0534,0.0526,0.0510,$$
$$0.0483,0.0527,0.0514,0.0471,0.0534,0.0509,0.0527,0.0504,0.0527,0.0455)^T$$

4.2.2 Objective weight determination

Combine the above-mentioned convergence normalization matrix Z with equations (9) and (10) to calculate the information entropy and objective weight of all indicators.

$$\lambda=(0.0409,0.0548,0.0440,0.0455,0.0548,0.0419,0.0506,0.0485,0.0475,0.0736,$$
$$0.0714,0.0433,0.0397,0.0411,0.0589,0.0509,0.0488,0.0476,0.0427,0.0535)^T$$

4.2.3 Final weight determination

According to the formula (11) and the obtained subjective weight μ and the objective weight λ, the Lagrangian multiplication optimization is performed, and the final index weights ω can be obtained.

$$\omega=(0.0425,0.0513,0.0442,0.0459,0.0540,0.0467,0.0515,0.0511,0.0502,0.0615$$
$$0.0590,0.0480,0.0454,0.0422,0.0563,0.0511,0.0509,0.0492,0.0476,0.0496)^T$$

4.3 TOPSIS sorting and decision making

Multiplying the above-calculated weight ω by the convergence normalization matrix Z to construct a weighted normalized decision matrix S:

$$S=\begin{bmatrix} 0.020631 & 0 & 0.020631 & 0.030947 \\ 0.043829 & 0.023907 & 0.011953 & 0 \\ 0.020408 & 0.034759 & 0 & 0.018171 \\ 0.036163 & 0.016013 & 0.023225 & 0 \\ 0.010590 & 0.031771 & 0 & 0.042361 \\ 0.019857 & 0 & 0.034589 & 0.024249 \\ 0.013459 & 0.026917 & 0.041778 & 0 \\ 0.032179 & 0 & 0.037288 & 0.013497 \\ 0.024411 & 0.040685 & 0.016274 & 0 \\ 0.039524 & 0 & 0.003750 & 0.046953 \\ 0 & 0.019665 & 0.008611 & 0.054921 \\ 0 & 0.026723 & 0.035631 & 0.017816 \\ 0.027660 & 0 & 0.029389 & 0.020745 \\ 0.024986 & 0.031233 & 0 & 0.018740 \\ 0.009801 & 0.047191 & 0.029162 & 0 \\ 0.021779 & 0.043557 & 0 & 0.015556 \\ 0.022160 & 0 & 0.042572 & 0.016969 \\ 0 & 0.038660 & 0.014720 & 0.026563 \\ 0.033178 & 0 & 0.017565 & 0.029275 \\ 0.019253 & 0.043320 & 0 & 0.014440 \end{bmatrix}^T$$

Using the weighted normalized decision matrix S, according to equations (12) and (13), calculate the optimal solution S^+ and the worst solution S^- in each service provider evaluation index.

$$S^+=(0.0309,0.0438,0.0348,0.0362,0.0424,0.0346,0.0418,0.0373,0.0407,0.0470$$
$$0.0549,0.0356,0.0294,0.0312,0.0472,0.0436,0.0426,0.0387,0.0332,0.0433)$$
$$S^-=(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)$$

According to equations (14) and (15), the Euclidean distances D_i^+ and D_i^- between each service provider R_i and the optimal solution S^+ and the worst solution S^- can be calculated; and then the service provider to be evaluated can be calculated according to formula (16). The closeness of R_i to the optimal solution S^+ is C_i, thus the final ordering, as shown in Table 4.

Table 4 Final rank by service providers

	R1	R2	R3	R4
Distance from S^+	0.1067	0.1095	0.1216	0.1131
Distance from S^-	0.1090	0.1225	0.1054	0.1117
Proximity C_i	0.5053	0.5280	0.4643	0.4969
Final rank	2	1	4	3

It can be seen from Table 4 that the gap between the four candidate service providers is small. If you want to choose the best partner, you should consider the proximity to the optimal solution S1. The closer the degree, the green logistics you can provide. The closer the service capability is to the optimal solution, the more it meets the cooperation requirements of Company A.

The order of the proximity C_i is: $C_2 > C_1 > C_4 > C_3$, so the final ranking of the green logistics service providers is: R2>R1>R4>R3. The results show that R2 is the best partner among the four candidates green logistics service providers. It is the green logistics service provider that is the preferred partner. The evaluation results of R2 and R4 are relatively good, which can be used as the potential partner of the company, and the evaluation result of R3 is the worst, and its serviceability does not meet the needs of the company's cooperation, it may not be considered in the short term.

5. Conclusion

In the context of "greening" of agricultural products logistics industry, in order to speed up the construction of new countryside and promote the accurate poverty alleviation process of rural e-commerce in China, it is essential for a set of scientific, effective, flexible and operable third-party logistics service providers to choose evaluation and selection methods. This paper designs a service provider evaluation index system that pays attention to the green execution ability of logistics enterprises. Considering the hesitation and biased subjectivity of experts in judging the importance of indicators, the combination of intuitionistic fuzzy sets and entropy weights is used to reduce the error of the single weight determination method on the result and increases the accuracy of the evaluation process, and provides a theoretical reference for the selection of third-party green logistics service providers of agricultural products in the future.

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