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RESEARCH ARTICLE

Cost control of cold chain delivery for logistics companies

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With the continuous development and application of modern logistics technology, logistics cost has become one of the important factors of enterprise competition. For the special field of cold chain logistics distribution, cost control is particularly critical. By studying the control method of cold chain distribution cost, this paper introduces how to reasonably optimize the distribution cost while effectively controlling the distribution cost so as to improve the competitiveness of enterprises. This paper sorts out the relevant theoretical overview and conceptual analysis and analyzes the current situation of cold chain distribution cost control in logistics companies. Then, the existing logistics cost control system is evaluated, and the hierarchical analysis method and model comprehensive evaluation method are used to analyze the current control system score and problems that require additional attention and find the cause of the problem. Finally, rectification suggestions are put forward to improve distribution costs to enhance the competitive strength of enterprises.

Keywords: logistics distribution, cold chain logistics, cost control, distribution efficiency, food

1. Introduction

With the continuous expansion of agricultural products and cold chain logistics in the market, more and more cold chain companies have entered the market competition (1). In order to maintain industry competitiveness, reduce comprehensive logistics costs, and improve customer satisfaction, the control of logistics costs has become the focus of enterprises. Especially in industries such as e-commerce, the status of logistics cannot be ignored (2, 3). Logistics costs directly affect the company's profits and have a crucial impact on its competitive position. Therefore, controlling the cost of logistics and distribution is of great significance to enterprises. This paper adopts the hierarchical analysis method and the fuzzy comprehensive evaluation method to analyze and evaluate the factors affecting the logistics distribution cost of logistics companies (4). By collecting data and analyzing the scores of the current control influencing factors, it is found that the cold chain distribution cost module needs additional attention and further sorts out the existing problems and causes and puts forward corresponding rectification suggestions to achieve the purpose of reducing logistics costs. Effectively reducing logistics costs can not only make product prices competitive but also bring more economic benefits to enterprises and help logistics companies improve their logistics service level (5).

With the continuous expansion of agricultural products and cold chain logistics in the market, more and more cold chain companies have entered the market competition (6). In order to maintain industry competitiveness, reduce comprehensive logistics costs, and improve customer satisfaction, the control of logistics costs has become the focus of enterprises. Especially in industries such as e-commerce, the status of logistics cannot be ignored (7, 8). Logistics costs directly affect the company's profits and have a crucial impact on its competitive position. Therefore, controlling the cost of logistics and distribution is of great significance to enterprises. This paper adopts the hierarchical analysis method and the fuzzy comprehensive evaluation method to analyze and evaluate the factors affecting the logistics distribution cost of logistics companies. By collecting data and analyzing the scores of the current control influencing factors, it is found that the cold chain

distribution cost module needs additional attention and further sorts out the existing problems and causes and puts forward corresponding rectification suggestions to achieve the purpose of reducing logistics costs. Effectively reducing logistics costs can not only make product prices competitive but also bring more economic benefits to enterprises and help logistics companies improve their logistics service level.

2. Literature review

In view of the research on the cold chain logistics model, Li et al. (9) pointed out that China's cold chain logistics market is expanding. Through empirical research, they have identified three different cold chain logistics models, namely, self-built cold chain logistics, third-party cold chain, and "self-operated + third-party" compound mode. Through the analysis of these three different logistics models, we have found out the bottlenecks in the development of cold chain logistics in China and put forward feasible suggestions. In addition, Liu et al. (10) studied the current situation of cold chain logistics of fresh agricultural products in Guangxi and found existing problems and development bottlenecks. Yu et al. (11) studied the current situation of cold chain logistics development of more than 100 fresh e-commerce companies, including infrastructure construction and consumer satisfaction, and found that the comprehensive score of the self-built logistics model was the highest. A cold chain logistics model in line with the actual development situation has been established to solve the practical problems encountered on the development road through multiple channels. Zhou et al. (12) studied the development status of cold chain logistics of more than 100 fresh e-commerce companies, including infrastructure construction and consumer satisfaction, and found that the comprehensive score of the self-built logistics model was the highest.

In terms of cold chain logistics distribution, Chen et al. (13) conducted an in-depth analysis of the cold chain distribution of pine mushrooms. Combined with the preservation methods of pine antler products and various preservation processes, they studied and discussed the main reasons for the time consumption and inefficiency of logistics and distribution of pine antler products. On this basis, they established a guarantee and a safe urban and rural public distribution service system, with the help of a safe and perfect information sharing system, replanning, and setting up logistics distribution outlets to improve the efficiency of logistics distribution. In addition, Yu et al. (14) discussed the issue from the perspective of interference management. By measuring the freshness of agricultural products and measuring the distribution service time, they built an acceptance recovery model of logistics distribution and used the start-up algorithm to analyze model requests to provide the efficiency and reliability of high-flow distribution. These studies provide new ideas and methods for the development of cold chain logistics and are expected to be more widely applied and promoted in practice.

In terms of logistics cost control, Chu et al. (15) pointed out that the use of advanced logistics technology can improve logistics efficiency, which can effectively improve all aspects of the entire logistics service, thus reducing labor and error costs. Zhou et al. (16) believe that in modern logistics companies, there will be a new development direction, that is, third-party logistics and outsourcing or subcontracting their business. For enterprises, reducing logistics costs is one of the keys to improving their competitiveness. Borgström et al. (17) pointed out that for today's enterprises, controlling logistics costs is to control the lifeline of the whole enterprise, so it is very important to solve the corresponding cost control problem. Due to the many factors affecting logistics today, attention should be paid to the collection, production, and sales of corresponding products; make full use of modern scientific and technological means to continuously improve the overall logistics and transportation system; and find the best solution. According to He et al. (18) logistics control is playing a more and more prominent role with the continuous rise of the service industry. It is conducive to adjusting the economic structure, strengthening regional coordination, and continuously enriching economic benefits.

3. Construction of the logistics delivery cost evaluation system

3.1. Establishment of the evaluation index system

According to the actual situation, this paper determines the criterion layer of timeliness, competitiveness, safety, and management A, that is, the first-level index layer. In the decision-making of these four first-level indicators, a total of 12 second-level indicators, namely, the indicator layer, are subdivided, and the entire indicator system is constructed, as shown in **Table 1** (refer to **Appendix Table 1**).

3.2. Construct the target layer and the first-level indicator layer judgment matrix

Experts are scored by Form A2 in the questionnaire and the importance of factors under the secondary indicator layer is compared, as shown in **Table 2**.

TABLE 1 | Evaluation index system.

Target layer	Level indicators 1	Level indicators 2
Factors influencing the cost of cold chain distribution A	Timeliness factor U1	Delivery distance U11
		Distribution station location U12
		Quality of distribution personnel U13
		Fulfillment tool selection U14
	Competitive factors U2	Infrastructure construction U21
		Cold chain input levels U22
		Distribution processing capacity U23
		Information processing capabilities U24
	Security factors U3	Cold chain distribution capabilities U31
		Cold storage capacity U32
	Management factors U4	Distribution team building U41
		Logistics management capabilities U42

3.3. Construct the judgment matrix of the first-level indicator layer and the second-level indicator layer

Experts are scored by Forms A3–A6 in the questionnaire and the importance of factors under the secondary indicator layer is compared, as shown in **Tables 3–6**.

Take the target layer and the first-level indicator layer A-Bi as examples.

Multiplication results:

$$a_1 = 1 \times 2 \times 1 \times 3 = 6.0000$$

$$a_2 = \frac{1}{2} \times 1 \times 1 \times 1 = 0.5000$$

$$a_3 = 1 \times 1 \times 1 \times 1 = 1.0000$$

$$a_4 = \frac{1}{3} \times 1 \times 1 \times 1 = 0.3333$$

$$(a = U1 \times U2 \times U3 \times U4)$$

Open to the nth power to get the eigenvector bi

$$b_1 = (a_1)^{\frac{1}{4}} = 1.5651$$

$$b_2 = (a_2)^{\frac{1}{4}} = 0.8409$$

$$b_3 = (a_3)^{\frac{1}{4}} = 1.0000$$

$$b_4 = (a_4)^{\frac{1}{4}} = 0.7598$$

Normalize BI: Get the indicator weight vector

$$w_A = \left(\frac{1.5651}{4.1658}, \frac{0.8409}{4.1658}, \frac{1.0000}{4.1658}, \frac{0.7598}{4.1658}\right)^T = (0.3757, 0.2019, 0.2400, 0.1824)^T$$

The maximum feature value corresponding to the weight vector w

$$Aw_A = \begin{bmatrix} 1 & 2 & 1 & 3 \\ 1/2 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1/3 & 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} 0.3757 \\ 0.2019 \\ 0.2400 \\ 0.1824 \end{bmatrix} = \begin{bmatrix} 1.5667 \\ 0.8122 \\ 1.0000 \\ 0.7495 \end{bmatrix}$$

$$\lambda_A max = \frac{\left(\frac{1.5667}{0.3757} + \frac{0.8122}{0.2019} + \frac{1.0000}{0.2400} + \frac{0.7495}{0.1824}\right)}{4} = 4.1171$$

The judgment matrix for the target layer and the criterion layer, n = 4, RI = 0.9, CI = (4.1171-4)/3 = 0.0390, CR = 0.0390/0.9 = 0.0434 = 0.1, is determined. Therefore, it is judged that the matrix A–Bi passes the consistency test.

Similarly, the index weight vector and consistency test value CR corresponding to the judgment matrix of the first-level index layer and the second-level index layer are calculated, and they all pass the consistency test.

3.4. Calculation of combined weights

After calculating the weights of the indicators of the criterion layer and the indicator layer corresponding to their parent indicators, the combined weights are calculated. The method is to multiply the weight of each indicator layer by its corresponding benchmark layer weight, refer to **Appendix Table 7**, as shown in **Table 7**.

4. The use of the fuzzy comprehensive evaluation method

4.1. Multifactor fuzzy judgment

The evaluation indicators of specific factors are scored according to the actual situation, refer to **Appendix Table 8**, and the specific data are shown in **Table 8**.

According to the expert scoring data in **Table 8**, the index membership of each indicator layer, that is, the initial membership degree, can be obtained, as shown in **Table 9**.

TABLE 2 | Judgment matrix of the target layer and first-level index layer.

A	Timeliness factor U1	Competitive factors U2	Security factors U3	Management factors U4	w_A	λ *max*	*CR*
Timeliness factor U1	1	2	1	3	0.3757	4.1171	0.0434 < 0.1 Pass the consistency check
Competitive factors U2	1/2	1	1	1	0.2019		
Security factors U3	1	1	1	1	0.2400		
Management factors U4	1/3	1	1	1	0.1824		

TABLE 3 | Index layer judgment matrix under timeliness factors.

Timeliness factor U1	Delivery distance U11	Distribution station location U12	Quality of distribution personnel U13	Fulfillment tool selection U14	wB1	λ max	CR
Delivery distance U11	1	2	2	6	0.4438	4.1050	0.0389 < 0.1 Pass the consistency check
Distribution station location U12	1/2	1	1/2	5	0.2120		
Quality of distribution personnel U13	1/2	2	1	4	0.2836		
Fulfillment tool selection U14	1/6	1/5	1/4	1	0.0606		

TABLE 4 | Judgment matrix of the index layer under competitive factors.

Competitive factors U2	Infrastructure construction U21	Cold chain input levels U22	Distribution processing capacity U23	Information processing capabilities U24	wB2	λ max	CR
Infrastructure construction U21	1	1	3	1	0.3126	4.1171	0.0434 < 0.1 Pass the consistency check
Cold chain input levels U22	1	1	2	2	0.3359		
Distribution processing capacity U23	1/3	1/2	1	1	0.1518		
Information processing capabilities U24	1	1/2	1	1	0.1997		

According to **Table 9**, the comprehensive fuzzy matrix of the secondary index layer is established.

(1) Evaluation of timeliness factors:

$$w_{B1} = \{0.4438\ 0.2120\ 0.2836\ 0.0606\}$$

$$R_{B1} = \begin{bmatrix} 0.4000 & 0.3667 & 0.1667 & 0.0667 & 0.0000 \\ 0.4333 & 0.1333 & 0.2333 & 0.1333 & 0.0667 \\ 0.5667 & 0.2333 & 0.0667 & 0.0667 & 0.0667 \\ 0.2667 & 0.2667 & 0.2000 & 0.2000 & 0.0667 \end{bmatrix}$$

$$S_{B1} = w_{B1} \cdot R_{B1} = \{0.4438\ 0.2120\ 0.2836\ 0.0606\} \times \begin{bmatrix} 0.4000 & 0.3667 & 0.1667 & 0.0667 & 0.0000 \\ 0.4333 & 0.1333 & 0.2333 & 0.1333 & 0.0667 \\ 0.5667 & 0.2333 & 0.0667 & 0.0667 & 0.0667 \\ 0.2667 & 0.2667 & 0.2000 & 0.2000 & 0.0667 \end{bmatrix}$$

$$= (0.4463\ 0.2733\ 0.1545\ 0.0889\ 0.0371)$$

(2) Evaluation of competitive factors:

$$w_{B2} = \{0.3126\ 0.3359\ 0.1518\ 0.1997\}$$

$$R_{B2} = \begin{bmatrix} 0.6000 & 0.2667 & 0.1333 & 0.0000 & 0.0000 \\ 0.0667 & 0.0667 & 0.1333 & 0.5000 & 0.2333 \\ 0.2333 & 0.4667 & 0.2000 & 0.0667 & 0.0333 \\ 0.2333 & 0.2333 & 0.4667 & 0.0333 & 0.0333 \end{bmatrix}$$

TABLE 5 | Index layer judgment matrix under safety factors.

Security factors U3	Cold chain distribution capabilities U31	Cold storage capacity U32	wB2	λ max	CR
Cold chain distribution capabilities U31	1	2	0.6667	2.0000	0.0000 < 0.1 Pass the consistency check
Cold storage capacity U32	1/2	1	0.3333		

TABLE 6 | Judgment matrix of the index layer under management factors.

Management factors U4	Distribution team building U41	Logistics management capabilities U42	wB2	λ max	CR
Distribution team building U41	1	1/2	0.3333	2.0000	0.0000 < 0.1 Pass the consistency check
Logistics management capabilities U42	2	1	0.6667		

TABLE 7 | Combination weight of each indicator.

Level indicators 1	weight	Level indicators 2	Weight	Combined weights	Ordination
Timeliness factor	0.3757	Delivery distance U11	0.4438	0.1667	1
		Distribution station location U12	0.2120	0.0797	6
		Quality of distribution personnel U13	0.2836	0.1065	4
		Fulfillment tool selection U14	0.0606	0.0228	12
Competitive factors	0.2019	Infrastructure construction U21	0.3126	0.0631	8
		Cold chain input levels U22	0.3359	0.0678	7
		Distribution processing capacity U23	0.1518	0.0306	11
		Information processing capabilities U24	0.1997	0.0403	10
Security factors	0.2400	Cold chain distribution capabilities U31	0.6667	0.1600	2
		Cold storage capacity U32	0.3333	0.0800	5
Management factors	0.184	Distribution team building U41	0.3333	0.0608	9
		Logistics management capabilities U42	0.6667	0.1216	3

$$S_{B2} = w_{B2} \cdot R_{B2} = (0.2920\ 0.2232\ 0.2100\ 0.1847\ 0.0901)$$

(3) Evaluation of safety factors:

$$w_{B3} = \{0.6667\ 0.3333\}$$

$$R_{B3} = \begin{bmatrix} 0.3667 & 0.4000 & 0.1667 & 0.0667 & 0.0000 \\ 0.1333 & 0.3000 & 0.2667 & 0.2000 & 0.1000 \end{bmatrix}$$

$$S_{B3} = w_{B3} \cdot R_{B3} = (0.2889\ 0.3667\ 0.2000\ 0.1111\ 0.0333)$$

(4) Evaluation of management factors:

$$w_{B4} = \{0.3333\ 0.6667\}$$

$$R_{B4} = \begin{bmatrix} 0.2333 & 0.4667 & 0.1333 & 0.1667 & 0.0000 \\ 0.3667 & 0.2667 & 0.2667 & 0.1000 & 0.0000 \end{bmatrix}$$

$$S_{B4} = w_{B4} \cdot R_{B4} = (0.3222\ 0.3333\ 0.2222\ 0.1222\ 0.0000)$$

Multifactor fuzzy assessment:

Assessment of the overall target layer:

$$w_A = \{0.3757\ 0.2019\ 0.2400\ 0.1824\}$$

$$R_A = \begin{pmatrix} S_{B1} \\ S_{B2} \\ S_{B3} \\ S_{B4} \end{pmatrix} = \begin{bmatrix} 0.4463 & 0.2733 & 0.1545 & 0.0889 & 0.0371 \\ 0.2920 & 0.2232 & 0.2100 & 0.1847 & 0.0901 \\ 0.2889 & 0.3667 & 0.2000 & 0.1111 & 0.0333 \\ 0.3222 & 0.3333 & 0.2222 & 0.1222 & 0.0000 \end{bmatrix}$$

$$S_A = w_A \cdot R_A = (0.3547\ 0.2966\ 0.1890\ 0.1196\ 0.0401)$$

TABLE 8 | Expert scoring data sheet.

Indicators	Excellent	Good	Average	Discrepancy	Poor
Delivery distance U11	12	11	5	2	0
Distribution station location U12	13	4	7	4	2
Quality of distribution personnel U13	17	7	2	2	2
Fulfillment tool selection U14	8	8	6	6	2
Infrastructure construction U21	18	8	4	0	0
Cold chain input levels U22	2	2	4	15	7
Distribution processing capacity U23	7	14	6	2	1
Information processing capabilities U24	7	7	14	1	1
Cold chain distribution capabilities U31	11	12	5	2	0
Cold storage capacity U32	4	9	8	6	3
Distribution team building U41	7	14	4	5	0
Logistics management capabilities U42	11	8	8	3	0

TABLE 9 | Results of indicator layer membership.

Indicators	Excellent	Good	Average	Discrepancy	Poor
Delivery distance U11	0.4000	0.3667	0.1667	0.0667	0.0000
Distribution station location U12	0.4333	0.1333	0.2333	0.1333	0.0667
Quality of distribution personnel U13	0.5667	0.2333	0.0667	0.0667	0.0667
Fulfillment tool selection U14	0.2667	0.2667	0.2000	0.2000	0.0667
Infrastructure construction U21	0.6000	0.2667	0.1333	0.0000	0.0000
Cold chain input levels U22	0.0667	0.0667	0.1333	0.5000	0.2333
Distribution processing capacity U23	0.2333	0.4667	0.2000	0.0667	0.0333
Information processing capabilities U24	0.2333	0.2333	0.4667	0.0333	0.0333
Cold chain distribution capabilities U31	0.3667	0.4000	0.1667	0.0667	0.0000
Cold storage capacity U32	0.1333	0.3000	0.2667	0.2000	0.1000
Distribution team building U41	0.2333	0.4667	0.1333	0.1667	0.0000
Logistics management capabilities U42	0.3667	0.2667	0.2667	0.1000	0.0000

4.2. Comprehensive evaluation results

According to the formula $M_i = S_i \cdot V$, the final score of the B1-B4 index and the total system A is obtained:

$$M_{B1} = S_{B1} \cdot V = (0.4463\ 0.2733\ 0.1545\ 0.0889\ 0.0371) \begin{bmatrix} 100 \\ 80 \\ 60 \\ 40 \\ 20 \end{bmatrix} = 80.0559$$

The score of the timeliness factor is between 70 and 80, and the final evaluation is good.

$$M_{B2} = S_{B2} \cdot V = (0.2920\ 0.2232\ 0.2100\ 0.1847\ 0.0901) \begin{bmatrix} 100 \\ 80 \\ 60 \\ 40 \\ 20 \end{bmatrix} = 68.8439$$

The score of the competitive factor is between 50 and 70, and the final evaluation is average.

$$M_{B3} = S_{B3} \cdot V = (0.2889\ 0.3667\ 0.2000\ 0.1111\ 0.0333) \begin{bmatrix} 100 \\ 80 \\ 60 \\ 40 \\ 20 \end{bmatrix} = 75.3333$$

The score of the safety factor is between 70 and 90, and the final evaluation is good.

$$M_{B4} = S_{B4} \cdot V = (0.3222\ 0.3333\ 0.2222\ 0.1222\ 0.0000) \begin{bmatrix} 100 \\ 80 \\ 60 \\ 40 \\ 20 \end{bmatrix} = 77.1111$$

The score of the management factor is between 70 and 90, and the final evaluation is good.

$$M_A = S_A \cdot V = (0.3547\ 0.2966\ 0.1890\ 0.1196\ 0.0401) \begin{bmatrix} 100 \\ 80 \\ 60 \\ 40 \\ 20 \end{bmatrix} = 76.1219$$

According to the analysis results of the above method, it can be seen that the overall result of the influencing factors of logistics cost control is 80.0559, which is between 70 and 90, and the evaluation result of this system is good, indicating that logistics cost control or some indicators need to be better controlled.

5. Suggestions for improving delivery costs

First of all, we rationally plan the logistics network and transportation routes and reduce unnecessary logistics links so as to reduce logistics costs and improve distribution efficiency. To this end, intelligent technologies such as GPS navigation and logistics big data analytics can be adopted to improve the efficiency of logistics operations while reducing the waste of time and resources. A reasonable delivery route is determined. Whether the delivery route is reasonable or not has a great impact on the delivery speed, cost, and benefit, so scientific methods are used to determine the reasonable delivery routes. In addition, for different cargo types, transportation distances, and timeliness requirements, a variety of distribution methods can be adopted, such as road, rail, and air, as well as express delivery, special line distribution, and self-pickup, so as to flexibly apply and reduce costs.

Second, choosing a more cost-effective logistics service provider is also an important strategy. By comparing with different logistics service providers, we can find more favorable logistics services, and through long-term cooperation, we can also build trust and work together to reduce distribution costs. In addition, strengthening inventory management and optimizing warehouse management is also an important aspect. We reasonably control inventory, reduce inventory costs, optimize warehousing management, improve warehousing efficiency, and reduce warehousing costs.

Finally, in order to improve distribution efficiency and service quality, we can also strengthen the training and management of distribution staff, improve their service awareness and professional level, and adopt a scientific distribution management mode. In addition, the introduction of intelligent logistics equipment, such as automated warehouse management systems, logistics robots, drones, and so on, can improve logistics efficiency, reduce logistics costs, and improve logistics service levels.

6. Conclusion

Based on relevant theoretical research, this paper summarizes the operation process and composition of logistics costs of e-commerce enterprises from the basic definitions and related concepts of logistics cost and cold chain logistics. This paper conducts theoretical research on the logistics of logistics companies on their own logistics, analyzes relevant cases from the perspective of logistics costs, sorts out the problems and causes in logistics control costs, and scientifically evaluates the existing factors affecting distribution costs.

Author contributions

XX has written all the content of this manuscript.

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Appendix: Questionnaire

Dear Sir/Madam

Hello! I hope that for you to understand the logistics cost control of J company, your opinion will be of great help for our research; the questionnaire is filled in anonymously, the answer option is not right or wrong. I hope you answer truthfully. I sincerely thank you for your cooperation.

1. Problem description

This questionnaire takes the logistics cost control evaluation index system of J logistics company as the survey objective and uses the analytic hierarchy method to analyze its impact factors.

TABLE A1 | Hierarchical model.

Target layer	Level indicators 1	Level indicators 2
Factors influencing the cost of cold chain distribution	Timeliness factor U1	Delivery distance U11
		Distribution station location U12
		Quality of distribution personnel U13
		Fulfillment tool selection U14
	Competitive factors U2	Infrastructure construction U21
		Cold chain input levels U22
		Distribution processing capacity U23
		Information processing capabilities U24
	Security factors U3	Cold chain distribution capabilities U31
		Cold storage capacity U32
	Management factors U4	Distribution team building U41
		Logistics management capabilities U42

Second, please judge the relative importance of the elements of each level by comparing them in pairs, determine the relative importance of the factors of the next layer to a factor of the previous level, and assign a certain score in the corresponding space according to the 1–9 scale method.

TABLE A2 | Scale and description.

Index degree a_{ij}	Compare indicator meanings	Ratio
9	Absolutely important	Factor I compared to Factor J
7	Extremely important	Factor I compared to Factor J
5	Very important	Factor I compared to Factor J
3	More important	Factor I compared to Factor J
1	Equally important	Factor I compared to Factor J
2,4,6,8	Median adjacent scale	Factor I compared to Factor J
1/3	Less important	Factor I compared to Factor J
1/5	Very not important	Factor I compared to Factor J
1/7	Extremely not important	Factor I compared to Factor J
1/9	Absolutely not important	Factor I compared to Factor J
1/2,1/4,1/6,1/8	Median adjacent scale	Factor I compared to Factor J

TABLE A3 | Target layer and first-level indicator layer judgment matrix.

A	Timeliness factor U1	Competitive factors U2	Security factors U3	Management factors U4
Timeliness factor U1	1			
Competitive factors U2		1		
Security factors U3			1	
Management factors U4				1

TABLE A4 | Index layer judgment matrix under timeliness factors.

Timeliness factor U1	Delivery distance U11	Distribution station location U12	Quality of distribution personnel U13	Fulfillment tool selection U14
Delivery distance U11	1			
Distribution station location U12		1		
Quality of distribution personnel U13			1	
Fulfillment tool selection U14				1

TABLE A5 | Indicator layer judgment matrix under competitive factors.

Competitive factors U2	Infrastructure construction U21	Cold chain input levels U22	Distribution processing capacity U23	Information processing capabilities U24
Infrastructure construction U21	1			
Cold chain input levels U22		1		
Distribution processing capacity U23			1	
Information processing capabilities U24				1

TABLE A6 | Indicator layer judgment matrix under security factors.

Security factors U3	Cold chain distribution capabilities U31	Cold storage capacity U32
Cold chain distribution capabilities U31	1	
Cold storage capacity U32		1

TABLE A7 | Indicator layer judgment matrix under management factors.

Management factors U4	Distribution team building U41	Logistics management capabilities U42
Distribution team building U41	1	
Logistics management capabilities U42		1

TABLE A8 | Expert scoring data table.

Indicators	Excellent	Good	Averag	Discrepancy	Poor
Delivery distance U11					
Distribution station location U12					
Quality of distribution personnel U13					
Fulfillment tool selection U14					
Infrastructure construction U21					
Cold chain input levels U22					
Distribution processing capacity U23					
Information processing capabilities U24					