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Cold Chain Logistics Distribution Center Location based on Multilevel Grey Model

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Abstract: Logistics distribution center location is a key part of the logistics system optimization, so it is especially important to choose a suitable location method. In this study, we build the evaluation index system of cold chain logistics distribution center and use the multilevel grey model to solve the cold chain logistics distribution center location problem. Finally, we use an example to show the model is practical to solve this problem and provides supervisor an effective optimization tools.

Keywords: Cold chain logistics; Lcation; Multilevel grey model

1. Introduction

With the development of society, the pace of life continues to accelerate so the demand for frozen products has increased year by year, which directly leads to the growth of cold chain logistics. Cold chain logistics distribution center plays a vital important role in cold chain logistics chain. It connects consumers and producers. Cold chain distribution center location determines the structure and size of the entire logistics network, which is the core part of the construction of cold chain logistics. Suitable chain logistics distribution center location, not only helps to ensure the quality of frozen products, but also can reduce transportation and distribution costs, improving cold chain logistics operational efficiency, optimizing cold chain logistics distribution system. It is significant to do some researches on cold chain logistics distribution center location.

Based on the cold chain logistics distribution center location, Wang (2008) analyzed the cold chain logistics system. By summarizing the models and basic theory of node location, he built the location optimized model in order to minimize relevant costs and used the heuristic model - hybrid genetic algorithm to solve it.In consideration of delivery time and frozen products quality. Yang (2011) established perishable goods distribution center location model which had a limited capacity and used Lagrange algorithm model to solve it. Rohit (2010) built a Delphi-AHP-TOPSIS framework to assess the performance of the cold chain of a company. The first stage of the Delphi method needed to identify and composite key factors and sub-factors. In the second stage of AHP method, a company must evaluate the performance of the cold chain from competitors. In the third stage, the company should use in order of preference TOPSIS to evaluate alternatives.

2. Cold Chain Logistics Distribution Center Location Model

2.1. Building Index System

Index system can be divided into quantitative index and qualitative index. This paper combines qualitative analysis with quantitative analysis to research on cold chain logistics distribution center location. By a large number of surveys and empirical analysis, index system is established as shown in Table 1. In the index system, quantitative indicators can be calculated directly by the corresponding calculation method and qualitative indicators can use the expert scoring assignment.

Table 1. Cold Chain Logistics Distribution Center Location Index System

Goal	Main-Criteria	Sub-Criteria
Cold Chain Logistics Distribution Center Location (A)	External factors (A1)	The average distance of the main roads (B1)
		The average distance of the water (B2)
		ecological impact (B3)
		land price (B4)
	Internal factors (A2)	Refrigerated cold storage capacity (C1)
		The average power consumption of cold storage (C2)
		Cold chain logistics costs (C3)
		Infrastructure costs (C4)
	Related factors (A3)	Product of perishability (D1)
		on-time-delivery rate (D2)
		quality measure up rate (D3)

2.2. Determining Index Weight

Building a judgment matrix: Based on 1-9 fundamental scale by Saaty (1980), this paper builds an n*n pairwise compare matrix, which can be expressed as:

$$C=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

Where $a_{ij}=1$ and $a_{ji}=1/a_{ij}$,i,j=1,2, ...n, and $a_{ij}>0$. Using a appropriate method to evaluate the largest eigenvalues.

The consistency: Before any calculation, the pairwise matrices must be complete and consistent. Thus, we define the consistency index as:

$$CI=\frac{\lambda_{\max}-n}{n-1} \quad (1)$$

Where $\lambda_{\max}$ is the largest eigenvalue of matrix.
This value is compared with an average over a large number of reciprocal random matrices of the same order, obtaining the consistency ratio (CR):

$$CR=\frac{CI}{RI} \quad (2)$$

Where RI is function of matrix size as shown in Table 2 and CR<0.01 is as an acceptable limit, otherwise need to be revised and adjusted accordingly.

Table 2. Values of RI

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Hierarchy general ranking: Rana (2016) proposed another task in the hierarchy is the synthesis of the judgments throughout the hierarchy in order to compute the overall priorities of the alternatives with respect to the goal. The weights are created by summing the priority of each element according to a given criterion by the weights of that criterion.

2.3. Determining Values of The Grey Relational Coefficient

Defining of data series: D represents the original data series where X0 and x1 show reference series and comparative series, respectively. The original data series can be show as:

$$D=\begin{bmatrix} x_0(1) & x_0(2) & \cdots & x_0(k) \\ x_1(1) & x_1(2) & \cdots & x_1(k) \\ \cdots & \cdots & \cdots & \cdots \\ x_i(1) & x_i(2) & \cdots & x_i(k) \end{bmatrix}$$

Normalize the data: Because the dimensions of each index is Inconsistent, the original data series must be normalized into a comparable sequence. In this paper, a linear data processing method is used to solve the problem, which can be expressed as:

$$Y_i(k)=\frac{x_i(k)-\min x_i(k)}{\max x_i(k)-\min x_i(k)} \quad (3)$$

Calculating absolute deviation: The absolute deviation can be calculated by these formulas:

$$|x_0(k)-x_i(k)| \quad (4)$$

$$\max_{i=1}^{n}\max_{k=1}^{m}|x_0(k)-x_i(k)| \quad (5)$$

$$\min_{i=1}^{n}\min_{k=1}^{m}|x_0(k)-x_i(k)| \quad (6)$$

Where k=1...m i=1...n
Calculating grey relational coefficient: The correlation coefficient between the reference series x0(k) and comparative series xi(k) can be computed as:

$$\zeta_i(k)=\frac{\min_i|x_0'(k)-x_i'(k)|+\rho\cdot\max_i|x_0'(k)-x_i'(k)|}{|x_0'(k)-x_i'(k)|+\rho\cdot\max_i|x_0'(k)-x_i'(k)|} \quad (7)$$

Where ρ represents the distinguish coefficient. The smaller that the value of ρ is, the bigger that the difference of correlation coefficient is. In this paper, the value of ρ is considered as 0.5.

2.4. Calculating Grey Relational Grade Based on AHP

When all the criterion have different weights based on AHP, the value of grey relational grade can be calculated as :

$$R_i=\sum_{k=1}^{n}w^*_i(k)\xi_i(k) \quad (8)$$

The bigger that the value of Ri, the closer that the alternative scheme is to optimal scheme.

3. Illustrative Example

In order to solve the problem of cold chain logistics distribution center location, this paper use an illustrative example to prove that the model is feasible.
By collecting the opinions of experts, we get four judgment matrices as follows:

A	A_1	A_2	A_3
A_1	1	1/3	2
A_2	3	1	5

A_3	1/2	1/5	1

A_3	D_1	D_2	D_3
D_1	1	1/2	1/3
D_2	2	1	1/2
D_3	3	2	1

A_1	B_1	B_2	B_3	B_4
B_1	1	3	2	1/3
B_2	1/3	1	2	1/5
B_3	1/2	1/2	1	1/3
B_4	3	5	3	1

A_2	C_1	C_2	C_3	C_4
C_1	1	3	1/2	3
C_2	1/3	1	1/3	1/5
C_3	2	3	1	1/2
C_4	1/3	5	2	1

We calculate the maximum eigenvalue and maximum eigenvector and check whether the consistency ratio is acceptable or not .The results are shown in the following Table 3.

The consistency ratio is acceptable and the results are shown in the following Table 4.

Suppose we have four location M1, M2,M3 and M4 to be chosen, and the original datum are shown as Table 5.

Normalize the original datum based on the formulas(4),(5),(6), the results can be expressed in the Table 6.

Taking advantage of the formulas (4),(5),(6) and (7),we can calculate grey relational coefficient and show them in the following Table 7.

Table 3. Level Simple Sequence

Judgment matrix	Eigenvector	λ_{max}	C.I.	R.I.	C.R.
A-A_i	[0.23,0.648,0.122]	3.004	0.002	0.58	0.0034
A_1-B_i	[0.238,0.133,0.115,0.514]	4.056	0.019	0.90	0.0844
A_2-C_i	[0.323,0.076,0.290,0.311]	4.103	0.034	0.90	0.0856
A_3-D_i	[0.164,0.297,0.539]	3.009	0.0045	0.58	0.0078

Thus, we get the weight of each factor, which can be expresses as:

$$W_i^* = [0.055 \quad 0.031 \quad 0.026 \quad 0.118 \quad 0.209 \quad 0.049 \quad 0.188 \quad 0.202 \quad 0.020 \quad 0.036 \quad 0.066]$$

where CI=0.027 RI=0.58 CR=0.047.

Table 4. Weight of Criterion

Goal	Main-Criteria	Sub-Criteria
Cold Chain Logistics Distribution Center Location (A)	External factors (A1) W1=0.23	The average distance of the main roads (B1) W11=0.055
		The average distance of the water (B2) W12=0.031
		ecological impact (B3) W13=0.026
		land price (B4) W14=0.118
	Internal factors (A2) W2=0.648	Refrigerated cold storage capacity (C1) W21=0.209
		The average power consumption of cold storage (C2) W22=0.049
		Cold chain logistics costs (C3) W23=0.188
		Infrastructure costs (C4) W24=0.202
	Related factors (A3) W3=0.122	Product of perishability (D1) W31=0.020
		on-time-delivery rate (D2) W32=0.036
		quality measure up rate (D3) W33=0.066

Table 5. Original Datum about Alternative Location

	B_1	B_2	B_3	B_4	C_1	C_2	C_3	C_4	D_1	D_2	D_3
M1	7.8	43	1	645	94	167	725	1127	5	0.93	0.91
M2	9.6	31	3	214	70	200	682	1560	4	0.81	0.98
M3	5.1	64	2	738	39	122	741	4672	3	0.96	0.88
M4	3.2	78	2	1156	130	187	510	6510	2	0.85	0.95

Table 6. The Normal Datum

	B_1	B_2	B_3	B_4	C_1	C_2	C_3	C_4	D_1	D_2	D_3
M_1	0.72	0.26	0	0.46	0.60	0.58	0.93	0	1	0.8	0.3
M_2	1	0	1	0	0.34	1	0.74	0.08	0.67	0	1
M_3	0.30	0.70	0.50	0.56	0	0	1	0.66	0.33	1	0
M_4	0	1	0.50	1	1	0.83	0	1	0	0.27	0.7

Table 7. Grey Relational Coefficient

	B_1	B_2	B_3	B_4	C_1	C_2	C_3	C_4	D_1	D_2	D_3
M_1	0.41	0.66	1	0.52	0.45	0.46	0.35	1	0.33	0.38	0.63
M_2	0.33	1	0.33	1	0.60	0.33	0.40	0.86	0.43	1	0.33
M_3	0.63	0.42	0.50	0.47	1	1	0.33	0.43	0.6	0.33	1
M_4	1	0.33	0.50	0.33	0.33	0.38	1	0.33	1	0.65	0.42

According to the formula (8), the final result of alternative location M1,M2,M3 and M4 can be expressed as: R1=0.5766, R2=0.6326, R3=0.6129 and R4=0.5305. Thus, M2 is optimal.

4. Conclusion

According to the characteristics of goods and cold chain logistics industry characteristics, we combine AHP with grey relational analysis to construct cold chain logistics distribution center location model.Grey relational analysis overcomes the defect that we determine the sort based on the independent and without disturbing indicators in AHP. The model not only takes the relative weight of each index into account but also consider the interrelationship between indicators. The illustrative example shows that the model can solve the problem of cold chain logistics distribution center location. It helps to choose a scientific and rational distribution center location, reduces transportation costs, cold chain logistics operating costs and improve the quality of logistics services.

References

[1] Joshi R, Banwet D K, Shankar R. Consumer link in cold chain: Indian sce nario[J]. Food Control, 2010, 21(8): 32-37.

[2] Gu Shanghua. Brief discussion oncity bus safety measures[J]. Journal of public transportation. (1): 2015-47 48.

[3] Singh R P, Nachtnebel H P. Analytical hierarchy process (AHP) application for reinforcement of hydropower strategy in Nepal[J]. Renewable and Sustainable Energy Reviews, 2016(55): 43-58.