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A study on the location selection of Cold Chain Logistics Distribution Centre Based on Entropy-TOPSIS Model: The Case of a City in Anhui Province

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ARTICLE INFO	ABSTRACT
   	The construction of cold chain distribution centres serves as a critical means of reducing post-harvest agricultural product losses and food waste during circulation. Hence, how to select and locate cold chain logistics distribution centres scientifically has become an important issue. This research proposes a location selection method based on the Entropy-Weighted TOPSIS approach to quantitatively select cold chain logistics distribution centres. First, a site selection index system is constructed from four dimensions: economic development level, distribution operation capacity, economic environments and cost factors. Subsequently, entropy method is employed to determine the weights, and a site evaluation model is constructed based on TOPSIS. The findings illustrate that Entropy-TOPSIS method can be applied to the cold chain logistics centre selection problems. Finally, this paper takes a selected city as a case study and applies the developed site evaluation model to determine the location of its cold chain logistics distribution centre.

1. Introduction

1.1 Research Background

With social and economic development, the continuous rise of living standards, the public's expectations for a better quality of life are also increasing correspondingly. According to data from China Statistical Yearbook 2021, The per capita consumption of vegetables, meat, aquatic products, and fresh melons and fruit increased from 169.1 kg in 2014 to 190.2 kg in 2021. The most significant growth was observed for fresh melons and fruits, which increased by a total of 12.7 kilograms. Thus, it demonstrates that the demand for fresh food, including agricultural products, fresh fruits and vegetables, meat and dairy products, is continuously expanding. In June 2014, the State Council released The Medium- and Long-Term Development Plan for the Logistics Industry, cold chain logistics emerged as the top priority among the twelve major projects identified. In 2021, in alignment with the decisions and requirements of the Central Committee of the Communist Party of China and the State Council, and guided by the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives Through the Year 2035 of the People's Republic of China, the "14th Five-Year" Cold Chain Logistics Development Plan was officially enacted. It addresses the construction issues related to cold chain logistics distribution centres: Integrated with the development of new urbanization and based on the spatial layout of county towns and key towns, a batch of cold chain logistics distribution centres will be established. Developing a number of mobile

cold storage at production origins, expanding refrigerated truck services, and the adoption of mobile cold storage leasing circuits as well as the "mobile cold storage + distribution centre (logistics park)" model will further enhance the efficiency of collecting and transporting goods from fields to bases in mobile cold chain logistics. This enhancement will ultimately reduce the post-harvest distribution costs for farmers dealing in frozen goods. The high loss in cold chain distribution primarily caused by the following three factors: (1) The inherent perishability of fresh products, which has strict requirements on environmental temperature and humidity; (2) Issues such as the low circulation rate of cold chain and the low proportion of full-chain cold coverage increases susceptibility to chain breaks; and(3) The existing cold chain facilities are inadequate to cope with market demand, creating a severe supply-demand mismatch. Consequently, the high consumer demand for both the quantity and quality of cold chain products is driving the cold chain distribution industry to explore more rational distribution models, routes, and the optimization of distribution centres particularly. As a critical bridge between producers, retailers, and consumers, cold chain distribution centres play a important role in maintaining the quality and quantity of fresh food, ensuring its safe and fresh delivery to end customers. Thus, the issue of locating cold chain logistics distribution centres is critically important. The case study city has not established a comprehensive cold chain logistics system currently, the basic equipment level of cold chain logistics is relatively low, and the related technology is yet to reach mature. As an economically underdeveloped regions, the city lacks qualified cold chain logistics personnel, which constraints the rapid development of cold chain logistics industry and the establishment of cold chain logistics distribution centre. Therefore, how to determine the location of the cold chain logistics distribution centre of the case study city has significant implications for the enhancement of cold chain logistics facilities.

1.2 Research Implication

The construction of a cold chain logistics distribution centre requires comprehensive consideration of multiple factors and represents a complex systematic decision-making problem. Constructing the cold chain logistics distribution centre needs substantial capital investment, while the operational processes of cold chain logistics are relatively complex. When selecting a location for a cold chain logistics distribution centre, it essential to consider economic factors and political factors as well as the specific realities of the study case city. It will improve efficiency of the whole cold chain logistics system significantly and facilitate the development of the city's cold chain logistics industry.

2. Literature Review

With the continuous improvement of living standards, the demand for cold chain logistics transportation has increased, making the site selection of cold chain logistics distribution centres a key focus for enhancing quality and efficiency in cold chain logistics. There has been extensive research on the location selection of logistics distribution centres both domestically and internationally, but relatively limited research specifically addressing cold chain logistics distribution centres so far.

2.1 Domestic Research

2.1.1 Research on Agricultural Cold Chain Logistics

This study [1]proposes an IoT-based supervisory system for agricultural cold chain logistics, integrating real-time data collection, environmental regulation, and a blockchain-enhanced privacy protection module. The system demonstrates superior computational efficiency, robust security performance, and enhanced real-time supervision capability, offering an innovative technical

solution for improving supply chain quality and efficiency. The paper conducts an in-depth analysis of China's agricultural product cold chain logistics policies from 2016 to 2023, utilizing text mining and visualization techniques combined with chronological stage division. By employing the Latent Dirichlet Allocation (LDA) model in a Python 3.7 environment, 21 topic keywords were extracted across three stages. Enhanced Chord Diagrams (ECD) were then used to visually analyze the importance of each topic, aiming to explore the evolutionary trends of policies at different stages[2]. This study identifies and examines 12 key factors hindering the development of agricultural cold chain logistics. The CRITIC method is used to determine the weight of each factor, and the minimum cumulative resistance model is employed to calculate the comprehensive resistance value for each province. Additionally, by integrating the minimum-cost path and gravity models, potential corridors for the sustainable development of cold chain logistics for fresh agricultural products (SD-CCLFAP) are classified at different levels[3]. Adopting a market-oriented approach, it aims to establish operational standards and a reliable performance evaluation index system for the low-temperature cold chain logistics of flowers. By applying system integration theory to build a multi-objective integrated optimization model, this research seeks to provide typical case studies and reference value for the standardized construction of cold chain logistics systems for agricultural products[4]. This study [5]proposes a Markov-optimized mean GM (1,1) model for forecasting demand in agricultural product cold chain logistics, which demonstrates higher accuracy and smaller errors compared to other models. The validated forecasting results provide targeted recommendations and theoretical support for the development of cold chain logistics.

Han, Sun [6] think while CCL is critical for ensuring the quality and safety of agriculture products and reducing post-harvest loss. traditional CCL systems are increasingly constrained by critical limitations. These include inadequate environmental sensing capabilities, delayed response mechanisms, and inefficient coordination. This reality underscores the critical necessity for a smart transformation, leveraging digital innovation to transition towards more resilient, efficient, and sustainable cold chain ecosystem. Zhang, Fan [7] find that the economic efficiency and technological factors of fresh agricultural product cold chain logistics show close associations with both environmental pressures and responses. Specifically, the number of employees in the logistics industry, the transaction volume of fresh agricultural products, the number of refrigerated vehicles, and cold storage capacity exhibit significant positive correlations with ecological quality. In contrast, per capita consumption of fresh agricultural products, the number of patent applications in cold chain logistics, and road density demonstrate significant negative correlations with the ecological environment. The influence of the number of cold chain logistics enterprises and the freight turnover of agricultural products transported via cold chain on the ecological environment displays fluctuating characteristics.

2.1.2 Research on Location Model for Cold Chain Logistics Distribution Centre

The location optimization problem for cold chain distribution is a fundamental issue. Wang, Zhan [8] describe an effective and environmentally conscious optimization model for logistics distribution centre location targeting the reduction of carbon emissions in the transportation process. By integrating multiple factors, including time penalties and carbon emissions, A low-cost and environmentally sustainable location model for cold chain logistics distribution centres was developed.

Zhang, Fu [9] propose a low-carbon cold chain logistics location optimization model through a comprehensive consideration of various factors influencing cold-chain products and the conversion of carbon emissions into cost metrics. Zhang, Yan [10]demonstrates the effectiveness of hybrid

optimization techniques in complex supply chain networks and dynamic market environments and implement the hybrid Tabu-Grey Wolf Optimizer algorithm to enhance distribution efficiency, reduce costs in the logistics process, and maintain product quality, thereby offering valuable insights for decision-makers in operational and strategic improvements. To tackle the two-echelon low-carbon location-routing problem (2E-LCLRP), Zhang, Wang [11] establish a mathematical model to minimize total costs, which encompass operating expenses, transportation costs, fixed costs, refrigeration costs, cargo damage costs, and comprehensive carbon emission costs. They also propose a hybrid ant colony optimization (HACO) algorithm, combining the elbow rule with an improved ant colony optimization (IACO) algorithm, to solve the 2E-LCLRP. The elbow rule was employed to determine the optimal number of front warehouses, and an enhanced ant colony algorithm was designed to optimize vehicle routing. Incorporating carbon emissions and traffic congestion into the consideration of urban cold chain logistics distribution, Yang and Jiang [12] propose a cross-period road segment travel time calculation method, and a multi-objective optimization model is constructed aiming to minimize the total costs, including comprehensive transportation costs, carbon emission costs, time penalty costs, cargo damage costs, and refrigeration costs. Zhou, Yao [13] construct a two-stage optimization model for regional cold chain logistics centre location. In the first stage, an improved clustering algorithm is employed to partition production areas based on multiple indicators. In the second stage, a modified centre-of-gravity method is applied to determine optimal site selection under multi-region and multi-product constraints. Using Yunnan Province as a case study, candidate locations including Kunming, Zhaotong, Lincang, Honghe, and Dali are derived and validated through comparative analysis. The proposed model provides a decision-support framework for optimizing agricultural product supply chain networks.

2.2 International Research

Based on an in-depth analysis of cold chain logistics, this study [14] develops a comprehensive temperature monitoring framework that emphasizes the integration of advanced sensors, IoT-driven smart systems, and standardized protocols. It identifies real-time data integration and technological innovation as key to enhancing reliability and safety in transporting and storing temperature-sensitive goods. The proposed framework provides both a theoretical foundation and practical guidance for advancing cold chain management. This study systematically analyzes six key risks in Cold Chain Logistics (CCL)—highlighting temperature deviation and equipment failure as the most critical—and examines their impact on sustainability performance (SP). It demonstrates that integrating Supply Chain Resilience (SCR) and Sustainability Innovation (SI) significantly mitigates these risks and enhances [15].

Rong, Yu [16] systematically investigate the location selection problem of cold chain logistics distribution centres from five key factors: human resource availability, delivery flexibility, natural conditions, environmental protection costs, and investment expenditures. Zhang, Chen [17] examine urban cold chain logistics distribution centre location optimization from a carbon emission perspective. Orjuela-Castro, Sanabria-Coronado [18] investigate location selection for cold chain distribution centres in mountainous regions, focusing on cost losses due to temperature and humidity variations. They address supply–demand matching for fresh products in mountainous areas by employing a mixed-integer linear programming model for solution. Durneva, Cousins [19]designs a three-tier logistics system involving producers, retailers, and distribution centres, aiming to satisfy a wide range of retailers with limited producers through joint inventory management and corresponding distribution centre siting. Wang, Ran [20] seek to effectively achieve energy saving and emission reduction in the location selection process for fresh agricultural product cold chain logistics.

Extending traditional distribution centre location models, they integrate freshness preservation and carbon emission reduction into the optimization framework. By constructing a bi-objective location model aimed at minimizing both total cost and carbon emissions, they design a two-stage heuristic algorithm to solve the model. This study[21] proposes an integrated MCDM model combining BWM, QFD, and MARCOS methods to prioritize customer requirements and allocate cold chain logistics resources effectively. Results identify precise temperature control and advanced sensors as key factors, enabling data-driven selection of optimal third-party logistics providers to enhance service quality and competitiveness.

In summary, scholars both domestically and internationally have conducted extensive research on the location selection of cold chain logistics distribution centres. Studies have addressed this issue from various influencing factors, including natural conditions, logistics costs, economic considerations, and carbon emissions, aiming to optimize the placement of such centres. However, most existing research primarily focuses on minimizing logistics costs, which fails to fully capture the critical aspect of delivery timeliness. As a result, ensuring timely distribution will emerge as a central focus in future studies on the location optimization of cold chain logistics distribution centres.

3. Fundamental Theories of Cold Chain Logistics Location Selection

3.1 Related Concepts of Cold Chain Logistics

3.1.1 Definition

A cold chain is a logistics network that maintains specific low-temperature conditions from production to consumption to preserve product quality based on commodity characteristics. Cold chain logistics is a systematic engineering process aimed at ensuring the quality of refrigerated and frozen foods, reducing loss, and maintaining required temperature ranges during production, storage, transportation, and sales.

3.1.2 Characteristic

Compared to conventional logistics, cold chain logistics maintains low temperatures throughout the process to ensure food quality, which illustrates more complex processes and technologies. Key characteristics include:(1) Timeliness: Perishable products transported via cold chain are characterized by limited shelf life and susceptibility to rapid deterioration. Consequently, cold chain logistics demands expeditious handling and seamless execution to minimize temperature deviations and preserve product integrity throughout the supply chain. (2) Complexity: Compared to conventional logistics, cold chain logistics is closely tied to technologies such as refrigeration, freezing, and thermal insulation. Some products are even subject to legal and regulatory constraints. Different products have specific requirements for temperature, humidity, and storage duration, reflecting the complexity of cold chain logistics. (3) High cost: Cold chain logistics incurs significantly higher costs compared to conventional logistics. First, equipment costs are substantial. Specialized machinery and facilities for food preservation require considerable capital investment. Second, operational expenses are significant. Refrigerated warehouses must maintain consistently low temperatures to ensure stability, leading to substantial electricity consumption. Additionally, the capital recovery period for cold chain logistics is prolonged, posing a financial challenge that many enterprises find difficult to sustain.

3.1.3 Operational Principles

The procedures must follow the 3C and 3P principles. The "3C Principles" refer to: maintaining product cleanliness and preventing contamination; rapidly chilling or freezing the product to bring it into allow-temperature state; and handling with great care throughout the process to avoid product

damage. The "3C Principles" refer to: selecting high-quality, fresh and contamination-free raw materials; employing appropriate processing techniques; and utilizing packaging methods that comply with health and sanitation standards to prevent environmental contamination. The storage and transportation processes must adhere to the 3Tprinciples. The "3T Principles" refers to ensuring the relationship between the time and required temperature, while consistently monitoring the product's tolerance (allowable variation). The entire cold chain process must satisfy the 3Q and 3M conditions. The "3Q Conditions" refer to: quality of equipment, quality of equipment, and quick operation, which aim to maintain agricultural products in a suitable environment and enhance equipment utilization efficiency. The "3M Conditions" refers to: requiring the use of preservation Means and Methods that comply with the specific characteristics of food, in order to achieve low-cost Management and optimal preservation outcomes.

3.2 Cold Chain Logistics Distribution Centres

3.2.1 Definition

The Cold Chain Logistics Distribution Cent is an organization responsible for receiving and processing order information from end-users. It sorts various goods received from upstream suppliers, and based on customer orders, performs operations such as picking, processing, and storage, ultimately carrying out distribution.

3.2.2 Classification

Based on the structural characteristics, the perform circulation duties, and the geographical scope of delivery, logistics distribution centres can be further classified into distinct categories, as illustrated in Fig 1.
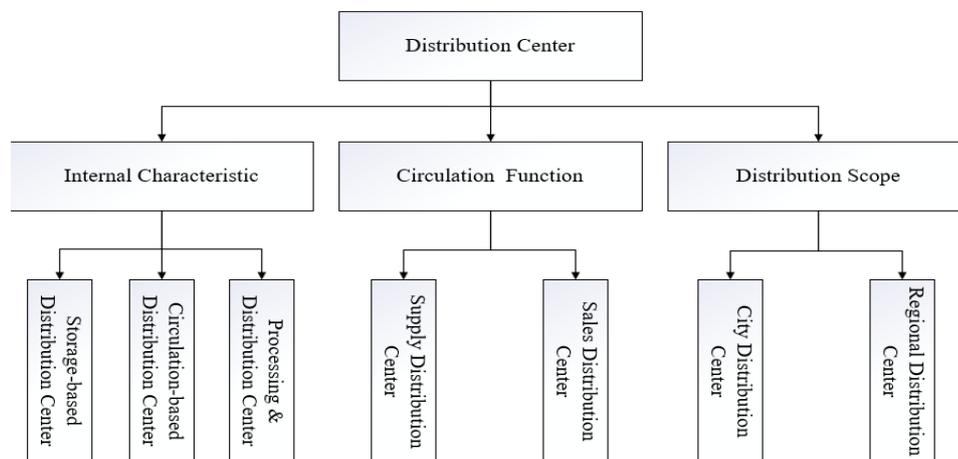

Fig.1. Classification of distribution centre

3.3 Location Selection for Cold Chain Logistics Distribution Centres

3.3.1 Principles for Cold Chain Logistics Distribution Centre Location

During the site selection process for cold chain distribution centres, four key principles should be adhered to:(1) Adaptability. The location selection of cold chain logistics distribution centres must align with national or regional economic development policies, as well as the distribution of logistics resources and demand patterns within the country. (2) Consistency. The issue of siting cold chain logistics distribution centres should be approached by viewing the national or regional logistics

network as an integrated system. This ensures that the location choice is consistent with regional distribution, productivity levels, and technological capabilities. (3) Economic Efficiency. In the development of cold chain distribution centres, relevant costs—including both construction expenses and operational costs—must be taken into account. Minimizing the total cost should be a fundamental principle in the site selection process. (4) Strategic Perspective. Cold chain distribution centres must be planned with a strategic vision. This involves, first, considering the overall situation, and second, adopting a long-term perspective. Partial interests should be subordinated to the broader picture, and short-term benefits should yield to long-term gains. Centres must not only meet current requirements but also define clear developmental objectives, positioning themselves at the forefront of the logistics industry.

3.3.2 Factors for Cold Chain Logistics Distribution Centre Location

Customer Distribution. When selecting a site for a cold chain logistics distribution centre, customer distribution should be considered primarily. The locations of customers directly affect the delivery distance of orders, thereby directly impacting both distribution costs and service quality.

Supplier Distribution. The goods handled by a cold chain distribution centre are supplied by vendors. If the logistics node is located near suppliers, the safety stock level for those goods can be maintained at a lower level.

Transportation Conditions. Transportation infrastructure is a critical factor influencing the cost and efficiency of logistics distribution.

Natural Conditions. The natural environment must also be treated as a significant factor in site selection. Prior to finalizing a location, a comprehensive survey of the topographical and geological conditions of the area is essential. Additionally, meteorological and hydrological conditions must be subjected to detailed analysis to assess the suitability of the site.

3.3.3. Method for Cold Chain Logistics Distribution Centre Location

Quantitative Analysis Methods. Quantitative analysis methods include the Centre-of-Gravity Method, Bi-level Programming, the Capacitated Facility Location Problem (CFLP) model, Mixed 0-1 Integer Programming, and Genetic Algorithms. These methods enable a more precise determination of the optimal location. As a classic location method, the Centre-of-Gravity Method treats the supply points and demand points within a logistics system as a mass distributed across a geographical plane and uses the system's calculated centre of gravity to identify the final site for the transportation network.

Qualitative Analysis Methods. Qualitative analysis methods primarily focus on the influencing factors and principles of site selection. Based on a comprehensive analysis of the expertise and practical experience of experts and managers, they determine the specific location of distribution centres. Main techniques include the Expert Scoring Method and the Delphi Method. This approach values historical experience, offering both simplicity and practicality.

4. methodology

4.1 Construction of the Evaluation Indicator System for Cold Chain Logistics Distribution Centre location Selection

The fundamental purpose of establishing an evaluation indicator system for cold chain logistics distribution centre site selection is to determine the optimal location through the assessment of these indicators. Consequently, the construction of the indicator system must comprehensively integrate various influencing factors and adhere to the principles of adaptability, consistency,

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economy, and strategic alignment. Based on the distinct characteristics of cold chain logistics distribution centres, this paper selects four dimensions as the evaluation criteria: economic development level, distribution operation capability, operational environment, and cost factors.

Considering the conditions of various candidate areas for the cold chain logistics distribution centre in the case study city comprehensively, this paper establishes an evaluation indicator system for site selection from the perspective of feasibility in system construction. As shown in Table 1, the factor layer includes: Economic Development Level, Distribution Operation Capability, Business Environment, and Cost Factors. The level of economic development is primarily reflected by the Gross Domestic Product (GDP) and the disposable income of urban residents, indicating the city's production capacity and consumption level. Distribution operation capability mainly includes the express delivery volume and the total highway mileage, which can demonstrate the scale of local express business and the condition of its express transportation infrastructure. The business environment includes the resident population and the growth in newly increased fixed assets investment in the sectors of transportation, warehousing, and postal services, capable of reflecting the local level of express logistics and its future development prospects. Cost factors are principally represented by the average wage in the transportation sector for non-private units and the land price level, which reflect the logistics costs in the region.

Table 1. Distribution Centre Indicator System

Objective Layer	Factor Layer	Indicator Layer
Site Selection Evaluation for the case study city's Cold Chain Logistics Distribution Centre	Economic Development Level X1	GDP X11
		Disposable Income of Urban Residents X12
	Distribution Operation Capability X2	Express Delivery Volume X21
		Total Highway Mileage X22
	Business Environment X3	Growth Rate of New Fixed-Asset Investment in Transport, Storage & Postal Services X32
	Cost Factor X4	Average Wage in Transport Sector (Non-Private Units) X41
		Land Price Level X42

4.2 Development of an Evaluation Model Integrating Entropy Weighting and TOPSIS
4.2.1 Definition of the Entropy Method and TOPSIS

The Entropy Method refers to one of the mathematical approaches for analyzing the degree of dispersion among indicators. The greater the degree of change, the greater the influence of this indicator on the overall evaluation. Entropy can be used to determine the scattering degree of the indices.

The TOPSIS method is a very common technique, also known as the "superiority-inferiority distance method." The TOPSIS algorithm evaluates each alternative for every decision criterion based on their relationship to the best and worst values; the best value can be termed the positive ideal solution, while the worst value becomes the negative ideal solution. Although the most common TOPSIS algorithm can calculate the distance between each indicator and the best and worst solutions

among the alternatives, it cannot inherently determine the weight values of the individual indicators. Consequently, the results often neglect the distinctions between different indicators.

4.2.2 Construction of the Entropy Method Model

First, construct the initial decision matrix. Taking the city's cold chain distribution centre as the research object, an indicator survey was conducted, and preliminary data was obtained. Assuming the indicator system consists of m attributes and there are n alternative solutions， let be the score of the indicator i for the alternative solution j, The initial decision matrix X is then given by:

$$A = \begin{pmatrix} a_{11} & \cdots & a_{m1} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nm} \end{pmatrix} \tag{1}$$

Next, data processing and the construction of a normalized matrix are conducted. The entropy method uses the ratio of each alternative's specific indicator value to the sum total of that indicator, thus eliminating the need for data normalization.

For benefit criteria，

$$A_{ij} = \frac{A_{ij} - \min(A_{1j}, A_{2j}, ..., A_{nj})}{\max(A_{1j}, A_{2j}, ..., A_{nj}) - \min(A_{1j}, A_{2j}, ..., A_{nj})} + 1 \tag{2}$$

For non-benefit criteria，

$$A_{ij} = \frac{\max(A_{1j}, A_{2j}, ..., A_{nj}) - A_{ij}}{\max(A_{1j}, A_{2j}, ..., A_{nj}) - \min(A_{1j}, A_{2j}, ..., A_{nj})} + 1 \tag{3}$$

To form a standardized matrix, the relationships between indicators must be unified. Therefore, all data can undergo standardization processing to obtain the standardized matrix.

$$P = (P_{ij})_{m*n} \tag{4}$$

Where,

$$P_{ij} = \frac{A_{ij}}{\sum_1^n A_{ij}} (y = 1, 2, ..., m) \tag{5}$$

P_{ij} corresponds to the proportion of the alternative x within indicator y. This is used to calculate the entropy value of the indicator y.

For the indicator y, the proportion occupied by the alternative x within that indicator. This is used to calculate the entropy value of the indicator y.

$$e_j = -k * \sum_{i=1}^{n} P_{ij} \ln(P_{ij}) \tag{6}$$

Calculate the coefficient of variation based on the indicators. For each indicator, the greater the variation among its values, the lower its corresponding entropy value, and the more significant its role in alternative evaluation becomes.

$$g_j = 1 - e_j \tag{7}$$

The greater g_j is, the more significant the indicator's role. Finally, the weight for each indicator is calculated as:

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$$W_j = \frac{g_j}{\sum_{i=1}^{n} p_{ij}} \tag{8}$$

4.2.3 Integration with the TOPSIS Model

Step 1: To create a weighted matrix, where each indicator weight is multiplied by the corresponding element in the normalized matrix to obtain the weighted matrix D.

$$D = (W_j * P_{ij})_{m*n} \tag{9}$$

Step 2: Determine the Positive and Negative Ideal Solutions：

$$H_j^+ = \left[\max(y_{1j}, y_{2j}, ... y_{nj}) \right] \tag{10}$$

$$H_j^- = \left[\min(y_{1j}, y_{2j}, ... y_{nj}) \right] \tag{11}$$

Step 3: Calculate the Euclidean distances from each evaluation object to their respective ideal solutions.

$$sep_j^+ = \sqrt{\sum_{i=1}^{n} (D_{ij} - H_j^+)^2} \tag{12}$$

$$sep_j^- = \sqrt{\sum_{i=1}^{n} (D_{ij} - H_j^-)^2} \tag{13}$$

Step 4: Calculate the comprehensive value for each indicator and sort them in descending order.

$$C_j = \frac{sep_j^-}{sep_j^+ + sep_j^-} (j = 1, 2, ..., m) \tag{14}$$

5. Results

This paper takes the case study city for empirical analysis. It analyzes the current state of cold chain logistics development in the city. Subsequently, the data required for site selection analysis are collected, and using the entropy-weighted TOPSIS model proposed in Chapter 3, the candidate locations are comprehensively analyzed, yielding the site selection results for the city's cold chain logistics distribution centre.

5.1 Current Status of the city's Cold Chain Logistics Development

The city is situated at the junction of Anhui Province, Henan Province, and Hubei Province, serving as the heart of the Dabie Mountain Revolutionary Old Base Area. Known as "West Anhui," it is located in the western part of Anhui Province, adjacent to the Yangtze River Delta Economic Zone. The city administers seven county-level divisions: JA District, YA District, YJ District, SC County, JZ County, HQ County, and HS County. With the continuous growth in the production, demand, and volume of fresh agricultural products entering the circulation sector, the cold chain logistics industry in the city has developed rapidly. According to statistics, the city currently has 425 cold chain logistics business entities, operating a total of 1,026 cold storage facilities. The total cold storage capacity reaches 567,000 cubic meters, with a storage volume of 369,000 tons, accounting for approximately 21% of the provincial total. There are 136 refrigerated trucks, representing about 4% of the total in Anhui Province. However, the existing cold storage facilities in the city are outdated and relatively small in scale, with small-scale cold warehouses making up 93.3% of the total. The city needs to enhance the development of its cold chain logistics, particularly the construction of cold chain distribution centres. Relevant data required for building cold chain logistics distribution centres were obtained from the

city's Statistical Yearbook 2021 released by the city's Municipal Bureau of Statistics and the Anhui Land Information Network.

Table 2. Indicator Data for the City

	JA	YA	YJ	HQ	SC	JZ	HQ
GDP (10000 yuan)	2925188	2975409	691651	2275870	3065375	1969459	1662570
Urban Residents' Disposable Income（yuan）	26850	25386	20451	18077	22402	19042	26812
Express Delivery Business Volume (10000 pieces)	3226.09	3055.14	20	511.08	2183.94	187.52	351.08
Highway mileage (km)	3543.10	4361.70	1229.40	4137.70	4339.30	4555.60	2560.40
Permanent population (10000 people)	83	92	22	94	70	50	29
Growth Rate of NEW Fixed Asset Investment in Transportation, Storage and Postal Service（%）	6.2	-1.3	-0.9	-0.8	-1	-1.1	-.1.1
Average Wage in Transport Sector (Non-Private Units) (yuan)	67467.9	68438	62998.4	74089.6	67042	69993	67042
Land Price Level (yuan per square meter)	1191.08	1149.66	756.13	909.54	1076.82	1065.89	1026.35

* **Data Source:** *the city's Statistical Yearbook*

5.2 Insufficient Development of Cold Chain Logistics in the City

5.2.1 Systemic Deficiencies in the Cold Chain Logistics System

Cold chain logistics is an efficient temperature-controlled system encompassing frozen processing, storage, transportation & distribution, and retail. However, in the City, the current capability is limited to providing cold chain handling for products only at certain stages or segments, leading to "chain breaks." Consequently, a fully integrated cold chain logistics system has not yet been established.

The infrastructure includes refrigeration warehouses (vehicles), constant-temperature warehouses (vehicles), and freezing warehouses (vehicles). The technology primarily encompasses refrigeration techniques and preservation technologies. Currently, the city remains at an overall backward level, resulting in an acute shortage of professional cold storage facilities and refrigerated vehicles. Advanced cold chain technologies have not yet been widely adopted in the city.

The development of cold chain logistics cannot proceed without professional technical and managerial personnel, who must possess solid foundational knowledge and be familiar with cold chain technologies and management models. Currently, most individuals engaged in cold chain logistics in the city have transitioned from traditional logistics backgrounds. While they may have extensive experience, they often lack technical expertise and are unfamiliar with the cutting-edge technologies in cold chain logistics. As an economically underdeveloped region, the case study city

lacks a corresponding talent pool in cold chain logistics. This shortage impedes the rapid growth of the cold chain logistics industry and also hampers the construction of cold chain logistics distribution centres.

5.3 Site Selection for Cold Chain Logistics Distribution Centres in the city

Based on the development of cold chain logistics, it is necessary to establish a cold chain logistics distribution centre in the city, Anhui Province. The candidate locations include the seven counties/districts of the city: JA District, YA District, YJ District, SC County, JZ County, HQ County, and HS County. The optimal site will be selected according to four dimensions: economic development level, distribution operation capability, business environment, and cost factors. On this basis, the entropy method is employed to assign weights to each indicator. Finally, the TOPSIS method is used to rank the candidate alternatives, determine the optimal solution, and derive the final result.

By applying Formulas (2) to (5) above to standardize the raw data, the normalized matrix can be obtained, as shown in Table 3.

Table 3. Normalized Indicator Data for the City

	JA	YA	YJ	HQ	SC	JZ	HQ
GDP (10000 yuan)	1.9409	1.9621	1.0000	1.6674	2.0000	1.5383	1.4090
Urban Residents' Disposable Income（yuan）	2.0000	1.8367	1.2718	1.0000	1.4951	1.1105	2.0000
Express Delivery Business Volume (10000 pieces)	2.0000	1.9467	1.0000	1.1532	1.6749	1.0523	1.1033
Highway mileage (km)	1.6956	1.9417	1.0000	1.8744	1.9350	2.0000	1.4002
Permanent population (10000 people)	1.8472	1.9722	1.0000	2.0000	1.6667	1.3889	1.0972
Growth Rate of NEW Fixed Asset Investment in Transportation, Storage and Postal Service（%）	2.0000	1.0000	1.0533	1.0667	1.0400	1.0267	1.0267
Average Wage in Transport Sector (Non-Private Units) (yuan)	1.5970	1.5096	2.0000	1.0000	1.6354	1.3694	1.6354
Land Price Level (yuan per square meter)	1.0000	1.0952	2.0000	1.6473	1.2627	1.2878	1.3787

Next, the entropy method is applied to calculate the weights. The weights for each indicator are computed according to Equations (6)-(8), as shown in Table 4.

Table 4. Weights of Indicators Calculated by the Entropy Method

Indicator	X11	X12	X21	X22	X31	X32	X41	X42
W_y	0.1512	0.1306	0.1110	0.1591	0.1370	0.0708	0.1334	0.1067

The indicator weights are calculated using the entropy method, and Formula (9) is applied to determine the weighted matrix D. Subsequently, the TOPSIS model is established. First, the weighted matrix is adopted, then the positive ideal solution and the negative ideal solution are

obtained according to Formulas (10) and (11). Finally, the Euclidean distances are calculated using Formulas (12) and (13).

sep_y^+=（0.130934、0.138714、0.304699、0.228949、0.144988、0.232518、0.232012）

sep_y^-=（0.294496、0.298491、0.174551、0.231109、0.266715、0.195988、0.184594）

Finally, according to Formula (14), the comprehensive ranking is conducted:

C_y=（0.692232、0.682726、0.364217、0.502348、0.647833、0.457373、0.443090）

Based on the comprehensive ranking results, the counties/districts of the city are ordered as follows: JA District > YA District > SC County > HQ County > JZ County > HS County > Yeji District. Analysis of factors such as economic development level, distribution operation capability, business environment, and cost reveals significant disparities among these regions. The scores vary considerably, with JA District achieving the highest composite score of 0.692232, followed by YA District at 0.682726. In contrast, Yeji District has the lowest composite score of only 0.364217, while the other four counties score around 0.45. The analysis indicates that each county/district possesses distinct strengths and weaknesses, but their developmental status is uneven, leading to marked differences in competitiveness across the city. Therefore, the primary choice between JA District and YA District can be made based on specific urban conditions, with YJ District being excluded from consideration. JA District, with its larger population, rapid economic growth, active private sector, developed transportation industry, and continuously improving logistics infrastructure, represents the optimal location for the cold chain logistics distribution centre.

6. Conclusion

Based on the observations and analytical insights of numerous scholars, we have preliminarily constructed a site selection evaluation indicator system, focusing primarily on economic development level, distribution operation capability, business environment, and cost factors. Applying the entropy-weighted TOPSIS method for analysis, this approach identifies JA District as the optimal location among the seven counties/districts of the City for establishing a cold chain logistics distribution centre. In practical terms, JA District demonstrates a solid foundation across all four dimensions: economic development, distribution capability, business environment, and cost. Furthermore, with a resident population of 830,000, it presents substantial demand for cold chain logistics and promising business prospects. This outcome also validates the alignment between the proposed site selection methodology and real-world conditions. The integrated entropy-weighted TOPSIS model employed in this study balances subjective and objective weightings, as well as qualitative and quantitative data, by comprehensively considering both subjective judgments and objective data. This integration enhances ranking accuracy and ensures a more scientific execution. The site selection for a cold chain logistics distribution centre must adhere to the principles of adaptability, economy, consistency, and strategy to achieve the goals of benefit maximization and service optimization.

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