Location Selection of Cold Chain Logistics Park Based on "H-F-A" Model

Huaqiong LIU[1] and Lixue FAN[2]

[1,2]School of Transportation and Logistics Engineering, Shandong Jiaotong University, china

Abstract. "Internet plus initiative" makes the logistics industry enter a new era. People pay more and more attention to cold chain logistics, so improving the development level of cold chain logistics is the key to increase enterprise profits.Choosing the location of a cold chain logistics park is the first and most important step in making a profit, so we should choose a strict and scientific method to calculate it. This paper aims at solving the problems in traditional layout methods, such as too objective location, too little quantitative data and so on, we put forward A model to carry out the calculation, through this method we can determine the reasonable construction address more efficient and quicker.The reasonable construction of cold chain logistics park can reduce the transportation cost of goods, reduce the operating cost, and promote the development of local economy and environment.

1.Current location selection situation

The methods used at present include Analytic hierarchy process(AHP), Grey Comprehensive Evaluation, Fuzzy Comprehensive Evaluation, data Envelopment Analysis, and many new methods that have appeared in recent years. The Analytic hierarchy process (AHP) quantifies the experiential decision of the judge, which is applicable to the situation where the objective structure is complex and the necessary data is lacking. This method divides the objectives, criteria, program measures and so on into different levels first. The obtained schemes are compared with each other, and the difficulty of quantitative analysis is solved. The grey system theory is mainly aimed at the uncertain system of the lack of information. After analysis, according to the distance of each evaluation object ideal condition.The closeness of the state gives the order of merit and inferiority. It does not require too much data, it presupposes that it is very close to reality, and the processing steps are simple. The fuzzy comprehensive evaluation method is based on fuzzy mathematics, applying the principle of fuzzy relation synthesis, quantifying some factors which are not clear in boundary and easy to quantify, and analyzing from many factors. A comprehensive evaluation of the status of membership level of the subject matter is carried out.

In addition to the common location methods mentioned above, there have been many new attempts in the location methods of logistics parks in recent years, such as the evaluation of ELECTRE- III, Analysis of BP neural network and so on. These methods have their own advantages and can solve the problem of location under different requirements, but there are also many shortcomings.

Table 1. Comparison of location selection methods

	Operational	Subjective	Compatibility	Economy
Factor - analytic hierarchy process	general	very good	general	good
Fuzzy comprehensive evaluation method	good	general	relatively good	relatively good
Data envelopment analysis	bad	relative good	general	bad

The reasonable location of the cold chain logistics park can accelerate the local resource flow, promote the vigorous development of the local economy, and reduce the transportation cost and operating cost to a certain extent. Therefore, it is necessary to carry out a careful demonstration and find the best alternative, but it is only qualitative or quantitative analysis. Unfortunately, it is difficult to draw a satisfactory conclusion. Therefore, this paper puts forward the 'H-F-A'model for cold chain logistics park location.

2.Step - by - step Site Selection

The "H-F-A" model is divided into the following three stages: the location determination of the alternative center, the calculation of the location, and the evaluation of the location. The "H-F-A" model overcomes the shortcomings of the previous methods. At the same time, the shortcomings of each method are made up to a certain extent, which makes the location of each cold chain logistics park more reasonable and more in line with the actual requirements.

2.1 Model establishment

First, set up a set of addresses in a certain area, and select a certain number of addresses that meet the minimum total cost of logistics and distribution as an alternative location. The model for establishing an alternative hub center is as follows:

$$\sum C = \mathrm{F} + \mathrm{T} + \mathrm{V} \tag{1}$$

- $\sum C$ is the total cost.
- F: Logistics Park Fixed Costs.
- T: Transport Costs.
- V: Park Change Costs.

However, the variable cost of cold chain logistics park refers to the management cost incurred when the cold chain logistics park distributes goods. If the variable cost is regarded as a linear function, it will be difficult to reflect the actual cost of the park, so that the calculated optimal scheme deviates from the actual situation.

Therefore, variable i is introduced, (1) becomes:

$$\sum C = \mathrm{F} + \mathrm{T} + \mathrm{iV} \tag{2}$$

At the same time, time constraints should be taken into account in the site selection model, especially for the cold-chain logistics park of multi-lot, small-batch cargo transport type. Time will seriously affect the ordering plan, the quantity of goods storage, the distribution and transportation, and so on. The end result will be reflected in the total cost. Therefore, the time factor should be introduced into the site selection model, so the model becomes:

$$\sum C = \varepsilon\ (\mathrm{F} + \mathrm{T} + \mathrm{iV} \tag{3}$$

- $M_G \leq 700\mathrm{km}$.
- $M_g \leq 490km$.
- M_G: One-way highway for transport vehicles up to 700km.
- M_g: Transport vehicles one way national Road farthest 490km.

Since the total cost is affected by many factors, the establishment of location model should be assumed as follows:

- Single source distribution;
- To meet customer demand for delivery;
- Only in the selected area to consider the selected cold chain logistics park site;
- Known user demand;
- Commodity freight is proportional to traffic;
- Park construction and;

- A one-time delivery of goods by delivery;
- operation costs are known.

2.2 Location selection calculation

In order to select a reasonable cold chain logistics park address, firstly filter out cold chain logistics park sites that will not meet the conditions of the alternative address based on the quantity of sites and time constraints; Secondly, remove the infeasible combination, a number of feasible sub-problems will be selected. Considering the number of cold chain logistics parks in the model, in m alternative cold chain logistics park sites, each time p alternative sites are picked up to combine, there will be C_m^p a combinations, the set of selected cold chain logistics parks located in each combination is denoted by h, steps are as below:

STEP1：Get C_m^p combinations through calculation；

STEP2： "The sum of the transportation time of the product from the manufacturer to the cold chain logistics park and the transportation time of the park to the customer is less than or equal to the customer's transportation time of the product " is regarded as a criterion to calculate the combination.

STEP3：If the conditions are met, the combination is selected, otherwise the combination is disqualified, h (h≤C_m^p) sub-problems will be left in the end.

STEP4： For each feasible sub- problem for the initial solution, freight cost T_{kj} is required relatively minimal (the total costs from the manufacturer to the cold chain logistics park freight cost h_{ki} and park to the customer freight costs are minimal)

$$\text{Min } T_{kj}=(h_{ki} + c_{ij}) \quad i \in h \tag{4}$$

STEP5： From the park's transportation costs and fixed costs to calculate the distribution center changes in the cost:

$$\text{Min V= Min } [\varepsilon(F_{kij} + C_{kij})] \tag{5}$$

STEP6：Repeat step STEP4 and step STEP5 to solve the feasible solution of each sub problem；

STEP7：It is a feasible solution to compare the feasible solution and obtain the minimum cost.

2.3 Evaluation of Park Location

The "factor-level analysis" approach takes into account the relative weights of the key factors, on the one hand, and the interrelationships between key factors. At the same time, it helps to scientifically and rationally choose cold chain logistics park construction site, reduce transportation distance and cost, reduce logistics operation costs, improve the value of goods.

In general, the main factors affecting the location of the hub are:

Table 2. Hub center location influencing factors

Influencing factors	**Condition**
Traffic	Near the important transport hub, with two or more modes of transport.
Economy	Adapt to market demand, the extent of existing facilities, land prices, labor conditions.
Environmental protection	Prohibit serious noise pollution and a lot of agricultural waste.
Service Level	To achieve on time delivery.
Operating environment	The region's preferential logistics industry policy.
Terrain climate	High temperature, terrain flat and should have the appropriate area and shape; temperature, wind, precipitation, frost-free period, permafrost depth, the average annual evaporation.
Public Utilities	City public facilities are well equipped.
Sustainable Development	Reduce the pressure on the city traffic and reduce the adverse impact of logistics on the urban environment.

The same objective function is usually affected by the different degree of variable factors. This paper will use factors - analytic hierarchy process to calculate and rank the variables that affect the location of the cold chain logistics park, making the location more reasonable.

2.3.1 Determine the influencing factors. The factors influencing the factors included in the system are grouped by factor-level analysis. The location of the cold chain logistics park is studied by using qualitative analysis and quantitative analysis. The index system is established and the fuzzy range of the influencing factors is determined so as to be used in the analysis calculation.

2.3.2 Model building. According to the factor - the basic principle of analytic hierarchy process, the location problem is decomposed into various constituent factors, and then the factors are composed of the multi - level analysis structure model based on the degree of correlation between the factors and the relationship between them. The steps are as follows:

STEP1：Determining the evaluation level of cold chain logistics park location model. It will be mainly divided into the overall level, factor layer, index layer and the program layer 4 levels；

STEP2：The index matrix is constructed in the index system, and the factor layer is constructed according to the commonly used 1 ~ 9 scale criterion. The overall evaluation layer matrix B=$(b_{ij})_{m\times m}$ and the index layer judgment matrix C=$(c_{ij})_{n\times n}$；

STEP3：The maximum eigenvalues of matrix B and C are obtained respectively: λ_{bmax}, λ_{cmax} and the corresponding eigenvector w_{ij}^{b}= [w_1^b, w_2^b,… , w_m^b] and w_{ij}^{c}= [w_1^c, w_2^c,… , w_n^c], the vector w_{ij}^{b}、w_{ij}^{c}

is the corresponding relative weight.

STEP4：Matrix Consistency Judgment and Error Analysis. Set the overall evaluation of A, which were divided into sub-evaluation factors, functional service level, economic benefits and environmental factors C_{ij} (i= 1, 2,… ,m; j= 1, 2,… , n) is the j th evaluation index of the i th evaluation factor, considering the actual situation, it also includes the option layer D_k(k= 1, 2,… , p).Indicator is

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

According to the corresponding judgment matrix, the root of the matrix changes with the judgment matrix B and C, the degree of consistency of the matrix can be checked by the change of the eigenvalue of the judgment matrix. The greater of consistency of judgment matrix deviation the greater of the CI; on the contrary, judgment matrix is close to be completely consistent.

STEP5：The determination of the weights of the indicators under the overall objectives;

STEP6: The calculated value of the program is weighted sum, the resulting value is the program comprehensive evaluation value, and then select the alternatives of cold chain logistics park sites according to the comprehensive evaluation value.

3. "H-F-A" Mode Application

With the "Belt and Road" strategy, cold chain logistics will be vigorously developed nationwide, and the regional characteristics fresh products will be transported in a wide range, "H-F-A" model is used in the northwest inland as an example.

Table 3. Indicators of major cities in the northwest

Index City	population (ten thousand)	GDP （one hundred million）	Total road mileage (km)	Road freight (ten thousand tons)	Total railway mileage (km)	Railway Freight (ten thousand tons)
Xi'an	855	5475	25135	49243	2757	899
Xianyang	492.86	1860	15074	8052	463	282
Lhasa	56	178.91	3335	619	1080	71
Urumqi	311	1311	23240	17853	2925	2275
Kashi	398	375	23439	2763	453	292
Yili	441	186	1011	5978	286	11
Xining	223	1077	2250	2781	800	491
Lanzhou	362	1100.39	1952	9531	356	974
Jiuquan	110	405.03	16368	2896	310	736
Yinchuan	199	763.26	4706	14787	311	489
Hohhot	287	1865.71	6236	14978	286	2990
Ordos	194	2643.2	18820	40206	1667	26402
Kunming	726	3,011	17581	16176	603	11931
Qujing	586	1,451	28080	12189	598	958

Nanning	666	1800	12800	27872	481	1981
Guilin	475	1109	12080	8351	435	218
Chengdu	1417	9108.89	22514	42537	569	764
Mianyang	416.39	960.2	19888	6663	583	110
Chongqing	2884.62	7894.24	127000	80695	1929	2337
Guiyang	432.46	1121.82	9710	19750	350	1519
Zunyi	612.7	908.76	26383	12954	780	631

Table 4-6 is obtained after calculation

Table 4. City Rankings

Ranking	**City**	**Ranking**	**City**
1	Ordos	12	Hohhot
2	Chongqing	13	Mianyang
3	Xi'an	14	Kashi
4	Kunming	15	Guilin
5	Urumqi	16	Yinchuan
6	Chengdu	17	Jiuquan
7	Nanning	18	Lanzhou
8	Zunyi	19	Xining
9	Qujing	20	Yili
10	Guiyang	21	Lhasa
11	Xianyang		

According to the calculation results, in respond to " Belt and Road " strategy, the cities Ordos, Chongqing, Xi'an, Kunming, Urumqi, Chengdu and Nanning are established as the construction address of the cold chain logistics park, the cold chain logistics park with the coastal area responds with each other to develop the business of the western region.

4.Conclusion

The location planning is the key in the construction of the cold chain logistics park. In this paper, the strict location and evaluation methods are used to consider and calculate the alternative addresses. The H-F-A model is a good way to overcome the shortcomings of less quantitative calculation data, location results are too deviate from the actual, site selection based on experience and other defects. This article intends to establish a sound cold chain logistics system nationwide, so that cold chain logistics network covering all parts of the country, to achieve the exchange of cold chain products, enhance people's quality of life and promote economic development of various places.

Reference

[1] Wang Jiaxu. Problems and countermeasures in the development of cold chain logistics of agricultural products in China . (Logistics Technology) pp 80-89.

[2] Zhou Qiwen. Study on the role of agricultural logistics park in regional economic development . (Journal of Sichuan Vocational and Technical College) pp 11-13.

[3] Huang Jianhui, Wang Wei, Li Quan.Guangdong Sanshui agricultural products cold chain logistics park construction research . (Anhui Agricultural Sciences Vol 6).

[4] Arduino, G., Carrillo Murillo, D. & Parola, F. 2015, "Refrigerated container versus bulk: evidence from the banana cold chain", (Maritime Policy & Management vol 42) chapter 3 pp 228.

[5] Freidberg, S. 2015, "Moral economies and the cold chain", (Historical Research vol 88) chapter 239 pp 125-137.

[6] Pearson, A. 2016, "Strengthening the Cold Chain", (ASHRAE Journal vol 58) chapter 8, p 64.

[7] Anonymous 2016, "Reducing food losses by improving cold chain coverage", (Appropriate Technology vol 43) chapter 1 p 40.

[8] Carullo, A., Corbellini, S., Parvis, M. & Vallan, A. 2009, "A Wireless Sensor Network for Cold-Chain Monitoring",(IEEE Transactions on Instrumentation and Measurement vol 58) chapter 5 pp 1405-1411.

[9] Uçar, A. & Ozçelik, A.Ö. 2013, "Individuals' knowledge and practices of the cold chain", (Ecology of food and nutrition vol 52) chapter 2 pp 116-129.

[10] Chaudhri, R., Borriello, G. & Anderson, R. 2012, "Monitoring Vaccine Cold Chains in Developing Countries", (IEEE Pervasive Computing vol 11) chapter 3 pp 26-33.

[11] Coulomb, D. 2008, "Refrigeration and cold chain serving the global food industry and creating a better future: two key IIR challenges for improved health and environment", (Trends in Food Science & Technology vol 19) chapter 8 pp 413-417.