

Design of Cold Chain Logistics Network Layout in Northwest China

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Abstract—Northwest China is a region where ethnic minorities live in and rich in land and resources. Moreover, in order to revitalize the economy and implement the "one belt and one way" development strategy, the government has launched a series of preferential policies for attracting foreign investment. Northwest China is located in the frontier and the core area of the Eurasian Economic Zone. It is the golden area of the future Eurasian Economic Zone. The establishment and implementation of cold chain logistics network in Northwest China will play an important role in the overall development of Northwest China.

Key word—*Northwest Chin; Cold Chain Logistics; Network Layout; Grey Clustering*

I INTRODUCTION

With the development of China's economy and the improvement of people's living standards, people have higher and higher requirements for the quality of fresh agricultural products. Cold chain logistics is one of the important ways of logistics activities [1]. Cold chain logistics covers the whole process of freezing processing, cold storage, cold chain transportation and cold chain sales, which is the best choice for fresh frozen goods. The development of cold chain logistics has great market prospects for the great output of fresh products in Northwest China. Therefore, the development of cold chain logistics of fresh agricultural products in Northwest China has become an issue that cannot be ignored.

II SUPPLY AND DEMAND ANALYSIS OF COLD CHAIN LOGISTICS MARKET

A. Analysis of Cold Chain Logistics Demand in Northwest China

Northwest China is rich in melons and fruits, dairy products, beef and mutton resources. Fresh products have huge output and excellent quality, which are popular with people everywhere, and bring infinite vitality to the development of cold chain logistics. Due to the long-term lack of large-scale refrigeration, refrigeration, constant temperature integrated cold storage, cold chain logistics has been quite backward, resulting in the northwest region cannot preserve products with different temperature requirements every year [2].

In Inner Mongolia with Hohhot as the leader, the output of dairy products is more prominent and the output of milk is relatively high. In 2013, due to retail withdrawal and rising beef prices and other factors, cow stocks and milk production

in the western region decreased in varying degrees. With the change of food consumption behavior brought by economic growth, income increase and urbanization, the rigid demand for dairy products will continue to grow. Good cold chain logistics layout can extend the milk sales path and shelf life. To some extent, cold chain logistics can lead the development of milk industry in Northwest China.

Xinjiang is located in the northwest of China with many kinds of great melons and fruits. Fresh and dry melons and fruits are in the city all year round. Xinjiang fruit enters the South China market, generally needs 5 to 6 days of day and night automobile transportation while the refrigeration storage and transportation equipment and facilities are relatively backward. It is understood that at present, less than 10% of fresh fruits are sold in cold chain transportation in Xinjiang. The transportation loss and cost is very high, which has become an insurmountable obstacle for Xinjiang fruits to develop South China market.

Gansu Province is rich in meat production, mainly beef and mutton. Gansu Province recently issued and implemented the Gansu Province Beef and Mutton Development Plan (2014-2020). Through increasing policy support and strengthening the construction of two breeding systems, the proportion of beef and mutton farming in the province will reach 50% to 60% by 2020. Thus, the supply of beef and mutton will be considerable in the future.

B. Analysis of Cold Chain Logistics Supply in Western China

Although there has been a certain scale of fresh agricultural products logistics distribution center in the western region of China and the construction of characteristic agricultural products logistics facilities has also been strengthened to a certain extent. However, compared with developed countries, the overall level of cold chain logistics of agricultural products in China is low, the whole circulation loss and the logistics cost remains high. Especially in the western region where the development is relatively lagging behind, the logistics infrastructure of agricultural products is relatively backward and inefficient. Since agricultural products warehousing, transportation conditions and tools, as well as information network, platform facilities are also relatively backward, agricultural products in the circulation process have heavy loss. At the same time, there is regional imbalance in the development of agricultural products logistics market in China. There is a gap between the development of economy and

consumption level in Western China and developed areas, and the information network system of every link of agricultural product logistics is still blank. Only a few enterprises have logistics information system, and the vast majority of enterprises do not have the ability to use modern information technology to process logistics information [3].

C. Necessity of Extending Cold Chain in Western China

From the perspective of political environment: The 13th Five-Year Plan puts forward new development concepts related to cold chain logistics. With the formulation of national logistics planning and the improvement of domestic regulations and supervision, logistics can become the pillar industry of urban development in the future. The improvement of domestic per capita consumption power, the improvement of fresh food quality requirements and the enhancement of awareness of cold chain standards have promoted the healthy development of cold chain industry [4].

From the perspective of economic environment: The overall level of cold chain logistics of agricultural products in China is relatively low, especially in the northwest region where the development is relatively lagging behind. Agricultural products logistics infrastructure is relatively backward and inefficient, resulting in serious loss of agricultural products in the circulation process and high logistics costs. The activation of rural market demand and the export of agricultural products in Northwest China have further stimulated the development of cold chain logistics industry. China's sustained economic development and the continuous expansion of opening to the outside world have brought huge development space for the logistics industry. At the same time, the further improvement of road facilities, such as highways and railways, has provided conditions for the export and domestic sales of fresh products in Northwest China.

From the perspective of social environment: In recent years, the development of China's cold chain logistics industry has rapidly extended from coastal areas to the northwest and central regions. The market segments such as fruit and vegetable cold chain logistics and dairy cold chain logistics have maintained a good momentum of development, gradually moving towards standardization and standardization. Most of the authoritative research institutes of logistics in China are in the eastern coastal cities, and the scientific research level of universities in the northwest region cannot be compared with that in the eastern region. Compared with other regions in China, the level of workers in Northwest China who are physically fit in handling and handling is significantly lower than those in eastern China who have professional knowledge and technology.

From the perspective of the technological environment: The logistics distribution center of fresh agricultural products has appeared in Northwest China and the construction of logistics facilities of characteristic agricultural products has been strengthened to a certain extent. The cold chain logistics standards in Northwest China cover a relatively small range of industry standards, mainly agricultural, meat products, dairy products, seeds and other products. The process involved in the Northwest Cold Chain is mainly the primary links of

harvesting, storage and transportation, which the technical content is relatively low. Some large-scale chain enterprises have begun to set up distribution centers of characteristic fresh agricultural products, fruits and vegetables with high technical difficulty, and initially set up supply chain and logistics system of characteristic agricultural products in Northwest China [5]. The government and the main circulation bodies have actively adopted advanced logistics technology and facilities, which has created a certain material basis for realizing the specialized operation of northwest characteristic cold chain logistics [6].

D. Basic Principles of Cold Chain Logistics Network Layout

As a complex system engineering, the layout of cold chain logistics network must be carefully investigated and all factors affecting site selection should be thoroughly investigated [7]. The principles of adaptability, coordination, economy and strategy should be followed in site selection [8].

1) Principle of adaptability

The location of cold-chain logistics should be in line with the economic development policies of the state, provinces and cities, with the distribution of logistics resources and demand in China and with the development of national economy and society.

2) Principle of coordination

The layout of cold chain logistics and the location of logistics should consider the national logistics network as a large system so that the facilities and equipment of logistics parks, logistics centers and distribution points can be coordinated in terms of geographical distribution, logistics operation productivity and technology level.

3) Principle of economic

The cost of location selection of cold chain logistics mainly includes two parts: construction cost and logistics cost (operation cost). Located in urban, suburban or outer suburban areas, the construction scale and cost of the auxiliary facilities for future logistics activities, as well as freight and other logistics costs are different. The lowest total cost should be taken as the economic principle for the location of logistics distribution centers.

4) Principles of strategic

The location of cold chain logistics layout should have strategic vision. One is to consider the overall situation; the other is to consider the long-term. Local interests should be subordinated to the overall situation, while current interests should be subordinated to long-term interests. It is necessary to consider the currently actual needs, but also rely on the scheme for further evaluation needs some more specific information.

III ESTABLISHMENT OF MATHEMATICAL MODEL FOR

LOCATION SELECTION BY GREY CLUSTERING METHOD

According to the analysis of population, agricultural products, meat production, poultry and egg production and milk production in several provinces in Northwest China, the cities with advantages in these provinces were selected as Yinchuan, Zhongwei, Guyuan, Ordos, Hohhot, Bayannaer, Xining, Zhangye, Jinchang, Baiyin, Lanzhou, Jiayuguan, Urumqi, Aletai, Kashgar, Hami and Tacheng. Each city can be

regarded as the supply source of cold chain logistics in Northwest China [9].

$\{x_i\}(i=1,2,\dots,m)$ For clustering object set;

$\{\alpha_j\}(j=1,2,\dots,n)$ For clustering index set;

$\{\mu_k\}(k=1,2,\dots,m)$ For clustering grey number set; that is, grey class set. The grey clustering steps are as follows:

Write out the whitening number matrix X of clustering, and divide the index into three levels: High, medium and low.

Identifying grey definite weighted functions $f_{jk}(x)$. According to $f_{jk}(x)$ three forms of expression and hierarchical criteria. The definite weighted functions and the definite weighted functions of each evaluation index are obtained. Among them $f_{jk}(x)$ refers to the whitening function of the JTH clustering index belonging to the KTH grey class. $f_{jk}(x)$ Usually in the following three forms:

① Greater than type $y_{jk}(1) < y_{jk} < \infty$

$$f_{jk}(x) = \begin{cases} 1 & x \in [y_{jk}, \infty) \\ \frac{x-y_{jk}(1)}{y_{jk}-y_{jk}(1)} & x_{il} \in [y_{jk}(1), y_{jk}] \\ 0 & x_{il} \notin [y_{jk}(1), \infty) \end{cases} \quad (1)$$

② Interval type $y_{jk}(1) < y_{jk} < (2)$

$$f_{jk}(x) = \begin{cases} \frac{x-y_{jk}(1)}{y_{jk}-y_{jk}(1)} & x \in [y_{jk}(1), y_{jk}] \\ \frac{y_{jk}(2)-x}{y_{jk}(2)-y_{jk}} & x_{il} \in [y_{jk}(1), y_{jk}(2)] \\ 0 & x_{il} \notin [y_{jk}(1), y_{jk}(2)] \end{cases} \quad (2)$$

③ Less than type $0 < y_{jk} < y_{jk}(1)$

$$f_{jk}(x) = \begin{cases} 1 & x \in [0, y_{jk}] \\ \frac{y_{jk}(1)-x}{y_{jk}(1)-y_{jk}} & x_{il} \in [y_{jk}, y_{jk}(1)] \\ 0 & x_{il} \notin [0, y_{jk}(1)] \end{cases} \quad (3)$$

TABLE I. CLUSTER COEFFICIENT OF 17 CITIES IN NORTHWEST CHINA

Clustering coefficient	Yinchuan	Zhongwei	Guyuan	Ordos	Hohhot	Bayan Nur	Xining	Zhangye	Jinchang
(high)	0.5636	0.1132	0.1824	0.8207	0.9928	0.1075	0.3027	0.0755	0.1326
(middle)	0.4142	0.2225	0.3354	0.1127	0.0071	0.5145	0.4862	0.1803	0.1519
(low)	0.0072	0.5873	0.5873	0.0706	0	0.3142	0.1598	0.6772	0.7059
Clustering coefficient	Baiyin	Lanzhou	Jiayuguan	Urumqi	Aletai	Kashgar Prefecture	Hami	Taicheng	
(high)	0.0664	0.48	0.0284	0.7326	0.0377	0.2421	0.2421	0.0126	
(middle)	0.4805	0.3363	0.1286	0.1484	0.2506	0.1209	0.1209	0.3851	
(low)	0.4158	0.1754	0.8382	0.1806	0.649	1.2259	0.5127	0.547	

Cluster analysis was performed. The three clustering coefficients of the same clustering object are taken as a clustering vector and the maximum clustering coefficients are found in the clustering vector θ_{jk} , from this we can determine the city x_i rank of η_i . As shown in Table I.

TABLE II. GREY CLUSTERING RESULTS OF 17 REGIONS IN NORTHWEST CHINA

x_i	Urumqi	Zhongwei	Yinchuan	Kashgar	Xining	Ordos	Bayan Nur	Aletai	Baiyin	Taicheng	Hohhot	Hami	Lanzhou	Guyuan	Jinchang	Jiayuguan	Zhangye
μ_k	high	low	high	low	middle	middle	middle	low	middle	low	high	low	high	low	low	low	low

A. Basic Layout Planning Based on Grey Cluster Method

Table II is the result of grey clustering of logistics nodes in Northwest China. As for the "high" nodes, it can be planned as logistics parks. Because of the high level of comprehensive development of such node cities, this kind of nodes meet the requirements of the logistics park for the

level of urban economic development, transportation facilities and logistics service capacity. The "middle" node can be planned as logistics center because the comprehensive development of such nodes is better, but their comprehensive capacity is slightly worse than that of logistics parks. They are suitable for connecting upstream logistics parks and downstream distribution centers to play a connecting role.

The "low" nodes can be planned as distribution centers and because the comprehensive development of such nodes is general, it is suitable to undertake small-scale and small-batch logistics distribution functions, constituting the

basic layout of cold chain logistics network in Northwest China, as shown in figure 1.

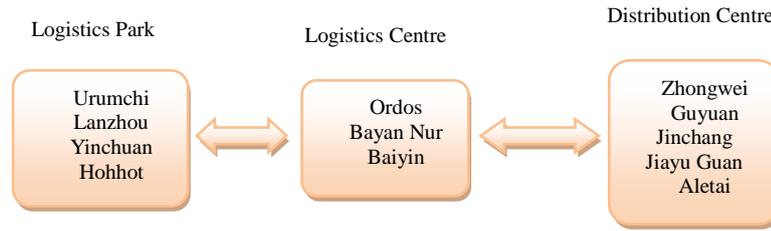


Fig. 1 Hierarchical Layout of Cold Chain Logistics Network

The location of cold chain network is generally considered from five aspects: direct cost, indirect cost, policy orientation, natural environment and traffic factors. In view of the great differences between the Northwest and the Eastern regions, this paper only examines the Northwest from the two aspects of the greatest differences in natural environment and traffic environment [10].

1) Natural environmental factors

During the construction of cold chain distribution center, the natural environment mainly includes meteorology, hydrology, geology and geomorphology. ①Meteorological conditions: Mainly considering temperature, frost-free period, precipitation, annual average evaporation and other indicators, as far as possible to shorten the open storage time of gale weather, and avoid the wind outlet of the city in monsoon area. ②Hydrological conditions: Avoid waterlogging areas and areas with high groundwater table and consult historical hydrological data in the area.

2) Traffic factors

Railway is an index that can reflect the degree of freight transport convenience in a region more comprehensively. For the cold chain layout, the connection degree with road network, port, high-speed and airport directly affects the distribution capacity and speed and represents the service capacity of the cold chain layout [11].

Hami region is an important place for Xinjiang to lead to the mainland of China and one of the important open ports for Xinjiang and Mongolia to develop border trade. In view of its unique geographical location and government support, Hami will be included in the logistics center city.

Tacheng area and Hami area have similar location principles and strategic significance. Similarly, Tacheng will also be included in the logistics center city. Figure 2 is final optimized hierarchical layout of cold chain network.

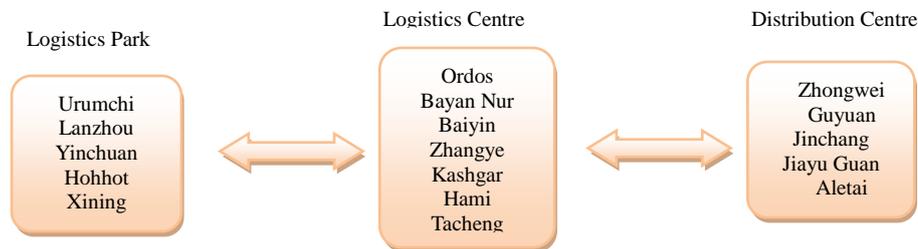


Fig. 2 Final Optimized Hierarchical Layout of Cold Chain Network

B. Layout optimization results

According to the case study of cold chain market in Northwest China, the model is optimized via combining qualitative and quantitative methods. Then, based on the alternative plan, the specific planning of cold chain logistics network in Northwest China is obtained. The results show that Urumqi, Lanzhou, Yinchuan, Hohhot and Xining are logistics parks; Ordos, Bayannaoer, Zhangye, Baiyin, Altay, Kashgar and Hami are logistics centers; Zhongwei, Guyuan, Jinchang, Jiayuguan and Altay are distribution points.

IV CONCLUSION

The scheme design determines the network node of logistics network based on the development status of cold chain logistics in Northwest China, empirically studying the logistics network layout of cold chain in this area, establishing

grey clustering model. Meanwhile, the development of cold chain logistics in Northwest China is comprehensively analyzed to give the specific planning of cold chain logistics network in Northwest China.

In view of the practical significance, this paper designs the logistics network layout of cold chain aiming at the gap of the northwest cold chain logistics market. This paper puts forward a theoretical model for cold chain logistics network in Northwest China. The establishment and implementation of this model not only greatly promotes the development of China's logistics industry, but also promotes the economic development of the whole city, reduces the gap between urban and rural areas and improves the competitiveness of the city. It plays an important role in the overall development of Northwest China and achieve the cold chain logistics system with regarding manufacture enterprises as the core, which

ensures the effective connection between wholesale market of origin and wholesale market of sales place and makes the whole supply chain longer and more complete.

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