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Evaluation on Regional Agri-food Cold Chain Logistics Competitiveness

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Abstract: Presently Chinese agri-food cold chain logistics industry is just at the initial stage which scarce a reasonable method to evaluate regional competitiveness. On the basis of multivariate statistical data, an assessment indexes framework for evaluating is established which is composed of three hierarchical levels, four subsystems and twenty assessment indicators. The established system is applied to evaluate regional agri-food cold chain logistics competitiveness with exemplification of Heilongjiang province, People's Republic of China, on which the competitiveness of the 13 prefecture-level cities is comprehensively analyzed with application of principal component analysis method, meanwhile the relevant classification is realized by system clustering. As a result, the related countermeasures for the respective layers to improve their competitiveness are put forward.

Key words: Agri-food cold chain, competitiveness, cluster analysis

INTRODUCTION

In recent years, with the adjustment of agricultural structure and the improvement of consumption level of the residents, Chinese fresh agri-food production and circulation has increased year by year, more and more attention has been paid to the agri-food cold chain in whole society. To speed up the development of this new industry, promote the sustained increase of farmers' income and ensure the consumers' safety, the National Development and Reform Commission formulated the "China Agri-food Cold Chain Logistics Development Planning" in June, 2010, in which the construction objects of agri-food cold chain logistics in 2015, seven major tasks, eight key projects and safeguard measures were put forward.

Heilongjiang is one of the famous agricultural province of China, with rich agricultural resources, where there are approximately 40000 square kilometers organ agri-food farming land which occupies 60% of whole Chinese organ agri-food farming land. In the Twelfth Five Year Development Planning of Heilongjiang Province, the construction of logistics system with the key of livestock products, agricultural materials, agricultural machinery and cold chain logistics has been presented, so as to enhance the agri-food cold chain logistics competitiveness, accelerate the upgrading of the industrial structure of agriculture and agricultural modernization, promote the development of rural and country economy.

In the study, we has established a evaluation indicators system on agri-food cold chain logistics competitiveness and collect the sample data of thirteen prefecture-level cities of Heilongjiang province, applied principal component analysis to evaluate the regional agri-food cold chain logistics competitiveness and proposed the related countermeasures according to the classified results with cluster analysis.

At present, many Chinese and foreign scholars studied about agri-food supply chain and competitiveness. Wang and Zhang (2009) summarized the competitiveness source of agri-food supply chain and assessed it through fuzzy factors analysis. Chen (2004) analyzed some measures to improve the competitiveness of the supply chain. There are two kinds of structures model of supply chain from the angle of reliability (Balachandran and Radhakrishnan, 2005). Shen and Liu (2011) proposed a stochastic flow network model to select suppliers in foodservice supply chain. A method to measure logistics system efficiency in sudden accident

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based on the reliability of supply chain was proposed by Seth *et al*. (2006), although they had not put forward the performance evaluation method which was defined by Mjoen and Tallman (1997) to describe in international joint ventures. Ahumada and Villalobos (2009) reveals that agricultural products supply chain has special characters such as market uncertainty, structural complication, imbalance of market efforts and vulnerability of products delivered which also means the significance of competitiveness assessment on the agri-food cold chain. Seth *et al*. (2006) established a framework for measurement of quality in supply chains, some of elements selected in above framework are cable to apply in agriculture products cold chain such as economic strength and infrastructure.

The aim of this research is to establish an assessment framework for regional agri-food cold chain logistics competitiveness according to circumstance on China.

EVALUATION INDICATOR FRAMEWORK

Index description: Agri-food cold chain logistics is the result of a certain stage of social and economic development which is influenced by internal and external factors. External factor are factors of macroeconomic, the government level, development level of science and technology and regional infrastructure construction etc. Internal factors come from medium and micro dynamic factors of agri-food cold chain logistics industry, including cold chain market demand, cost, organization, management and personnel training of the inner industry.

As a practical security evaluation system, we follow the scientific, comprehensive and operational principles and take into account the difference and regional common basis on thirteen region of Heilongjiang province and then establish the comprehensive evaluation index of agri-food cold chain logistics competitiveness as Table 1 shown. An assessment indexes framework for evaluating are established which is composed of three hierarchical levels (objective level, systemic level and elements level), four subsystems and 20 assessment indicators. Results of application show that the indexes framework is suitable, practical, convenient and scientific for assessment on agri-food cold chain logistics competitiveness of Heilongjiang province.

Evaluation method: This study aims to analyze the agri-food cold chain logistics development level of 13 prefecture-level administrative of Heilongjiang province, describe the regional advantages and disadvantages and figure out the key influence factor affecting the competitiveness. For the sake of the division of the whole Heilongjiang area in the second stage of data analysis, in the comprehensive evaluation results it is essential not only to get the comprehensive evaluation score and its rank of each region but also to determine their score and ranking in the three aspects of evaluation system.

In view of the above requirements, we choose principal component analysis as our method of comprehensive evaluation. The principal component analysis is a kind of dimension reduction, in which multiple variables in complex systems will be changed into new and less variables, meanwhile original information reflected in multiple variables can be kept as far as possible, so as to simplify complex problems. In this paper, the main standard to determine the number of principal component contribution rate is higher than 80% and the ratio to variance contribution proportion of

Table 1: Evaluation index of agri-food cold chain logistics competitiveness

Objective level	Systemic level	Elements level	
Agri-food cold chain logistics competitiveness	Economic strength	Total population	X_1
		The per capita GDP	X_2
		Gross value of the first industry	X_3
		Gross value of the third industry	X_4
		Household consumption	X5
		Gross output Value Agriculture	X_6
		Per capita annual net income of rural households	X_7
		Local fiscal revenue	X_8
		Total retail sale of consumer goods	X_9
	Infrastructure	Total investment in fixed assets	X_{10}
		Length of Highways	X_{11}
		Urbanization rate	X_{12}
		The total value of transport, warehousing service	X_{13}
	Cold chain logistics demand	Output of livestock products	X_{14}
		Output of aquatic products	X_{15}
		Milk crop	X_{16}
		Yield of fruit and vegetable	X_{17}
		Urban per capita disposable income	X_{18}
	The level of science and technology personnel	The number of Internet users	X_{19}
		Number of science and technology personnel	X_{20}

principal components after rotation is determined as weight, the summary of weighted score of each principal component is deem to the comprehensive scores of each regional agricultural products cold chain logistics competitiveness and the ranking is determined according to the comprehensive score.

COMPREHENSIVE EVALUATION

Data collection and standardization: A group layer of communication is integrated to enable message broadcasting among the distributed application members. According to the above indicators, we collected relevant data, some of which originated from the "statistical yearbook of Heilongjiang Province in 2012". However, due to the lack of comprehensiveness because measurement units and nature of each index is often different actually, the analysis with the direct original data would result in the strong analyzing effect of high numerical index and the weak analyzing effect of low numerical index, then the weighted analysis of each index is not unified. We therefore carried out the unified handling with raw data of those indicators to realize the dimensionality reduction standardization using SPSS19.0 software, thus got the standard dimensionless data. KMO and Bartlett test results show the high significant consistent degree, so it is suitable for principal component analysis.

Principal component analysis: According to the scree plot of the factor analysis results (omitted herein), inflection point occurred in the position of third factor, thus the former three factors are the main component and the remainders are small factors.

In this study, we define the eigenvalue of explanation variance data value is greater than 1.5. The total variance interpretation of each extracted principal components is shown in Table 2. As can be seen, the eigenvalue of the first main factor is 13.208, explained 66.038% of the total variance explained which means the obvious characteristics of main factor. The eigenvalue of the second main factor is 1.962, explained 9.808% of the total variance and explained 75.846% of the total variancetogether with the first factor.

The eigenvalue of the third main factor is 1.645, explained 8.227% of the total variance and explained 84.073% of the total variance together with the first and second main factor. According to the principle that the total explained variance accounted for more than 80%, the factors extracted above should be determined as principal factors to analyze, thus the the three common factors are deem to the principal component of competitiveness evaluation on regional agricultural products cold-chain of Heilongjiang province.

Here, we convert the factor load matrix to standardized orthogonal vector, the actual values of principal components load matrix is the product of unit eigenvector and the corresponding eigenvalue which can be calculated by using the following formula:

$$e_{ij} = \frac{a_{ij}}{\sqrt{\lambda_i}} \quad (1)$$

Table 2: Eigenvalue and variance contribution statement

	Initial eigenvalues			Extraction sums of squared loadings		
X	Total	Var. (%)	Cum. (%)	Total	Var (%)	Cum (%)
1	13.208	66.038	66.038	13.208	66.038	66.038
2	1.962	9.808	75.846	1.962	9.808	75.846
3	1.645	8.227	84.073	1.645	8.227	84.073
4	1.222	6.110	90.183			
5	0.755	3.775	93.958			
6	0.507	2.535	96.493			
7	0.325	1.625	98.118			
8	0.172	0.860	98.978			
9	0.097	0.486	99.463			
10	0.086	0.430	99.894			
11	0.017	0.087	99.980			
12	0.004	0.020	100.000			
13	$7.147E^{-16}$	$3.573E^{-15}$	100.000			
14	$3.405E^{-16}$	$1.702E^{-15}$	100.000			
15	$2.096E^{-16}$	$1.048E^{-15}$	100.000			
16	$2.301E^{-17}$	$1.151E^{-16}$	100.000			
17	$-4.590E^{-17}$	$-2.030E^{-16}$	100.000			
18	$-2.223E^{-16}$	$-1.110E^{-15}$	100.000			
19	$-5.370E^{-16}$	$-2.690E^{-15}$	100.000			
20	$-8.430E^{-16}$	$-4.220E^{-15}$	100.000			

Table 3: Standardized orthogonal eigenvector matrix

Variable	t1	t2	t3
X_1	-0.203600	0.22346	0.20973
X_2	0.269380	0.50690	-0.02339
X_3	0.264430	0.07100	0.08576
X_4	0.230580	-0.04855	-0.19726
X5	0.220680	-262.01000	-0.21285
X_6	0.266900	0.03641	-0.13411
X_7	0.026993	0.03784	0.10682
X_8	0.262230	-0.10209	-0.08966
X_9	0.221780	-0.07568	0.39296
X_{10}	0.215450	-0.00785	0.46157
X_{11}	0.203890	0.14136	0.38672
X_{12}	0.262500	0.04284	-0.13177
X_{13}	0.236640	-0.16420	0.14502
X_{14}	0.266900	-0.05854	0.06082
X_{15}	0.236.64	-0.26986	-0.02495
X_{16}	0.155460	-0.47619	-0.246.38
X_{17}	0.109240	0.34911	-0.32279
X_{18}	0.227280	0.25344	-0.28848
X_{19}	0.190960	0.34197	-0.13800
X_{20}	0.169220	0.45048	0.01030

where, a_{ij} is the load coefficient of variable number j to principal component number i in principal components load matrix prior to rotation and λ_{ij} is the eigenvector of principal component number 1 and e_{ij} is the corresponding value of standardized orthogonal vectors. Standardized orthogonal eigenvector matrix is shown in Table 3.

Though the Table 3, the proportion of all principal components can be obtained, the first principal components is 13.208 and the second and third one is namely 1.962 and 1.645, with the original data standardization formula as following:

$$y = z_x \times t \quad (2)$$

where, $Z_x$is the matrix of variables after standardization and t is standardized orthogonal eigenvector matrix realized through MATLAB. The formula for the calculation of the comprehensive score is as follows:

$$y_c = 13.208y_1+1.962y_2+1.645y_3 \quad (3)$$

CLUSTER ANALYSIS

In this study, by using system clustering method, the regional agricultural products cold-chain logistics competitiveness is classified from the pespective of competition, where the data cited from Table3. As the data of principal component scores in Table¢ó has the same variable unit, it can be used directly without the need for standardization. We apply sample clustering to select correlation clustering method and select the tree map as the statistics of object distance and similarity coefficient. Through the operation of SPSS19.0, the dendrogram of cluster analysis can be shown in Fig. 1 (Note: 1-13 is the sequence number in Table 4).

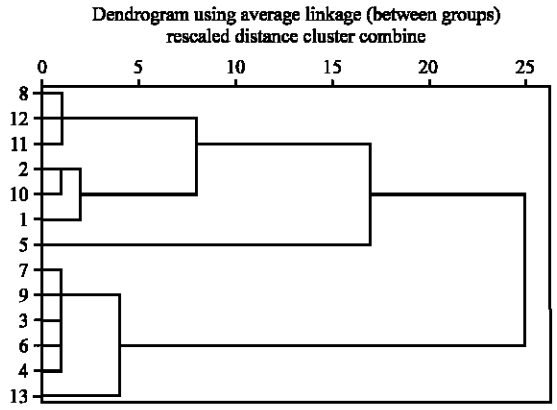

Fig. 1: Dendrogram of cluster analysis on regional agri-food cold chain logistics competitiveness

According to cluster analysis dendrogram we obtained the result of cluster analysis. In the first merge classification Harbin divided as a separate category, so we carry out the individual analysis on Harbin. In the overall rankings and the first and second principal components, Harbin ranks first, with the highest score, so it takes leading advantages. Indeed, the agricultural products cold-chain logistics infrastructure of Harbin is most excellent, the regional resources and agricultural products cold chain logistics resource advantages are rather larger than any other religion in Heilongjiang province. Coupled with the construction of many projects, i.e., Hada fruit and vegetable wholesale market, Harbin Runheng Agricultural Products Logistics Park and Shuangcheng Fruit and Vegetable Cold Chain Base, the advantages of Harbin will continue. At the same time, Harbin as a sub-provincial city, has the good economic foundation which any city in other regions could not be compared with, so agricultural base, geographical and economic conditions provide the basis for the development and enormous resource for Harbin to become the center city of northeast Asian agricultural products cold chain with great potential.

Qigihar and Mudanjiang are classified in one category, we analyze them as a kind of category, where the comprehensive score ranking of Qigihar, Mudanjiang is namely the third and fourth, because their comprehensive situation is close. Comparing with Qiqihar, there is a minor disadvantage in three principal components of Mudanjiang. Indeed, the rankings of Mudanjiang in the three principal component shows that Mudanjiang needs to improve the basic facilities, especially the cold chain logistics facilities. Qigihar and Mudanjiang, respectively belong to west and east area of Heilongjiang province; they need to strengthen the construction in the hardware and services so as to better improve their own advantages.

Table 4: The main components and the comprehensive score

No	Religion	Y_1	Y_2	Y_3	Y_c	Rank
1	Harbin	9.3800	2.0210	-1.5650	6.264	1
2	Qiqihaer	2.1880	0.4960	0.8230	1.561	3
3	Jixi	-1.7360	1.4360	1.0620	-0.919	8
4	Hegang	-3.4760	0.2940	0.2420	-2.245	12
5	Shuangyashan	-1.6230	-0.0480	-0.7650	-1.139	9
6	Daqing	-0.4540	1.5430	1.0830	-0.059	6
7	Yichun	-3.2340	0.7650	-0.4690	-2.099	11
8	Jiamusi	0.5040	-1.3560	0.2090	0.217	5
9	Qitaihe	-3.8010	1.2780	-0.2160	-2.402	13
10	Mudanjiang	1.3655	-1.9818	-1.6018	0.576	4
11	Heihe	-0.8310	-1.1570	-0.7750	-0.726	7
12	Suihua	3.9060	-1.7080	3.0190	2.660	2
13	Daxinganling	-2.1860	-1.5820	-1.0460	-1.686	10

Suihua, Heihe, Jiamusi in all taxa are of the same category. Although Suihua has a relatively weak economic base but the population is over 5.5 million which is next only to the provincial capital Harbin and has a biggest producer of pork in Heilongjiang. However, the disadvantage of tertiary industry limits the cold chain industry which gives it a space in the future to strengthen the service industry driven and enhance its own strength. As to ranking in three principal components, Jiamusi is in intermediate position and Heihe is in relatively back position, so the two cities should vigorously develop in infrastructure and the tertiary industry, fill the gaps according to their own lack of conditions and improve their own competitiveness. Because Yichun, Qitaihe, Jixi, Daqing, Hegang, Daxinganling are classified as a class in the third, fouth and fifth sort, we carry out the independent analysis. In the overall ranking Daxinganling, Yichun, Hegang, Qitaihe, respectively placed from tenth to thirteenth and Daqing ranked sixth, Jixi ranked eighth. In the first principal component rankings above regions are reciprocal which indicates that their economic strength is relatively low.

However, we should admit that in second and third principal components ranking Daqing have a comparative advantage. This reflects the relative advantage of infrastructure construction and consumption level is higher. Without a doubt dairy production capacity of Daqing is beneficial to the ranking of Daqing which occupied 8% of the national dairy production.

In the 4 classifications Shuangyashan is in a separate category each time. The low comprehensive ranking is more or less related to the situation of Shuangyashan. The natural conditions of Shuangyashan are relatively poor, compared with other regional city resources. As a representative of the exhausted coal resource city, its industrial transformation and effect is not as good as other city. Obviously the agricultural products cold chain logistics competitiveness are relatively weak. As a result, it is essential for us to figure out how to achieve the tradeoff of supply capacity and resources maintenance of these cities.

CONCLUSION

Based on the above analysis, we can find that the regional competitiveness of agri-food cold chain logistics in Heilongjiang province is placed in imbalance The geographical position of Harbin and Suihua is very close, their population and agri-food cold chain logistics basic are in good condition, so they should accelerate the development of a number of cold chain logistics enterprises, encourage enterprises to construct temperature storage facilities in the place of origin and sale destination, realize low temperature control from the source, establish cold chain logistics system made manufacturing enterprise as the core and realize effective cold chain logistics link between origin market and sale market. It is crucial for the two cities to encourage large retail enterprises to carry out the construction of agricultural products distribution center and supply the third party logistics service. Harbin shall integrate Suihua to construction of Great Harbin international agricultural products cold chain logistics circle, amplifying the centripetal effect in Heilongjiang province and northeast Asia.

Qigihar and Mudanjiang belong to west and east side of centered Harbin. Combining with Daqing, Qigihar could be developed for agricultural products cold chain west logistics zone, establishing the agricultural products cold chain logistics system of main varieties and key areas, with the emphasis on the development of dairy, beef and mutton, fruit and vegetable cold chain. Coupled with natural adjacent advantage with Russian and the policy advantage of Heilongjiang province about Harbin-Mudanjiang-Suifenhe-Dongning economic development strategy, Mudanjiang shall focus on the development of agri-food cold chain logistics industry oriented to Russia, strive to develop into agri-food distribution center oriented to Russia and regional cold chain logistics resources cluster. Jiamusi, located in East of Heilongjiang, should focus on the construction of cold chain logistics infrastructure, improve cold chain logistics technical level and aim for the eastern regional agricultural products cold

chain logistics center to guarantee and supply resource-exhaust cities in east area. So Jiamusi shall hammer at strengthening the building of cold and cool storage facilities of wholesale markets and other important agricultural products logistics nodes, establish low temperature distribution and processing center for fresh agricultural products based on agricultural products processing enterprises and markets, improve temperature control facilities in the processing of agricultural products, complete the infrastructure matching cold chain logistics facilities and improve the technical level of cold chain logistics.

Other regions should be based on their own conditions, grasp the opportunity, carry out scientific orientation, appropriately develop characteristic agricultural products cold chain logistics projects, i.e., Government of Daxinganling and Yichun focus on the development of blueberry fruit processing industry cluster, speed up construction of distribution and processing base with the function of sorting, cleaning, cutting, cold storage, so as to build cold chain logistics network with the nodes of brand food processing and marketing base. Heihe Russian Agricultural Product Base and Jixi International Trade Logistics Park can moderate development of export leg of cold chain logistics. Wanpuyuan Vegetable Wholesale Market in Hegang and Chuncheng Agricultural Products Wholesale Markets in Shuangyashan should be deem to the local key projects to establish regional vegetable and fruits cold chain distribution center integrated with muliti-function as transaction, refrigerated, quality inspection, transportation and delivery.

Based on the sample data of 13 cities in Heilongjiang Province, this study mainly applies the method of principal component analysis and system cluster to carry out comprehensive evaluation and analysis on the competitive ability of regional agricultural products cold chain logistics, provide a basis for government and relevant units to establish agricultural products cold chain logistics system and logistics enterprises to determine investment decision However, because China is vast in territory, the natural conditions are different, has a wide range of the agricultural products and the cold chain logistics characteristics have obvious differences, it is essential and crucial to further study how to overcome the influence to establish a evaluation system aiming at science and universe and appropriation.

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