Research on Regional Network Logistics Node Selection in Shanxi Province Based on Axial-Spoke Theory

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Abstract: The construction and optimization of regional logistics network plays an important role in the coordinated development of regional economy. This paper builds a regional logistics network based on the axe and spoke theory. It constructs an index evaluation system by selecting 11 indicators in three aspects: economic development level, logistics market demand, and logistics infrastructure. It uses the data of 11 cities in Shanxi Province as the research object and uses the main component the analysis method evaluates the logistics capacity of each city in Shanxi Province, so as to determine the axis city and the node level of each city. A Shanxi regional logistics network with Taiyuan as the primary axis city and Yuncheng, Linfen, and Jinzhong as secondary axis cities was constructed.

1. Introduction

The logistics industry is the artery and basic industry for the development of the national economy. In recent years, with the continuous development of the regional economy, the development of regional logistics in China has also shown a rapid growth trend, but in general it is still in the initial stage. The problems of irrational resource allocation, incomplete logistics network structure, and uneven informatization have become increasingly prominent. Shanxi Province is located in the central region of China and is rich in resources. In the context of economic globalization, in order to ensure the healthy and sustainable development of Shanxi's economy, the government has focused on the structural reform of the Shanxi industry, and the good development of the logistics industry, which has an important impact on the development of the tertiary industry in Shanxi Province, directly determines Shanxi The excellent situation of the provincial regional economy. Therefore, building a more comprehensive regional logistics network is of great significance for reducing logistics costs and improving regional logistics service levels, and also provides a new impetus for the economic development of Shanxi Province.

2. Literature Review

Foreign scholars O'Kelly first proposed the concept of the hub-and-spoke network model [1]. Domestic scholars' research on the hub-and-spoke network started later than foreign scholars. Taking Guizhou Province as an example, Wang Yuqin determined the logistics network with Guiyang, Zunyi, Liupanshui as the logistics node hub based on the axe and spoke theory, and combined with the main analytic hierarchy process, to provide suggestions for the development of the logistics industry in Guizhou; Luo Yi et al. Applied the shaft-and-spoke theory to the cold chain The problem of logistics network design, and the reconstruction of the evaluation system based on the actual situation of cold chain logistics in Guizhou, and the selection of indicators reflecting cold chain logistics capabilities for analysis, thus constructing a spoke-and-spoke cold chain logistics network in Guizhou Province; Based on the selection of logistics node cities by using the principal component analysis method, the radiation range of the axial city was determined by reconstructing the gravity model, and finally the shaft-and-spoke logistics network in Guangxi was constructed.

3. Status of Logistics Development in Shanxi Province

In recent years, Shanxi Province has actively adapted to the economic transformation and carried out industrial structural reforms, coupled with a large amount of investment in infrastructure construction and the improvement of the informatization level of logistics enterprises, the modern logistics industry in Shanxi Province has developed rapidly. However, there are still some problems in the logistics industry in Shanxi Province, which are mainly reflected in the following aspects:

(1) The scale of logistics enterprises is small and their competitiveness is not strong. There are a large number of logistics enterprises in Shanxi Province, but they lack leading enterprises. Most logistics companies are weak and scattered, and there is still a large gap compared with the national outstanding logistics companies. Logistics companies lack long-term, overall planning for their own development, which leads to inefficiency and poor profitability.

(2) The layout of the logistics park is not reasonable enough and lacks overall planning. At present, Shanxi Province has a number of completed or under construction logistics parks, but the construction positioning of these logistics parks is unclear, lacking a global plan before construction, and cannot effectively integrate with the local transportation network, which is not conducive to the overall logistics industry cost of the province Decrease and increase work efficiency.

(3) Lack of senior logistics talents and insufficient professionalism in the logistics industry. Although the number of employees in the logistics industry in Shanxi Province is increasing, most of the practitioners are of low quality and lack workers who have professional logistics skills. There are major loopholes in logistics system design and logistics information management, and the overall professionalism of the logistics industry is insufficient.

According to the above analysis of the development status of the logistics industry in Shanxi Province, building a cost-effective and modern logistics network in Shanxi Province is of great significance for reducing logistics costs, improving economic benefits, and optimizing the industrial structure in Shanxi Province. Therefore, this paper builds the regional logistics network of Shanxi Province based on the axe and spoke theory, with a view to providing a reference for the optimization of logistics system in Shanxi Province.

4. Construction of Axle-Spoke Logistics Network

4.1 Hub and spoke network

Axle-spoke logistics network is a centralized transportation system based on the central station of a large logistics hub. The axle-spoke logistics network is constructed by one or more nodes in the logistics system as hub points, and each node at a non-hub point is connected to each other by the hub point. In the specific operation of the axle-spoke logistics network, the goods are transported to the hub through each node, and the hub will collectively deliver the goods with the same destination to the final receiving place. Compared with the direct network, although the spoke-and-spoke network increases the actual transportation of goods, it has formed economies of scale on the network trunk line, improved economic efficiency and reduced waste of resources.

The axle-spoke network has density, structure, and economies of scale. Therefore, the optimization of the logistics network structure is of great significance to improve the economic efficiency of regional logistics. In regional logistics network planning, the choice of an axis city is an important factor in constructing an axis-spoke network. Therefore, it is necessary to select appropriate evaluation indicators to build a scientific evaluation index system, and use this as a standard to evaluate the comprehensive logistics capabilities of cities in Shanxi Province, so as to select the axial cities of the Shanxi Province’s hub-and-spoke network to construct more reasonable logistics network structure.

4.2 Index system construction

Aiming at the economic development of Shanxi Province and the status of the logistics industry, and taking into account the factors affecting the logistics industry and the availability of index data, this article reviews the comprehensive logistics of cities in Shanxi from three dimensions: economic

development level, logistics market demand, and logistics infrastructure. Ability to assess. The level of economic development can reflect the degree of economic and social development of a region. The regional economic level of a region largely determines the logistics level of the region. It is an important influencing factor on the comprehensive capacity of regional logistics, including regional GDP, public five indicators are fiscal revenue, total imports and exports, total retail sales of consumer goods, and investment in fixed assets throughout the society. The logistics market demand reflects the development prospects and vitality of the logistics industry in a certain region, including two indicators of freight volume and cargo turnover. The logistics infrastructure represents the basic status of logistics in a region, including the total indicators of post and telecommunications services and the mileage of highways.

Table 1 Evaluation Index of Hub-and-spoke Logistics Network Hub Nodes.

Primary Indicator	Secondary Indicator
The level of economic development	Gross Regional Product (X1), Public Financial Revenue (X2), Total Imports and Exports (X3), Total retail sales of consumer goods (X4), investment in fixed assets of the whole society (X5).
Logistics market demand	Freight volume (X6), cargo turnover (X7).
Logistics infrastructure	Total Post and Telecommunications Services(X8), Highway Opening Mileage (X9).

4.3 Data analysis

Based on the data of 11 cities in Shanxi Province, the principal component analysis was performed using SPSS software.

(1) Extract the principal components. By SPSS software, the main component list of Table 2 was obtained. According to the data of each component shown in Table 2, the eigenvalues of the first two components are greater than one, and the cumulative contribution rate is 93.863%, exceeding 85%, so the first two components are selected as the main component for analysis.

Table 2 List of principal components.

Ingredient	Initial eigenvalue			Extract load sum of squares		
	Total	Variance percentage	Grand total%	Total	Variance percentage	Grand total%
1	6.358	70.648	70.648	6.358	70.648	70.648
2	2.089	23.215	93.863	2.089	23.215	93.863
3	0.319	3.547	97.410			
4	0.120	1.334	98.743			
5	0.075	0.829	99.572			
6	0.026	0.289	99.861			
7	0.009	0.103	99.965			
8	0.003	0.033	99.998			
9	0.000	0.002	100.000			

(2) Principal component load calculation. By SPSS software, the principal component load matrix of Table 3 was obtained. Table 4 is the main component scoring matrix. The specific expression is as follows:

$$W1=0.153X1+0.147X2+0.144X3+0.155X4+0.147X5+0.132X6+0.063X7+0.156X8-0.016X9 \quad (1)$$

$$W2=-0.092X1-0.133X2-0.162X3-0.045X4+0.101X5+0.238X6+0.403X7-0.005X8+0.441X9 \quad (2)$$

X in formulae (1) and (2) is the data after normalization.

Table 3 Principal component matrix.

	Load Matrix Ingredient		Scoring Matrix Ingredient	
	1	2	1	2
X1	0.973	-0.191	0.153	-0.092
X2	0.932	-0.277	0.147	-0.133
X3	0.918	-0.339	0.144	-0.162
X4	0.988	-0.094	0.155	-0.045
X5	0.935	0.212	0.147	0.101
X6	0.838	0.498	0.132	0.238
X7	0.400	0.842	0.063	0.403
X8	0.989	0.010	0.156	-0.005
X9	-0.101	0.922	-0.016	0.441

(3) Calculation of comprehensive city score. Calculate the comprehensive score F of each city, where the weight is the ratio of the feature value of each principal component to the sum of the feature values of the two principal components, and a calculation formula can be obtained:

$$F = \frac{\lambda 1}{\lambda 1+\lambda 2} W1 + \frac{\lambda 2}{\lambda 1+\lambda 2} W2 \tag{3}$$

In the formula, λ represents the characteristic value of the principal component.

According to the characteristic values obtained in Table 2, the following formula is obtained through calculation:

$$F = 0.753\ W1 + 0.247 W2 \tag{4}$$

Based on formula (4), comprehensive scores and rankings of each region are shown in Table 5.

Table 4 Comprehensive scores and rankings by region.

Area	W1	W2	Overall Ratings	Ranking
Taiyuan	2.726	-1.126	1.774556	1
Datong	-0.112	-0.103	-0.10978	6
Yangquan	-1.068	-1.378	-1.14457	11
Changzhi	-0.035	-0.135	-0.0597	5
Jincheng	-0.427	-0.888	-0.54087	9
Shuozhou	-0.859	-0.913	-0.87234	10
Jinzhong	0.042	0.814	0.232684	4
Yuncheng	0.305	1.534	0.608563	2
Xinzhou	-0.493	0.663	-0.20747	8
Linfen	0.241	1.287	0.499362	3
Luliang	-0.22	0.186	-0.11972	7

4.4 Axis city Selection

As can be seen from Table 5, Taiyuan ranked first with a comprehensive score of 1.774556. As the capital city of Shanxi Province, Taiyuan's economic and social level indicators are much higher than the rest of Shanxi Province. The infrastructure of Taiyuan City is relatively complete. Many railway trunk lines, such as the Taizhong Bank Railway, Taijiao Railway, Beijing-Taiwan High-speed Railway, and Beijing-Kunming High-speed Railway, are gathered here, which is an important transportation hub in North China. Located in the central and northern part of Shanxi Province, it has a strong radiating role in the development of logistics in Shanxi Province. In recent years, with the construction of the “Belt and Road”, Taiyuan City has gradually increased its investment in infrastructure construction and strengthened its integration with international standards. Historically, Shanxi has been an important part of the "Belt and Road" business district, and Taiyuan has obvious geographical advantages. To the east, integrate the Beijing-Tianjin-Hebei and the Bohai

Rim Economic Zone, and use policy advantages to accelerate development; to the west, connect the western region, and use transportation advantages to assume the land hub of the Silk Road Economic Belt. In addition, many large-scale logistics parks are constantly being built and improved, and the comprehensive logistics level of Taiyuan City is steadily improving. Therefore, Taiyuan City should be the first-level axis city of the logistics network in Shanxi Province.

Yuncheng ranked second with a comprehensive score of 0.608563. Yuncheng City is located in the southwest of Shanxi Province and has a good geographical advantage. The freight turnover of Yuncheng City far exceeds the rest of Shanxi Province. In ancient times, Yuncheng City was named after the "city of salt transportation" and has good freight transportation conditions. Linfen and Jincheng ranked third and fourth, respectively. The three cities in Yuncheng, Linfen and Jinzhong are ranked second in Taiyuan, but they still have a stronger level of logistics services compared to other regions in Shanxi Province. Therefore, these three cities are regarded as the secondary axis cities of the spoke-and-spoke logistics network, and the rest of Shanxi Province is used as the spoke points, which are connected to the axis cities through the main transportation lines. Cooperating with the highway and railway transportation network in Shanxi Province, the spoke-and-spoke logistics network can cover the entire province and form a smooth logistics network.

5. Conclusion

Based on the axe and spoke theory, this paper uses principal component analysis to study the construction of the logistics network in Shanxi Province. Based on the construction of an index evaluation system, the comprehensive logistics capacity rankings of various regions are determined, thereby determining the logistics node levels of each region in Shanxi Province, which has a certain reference role for the construction of the logistics network in Shanxi Province.

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