Spatial and Temporal Evolution Characteristics of A-grade Logistics Enterprises in Hubei Province

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Abstract. A-grade logistics enterprises are the carriers of the regional economy, which are important for promoting the coordinated development of the regional economy. Based on the data of A-grade logistics enterprises in Hubei Province, this paper uses nuclear density analysis, hot spot analysis, and spatial autocorrelation analysis to study the spatial change pattern of A-grade logistics enterprises. The results show that: (1) From 2011 to 2021, the A-grade logistics enterprises in Hubei Province show the clustering pattern from "single core" to "triple-core", and the degree of clustering has been strengthened. (2) Wuhan City has a "siphon effect" on Ezhou City and Xianning City, and the A-class logistics enterprises in the province are developing towards a balanced direction. The study can provide reference for the rational layout of A-grade logistics enterprises in Hubei Province and the coordinated development of the region.

Keywords: A-grade logistics enterprises · Hubei Province · spatial distribution

1 Introduction

As an important province in the central region of China, Hubei Province is known as the "middle of China", with intensive transportation infrastructure and a broad consumer market, and has the obvious location and market advantages in the development of the modern logistics industry. The work report of the Hubei provincial government proposes to promote the regional development layout of "one main leading, two wings driving, and the whole area synergy", which provides a good policy background for the development of A-class logistics enterprises, the improvement of supply chain modernization, the high-quality development of economy, and the enhancement of regional competitiveness in Hubei province. The development of logistics enterprises in turn promotes the formation of this regional development pattern and realizes the strategic mission of Hubei Province as the "central pivot".

Logistics companies, as the bearers of logistics activities, are the main and key to the quality development of the logistics industry, playing this important role as a link between regions, promoting inter-regional communication and fostering economic growth. Logistics activities are concentrated around large cities to access and serve these important

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markets. However, at a more granular level, factors such as land prices and logistics policies make non-central cities more desirable for logistics firms, a phenomenon known as "logistics diffusion" or "decentralization". Scholars have been studying the spatial distribution of logistics companies for a long time [1]. Cidell found that while most U.S. metropolitan areas have experienced "decentralization" in the spatial distribution of freight-related activities, new "decentralization" had occurred in some small and medium-sized cities, suggesting a more complex process than simple "decentralization. This was a more complex process than simple "decentering". Different scholars have chosen different research objects to study the spatial distribution of the logistics industry. From the perspective of land use, DURMUŞ A [2], YUAN Q [3] GIULIANO G et al. [4], KANG S [5] and STRALE M et al. [6] focused on the often neglected impact of the wholesale industry on the spatial structure of cities. Other scholars have studied the movement trajectories of freight trucks, a dynamic logistics facility. For example, Sakai [7] studied the "decentralization" of logistics facilities in the Tokyo metropolitan area based on the data collected on the trajectories of trucks. In terms of "decentralization" and relative decentralization, measuring the average distance was naturally the most direct and effective method. For example, the average distance to all jobs or population centers was a common indicator to assess the "decentralization" of warehouses; the average distance of warehousing and distribution centers to logistics companies and population was used to check whether warehouses were closer to consumers in the context of economic and trade globalization and e-commerce [8, 9]. The Gini coefficient was one of the most common indicators of concentration and was used to describe the degree of concentration of warehousing facilities in geographical units. The higher the Gini coefficient, the more uneven the distribution of warehousing facilities was, with most of them concentrated in a small number of geographical units. Most of the existing studies revealed the spatial concentration pattern of logistics enterprises utilizing geospatial mappings, such as kernel density analysis, buffer zone analysis [10], cold hot spot analysis [11], the center of gravity model [12]. Moran'I index and local indicators of spatial association (LISA) were the main indicators to measure spatial clustering.

Combing the relevant literature, it can be found that the current research on the spatial layout of the logistics industry is relatively rich, most of the existing research have based on urban cluster scale research, developed country metropolitan area research and nationwide research, less research based on Hubei Province. The existing research chooses warehousing industry, wholesale and retail industry, cold chain enterprises as objects, few research is based on A-class logistics enterprises. Taking A-grade logistics enterprises as research samples can provide insight into the development and evolution of logistics enterprises in Hubei Province, and further reveal the spatial evolution process of logistics industry in Hubei Province. Based on the data of A-grade logistics enterprises in Hubei Province from 2011 to 2021, this paper is also useful to provide reference for the reasonable distribution of logistics enterprises in other provinces.

2 Methodology

2.1 Kernel Density Estimation Method

Kernel density estimation is a non-parametric way to visualize the density of point data, which can visually reflect the spatial density of geographical features. In this paper, the kernel density estimation method is used to visualize the spatial distribution density and evolution of A-grade logistics enterprises in Hubei Province.

$$g(x, y) = \frac{1}{nh} \sum_{i=1}^{i=n} [1 - \frac{(x - ai)^2 + (y - b_i)^2}{h}]^2 \tag{1}$$

where: $g(x, y)$ is the kernel density value at the specific location (x, y); h is the smoothing parameter; x and y are the geographical locations of the logistics enterprises. a_i and b_i denote the location of the logistics enterprise with x and y as the center of the circle.

2.2 Spatial Autocorrelation Analysis

The global spatial autocorrelation is mainly used to measure the average degree of spatial differences between the data at a certain location and the data in other regions, which is usually expressed by Moran's I. The local spatial autocorrelation is mainly used to measure the local spatial correlation characteristics of the study object, which is usually expressed by Local Moran's I with the following formula.

$$Moran'sI = \frac{n}{S_o} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{i,j} y_i y_j}{\sum_{i=1}^{n} y_i^2} \tag{2}$$

$$S_0 = \sum_{i=1}^{n} \sum_{j=1}^{n} W_{i,j} \tag{3}$$

$$\mathrm{Loc}alMoran'I = z_i \sum_{i=1}^{i=n} W_{i,j} z_j \tag{4}$$

where n is the total number of elements, S_0 is the aggregation of all spatial weights, y_i is the deviation of the attribute of element i from its mean value, W_{ij} is the spatial weight between elements i and j; z_i and z_j are the normalized values.

2.3 Hotspot Analysis

Hot spot analysis uses vectors to identify the locations of statistically significant hot and cold spots in the data. In the study of the spatial distribution characteristics of A-grade logistics enterprises in Hubei Province, hot spot analysis is used to study the gathering areas of logistics enterprises in space. The calculation formula is as follows.

$$G_i^* = \frac{\sum_{j=1}^{n} W_{i,j} x_j - \overline{\mathrm{X}} \sum_{\mathrm{j}=1}^{n} W_{i,j}}{S \sqrt{\frac{[n \sum_{j=1}^{n} W_{i,j}^2 - (\sum_{j=1}^{n} W_{i,j})^2}{n-1}}} \tag{5}$$

where G_i^* is the hotspot analysis Getis-Ord value, which is used to analyze the degree of clustering of attribute values at the local spatial level; x_j is the contribution of element j, w_{ij} is the spatial weight of elements i and j, n refers to the total number of elements.

3 Spatial Evolutionary Characteristics Analysis

3.1 Spatial Clustering Characteristics

With the help of ArcGIS10.7 software kernel density analysis tool, the evolution of kernel density of Class A logistics enterprises in Hubei Province was generated every 5 years during 2011–2021 (Fig. 1). As can be seen from Fig. 1, the nuclear density of A-grade logistics enterprises in Hubei Province has gradually expanded over time, and the development of A-grade logistics enterprises is mainly concentrated in the early stage, with Wuhan as the center of concentration. "Although Shiyan has a certain number of A-grade logistics enterprises, it is in the second-low value zone in 2016 and 2021, with low nuclear density and no diffusion to nearby areas".

In 2011, the transportation infrastructure in Hubei Province was not yet perfect, the scale of the modern logistics industry was small, the overall nuclear density value of A-class logistics enterprises in each city was low, and the main agglomeration area was Wuhan City; with the State Council successively issued the "Logistics Industry Adjustment and Revitalization Plan" and "Opinions on Policies and Measures to Promote the Healthy Development of the Logistics Industry", and recently strengthened the support for the logistics industry, by 2016, the nuclear density value of A-class logistics enterprises in Hubei Province gradually increased, and the agglomeration effect was gradually enhanced. With the "Twelfth Five-Year Plan", the logistics node cities are planned around the province's "one main and two vice" layout, with Wuhan as a national logistics node city and Xiangyang and Yichang as regional logistics node cities. With the implementation of the policy of logistics node cities, Wuhan is still the concentration center of A-grade logistics enterprises, while Xiangyang and Yichang are beginning to emerge as regional concentration centers; by 2021, the spatial pattern of A-grade logistics enterprises in Hubei cities will be stable, showing a spatial distribution pattern with Wuhan, Xiangyang and Yichang as concentration centers.

From the perspective of spatial diffusion, the distribution of A-grade logistics enterprises in Hubei Province is in line with the first effect of geography, where everything is related and the association of things close to each other is more sophisticated. From the figure, it can be seen that the A-grade logistics enterprises in cities close to the high point of nuclear density are developed earlier, and the nuclear density values of A-grade logistics enterprises in cities such as Ezhou and Huangshi near Wuhan are higher during 2011–2021, but their diffusion effect decreases with the increase of distance.

3.2 Spatial Association Characteristics

3.2.1 Global Spatial Association Features.

To reflect the overall correlation of A-grade logistics enterprises in Hubei province, the global Moran index of the number of A-grade logistics enterprises in each city of Hubei

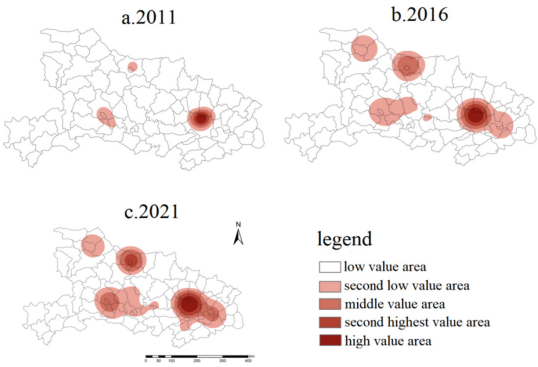

Fig. 1. Evolution of Nuclear Density of A-grade Logistics Enterprises in Hubei Province

province in 2011, 2016 and 2021 was calculated with the help of GeoDa software, and the global spatial autocorrelation characteristics were analyzed. The Moran indices of the selected years are all negative, indicating that the number of A-grade enterprises in Hubei province shows negative spatial correlation. Between 2011 and 2016, the Moran index decreases from −0.154 to −0.196, indicating that the spatial differences between these five years are gradually increasing, and the diffusion effect brought by the clustering of A-grade logistics enterprises in one region does not have the reduction of its gap with the surrounding cities. Between 2016 From 2016 to 2021, the Moran index rises to − 0.19, which indicates that the spatial difference is gradually becoming smaller, and the A-grade logistics enterprises in Hubei Province develop in the direction of equilibrium.

3.2.2 Local Spatial Association Features.

In order to accurately identify the local correlation characteristics of the spatial differentiation of A-grade logistics enterprises in each city of Hubei Province in the selected years, the LISA significant clustering map of A-grade logistics enterprises in Hubei Province from 2011 to 2021 was drawn (Fig. 2). On the whole, there are only two clustering patterns distributed in the spatial distribution of A-grade logistics enterprises in Hubei Province during the study period. Among them, high-low clustering (H-L) type cities were absent in 2011 and Wuhan in 2016, but disappeared in 2021. The emergence and disappearance of H-L type cities reflect the polarization effect among cities in the early stage of the development of A-grade logistics enterprises, with developed regions continuously accumulating favorable factors to further concentrate production, accelerate economic and social development, and accelerate The polarization effect disappears with the development of A-class logistics enterprises in each city at the later stage. Although Wuhan City has a high level of its own logistics development, it does not play a diffusion and spatial spillover effect to drive the development of neighboring cities. The distribution of low-high clustering (L-H) type cities is stable during the study period, with Ezhou, Xianning and Jingzhou in 2011, Ezhou in 2016, and Ezhou and Xianning in 2021, indicating that these cities, especially Ezhou, have been influenced by the "siphon effect" of Wuhan in recent years and are in the siphon tide The "low-lying area", the city's logistics development level and the surrounding cities have a large gap.

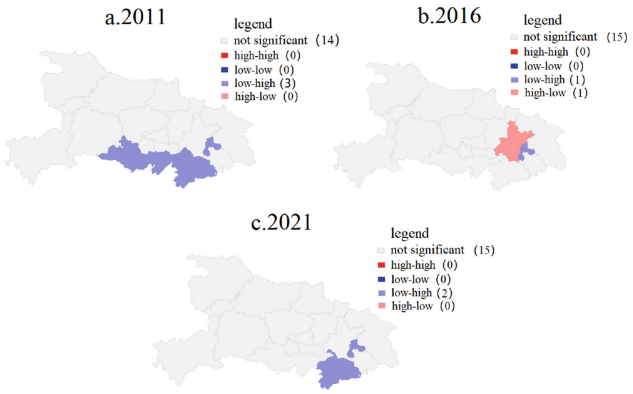

Fig. 2. LISA Significance Clustering Map

Using the hotspot analysis method, 2011, 2016 and 2021 A-grade logistics enterprises in Hubei Province were calculated G_i^* values, and reflected on the map through the inverse distance weighting method to draw a cold hotspot distribution map of A-grade logistics enterprises in Hubei Province, as shown in Fig. 3. It can be seen from the figure that the hot spot value area in 2011 was distributed in the southwest of Hubei, and the hot spot value near Xiangyang was the highest. It can be seen that in 2011, Xiangyang had already appeared agglomeration and development trend, and the cold value area was mainly distributed in the northwest of Hubei. The hot spot distribution in 2016 and 2021 is the same, which means that the A-grade logistics enterprises in Hubei Province developed smoothly according to the existing pattern during these five years. The value of the hot spot area increases and the value of the cold spot area decreases, which means that the high concentration degree deepens and the low concentration degree decreases, and the spatial distribution of A-grade logistics enterprises in Hubei Province is developing in the direction of coordination.

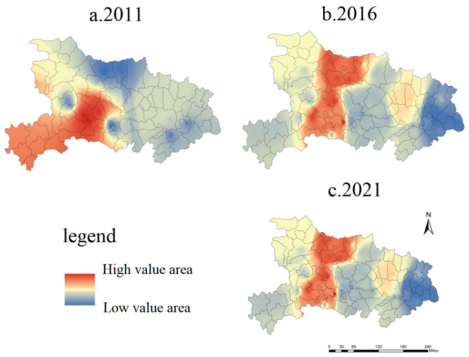

Fig. 3. Hotspot Distribution of A-grade Logistics Enterprises in Hubei Province

4 Conclusion

The spatial distribution of logistics enterprises reflects the location choice and spatial evolution of logistics-related economic activities, while the development of logistics industry is closely related to urban development. Based on logistics location theory, this paper explores the spatial change process and influencing factors of logistics enterprises from the provincial scope. Comprehensive use of nuclear density analysis, cold and hot spot analysis and other methods to analyze the characteristics of the spatial evolution of A-class logistics enterprises in Hubei Province from 2011 to 2021 and the analysis of influencing factors, this paper draws the following main conclusions.

(1) Over time, the nuclear density of A-grade logistics enterprises in Hubei Province has gradually expanded, with the agglomeration effect dominating the development of A-grade logistics enterprises in the early stage and the agglomeration and diffusion effects co-existing in the later stage, with the agglomeration centers mainly in Wuhan, Yichang and Xiangyang.
(2) The spatial effect brought by the cities with a concentration of A-class logistics enterprises in Hubei Province has not driven the development of neighboring cities.

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