Spatial Pattern and Heterogeneity of Port & Shipping Service Enterprises in the Yangtze River Delta, 2002–2016

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Abstract: Using the 'theoretical hypothesis—empirical study—case verification' method, this paper studies the spatial distribution and differentiation of port & shipping service enterprises (PSSE), as well as the variation process and underlying mechanism in the Yangtze River Delta (YRD). First, through inductive and deductive reasoning, we propose the following hypothesis: the regional distribution of different types of PSSE would show different spatial agglomeration-decentralization tendency; and there would be distinct regional differentiation in the industrial structure of the enterprises. Second, based on data obtained from enterprises, empirical research is conducted using Gini coefficient and spatial interpolation simulation methods. Results show that: 1) The overall enterprise distribution is decentralized within a city. 2) Different types of enterprises show different spatial agglomeration-decentralization tendencies. At 3000 m × 3000 m grid scale, there is an agglomeration tendency along seas and rivers in the spatial distribution of enterprises. Shanghai has been identified consistently as a hot spot. 3) There is significant regional differentiation in 12 port cities with respect to the industrial structures of enterprises. Finally, the transportization and the increase of shipping service demand, the globalization and the expansion of multinational corporate activities, the hierarchization and the cooperation among port cities as well as the decentralization and the behavioral difference between the central and local states can be seen as main driving mechanism of the spatial phenomenon.

Keywords: port & shipping service enterprises; spatial distribution; regional differentiation; hub port city; Yangtze River Delta

1 Introduction

Since the 1990s, ports have become increasingly involved in global production and circulation (Gereffi et al., 2005). With the formation of a multinational production network, establishment of global supply chains, restructuring of international liner shipping, and the rise of the shipping service industry, the scale and function of the port system has undergone profound changes

(Lam and Yap, 2011; Monios and Wilmameier, 2016). These changes have not only taken place in the freight transportation service market, but are more extensive in other third-party service markets, such as railroad, air transportation, trucking, freight, and information and financial services (Rodrigue et al., 2009). Port system is an important linkage in the global value chains. The evolution of its spatial structure depends not only on the transportation volume between ports and variation of the

shipping routes, but also on the variation of network relationships as well as the spatial differentiation among different types of ports & shipping service enterprises (PSSE) (e.g., ship company, multimodal transport provider, freight forwarding enterprise, and financial institutions) (Robinson, 2002). Many global hub port cities (e.g., London, New York, Singapore, Hong Kong, China) have been through the transformation from hub port centers to global trade or supply chain centers. The processes have greatly promoted the expansion of the port and shipping service industry (enterprises), structural upgrading, and spatial differentiation (Wang and Cheng, 2010; O'Connor, 2010). In this context, the spatial distribution and differentiation of port and PSSE have become new topics in the area of port geography.

Slack (1989) first reported the spatial agglomeration tendency of different port service industries and enterprises. Since then, location selection of PSSE has attracted a significant amount of academic attention (Glasmeier and Kibler, 1996; Sivitanidou, 1996; Hong and Chin, 2007; O'Connor, 2010). Studies show that the distribution of PSSE is influenced by different factors across various spatial scales. Specifically, in the urban scale, the main factors include the locations of ports and urban central business district (CBD), land rents, as well as the intrinsic characteristics of enterprises and the business relationship between enterprises (Wong, 1982; Chu and Chiu, 1984). In the regional scale, the main factors are common labor resource, wide supplier and customer base, knowledge spillover effect, low transaction cost (De Langen, 2002), governmental policy support, long-term relationship between enterprises and financial institutions, and human resource management based on long-term collaboration (Wilmsmeier and Monios, 2016; Shinohara, 2010). Wang and Cheng (2010) constructed a conceptual model of multiple trade centers. Through questionnaires and surveys, they further analyzed the spatial differentiation of PSSE at different levels of the value chain in the Pearl River Delta, and revealed the obstructive factors in the transformation of Hong Kong, China port from a freight hub to a global value chain center. Talley et al. (2014) reported that the port service chain was a network for freight transportation, which involved transportation companies, port, shipper's service network, *etc*. The interdependent network relationship between the PSSE is the key to the competitiveness of the port service. In contrast to the

systematic and comprehensive studies conducted in other countries, domestic geographic studies on the port and shipping service industry were scarce. Wang (2008) was the first to note the effects of organizational behavior of shipping enterprises on global shipping networks. Chen et al. (2010) found that the port service industry in Guangzhou generally showed an agglomeration tendency towards outside and urban CBD. Mo et al. (2010) investigated the spatial distribution of logistics enterprises in Guangzhou, which showed a significant centralized agglomeration pattern. Zong et al. (2011) analyzed the spatial network organization of local comprehensive service logistics enterprises in the context of globalization. Cao (2012) studied the location characteristics of port and shipping enterprises in the logistics area of Shanghai port, and their spatial connections. Liang et al. (2014) analyzed the spatial differentiation patterns of port logistics enterprises in Shanghai using enterprise data.

Twelve port cities along the sea and Yangtze River were selected in this study for empirical research: Shanghai, Ningbo-Zhoushan, Nanjing, Suzhou, Nantong, Jiaxing, Wenzhou, Taaizhou (Zhejiang), Wuxi, Zhenjiang, Yangzhou, and Taizhou (Jiangsu). These ports are located at the junction of the '21st century Maritime Silk Road' and the 'Yangtze River Economic Zone'. They are the core cities of the Yantze River Delta, which is the first world-class port group in China, with the most densely distributed ports and largest throughput. They play an essential role in China's port economy and opening structure. In 2016, the cargo throughput, container throughput and foreign trade throughput of the above-mentioned ports in the region accounted for 35.2%, 35.8% and 34.0% of the national total respectively. Cargo throughput and container throughput accounting for the proportion of the Yangtze River Delta Region reached about 90%. These twelve port cities have always been the major gathering and leading areas for the development of the domestic port and shipping service industry. The development of the port and shipping services industry and the adjustment of the space structure are increasingly active and have become an important microcosm of the evolution of the global port and shipping service industry and the evolution of the space structure. The number of PSSE has increased from 2866 in 2002 to 23 710 in 2016, indicating an average annual increase of 16.3%. Therefore, the

selection of these 12 ports (cities) in this study is remarkably typical and representative. The 'hypothesis-empirical research-verification' method was used in this study. Based on the data from PSSE in the YRD, we aim to answer the following questions: 1) what are the patterns of spatial distribution and differentiation of PSSE at different scales? 2) What is the regional differentiation tendency in the industrial structure of these enterprises among different types of port cities? 3) What are the mechanisms underlying the spatial distribution and differentiation?

2   Data and Methodology

2.1   Data collection

Data used in this study were enterprise classification data and point site data. According to the value chain theory, the PSSE were divided into 12 sectors, namely transportation (handling) and warehousing, ship material supply, dock construction and river channel dredge, ship agent, ship and equipment repair, service supply, ship management and information consultation, ship accounting and registration and inspection, technology development and educational training, shipping finance and insurance, maritime law and arbitration and supply chain management. In general, these 12 sectors were classified into three categories: transportation and warehousing (TWEs), agency and repair (AREs), and advanced service (ASEs) (Table 1). From the distribution of enterprises on the value chain, the transportation and warehousing enterprises are generally in the lower

end; agency and repair enterprises are in the middle, of which the additional value is higher than that of the first category. Advanced service enterprises, located in the higher end of the value chain, are knowledge-intensive service industries, which are associated with high additional value.

Data were obtained from the websites of China Shipping Online and China Shipowners' Association, as well as data published in *the China Ports Yearbook* (2002–2017), the Business Directory from the yellow pages of corresponding cities, local port associations and departments, and the field research materials of some ports. After screening, data from 2866, 7931, 16861 and 23710 enterprises were obtained in 2002, 2007, 2013 and 2016, respectively. Data of nullified enterprises were included before the nullification of registration. In terms of data processing, we first organized basic information from sample enterprises (e.g., establishment and nullification date, detailed address, main business, and category) using the State Administration for Industry and Commerce website (http://gsxt. saic.gov.cn/). Then, geographical coordinates analysis and conversion technology were used to convert the address information to coordinates, thereby establishing the spatial attribute database for these enterprises.

2.2   Theoretical hypothesis

The distribution and differentiation of PSSE are inevitable outcomes in the late stage of transportization andpost-transportization. It is a new economic and geographic

Table 1   Classification of port & shipping service enterprises in the Yangtze River Delta based on the value chain

Sectors	Category	Position on the value chain
Transportation (handling) and warehousing	Transportation and warehousing enterprises (TWEs)	Low-end
Ship material supply	TWEs	Low-end
Dock construction and river channel dredge	TWEs	Low-end
Ship agent	Agency and repair enterprises (AREs)	Middle
Ship and equipment repair	AREs	Middle
Service supply	AREs	Middle
Ship management and information consultation	AREs	High-end
Ship accounting and registration and inspection	AREs	High-end
Technology development and educational training	AREs	High-end
Shipping finance and insurance	AREs	High-end
Maritime law and arbitration	AREs	High-end
Supply chain management	AREs	High-end

landscape emerging from economic globalization, port (city) regionalization, and Chinese economy decentralization (Fig.1).

Transportization is an important feature of industrialization. In the mid-late industrialization period, with the completion of transportization, the ratio of bulk cargo in transportation volume started to decrease, while the ratio of piecewise containers gradually increased. The total volume measured in tons and ton-kilometers increased at a slower rate or even decreased. Modern logistics and supply chain management gradually became the main organization mode for transportation, with more and more demands for derivative services. Meanwhile, along with the progression of globalization, multinational enterprises with global management strategies and motivations have gradually dominated the global production trading activities, and global flow of foreign direct investment (FDI). Driven by the global production network and supply chain established by multinational enterprises, the regionalization of ports (cities) has accelerated, with strengthened connections and cooperation between ports. The port hierarchy of 'feeding port-branch port-main port-hub port' has gradually formed. Due to economies of scale, hub ports are usually the terminal ports of international container liners, so they become the focal sites for international cargo transportation and merchandise trading. In this context, hub port cities attract more multinational or

multiregional economic, trading and capital activities, appealing to multinational enterprises, especially ship enterprises, container enterprises, large-scale international warehousing, and logistics enterprises (Bichou and Bell, 2007; Notteboom, 2010). Hence, service enterprises derived from port and shipping services grow rapidly. A few hub port cities become the main place for the agglomeration of port and shipping service enterprises.

During the process of advancement of international division and cooperation, featured by outsourcing, subcontracting, and global purchasing, as well as the expansion of global production network, capital transfer and enterprise migration have become easier and more frequent. Some hub port cities have started to evolve into offshore industry centers, and the manufacturing industry has gradually transferred or upgraded. Various advanced production services have emerged, resulting in enormous demands for port, shipping, and related services. Taking Hong Kong, China as an example, in the 1970s the labor-intensive manufacturing industry and trade were equally important. In the 1990s, trade, finance and shipping services grew exponentially, and Hong Kong, China became the second largest service economy in the world. Until 1996, transportation and related services accounted for nearly 10% of its GDP. Along with globalization, port and shipping services showed development tendencies toward category refinement, service specialization, and a distribution hierarchy after entering the transportization finishing stage. Besides warehousing and transportation, intermediate agencies, such as ship agent and freight forwarders, and new service categories, have emerged. Ship repair and technological services were further improved. In order to expand market share, multinational port and shipping service enterprises promoted horizontal and longitudinal expansion of the industrial chain (Slack, 1999; Mccal et al., 2004), and provided related service criteria and quality control for port and shipping service enterprises in developing regions and countries. Meanwhile, the technical and capital-intensive characteristics of port and shipping services were gradually highlighted. Corresponding countries and local governments (especially in developing regions) have continuously strengthened planning guidance and policy support. The port and shipping service enterprises in different sectors determine the distribution based on their positions in the
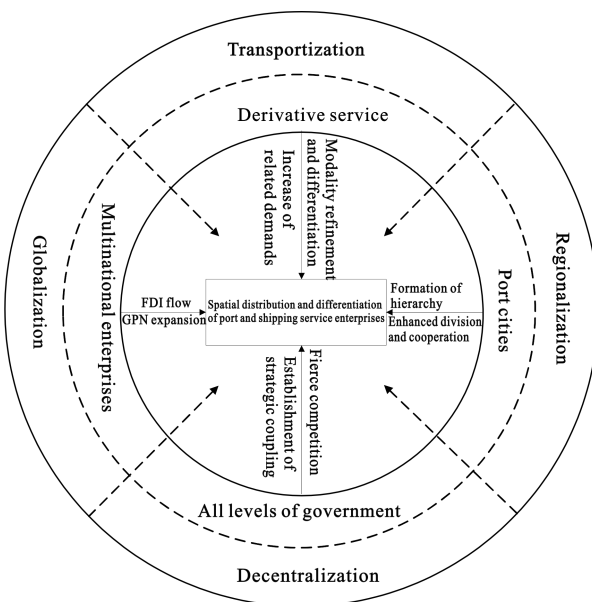

Fig. 1 Mechanism of space distribution and differentiation in port & shipping service enterprises

value chain. Specifically, global hub port cities usually attract advanced service enterprises, while regional hub port cities and other ordinary port cities are favorable for transportation and warehousing, and agent and repair service enterprises. Thus, in a certain region, the characteristics of spatial distribution and differentiation of PSSE have emerged (Fig.2).

With the development of economic globalization, port (city) regionalization, and post-transportization, the transformation of a global hub port city to a global trade center or supply chain center has accelerated. New port service industries are further derived and high-end features highlighted. For example, shipping finance and intermediary elements are highly concentrated in London, with its ship financing scale and tanker charter business accounting for 18% and 50% worldwide, respectively. On the other hand, some hub cities in developing regions or countries are rising up through the global value chain by forming strategic partnerships, embedding, and coupling with leading global companies. Now, the spatial distribution and differentiation of port shipping service enterprises are more remarkable than before (Fig. 2). While the advanced service types of shipping enterprises tend to agglomerate in global hub port cities, the surrogate and repair types, especially the transportation and warehousing shipping service enterprises, tend to be widely distributed in all port cities. It is important to note that, as one of the important featuresof China's reform, opening-up, and economic transfor mation, the central government decentralizes its power
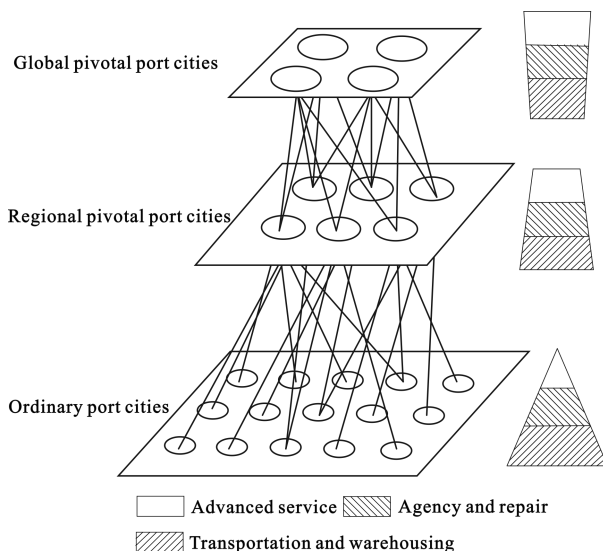
to the local government. In this decentralization process, on one hand, the governments of port cities have gained more autonomy in economic development, which will certainly stimulate the local government to vigorously attract port service enterprises by providing market access, land supply, tax incentives, and public services. On the other hand, decentralization exacerbates not only the horizontal competition between peer port city governments, but also the vertical competition between the port city governments and their superior governments, which will have a profound impact on the spatial differentiation and distribution of the port service enterprises. This will often delay the aggregation of advanced service enterprises and promote the spatial balance among surrogate, repairing and building, transportation and storage enterprises.

In summary, we proposed the following theoretical hypothesis: due to the interaction between transportization, globalization, regionalization and decentralization, the spatial distribution and differentiation of port and shipping enterprises became apparent in a certain region. Advanced service enterprises tend to agglomerate in global hub port cities. Agent and repair, and transportation and warehousing service enterprises tend to disperse and distribute widely in regional hub and ordinary port cities.

2.3 Methodologies

In addition to common statistical methods, two modeling methods were used in this study.

(1) Gini coefficient model. Taking the 12 port cities as basic units, we applied the Gini coefficient model to estimate the dynamic variation of spatial agglomeration and dispersion of PSSE in the YRD. The formula is shown below:

Fig. 2 Spatial distribution and differentiation in port & shipping service enterprises

$$G = \sum_{j=1}^{m} 1 - \mu_j \times (2Q_j - s_j) \qquad (1)$$

where G is the Gini coefficient, ranging from 0 to 1. The larger G is, the stronger the spatial agglomeration, and vice versa; m is the number of port cities; U_j is the proportion of enterprises of the jth city in the Yangtze Delta; s_j is the actual share of number of enterprises to the jth city; Q_j is the accumulated share of number of enterprises up to the jth city.

(2) Spatial interpolation simulation. The area for empirical research was meshed with 3000 m × 3000 m

grids, resulting in a total of 37 500 elements. The number of enterprises in each element was then obtained by connecting the grid with the coordinates of the enterprises. Taking the number of enterprises as a statistical variable, we converted the grid elements into point elements, which were used for inverse distance weighted (IDW) interpolation. Thus, the distribution of PSSE in the YRD could be expressed as a continuous surface. IDW is a common spatial interpolation method. Basically, an unknown point is affected by a known point in a shorter distance more than that in a longer distance. The contribution of an affecting point is inversely proportional to the distance:

$$Z_{(x)} = \left(\sum_{i=1}^{n} \frac{Z_i}{d_i^k} \right) \bigg/ \left(\sum_{i=1}^{n} \frac{1}{d_i^k} \right) \qquad (2)$$

where $Z_{(x)}$ is the estimated value for point x; Z_i is the value of known point i; d_i is the distance between points i and x; n is the number of known points; k is a predetermined power, here $k = 2$. Using IDW interpolation, spatial interpolation simulation was carried out to estimate the following variables of PSSE in the YRD between 2002 and 2016: total number of enterprises, number of transportation and warehousing enterprises, number of agent and repair enterprises and number of advanced service enterprises, thereby illustrating the agglomeration and differentiation of PSSE.

3   Spatial Heterogeneities of Port & Shipping Service Enterprises

3.1   Patterns of PSSE at a macro-city scale

Taking port cities as basic elements, the calculated Gini coefficients are shown in Fig.3 and Table 2. In Fig.3, the Gini coefficients of PSSE in the YRD showed a decreased tendency with fluctuations, indicating that the overall spatial distribution was decentralized. The Gini coefficients of transportation and warehousing enterprises decreased greatly each year, showing significant dispersion characteristics. The Gini coefficients of agent and repair enterprises decreased with fluctuations in a smaller range, suggesting that the dispersion characteristics were not significant. The Gini coefficients of advanced service enterprises also decreased with fluctuations, although the absolute values of Gini coefficients were much larger than the other enterprises shown above. Besides, the Gini coefficients started to increase
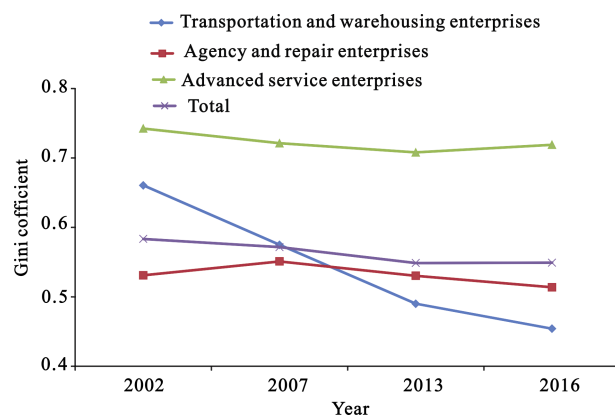
Fig. 3   The change of Gini coefficient of port & shipping service enterprises in the Yangtze River Delta

in 2013, suggesting spatial agglomeration of advanced service enterprises.

As shown in Table 2, among all 12 sectors, the three sectors under the transportation and warehousing category showed significant decreasing trends in their Gini coefficients, suggesting significant decentralizing trends in their spatial distribution. The Gini coefficients of the three sectors under the agency and repair category showed complex changes. The Gini coefficients of ship agent and ship and equipment repair enterprises showed a fluctuating and decreasing trend, suggestive of decentralizing characteristics in the spatial distribution of these two sectors; however, the Gini coefficient of service supply enterprises showed an increasing and fluctuating trend, suggesting a certain degree of centralizing trend. For the enterprises of the six sectors under the advanced service category, the Gini coefficients of ship accounting and registration and inspection showed an increasing and fluctuating trend, suggesting a certain degree of centralizing trend. However, although the Gini coefficients of the remaining five sectors showed a decreasing and fluctuating trend in general, their absolute values were significantly higher than the values of the six sectors under the transportation and warehouse category and the agency and repair category, suggesting that the enterprises of these five sectors under the advanced service category were more spatially centralized.

3.2   Patterns of PSSE at a micro-grid scale

Taking grids as basic elements, the spatial interpolation results are shown in Fig. 4 to Fig. 7. The distribution of PSSE in the YRD showed the following spatial differentiation patterns.

Table 2   The Gini coefficient changes of enterprises under the port & shipping service enterprises in the Yangtze River Delta

Category	Sector	year			
		2002	2007	2013	2016
Transportation and warehousing	Transportation, handling and warehousing	0.692	0.612	0.542	0.507
	Ship material supply	0.591	0.563	0.535	0.531
	Dock construction and river channel dredge	0.555	0.540	0.437	0.419
Agent and repair	Ship agent	0.699	0.713	0.668	0.632
	Ship and equipment repair	0.492	0.487	0.491	0.486
	Service supply	0.708	0.721	0.684	0.727
Advanced service	Ship management and information consultation	0.775	0.704	0.651	0.646
	Ship accounting, registration and inspection	0.655	0.660	0.691	0.686
	Technology development and educational training	0.786	0.759	0.751	0.738
	Shipping finance and insurance	0.900	0.907	0.901	0.881
	Maritime law and arbitration	0.917	0.917	0.75	0.75
	Supply chain management	0.800	0.800	0.794	0.777

(1) Spatial differentiation of overall distribution of PSSE. As shown in Fig.4, there is an obvious agglomeration tendency in PSSE in the YRD, specifically along the Yangtze River and the coast. The interpolation density for Shanghai was always the largest. In 2002, Shanghai was the only hot spot for agglomeration of these enterprises. There are few scattered secondary hotspots in other cities. In 2007, Nanjing and Ningbo-Zhoushan became secondary hotspots. In addition, the density of enterprises increased greatly in Yangzhou along the canal, Wuxi and Nantong along the Yangtze River, and Taaizhou Jiaojiang estuary. In 2013, the number of enterprises in each city continued to increase. Along the Yangtze River, a port and shipping service enterprise zone, has emerged. The middle part of Suzhou, Jingjiang in Taaizhou, and Oujiang in Wen-

zhou, have become the new enterprise agglomeration areas. In 2016, the port and shipping service enterprise zone expanded in the north-south direction. In coastal areas, the distribution remained clustered around Ningbo-Zhoushan, Taaizhou and Wenzhou. Continuous distribution of enterprises has yet to be formed.

(2) Spatial differentiation of transportation and warehousing enterprises. As shown in Fig. 5, between 2002 and 2016, the transportation and warehousing enterprises gradually decentralized. New enterprises were mainly distributed along the Yangtze River and the coastal area, suggesting an obvious location selection tendency. At the city level, the densities of transportation and warehousing enterprises under port and shipping service in some general port cities, such as Jiaxing, Zhenjiang and Yangzhou, have significantly increased,
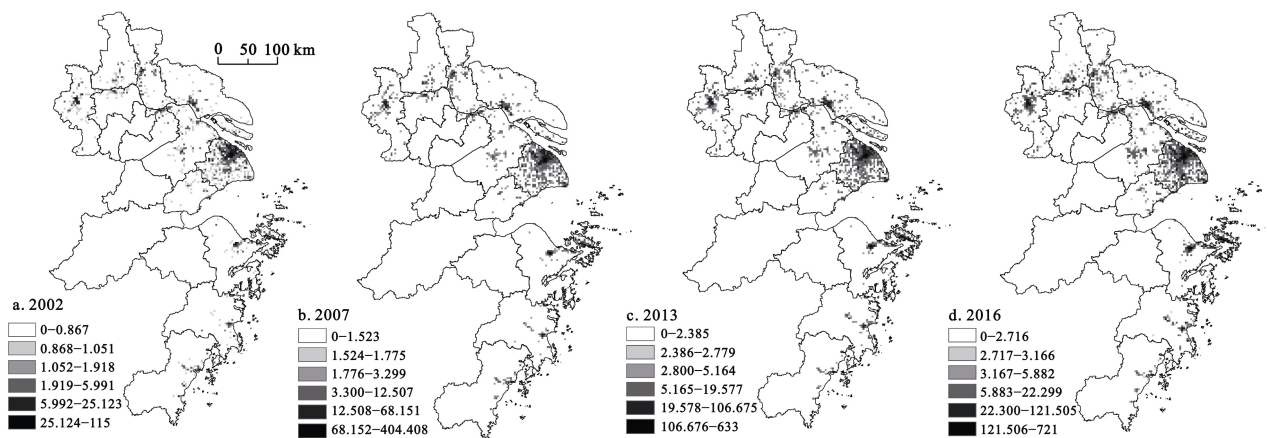
Fig. 4   Overall density distribution of the port & shipping service enterprises (PSSEs) in the Yangtze River Delta (*Z* score)
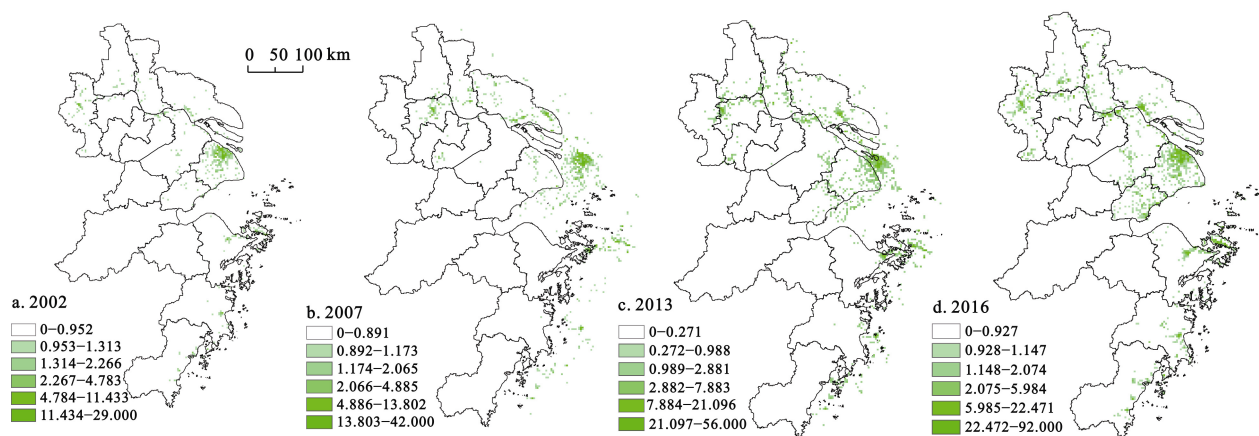
Fig. 5 Density distribution of port & shipping service enterprises (TWEs) for transportation and warehousing in the Yangtze River Delta (Z score)
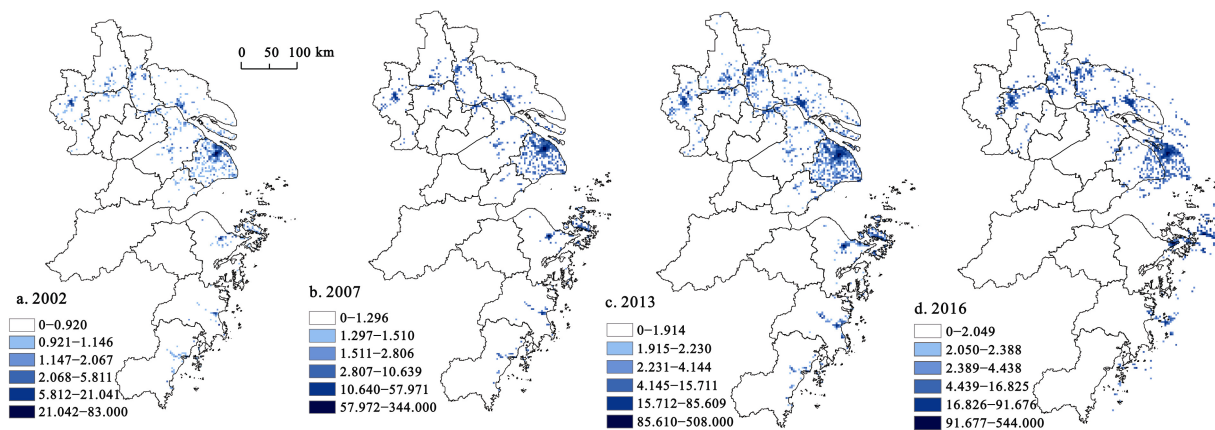
Fig. 6 Density distribution of port & shipping service enterprises for agency and repair (AREs) in the Yangtze River Delta (Z score)

while the densities in regional and global hub port cities, including Shanghai, Ningbo-Zhoushan and Nanjing, have increased, albeit relatively slowly.

(3) The spatial differentiation of agent and repair enterprises under port and shipping service. As shown in Fig. 6, the spatial distribution of agent and repair enterprises in the port and shipping category also tend to orient along the river and coast; its distribution characteristic is more decentralized than that in the shipping and warehousing enterprises. The enterprise densities in Nanjing, Ningbo-Zhoushan, Yangzhou, Zhenjiang and Nantong have significantly increased, while the densities in Suzhou, Jiaxing and Wenzhou have not.
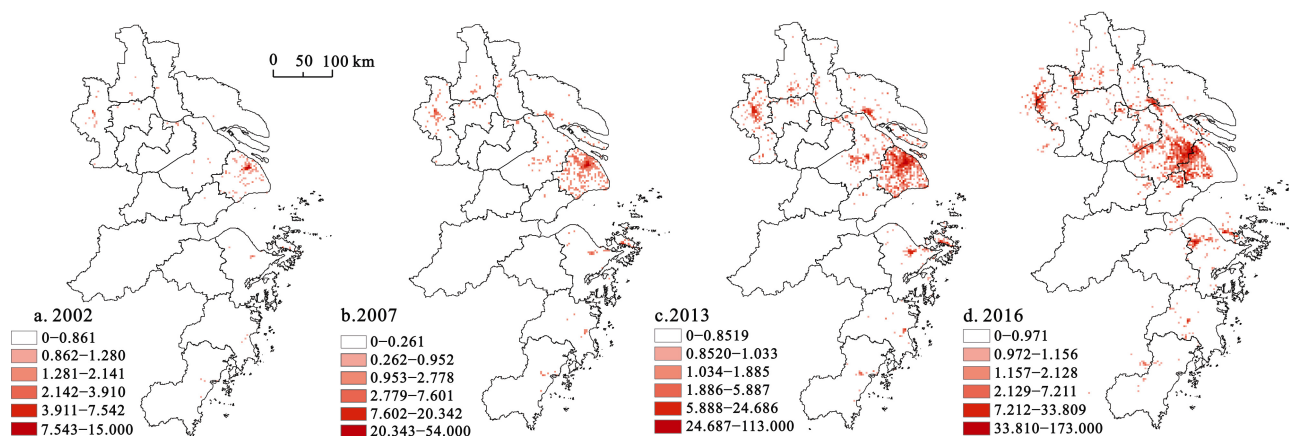
(4) The spatial distribution of advanced service enterprises under port and shipping service. As shown in Fig.7, the distribution of advanced service enterprises under port and shipping service is relatively centralized

In 2002, the enterprises were generally concentrated in Shanghai, and there was only sporadic distribution in other cities. By 2007, the interpolation density in middle Suzhou area, Nantong riverside area, northeastern Ningbo and Zhoushan have shown a significant increasing trend. After 2007, the advanced service enterprises have mostly aggregated around Shanghai, Ningbo-Zhoushan and Nanjing.

4 Regional Differentiation of the Industry Structure for Port & Shipping Service Enterprises

The twelve port cities in the YRD can be generally classified into three types: global hub port city, such as Shanghai, typical regional hub port cities, such as

Fig. 7 Density distribution of port & shipping service enterprises for advanced service (ASEs) in the Yangtze River Delta (Z score)

Ningbo-Zhoushan and Nanjing, and the other nine general port cities. For the past 20 years, the numbers of PSSE in all three types of port cities have significantly increased. However, their industry structures have shown very different differentiation trends (Table 3).

(1) The industry structure differentiation of PSSE in the global hub port city. In Shanghai, the number of PSSE under the transportation and warehousing, agent and repair, and advanced service sectors have increased from 499, 766 and 164 in 2002 to 991, 4732 and 3905 in 2016, respectively. The annual average growth rates for these three sectors are 5.02%, 13.89% and 25.41%, respectively. Advanced service enterprises have the highest growth rate, followed by agent and repair enterprises, and then transportation and warehousing enterprises. The growth rates are significantly different. Meanwhile, the percentage of total PSSE comprised of agent and repair enterprises and transportation and warehousing enterprises have decreased by 4.46% and 24.63%, respectively. However, the percentage of advanced service enterprises has increased from 11.48% to 40.56%, which is approximately four times that of the transportation and warehousing enterprises. In summary, the industry structure of PSSE in Shanghai, the global hub port city, has evolved quickly, with the development concentrated on advanced service enterprises and agent and repair enterprises; and there is an obvious trend towards 'high-end' industry.

(2) The industry structure differentiation of PSSE in regional hub port cities. During 2002 to 2016, in the regional hub port cities, Ningbo-Zhoushan and Nanjing, the number of transportation and warehousing service

enterprises increased from 202 to 1042, with an annual growth rate of 12.42%, which is higher than that of the global hub port city—Shanghai. The number of agent and repair service enterprises also increased from 346 to 4028. In 2016, these enterprises accounted for 64.26%, and became a major component of the port and shipping service industry in these regional hub port cities. Meanwhile, the number of advanced service enterprises quickly increased from 45 to 1198. However, in 2016 the proportion of enterprises was only 19.11%, a mere 2.59% higher than that of the transportation and warehousing service, and significantly lower than the proportion of advanced service enterprises in the global hub port city. Therefore, the industry structure of PSSE in regional hub port cities have evolved with fast development of the agent and repair enterprises and development of certain advanced service enterprises.

(3) The industry structure differentiation of PSSE in general port cities. Among the PSSE of nine general port cities, the number of transportation and warehousing service enterprises has maintained a fast increasing trend, from 191 in 2002 to 1372 in 2016. The average annual growth rate was up to 15.12%, which is significantly higher than those of global and regional hub port cities. This suggests that transportation and warehousing service enterprises continues to be the leader in the industry structure of port and shipping service. The number of agent and repair enterprises increased from 620 in 2002 to 5218 in 2016, with an average annual growth rate of 16.43%. Although the proportion of port and shipping service has slightly declined, it has remained the main part of the industry structure in PSSE in general

Table 3 Changes of the industry structure of port city enterprises

Port cities	Port and shipping service industry	Number of enterprises (proportion/%)			
		2002	2007	2013	2016
Global hub port cities	Advanced service	164 (11.48)	621 (16.68)	1892 (27.21)	3905 (40.56)
	Agent and repair	766 (53.60)	2346 (63.00)	4111 (59.12)	4732 (49.15)
	Transportation and warehousing	499 (34.92)	757 (20.33)	951 (13.68)	991 (10.29)
	Total	1429 (100)	3724 (100)	6954 (100)	9628 (100)
Regional hub port cities	Advanced service	45 (7.59)	173 (9.62)	598 (13.92)	1198 (19.11)
	Agent and repair	346 (58.35)	1120 (62.26)	2858 (66.53)	4028 (64.26)
	Transportation and warehousing	202 (34.06)	506 (28.13)	840 (19.55)	1042 (16.62)
	Total	593 (100)	1799 (100)	4296 (100)	6268 (100)
General port cities	Advanced service	33 (3.91)	158 (6.56)	618 (11.01)	1224 (15.66)
	Agent and repair	620 (73.46)	1761 (73.13)	3960 (70.58)	5218 (66.78)
	Transportation and warehousing	191 (22.63)	489 (20.31)	1033 (18.41)	1372 (17.56)
	Total	844 (100)	2408 (100)	5611 (100)	7814 (100)

port cities. The number of advanced service enterprises has increased from 33 in 2002 to 1224 in 2016; however, the proportion of enterprises is a mere 15.66%, lower than those of global and regional hub port cities. Thus, the development of port and shipping enterprises in many general port cities has mainly focused on middle or lower end enterprises in the value chain, such as agent and repair enterprises and transportation and warehousing enterprises. The development of advanced service enterprises has been very limited.

5 Driving Mechanisms Underlying the Locational Heterogeneity of Port & Shipping Service Enterprises

5.1 Transportization and the increase of shipping service demand

With the development of transportation, significant changes have taken place in the structure of freight transport and logistics organizations. Also, there is an increasing demand for transport services and ever-changing service formats. This has greatly promoted the development of the service industry, especially the port and shipping industry. The YRD is the gateway area of China. Since the reform and opening-up, the industrialization and transportation have been rapidly developing, and industrial structure transformation and upgrade have been continuously accelerating in this area. In 2015, the workforce quotas of the three-sector industrial structure in the YRD adjusted to 2.8: 43.4: 53.8. For the

first time, the tertiary industry exceeded 50%, which was 2.3% higher than the national average level, and was very close to the post-industrial stage (Huang and Li, 2017). During this process, the freight transportation in the YRD has undergone continuous adjustment, as the proportion of heterogeneous container load freight rapidly increased and the containerization process significantly accelerated. Meanwhile, the development of YRD port logistics was also significantly promoted by the planning and construction of Shanghai International Shipping Center and the Yangtze River 12.5-meter deep water channel at the lower reaches of Nanjing. In 2016, port and container throughput in the YRD reached 3.799 billion tons and 77.01 million TEU, accounting for 31.95% and 35.33% of the total amount in China, respectively. At present, the entire YRD region is transforming from a perfect transportization era to a post-transportization era. The port logistics organization model has undergone significant changes; and the demand for transportation derivative services, especially high-end port services, continues to increase. All of these have continuously induced and promoted the emergence and differentiation of new demands and new business opportunities in the YRD for the port shipping service industry, such as freight forwarders, shipping agents, shipping information consulting, shipping finance and insurance. Take Shanghai for example, by the end of 2015, there were 54 insurance companies and 363 insurance intermediaries on the shipping insurance market. Annual shipping and freight insurance income

was 3.833 billion yuan (RMB), accounting for 26.8% of the total national shipping freight insurance premium income. Commercial banks, policy banks and financial leasing companies in Shanghai have credited 24.4865 billion yuan to shipping related enterprises, including shipping, ship building and port management companies. The China Maritime Arbitration Commission, Shanghai Branch, accepted 101 cases in that year and the subject matter of controversy was 1.187 billion yuan. A total of 320 cases were accepted by Shanghai International Arbitration Court and the subject matter of controversy was 411 million yuan. In addition, ship trade, shipping consulting, brokers, information, e-commerce, shipping derivatives trading and other shipping derivative services in Shanghai have been rapidly developing; and Shanghai's status as an international shipping service center has been continuously highlighted.

5.2 Globalization and the expansion of multinational corporate activities

The economic globalization process, represented by the activities of multinational corporations, has been continuously developing, and enhanced the extensive flow of resources, capital, technology, and other factors in the global scope. All these have led to the accelerated reconstruction of the global production network, shipping network and FDI spatial pattern (Pettit and Beresford, 2009; Liao and Hong, 2013). This has greatly promoted power relation and spatial structure evolution of the global supply chain. The advantages of global cities (regions) in the supply chain network have been highlighted. The YRD, one of the earliest open regions and the most industrialized area in China, has become an important strategic node for global production network and investment of multinational companies. In 2016, the actual utilization of foreign capital in the YRD region was US $ 60.654 billion, accounting for 48.13% of the total utilized foreign capital in China. Among them, the tertiary industry actually utilized foreign capital of 38.095 billion US dollars, accounting for 62.81% of the actual utilization of foreign capital in the YRD. Tertiary industry has become the main area attracting FDI in the YRD region, which provides important fund, technology and management experience for the development of the port and shipping industry. Along with this process, the YRD has risen rapidly and become a major container

and shipping market source for the Asia-Pacific region and the world. Many world renowned PSSE and institutions have settled in this region, such as the Clarkson shipping brokers, Braemar shipping brokers, V-SHIP Group (British) and the London Maritime Services Association. All these have a significant impact on the spatial distribution and differentiation of the PSSE in the YRD. Moreover, since the state council made the strategic decision in 1996 to build the Shanghai International Shipping Center, Shanghai has developed into an important destination for transnational investment of global PSSE. Currently in Shanghai, there are about 250 foreign representatives for international maritime transport and auxiliary industries. Maersk, Mediterranean, COSCO Shipping, and other world-renowned liner companies have settled in or set up branches in Shanghai. Forty-one wholly foreign-owned shipping companies and 12 foreign shipping insurance companies have been established in Shanghai. Twenty-two foreign classification societies, including 9 major classification societies, have settled in China; and 15 of them (68.2%) are headquartered in Shanghai. All these have provided a powerful driving force for the construction of Shanghai International Shipping Center and the gathered development of YRD PSSE.

5.3 Hierarchization and the cooperation among port cities

There is strong consistency between the development of port service industry and the scale of port level, but there are obvious differences in the orientation of different types of port service industry. With the improvement of the port grade system and the optimization of the division of labor functions in the port, the advanced service shipping service enterprises tend to gather in the hub port cities while the agents building and shipping and storage shipping service enterprises have developed in the regional hub port cities and the general port cities. With strong support for the Yangtze River economic zone and YRD economic hinterland, the port throughput continues to grow rapidly and the port structure is increasingly stratified in the YRD region. The system of hub port-trunk port-branch port-feeder port has gradually formed. Shanghai is the global hub port in this system; Ningbo-Zhoushan and Nanjing are the regional hub ports, and Suzhou and Nantong are important components of this system. For example, in 2015, the cargo

throughput in the port of Shanghai reached 717 million tons, putting it in second place worldwide. Its container throughput was 36.527 million TEU, taking the first place spot worldwide, a spot it held for many years. The container liner density was 3290 runs per month. It has established container cargo exchanges with over 2700 harbors from 214 nations and regions throughout the world. The Port of Shanghai is the hub with the most container routes and the widest coverage in Mainland China. The Port of Ningbo-Zhoushan completed 889 million tons of cargo throughput and has ranked as the largest in the world for four years in a row. Its container throughput was 20.626 million TEU and was ranked as fourth in the world with 236 ocean and sea container routes in total. The Port of Nanjing completed 222 million tons of cargo throughput and 2.94 million TEU of container throughput with 77 container routes. On the other hand, there are tremendous differences in economic scales, industry structures and market environment of cities with harbors in the YRD. The differentiation of port cities' function and structure is becoming significant; and the functional connections and the degree of labor division and cooperation are continuously strengthened. Shanghai is the core city of the YRD Economic Zone; it is the center of the international economy, finance, trade and shipping with competitive international influence. With a strong economic basis, R&D and innovation capability and synthetic service function, Shanghai plays a key role in serving the whole country, and shows the world that it is a modern service industry center. Nanjing is a comprehensive traffic hub with significant advantages of historical culture, science and human resources; it is the national base for advanced manufacturing, center for scientific innovation, regional logistics and modern service industries in the northern YRD. Ningbo is one of the five largest regional centers in the YRD, and is also the economic center in the southern YRD, advanced manufactural base and modern logistic base. Because of the mutual coupling effect of ports and cities, and the advantages of agglomerative economies and economies of scale, global and regional hub cities like Shanghai, Nanjing and Ningbo have become the core cities for the aggregation of advanced PSSE, such as ship brokerage, shipping finance and insurance, maritime arbitration and law. All these play an important role in supporting and strengthening the spatial distribution and differentiation of PSSE.

5.4 Decentralization and the behavioral difference between the central and local states

With the reform of decentralization, the enthusiasm of the port construction and industrial development of local governments at all levels has been demonstrated. Governments at all levels have become the regulatory and beneficiaries of port construction and the development of the port and shipping services industry. Differences in policy orientation will lead to different Inter-city air and sea service network construction and cooperation, but on the other hand will exacerbate each other's competition. With accelerated market-oriented reform and gradual decentralization of the central government to local governments, the decentralization of rights, resources and responsibilities has strengthened the autonomy of port cities in the YRD, and stimulated their enthusiasm for expanding port logistics and promoting port service enterprises (Li et al., 2014). These have provided a very strong policy response to the rapid integration of PSSE in the YRD in recent years. However, decentralization has also provided a hotbed for the narrow-minded 'sectionalism' or 'local protectionism' by local governments, which has intensified the competition among the port city governments within the YRD as well as between the port city government and the higher level government. The distribution optimization and factor agglomeration of the port and shipping service industry have been emphasized in the nationally issued 'Opinions of the Ministry of Transport on Accelerating the Development of the Modern Shipping Service Industry' and 'Guiding Opinions of the State Council on Promoting the Development of the Yangtze River Economic Belt by Relying on the Golden Waterway'. However, a unified development plan is still lacking for the port and shipping service industry in each port city, and the level of intra-industry labor division is relatively low. Hub port cities benchmarked an international shipping center in their planning for the development of the local port and shipping service industry. Priority was given to the development of knowledge and capital-intensive services in the upstream of the industry, and the establishment of 'large and comprehensive' port and shipping industries was set as the goal for future developments. Port cities are competing to introduce preferential policies to attract port service enterprises to settle in. For example, in the 'Opinions on Accelerating the Healthy Development of Ningbo Shipping Industry'

issued by Ningbo city, it proposed to increase the support for the development of functional shipping service agencies and promote the aggregation of modern shipping services, such as shipping trade, finance and insurance, to form a modern shipping financial service system featuring professional shipping insurance services. In the 'Three-Year Action Plan for the Construction of the Nanjing Yangtze River Shipping & Logistics Center (2015–2017)' issued by Nanjing city, they emphasized that there should be a focus on cultivating trade, finance, information, law and other shipping logistics services, to create an efficient shipping service support system. The competition for high-end port and shipping service elements among hub port cities has led to the homogeneous competition in the port and shipping service industry in the YRD, which has hindered the integration process of the regional port and shipping service market. Moreover, with the under-developed port and shipping service industry in the YRD, the disordered competition has restricted the policy convergence in building Shanghai International Shipping Center, as well as decreased the efficiency in allocating regional port and shipping service elements.

6 Conclusions

In this paper, based on a basic theoretical hypothesis and the enterprise data in 4 temporal cross-sections of 2002, 2007, 2013 and 2016, we conducted an empirical analysis for the spatial distribution and differentiation of PSSE in the YRD region. The main conclusions of this paper are as follows.

(1) At the city scale, enterprise distribution is overall decentralized. Decentralization is more significant in the transportation and warehousing category as well as the agent and repair category enterprises, meanwhile, the advanced service enterprises are more agglomerated.

(2) The spatial interpolation simulation results showed that at the 3000 m × 3000 m grid scale, the spatial agglomeration tendency of enterprise distribution is more significant with spatial orientation along the riverside and the coast. Shanghai is always the hotspot. In 2007, Nanjing and Ningbo-Zhoushan became secondary hotspots. In 2013, a stretch of spatially continuous 'dense belt of port and shipping service enterprises' was formed.

(3) There is apparent regional differentiation of the

industrial structure evolution in these 12 port cities. Shanghai, a global hub port city, is characterized by the advanced service and agent and repair enterprises, with a clear trend toward the 'high-end' industry. Two regional hub port cities, Ningbo-Zhoushan and Nanjing, are mainly focused on agent and repair enterprises, and also features advanced service and transportation and warehousing enterprises. The other nine general port cities are mainly characterized by medium and low-end transportation and warehousing as well as agent and repair enterprises.

(4) The main mechanisms underlying the spatial distribution and differentiation of the aforementioned enterprises includes the inducing and driving mechanisms of shipping service demand in the late perfect transportization phase, the expansion and attracting mechanisms of global production network expansion and increased activities of transnational corporations, the support and strengthening mechanisms of port city hierarchicalization and stratification, and the response and restriction mechanisms of central and local governments' policy orientation differences.

However, as an exploratory work, the issue involved in this article needs to be explained: due to the sensitivity of internal information, especially financial data, most enterprises choose the turnover of non-public enterprises in the business information publicity. As it is difficult to obtain the enterprise size data, this article is mainly based on the enterprise point data, which to some extent affected the depth of empirical analysis.

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