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International Freight Forwarding Services Network in the Yangtze River Delta, 2005–2015: Patterns and Mechanisms

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Abstract: This study examined the spatio-temporal trajectories of the international freight forwarding service (IFFS) in the Yangtze River Delta (YRD) and explored the driving mechanisms of the service. Based on a bipartite network projection from an IFFS firm-city data source, we mapped three IFFS networks in the YRD in 2005, 2010, and 2015. A range of statistical indicators were used to explore changes in the spatial patterns of the three networks. The underlying influence of marketization, globalization, decentralization, and integration was then explored. It was found that the connections between Shanghai and other nodal cities formed the backbones of these networks. The effects of a city's administrative level and provincial administrative borders were generally obvious. We found several specific spatial patterns associated with IFFS. For example, the four non-administrative centers of Ningbo, Suzhou, Lianyungang, and Nantong were the most connected cities and played the role of gateway cities. Furthermore, remarkable regional equalities were found regarding a city's IFFS network provision, with notable examples in the weakly connected areas of northern Jiangsu and southwestern Zhejiang. Finally, an analysis of the driving mechanisms demonstrated that IFFS network changes were highly sensitive to the influences of marketization and globalization, while regional integration played a lesser role in driving changes in IFFS networks.
Keywords: international freight forwarding service network; pattern; mechanism; headquarters-branch method; Yangtze River Delta

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1 Introduction

Network thinking has gradually become a key approach for the evaluation of urban/regional organization (Castells, 1996; Shearmur and Doloreux, 2015), particularly in the context of deepening globalization and informatization. Accordingly, a large number of qualitative and quantitative studies have been conducted that have (re)examined urban systems in the context of intercity connections (Camagni and Capello, 2004; Alderson et al., 2010; Ducruet and Beauguitte, 2014; Parnreiter, 2014; Wang and Jing, 2017) on multiple scales, ranging from global (Taylor and Derudder, 2016), to national (Pan et al., 2017; Derudder et al., 2018), and regional (Hall and Pain, 2006).

One of the main features of urban network studies is the multiplexity of intercity linkages (Burger et al., 2014). A specific urban/regional system's network organization may be projected from various intercity connectional lenses; however, these different connections

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do not necessarily have the same spatial patterns. In empirical studies, different agents that produce connections have been discovered, including corporate organizations (Taylor, 2001), air travel links (Smith and Timberlake, 2001), knowledge cooperation (Li and Phelps, 2017), internet connections (Zhen et al., 2012), transport infrastructure links (Liu et al., 2016), and commuter flows (De Goei et al., 2010). There are well-documented multi-facetted urban networks in the Yangtze River Delta (YRD), the case study region in this research, that illustrate the key features of network organization. Based on the locational strategies of producer service firms, Zhao et al. (2017) mapped these intercity connections using published data. Li and Phelps (2017; 2018) mapped the knowledge linkages, and Zhang et al. (2016) use location-based social media data to chart the movement of people within the region. These different networks share similar intercity connectional patterns. On the one hand, they both present a power-law distribution for the connectivity of cities and city-dyads; on the other hand, they suggest different features associated with different agents. As a result, we can not simply define the networking structure of an urban system from a single and/or several 'cherry-picked' lenses. The examination of multiple types of linkages is therefore crucial in urban network research.

Against this backdrop, this study explored a previously unexamined lens of intercity connections, the international freight forwarding service (IFFS) network, which is a key part of global commodity flows in the era of globalization. Rather than moving from manufacturers or producers to the market in a direct manner, the flow of international freight has always been operated by means of the IFFS. IFFS enterprises are engaged in the organization of a series of freight flow procedures, such as transferring, customs clearance, warehousing, and trucking. The domestic intra-firm organization of IFFS enterprises therefore can reflect how international freight is organized and/or assembled at a city to city (i.e., regional) scale (before transferring to the overseas market). In this study, we mapped IFFS networks in the YRD, and therefore our study provides an empirical addition to the literature regarding urban network mapping.

However, the objective of the study was not limited to showing the patterns of urban networks from the new lens of the IFFS. A second objective was to examine how and why IFFS networks have changed in the last decade. With the functional integration of logistics supply chains (Robinson, 2002), airport systems, ground transportation systems, and logistics services, the various parts of a typical urban network are realigning and converging. Super carriers and integrated service providers have emerged and evolved (Notteboom, 2002). Many portal cities (regions) around Asia-Pacific are transforming from hub ports to global trade and supply chain centers (Wang and Cheng, 2010; O'Connor, 2010). The distribution and division of the functions of IFFS enterprises in different cities have significantly diverged, which has directly influenced the role of each city in the IFFS network. The IFFS network has therefore become an important topic in transportation geography. Cidell (2010) found that there were significant differences in the selection of location among different types of logistics enterprises and among the functional departments (headquarters and subsidiaries) of the same logistics enterprise. The development of logistics enterprises has highlighted the network characteristics of multi-level distribution (Hesse and Rodrigue, 2004). Wang (2008a; 2008b) explored the spatial organizational network of logistics enterprises and found that logistics companies construct their corporation factor networks at urban and regional scales. Taking Guangzhou, Suzhou, Shanghai, and Shenzhen as examples, Mo et al. (2010), Cao (2011; 2012), Liang et al. (2013), and Zong et al. (2011) analyzed the spatial distribution of logistics companies. Based on an investigation of the hierarchical structure, spatial pattern, network connection, and complexity features of China's container transportation organization network, Ye et al. (2017) found close and extensive linkages between the national and regional hub cities.

Against this backdrop, this study attempts to improve our understanding of the evolution of logistical systems in the context of deepening globalization in the YRD, which may have potential contributions to implement export-oriented economic policies in general, and also enriches and expands the method and content for studying the logistics network in other Chinese mega-city regions.

2 Materials and Methods

2.1 Study area

Since China's 'Reform and Opening Up', the YRD has become one of the most economically developed regions in the country. According to the definition adopted by the 'Regional Planning of the Yangtze River Delta Region', the YRD region has grown from 16 to 25 cities, including Jiangsu and Zhejiang provinces as well as Shanghai (Fig. 1). In this region, there is a good foundation for the development of an export-oriented economy and logistics industry. It is also an important platform enabling China to participate in international competition, and thus acts as a crucial engine for economic and social development. The regional GDP of the YRD reached RMB 13.85 trillion in 2015, and the volume of imports and exports totaled USD 1.3 trillion. The combined container throughput of Shanghai and Ningbo-Zhoushan ports reached 36.5 million and 20.6 million TEU in 2015, respectively (SSB, 2016; JSB, 2016; ZSB, 2016). This resulted in Shanghai and Ningbo-Zhoushan being ranked the first and the fifth largest container ports in the world, respectively. With the expedited advancement of the 'Belt and Road Initiative' and the 'Yangtze River Economic Belt Strategy', the YRD will further improve the degree of 'opening up', while simultaneously creating demand for international trade. This in turn will provide more opportunities for the further development and evolution of international freight forwarding service (IFFS) networks.

Since 2005, the administrative boundaries of some districts and counties of the YRD have been constantly adjusted. By taking the delineation of the administrative boundaries in 2015, the scope of the YRD in this study consisted of 25 prefecture level and above cities. According to the differences in regional development in Jiangsu and Zhejiang provinces, the provinces in question were divided into central, southern, and northern Jiangsu, and northeastern and southwestern Zhejiang Province (Table 1).

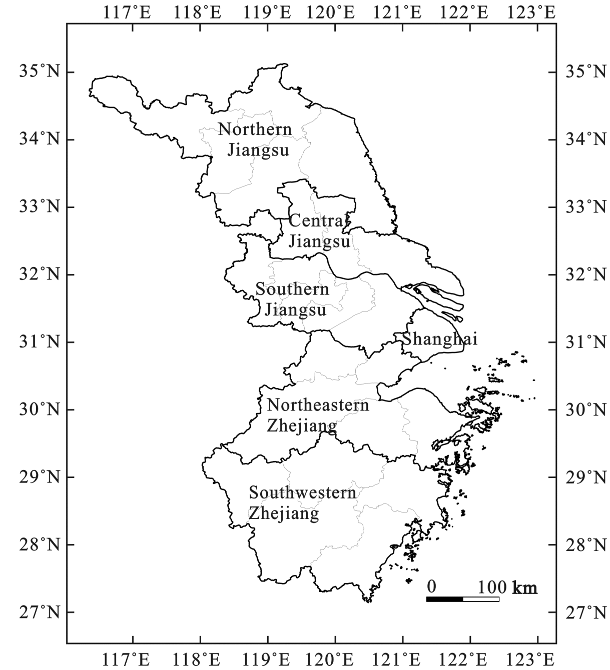

Fig. 1 Location and spatial organization of the Yangtze River Delta (YRD)

Table 1 Cities in the different regions of the Yangtze River Delta (YRD)

Regions	Cities
Central Jiangsu	Taizhou, Yangzhou, Nantong
Southern Jiangsu	Nanjing, Suzhou, Wuxi, Changzhou, Zhenjiang
Northern Jiangsu	Xuzhou, Liangyungang, Yancheng, Huai'an, Suqian
Northeastern Zhejiang	Hangzhou, Ningbo, Huzhou, Jiaxing, Shaoxing, Zhoushan
Southwestern Zhejiang	Quzhou, Jinhua, Taaizhou, Lishui, Wenzhou

2.2 Data collection

The urban network is constructed based on the location strategies of firms in different cities. The headquarters-branch method of assessing urban networks was first proposed by Alderson and Beckfield (2004). It has subsequently become one of main approaches to map connectivity of cities and city-dyads in urban networks (Hino, 2007). As a first step, we analyzed the spatial distribution of headquarters and subsidiaries in YRD cities. According to the direction of the organizational connections among enterprises, we integrated the enter prise networks, and formed an IFFS network between cities. Considering the data availability, we selected 2005, 2010, and 2015 as reference years for analyzing the IFFS networks in the YRD.

Data were obtained from the International Freight Forwarder Information Management System of the Ministry of Commerce (business registration as of December 2015). Using the registered and existing IFFS subsidiary companies in the YRD as queries, we searched the basic business information inquiry systems of the Shanghai, Jiangsu, and Zhejiang Industrial and Commercial Bureaus to screen for businesses based on their time of registration, place of registration, and scope of the business. We identified 941 qualified sample enterprises with headquarters in the YRD. The following three types of data were excluded from the analysis.

(1) Subsidiary companies within the research area, but with headquarters located outside the research area.

(2) Headquarters and subsidiary companies within the same city, but with no subsidiary companies in other cities in the research area, e.g., enterprises or only the enterprise headquarters were located in the research area, but not any of their subsidiaries.

(3) Both headquarters and subsidiaries located within the research area and within in the same city, although some subsidiaries were located within other cities in the YRD. In this case, subsidiaries in the same city as the headquarters were excluded, although subsidiaries in other cities were included in the analysis.

2.3 Calculation model

The number of branches in the city nodes is considered to be an index of network relevance. The inter-city out-in scope of the distribution of headquarter-subsidiary linkages among companies reflects the value section characteristics of the functional linkage between cities (Zhao et al., 2014). To distinguish the importance of headquarters and subsidiaries, three quantitative service values (0, 1, and 3) were assigned according to a company's rank. A service value of '3' indicated that the company headquarters were located in the city, a value of '1'indicated that a subsidiary company was located in the city, and a value of '0' indicated that there was no subsidiary company. Finally, we created a 25 × 25 asymmetric matrix containing the pairwise relationships between 25 cities, i.e., the IFFS network relationship matrix based on enterprise headquarter-subsidiary linkages (Table 2). The calculation process was as follows.

Assuming there were m IFFS enterprises in n cities, with V_{ij} representing the service value of company j in city i, then the connectivity of the IFFS network for the headquarters of company j in city a and its subsidiary in city b is:

$$C_{ab,j} = V_{aj} \times V_{bj} \tag{1}$$

where V_{aj} is the service value of company j in city a, and V_{bj} is the service value of company j in city b.

Conversely, the connectivity of the IFFS network for the headquarters of company k in city b with its subsidiary in city a is:

$$C_{ba,k} = V_{bk} \times V_{ak} \tag{2}$$

Consequently, the inter-city connectivity of the IFFS network between cities a and b can be represented as:

$$C_{ab} = \sum_{j=1}^{e} C_{ab,j} + \sum_{k=1}^{f} C_{ba,k} \tag{3}$$

where e and f represent the number of companies with headquarters located in cities a (b) and subsidiaries in cities b (a), respectively. Therefore, the inter-city connectivity of the IFFS network between any two cities can be determined using this method.

For each city in the $n \times n$ matrix in Table 2, the connectivity's were summed by rows or columns:

$$N_a = \sum_{i=1}^{n} C_{ai} \quad (a \neq i) \tag{4}$$

$$R_a = \sum_{i=1}^{n} C_{ia} \quad (a \neq i) \tag{5}$$

$$C_a = N_a + R_a \tag{6}$$

$$S = \sum_{i=1}^{n} N_a + \sum_{i=1}^{n} R_a \tag{7}$$

where C_{ai} is the total inter-city connectivity where a company has its headquarters in city a and a subsidiary in city i ($a \neq i$), while C_{ia} is the inverse. N_a is the out-degree of city a, representing the capacity of city a to have control over other cities. R_a is the in-degree of city a, representing the capacity of other cities to have control over city a. C_a is the vertex degree of city a, re flecting the nodality of city a as a node in the network,

Table 2 Relationship matrix for an international freight forwarding service (IFFS) network

		Location of subsidiaries				Out-degree
		C_1	C_2	…	C_n	
Location of headquarter	C_1		C_{12}	…	C_{1n}	N_1
	C_2	C_{21}		…	C_{2n}	N_2
	…	…	…	…	…	…
	C_n	C_{n1}	C_{n2}	…		N_n
	In-degree	R_1	R_2	…	R_n	S

with higher values representing a better integration into the entire IFFS network. S represents the connection strength of the total network.

To eliminate the effects of dimensions and facilitate a comparison of the IFFS network connectivity at different temporal cross-sections, a relative city network linkage index (P_a) was introduced. This is defined as the ratio of the city vertex degree (C_a) and highest city vertex degree (C_h) at a certain temporal cross-section. The relative city network linkage index for city a is:

$$P_a = \frac{C_a}{C_h} \qquad (8)$$

3 Trajectories of the IFFS Network Dynamic

Based on these methods, we analyzed three IFFS networks in the YRD in 2005, 2010, and 2015. We considered the spatial patterns and changes in these patterns by focusing on the hierarchy and service capacities of nodes; their strength, density, network structure; and the diversification of their functions. Additionally, we examined the impact of administrative borders on IFFS connections.

3.1 Hierarchy of nodes

The vertex degree obtained from Equation (6) showed that there were hierarchical characteristics in the IFFS network nodes, and the ranking of these nodes changed significantly. In 2015, the vertex degrees of Shanghai, Ningbo, Nanjing, Suzhou, and Hangzhou were 1941, 1179, 678, 471, and 381 respectively. Fig. 2 shows the relative network connectivity (P_a) from the highest to the lowest. We discovered that the 'level-dropping' trend in relative linkage indices was generally attenuated after the eighth city. There was also an evident change in the node order. Furthermore, hierarchical clustering was analyzed using SPSS 13.0 (Table 3). For 2015, the IFFS network nodes in the YRD could be divided into three levels.

Shanghai was always placed in the first level and its P_a were 1.49, 1.67, and 1.65 in 2005, 2010, and 2015, respectively. There were 150, 423, and 528 IFFS companies with headquarters in Shanghai in 2005, 2010, and 2015, respectively, indicating the city's increasing polarization effect as an international shipping center. Ningbo, Nanjing, Suzhou, and Hangzhou were the secondary network hub nodes, and their relative linkage indices remained in the range of 0.2–0.7. In 2010, Ningbo replaced Nanjing as the secondary hub. Suzhou and Hangzhou remained in fourth and fifth position in the network. This ranking was not fully consistent with the rankings in the existing city and producer service industry based network hierarchy systems (Wang et al., 2014), which may reflect the uniqueness of the IFFS network. Wuxi, Nantong, and the remaining twenty cities were placed in the third level. Generally, Wuxi and Nantong were always ranked as the top two cities within this level. The status of Lianyungang, Lishui, Shaoxing, Jinhua, and the other node cities also increased significantly.

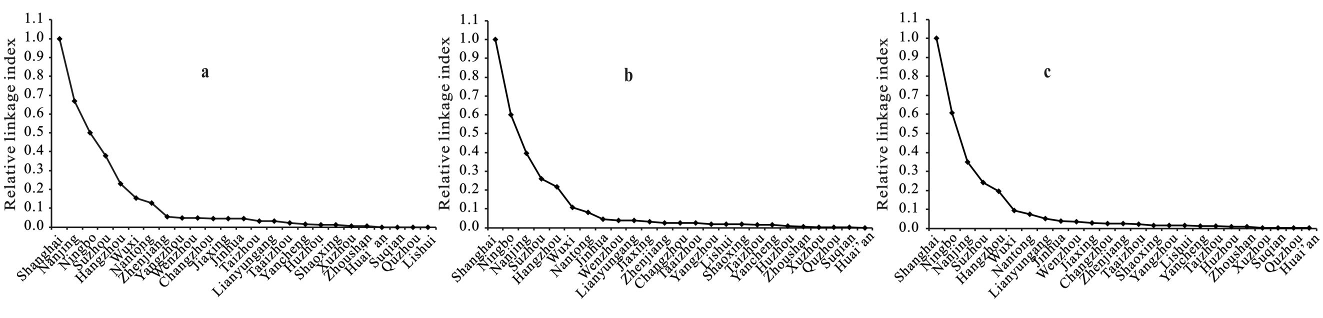

Fig. 2 Ranking of cities according to the relative linkage index for (a) 2005, (b) 2010, and (c) 2015

Table 3 Hierarchical distribution of nodal connectivity's of the international freight forwarding service (IFFS) network in the Yangtze River Delta (YRD) in 2015

Level	P_a	Number	Cities
I	1	1	Shanghai
II	0.2–0.7	4	Ningbo, Nanjing, Suzhou, Hangzhou
III	<0.2	20	Wuxi, Nantong, Lianyungang, Jinhua, Wenzhou, Jiaxing, Changzhou, Zhenjiang, Taaizhou, Shaoxing, Yangzhou, Lishui, Yancheng, Taizhou, Huzhou, Zhoushan, Xuzhou, Suqian, Quzhou, Huai'an

3.2 Service capacities of nodes

IFFS node connections could be divided into intra-regional and inter-regional connections. The outward radial link capability of each node was analyzed at the city level by calculating the extraversion degree of the IFFS. At the province level, the connection between a node and other cities outside the same province was considered to be the inter-regional connection. By calculating the intra-regional connection strength, the nodal radial link capability could be determined:

$$r_i = \frac{C_{si} / (n_s - 1)}{C_i / (n - 1)} \tag{9}$$

where n_s and n are the number of nodes in the corresponding province for city i and the entire research area, respectively. C_{si} represents the inter-city connectivity between city i and other cities in the same province. C_i is the overall vertex degree of city i. If $r_i>1$, the network connection is primarily in the corresponding province. A value of r_i approaching 1 suggests that intra-provincial connections are weakening, and vice versa. If $r_i<1$, the network connection is mainly outside the province, and an r_i approaching 1 suggests that inter-provincial connections are weakening, and vice versa.

Using the two aforementioned indicators, the internal and external service capacities of cities in 2005 and 2015 were calculated (Table 4). For Shanghai, Nanjing, and Hangzhou, the outward radial links for the IFFS were at an absolute advantage. The intra-regional connection intensities (r_i) of Nanjing and Hangzhou were greater than 1, i.e., 1.31 and 1.43 in 2005, and 1.04 and 1.55 in 2015, respectively. This shows that the IFFS connection intensity of Nanjing and Hangzhou suggested they were mainly intra-provincial cities.

Table 4 Changes in the service capacities of nodes in 2005 and 2015

Nodal city	Extraversion degree of the IFFS (k)			Intra-regional connection intensity (r_i)		
	2005	2015	2005–2015	2005	2015	2005–2015
Shanghai	0.82	0.82	–0.01	—	—	—
Nanjing	0.75	0.66	–0.09	1.31	1.04	–0.28
Suzhou	0.04	0.19	0.14	1.13	0.76	–0.37
Wuxi	0.21	0.15	–0.07	1.36	1.07	–0.29
Changzhou	0.00	0.24	0.24	1.75	1.29	–0.46
Nantong	0.30	0.31	0.01	1.04	0.88	–0.17
Taizhou	0.17	0.13	–0.04	1.67	1.75	0.08
Yangzhou	0.22	0.20	–0.02	1.78	1.60	–0.18
Zhenjiang	0.00	0.06	0.06	2.00	1.63	–0.38
Xuzhou	0.00	0.00	0.00	2.00	2.00	0.00
Lianyungang	0.33	0.39	0.06	0.67	0.67	0.00
Huai'an	—	0.00	0.00	—	2.00	2.00
Yancheng	0.67	0.33	–0.33	2.00	1.56	–0.44
Suqian	—	0.00	0.00	—	1.00	1.00
Hangzhou	0.62	0.71	0.09	1.43	1.55	0.12
Ningbo	0.25	0.17	–0.08	0.58	0.39	–0.20
Wenzhou	0.00	0.22	0.22	1.60	1.98	0.38
Jiaxing	0.25	0.16	–0.09	2.10	1.90	–0.21
Huzhou	0.50	0.14	–0.36	1.20	1.03	–0.17
Shaoxing	0.00	0.36	0.36	2.40	1.96	–0.44
Jinhua	0.00	0.28	0.28	1.80	1.92	0.12
Quzhou	—	0.00	0.00	—	1.20	1.20
Zhoushan	0.00	0.40	0.40	2.40	2.40	0.00
Taaizhou	0.25	0.29	0.04	2.40	2.40	0.00
Lishui	—	0.00	0.00	—	2.16	2.16

Note: a city was considered a node in this study and the inner-region connection of Shanghai was therefore not presented

For multi-port gateway regions such as Ningbo, Suzhou, Lianyungang, and Nantong, the outbound functionality of the IFFS strengthened gradually. Ningbo's extraversion degree of the IFFS (k) decreased slightly, while its value of r_i was always less than 1, with a decreasing trend. The value of r_i for Suzhou also decreased from 1.13 in 2005 to 0.76 in 2015. In the remaining 16 nodal cities, including Wuxi, Changzhou, and Taizhou, the values of r_i were greater than 1. This indicates that connections were mainly intra-provincial, and the extraversion degree was low.

3.3 Network strength, density, and structure

Total network strength and coverage density were measured using Equation (7). In Fig. 3, the width of the line characterizes the connection value. The total network strength increased from 1902 to 5622 during the period of 2005 to 2015, with a remarkable average annual increase of 12.8% (Fig. 3). Network coverage density increased from 84% to 100% during the same period. There were significant hierarchical characteristics in the inter-city network (Table 5). There were three, five, and five connections with a total network strength greater than 90 in 2005, 2010, and 2015, accounting for 6.00%, 8.19%, and 7.58% of the total data for the city groups, respectively. However, their network strength amounted to 42.9%, 61.5%, and 62.3% of the total network strength, respectively. Combined with a node-level analysis, a multi-level radial network structure centered in Shanghai was formed (Fig. 3). Level I inter-city connections included Shanghai-Ningbo, Shanghai-(Suzhou)-Nanjing, and Shanghai-Hangzhou. The Shanghai-Ningbo IFFS network was always ranked the highest. The values of C_{ab} in 2005, 2010, and 2015 were 192, 711, and 921, respectively. The level II intercity connections included Shanghai-Wuxi, Shanghai-Nantong, Shanghai-Lianyungang, Hangzhou-Ningbo, and Nanjing-Wuxi. The connections between Shanghai and node cities in central, southern, and northern Jiangsu were increasingly strengthened. The Nanjing-Wuxi and Hangzhou-Ningbo networks were the primary networks in Jiangsu and Zhejiang provinces, respectively. Level III intercity connections were generated from level I and II nodes, as well as all other level III nodes. These included Hangzhou-Jiaxing, Hangzhou-Taaizhou, Nanjing-Nantong, and Nanjing-Zhenjiang.

3.4 Impacts of administrative borders on IFFS connections

Despite the presence of administrative border barrier effects, inter-provincial IFFS connectivity increased during the period from 2005 to 2015 (Fig. 4). There were strong connections between Shanghai-Jiangsu and Shanghai-Zhejiang. The comprehensive connectivity of

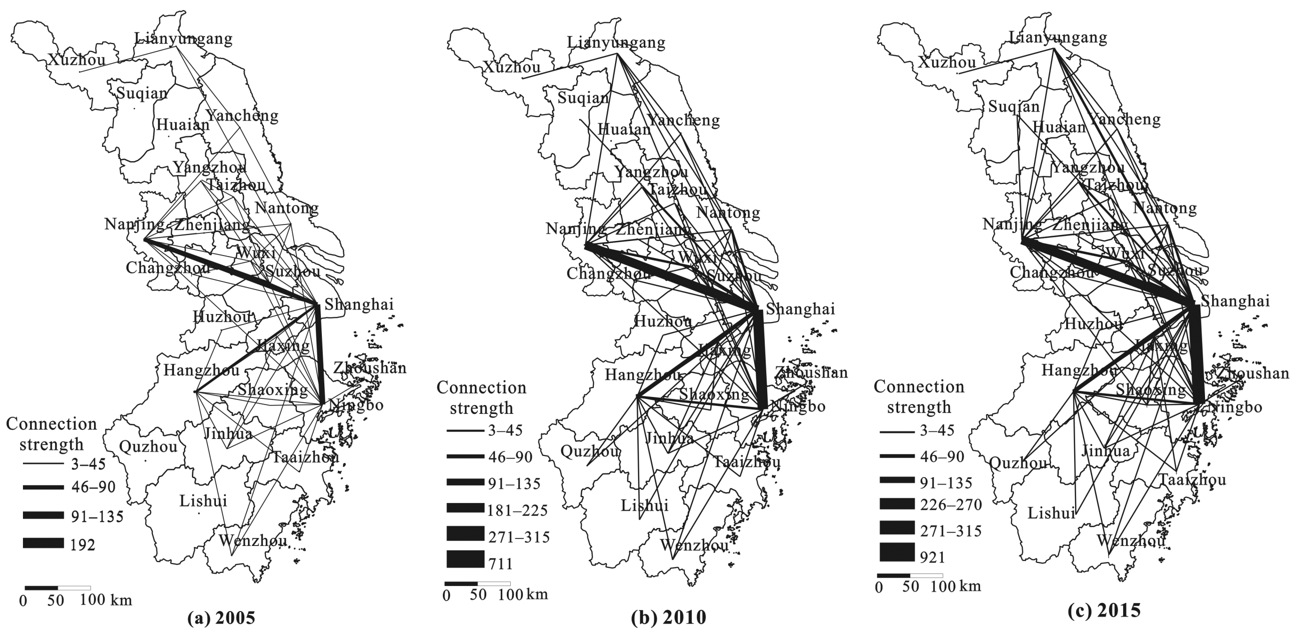

Fig. 3 International freight forwarding service (IFFS) networks in the Yangtze River Delta (YRD) in 2005, 2010, and 2015

Table 5 Descriptive statistics of city-dyad international freight forwarding service (IFFS) network connectivity's in the YRD

Connection strength	Number of connections			Connection frequency (%)			City pairs		
	2005	2010	2015	2005	2010	2015	2005	2010	2015
3–45	45	52	56	90	85.25	84.85	Other	Other	Other
46–90	2	4	5	4	6.56	7.58	Shanghai-Hangzhou[1], Shanghai-Suzhou[1], Nanjing-Wuxi[23], Hangzhou-Ningbo[23] Shanghai-Nantong[23], Shanghai-Wuxi[23], Shanghai-Lianyungang[3]		
>90	3	5	5	6	8.19	7.58	Nanjing-Suzhou[123], Shanghai-Nanjing[123], Shanghai-Ningbo[123], Shanghai-Hangzhou[23], Shanghai-Suzhou[23]		

Note: 1, 2, and 3 represent the years of 2005, 2010, and 2015, respectively

Shanghai-Zhejiang increased from 274 in 2005 to 1116 in 2015, while the connectivity of Shanghai-Jiangsu increased from 282 in 2005 to 827 in 2015. However, the comprehensive connectivity between Zhejiang and Jiangsu increased slowly, from 15 in 2005 to 72 in 2015. This was similar to the reported evolution of financial flow distribution patterns (Ji and Chen, 2014).

The IFFS networks of Jiangsu and Zhejiang developed rapidly, with some regional disparities in both provinces (Fig. 5). The IFFS networks of Jiangsu were primarily located in southern Jiangsu and between central and northern Jiangsu. The IFFS networks in southern Jiangsu were relatively weak. The total connection strength of the IFFS network between the northern Jiangsu cities increased from 396 in 2005 to 576 in 2015, accounting for 70.97% and 65.75% of the total network, respectively. The network between the cities in southern Jiangsu and the three cities in central Jiangsu strengthened, with the total connection strength increasing from 51 in 2005 to 66 in 2015. The network between southern and northern Jiangsu was mainly centered in Nanjing, and the networks between the three cities of Xuzhou, Suqian, and Huai'an, and other cities were weak. The IFFS networks of Zhejiang were mainly centered in northeastern Zhejiang. The network in southwestern Zhejiang was relatively weak. The total IFFS network connection strength within northeastern Zhejiang increased from 126 in 2005 to 342 in 2015, accounting for 56.76% and 47.5% of the total network, respectively. The network between northeastern and southwestern Zhejiang has increased from 90 in 2005 to 282 in 2015. The status of Hangzhou in the IFFS network rose significantly, although the networks in Quzhou, Lishui, and other cities were relatively weak.

4 Underlying Mechanisms of IFFS Network Evolution

4.1 Analytical framework

As an important part of the logistics industry, the development of the IFFS industry is mainly affected by the regional export-oriented economy, foreign trade, and the construction of transportation hubs. Currently, the YRD has taken the lead in establishing an open economic

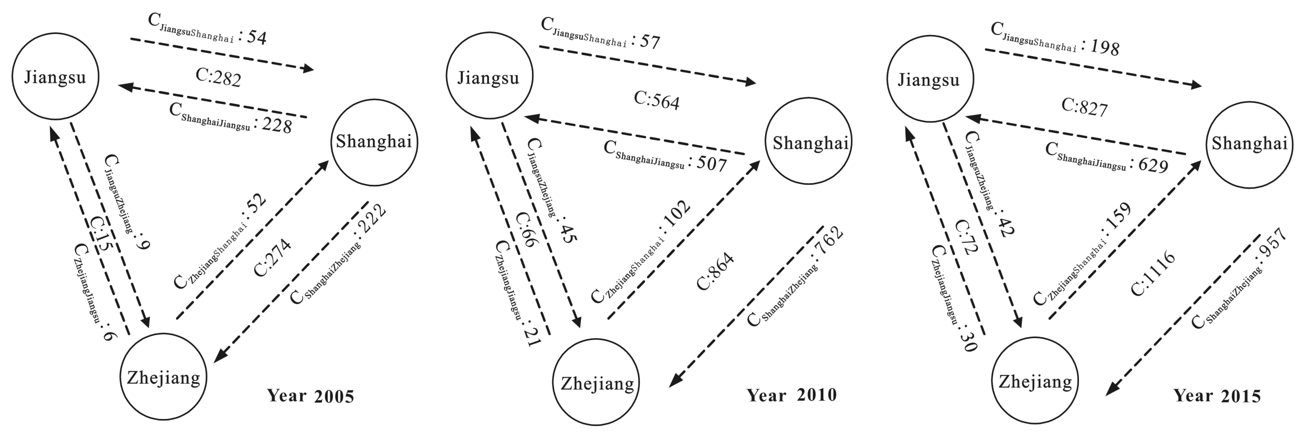

Fig. 4 Evolution of comprehensive connectivity in the international freight forwarding service (IFFS) network at the province level

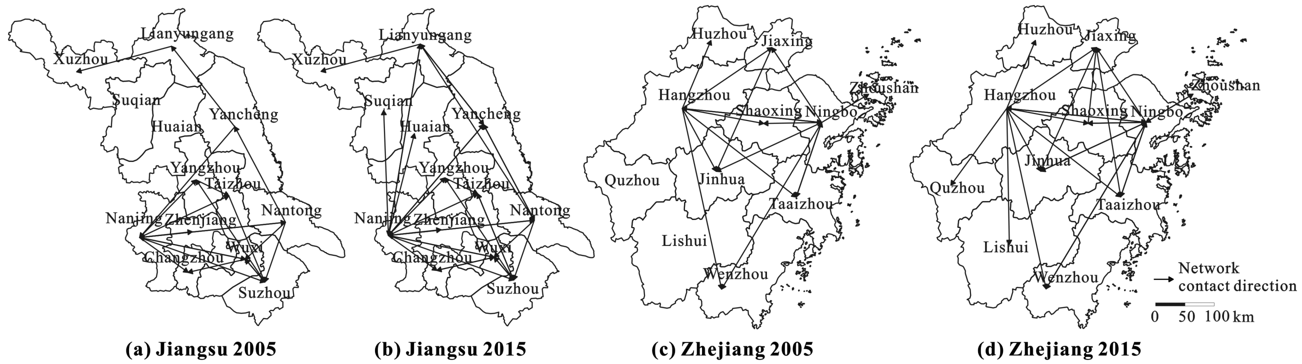

Fig. 5 Pattern of the changes in the international freight forwarding service (IFFS) network between 2005 and 2015 in Jiangsu and Zhejiang

system in China, and a comprehensive, multilevel, and high standard of 'opening-up' pattern has developed in the region. Marketization, globalization, and decentralization are important driving forces behind the restructuring of regional economic patterns in China (Wei, 1994; Wei and Li, 2002). Moreover, the YRD is a pioneering metropolitan area that has undergone regional integration (Song et al., 2013). Integration has become a new driving force of IFFS networks, in addition to marketization, globalization, and decentralization. In this study, we analyzed the underlying mechanisms of the evolution of the IFFS network, from a comprehensive and unified angle based on marketization, globalization, decentralization, and integration (Fig. 6).

4.1.1 Marketization and IFFS networks

In the context of a planned economic system, the IFFS industry has developed as a highly-centralized management mechanism to adapt to China's foreign trade system (Mei and Liu, 2010). With the advancement of economic reform, especially the completion of the transition period after China joined the World Trade Organisation (WTO) in 2005, nearly all businesses related to IFFS, with the exception of legal inspection, switched from restricted operations to be open to all investors. In March 2005, the Ministry of Commerce published the 'International Freight Forwarding Enterprise Record (Interim Measures)' (Ministry of Commerce Order No. 9 of 2005). This marked the inception of the registration-based IFFS market into a fully open stage. The resulting increase in the number of business entities has been enormous. In 2005, the total number of IFFS organizations (headquarters and subsidiaries) was 327 but this had skyrocketed to 941 by the end of 2015. At the same time, IFFS enterprises gained more autonomy. Based on their own development strategies and market demands, companies were able to make their own

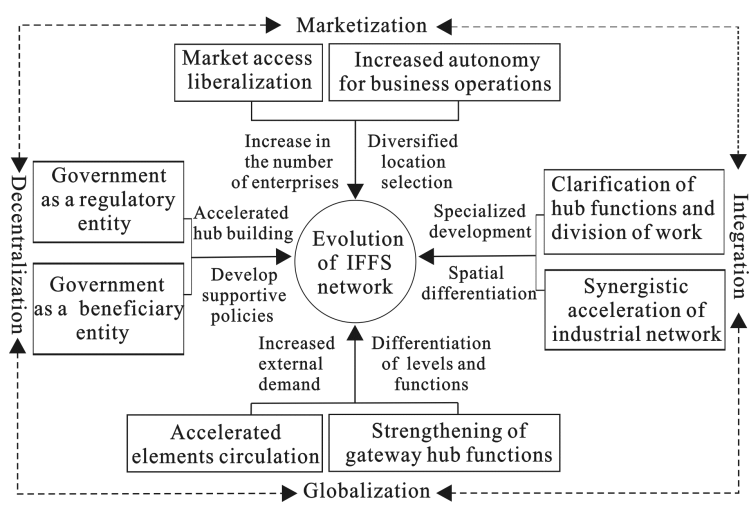

Fig. 6 A framework for analyzing the driving mechanisms of an international freight forwarding service (IFFS) network

decisions to establish headquarters and subsidiaries in the cities of the YRD. This improved the IFFS capacity of every city in the YRD and promoted the development of an IFFS network.

4.1.2 Globalization and IFFS networks

With the continuous deepening of the 'Reform and Opening Up' process, and the acceleration of economic globalization and multinational corporation-dominated global production, trade and circulation structures have differentiated at a rapid pace. As an important gateway to the Asia-Pacific region, the YRD has always been a prime location for foreign investment due to its convenient location, versatile industrial facilities, and the availability of technology and qualified personnel. Statistics show that from 2005 to 2015, total foreign investment in the YRD increased from USD 538.6 billion to USD 1735.3 billion, while the total import and export volume of goods for foreign-invested enterprises increased from USD 352.56 billion to USD 722.24 billion (SSB, 2006; 2016; JSB, 2006; 2016; ZSB, 2006; 2016). This led directly to strong foreign trade and the need for international transportation, stimulating the development of the IFFS industry. To be more competitive, IFFS enterprises need to constantly expand their functions, strengthen their links with hub cities, and optimize their subsidiaries to gain networked resource allocation advantages. In addition, the hierarchical structures and functional links between nodes have started to differentiate. With a pivotal hub city at its core, the linkage between the IFFS network and other cities has formed and rapidly developed.

4.1.3 Decentralization and IFFS networks

Local governments have considered the benefits of decentralization for economic development (Qian and Weingast, 1997). The evolution of the IFFS network has had two primary effects. First, following the systematic reform of ports and airports, territorial management has provided greater autonomy for local governments regarding development. For example, the 'Suggestions on Deepening the Institutional Reform of the Central Leadership and the Dual Leadership on Ports' (State Council, 2001) suggested decentralizing all ports, so that they would move from dually managed by central and local governments to become solely managed by local governments. Government administration and enterprise management for effective port operation needs to be separated, and systematic port management reform needs to be undertaken in Shanghai, Nanjing, Ningbo, Zhenjiang, Nantong, and Lianyungang. Local governments have become the main regulatory body for port and airport construction, which has prompted local governments to quickly develop and deploy IFFS and logistic industries related to port and civil aviation infrastructure. In addition to systematic reform and localization, fiscal decentralization has resulted in local governments becoming the main beneficiaries of infrastructure construction. By relying on strategic resources, including ports and airports, local governments are able to agglomerate related elements through the planning and construction of logistics parks and service clusters, thus enhancing the competitiveness of a city. However, local governments may also issue measures that hinder inter-provincial resource circulation (He et al., 2008), which may affect the development of inter-provincial IFFS networks.

4.1.4 Integration and IFFS networks

The YRD has evolved from 'superficial integration' into a 'deep integration' phase (Zhang, 2013), despite the effect of regional integration in promoting intercity interactions being in doubt (Li and Wu, 2013; Zhang et al., 2017). In terms of ports and aviation, divisions and cooperation between hubs have been seriously considered and promoted. For example, the Shanghai Composite Port Administration Committee issued the 'Guiding Opinions on Promoting Cooperation Regarding Ports and Shipping in the Yangtze River Delta', in which specific requirements were proposed for the regional planning and coordination of ports, development of a modern shipping services and logistics industry, and a comprehensive pilot area for the development of international shipping. This directly impacts the distribution of the functional departments of IFFS enterprises, which are closely related to air and sea hubs. In addition, with the spatial restructuring of the global industrial chain, the synergy and deep fusion of the industrial chain in the YRD are currently being promoted, leading to close network and industry connections between companies and organizations in different cities. For example, General Electric's (GE) headquarters are in Shanghai, and the company deploys production bases or service departments in Wuxi, Nanjing, Changzhou, Hangzhou, and Wenzhou (Wu and Ning, 2012). There is a frequent exchange of trans-regional and trans-provincial elements, which places new requirements on the development of the IFFS.

4.2 Empirical analysis

Based on the aforementioned theoretical framework, the Quadratic Assignment Procedure (QAP) was used to quantify the driving mechanism for the evolution of IFFS networks in the YRD. Based on a re-sampling, QAP compares the similarity of elements from two matrices and calculates the similarity coefficient of the matrix pair (Krackhardt, 1988). Considering the influence of marketization, decentralization, globalization, and integration on the strength of the IFFS network, and following the basic principles of science, integrity, operability, and continuity, we selected indicators from these four aspects and calculated the difference matrices. We then constructed analytical models for the years 2005, 2010, and 2015 with the difference matrices as explanatory variables and the IFFS network in the YRD as the dependent variable. A regression analysis was then conducted using the QAP. The marketization indicator was characterized using the annual fiscal expenditure as a percentage of GDP and non-state-owned investment proportions. The proportion of fiscal expenditure to GDP and the degree of marketization were negative related indicators, reflecting the degree of marketization in the distribution of resources. The share of the non-state-owned economy in the total investment in fixed assets by society as a whole reflects the degree of market-oriented development of non-state-owned enterprises. The globalization indicator was characterized by foreign direct investment, and the total volume of imports and exports. The former reflects the level of economic globalization, and the latter represents the level of development of foreign trade. The decentralization indicator was characterized by the financial self-sufficiency rate, where the local general fiscal revenue accounted for the proportion of local revenue. This reflects the ability of local government to undertake infrastructure construction and resource allocation. From previous analyses, we know that provincial administrative boundaries affect the YRD's IFFS connections. Therefore, a dummy variable was introduced to measure the role of provincial administrative boundaries, with '1' representing the situation where both cities were located in the same province and '0' representing the situation where the cities were located in different provinces. The data were collected from statistical yearbooks of Shanghai, Jiangsu, Zhejiang and China (SSB, 2006; 2011;2016; JSB, 2006; 2011; 2016; ZSB, 2006; 2011; 2016; NBSC, 2006; 2011).

The results of the QAP analysis showed that the impact of marketization, globalization, decentralization, and integration on the evolution of the IFFS network in the YRD was in line with theoretical expectations, and the overall interpretative ability increased from 45.2% in 2005 to 49.6% in 2015 (Table 6). Four important conclusions can be drawn from this comparison.

(1) The regression coefficient between government financial intervention and the IFFS network was significantly negative, indicating that YRD city government intervention in economic activity using financial means gradually weakened with the perfection of the market mechanism. IFFS companies began to aggregate in cities with a high degree of market openness, and thus promoted the development of the IFFS network. At the

Table 6 Analysis of the driving mechanisms underlying the changes in international freight forwarding service (IFFS) networks

Types	Explanatory variables	Regression coefficient		
		2005	2010	2015
		QAP Regression	QAP Regression	QAP Regression
Marketization	Fiscal expenditure as a percentage of GDP	–0.138**	–0.048*	–0.022*
	Non-state-owned investment proportion	0.068*	0.119*	0.137**
Globalization	Foreign direct investment	–0.129*	–0.124*	0.159*
	Total import and export volume	0.131*	0.274**	0.316*
Decentralization	Financial self-sufficiency rate	–0.083	0.009	0.062*
Integration	Administrative boundary	–0.008	–0.035*	–0.041*
	R^2	0.452	0.475	0.496

Note: * significant at 10%; ** significant at 5%

same time, non-state-owned economic investment stimulated market vitality to a certain extent, so that the choice of location for an IGG enterprise is more 'rational'. Thus, this process indirectly promotes the spatial agglomeration and network development of IFFS enterprises in the YRD. The significance of this variable also increased with the evolution of market processes.

(2) The regression coefficients between the two global indicators and the IFFS network were significantly positive in 2015. This shows that the rapid influx of foreign direct investment and the rapid expansion of import and export trade significantly improved the city's foreign trade cargo transport needs and promoted the development of the IFFS network. The greater concentration of foreign investment and import and export trade, the higher the value of the network will be. In other words, the development of an export-oriented economy stimulates the development of the IFFS market; therefore, IFFS enterprises tend to provide capital cities with a strong demand for foreign trade. This is similar to the findings of Zong et al. (2011). The regression coefficients for the relationship between foreign direct investment and the IFFS network were negative in 2005 and 2010. This is mainly due to two factors. After China joined the WTO, foreign investment increased and the international freight market gradually opened to the country. However, the key areas for foreign investment were manufacturing industries operating in an export-oriented economy, and it was therefore difficult for IFFS to meet the demand due to the single nature of the services required. After the financial crisis, the volume of foreign direct investment contracted, with investment turning to service and technology-intensive industries, which led to a reduction in demand for outward transportation (Wang et al., 2013; Wu et al., 2014).

(3) The correlation between the financial self- sufficiency rate and the IFFS network turned from negative to positive, which indicates that local governments improved their ability to self-control factor resources, and then arrange facilities and establish policy according to local demand. This can attract IFFS companies to cities with a high financial self-sufficiency, and thus accelerate the external density of these cities.

(4) Provincial administrative boundaries still have a restrictive effect on the flow of resources in the IFFS industry. Some IFF enterprises are more inclined to deploy their facilities within one province. Meanwhile, inter-provincial competition between local governments still continues.

5 Conclusions

In this study, we mapped one particular type of intercity connection, an intercity IFFS network. Apart from adding an empirical study to the literature on mapping multiple urban networks, this study revealed the specific formations of intercity interactions associated with the IFFS. It has therefore enhanced our understanding of the YRD's logistics system, as well as its changes in the context of increasing globalization. This study can be concluded by discussing the key findings with regard to the regional organization of IFFS networks as follows.

(1) High-level administrative central cities, such as Shanghai, Nanjing, and Hangzhou, in which the outward radiation capacity were generally strong, were positioned at a higher level in the IFFS network. The hub cities around Shanghai, such as Ningbo, Suzhou, Lianyungang, and Nantong also played an important role in the IFFS network. In particular, Ningbo replaced Nanjing to become the second largest IFFS network hub in 2010, due to its unique location.

(2) A multi-level radial network structure has formed and is centered in Shanghai. There are significant regional disparities in the inter-provincial IFFS networks of Jiangsu and Zhejiang. Moreover, the development of IFSF networks in northern Jiangsu and southwestern Zhejiang was relatively slow.

(3) The IFFS connections for both Shanghai-Jiangsu and Shanghai-Zhejiang were increasingly strengthened. Due to barriers in the inter-provincial IFFS network, the IFFS connection between Jiangsu and Zhejiang developed relatively slowly.

(4) An analysis of the driving mechanisms demonstrated that the evolution of the IFFS network in the YRD was comprehensively affected by marketization, globalization, decentralization, and integration. Of these factors, marketization was the key underlying driving force for the evolution of the IFFS network. Marketization's demands on IFFS also represented an important factor that influenced the development of the IFFS network. The role of integration in promoting the evolution of the IFFS network was still relatively weak, and this will require further coordination and promotion at the local level in the future.

The development and evolution of the IFFS network are complex processes, which involve interactions among different business types and regions. An exploratory analysis of the IFFS network in the YRD was conducted in this study. However, it was limited by data acquisition and future studies should explore the following three aspects. First, due to the lack of business information between IFFS enterprise headquarters and subsidiaries, and between enterprises, the network analysis in this study was based on relational data between enterprise headquarters and subsidiaries, which would not exactly represent an actual IFFS network. Second, IFFS enterprises often simultaneously have sea, air, and land transportation functions. However, due to a lack of detailed enterprise operation information, we conducted an overall analysis of the evolution of an IFFS network according to the business activities registered by the enterprises. We did not investigate the evolution of a stratified IFFS network. Third, this study constructed a theoretical framework for the evolution of the IFFS network and conducted an empirical analysis. However, the statistical standards for some indicators in each city may vary. In the current analysis, we selected representative indices and simply constructed the indicators, which may require future improvements.

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