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An Empirical Study on Chinese City Network Pattern Based on Producer Services

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Abstract: Globalization and informatization have accelerated city networking process over the world, which makes research on city network a hot topic in the fields of urban geography and economic geography. With Chinese economic structure adjustment and city economic growth, producer services have begun to play an increasingly important role in city-region networking. This paper employs the methodology of world city network to analyze and explain the spatial development characteristics of China's urban network system based on the data of nationwide producer services enterprise network. The research result indicated that the distribution of producer services network has a positive effect on the development of Chinese city networks. City network connectivity is closely related to the significance of city in producer services development, and the former will gradually decline with the drop of the latter. Accordingly, the 64 cities can be divided into the national central cities, regional central cities, sub-regional central cities and local central cities in accordance with their position and role in the nationwide producer services network. It is concluded that high-grade cities with quality producer services dominate the pattern of Chinese city networks and there emerges three spatial agglomerations of producer services enterprises in Changjiang (Yangtze) River Delta, Zhujiang (Pearl) River Delta and Beijing-Tianjin-Tangshan Economical Region. Moreover, the distribution of different producer services industry varies from city to city, which also affects the characteristics of network development.

Keywords: world city network; producer services; urban hierarchy; network connectivity; Chinese city network

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1 Introduction

Since the 1990s, with the acceleration of globalization and informatization, cities have crossed their geographical boundaries and connected each other through a variety of high-speed worldwide or regional cities networks, which gives rise to the research focusing on city network at home and abroad.

Early scholars concentrated on the impact of the flight and goods traffic, the throughput of the port, road traffic, railway traffic and other kinds of traffic flow on the urban networks (Goetz, 1992; Ho and Timberlake, 2000; Mat, 2004). With the increasing significance of information technology, many scholars began to integrate information factors into the study of the urban network, and developed the Network Paradigm on the basis of complicated intercity connection (Batty, 1991). Since then, the city network under the influence of globalization and information technology has become the research focus of urban geography.

Castells (1989; 1996) proposed a new concept named space of flow emphasizing the value of urban nodes, which no doubt provides a theoretical framework and research starting point for the influence of globalization

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and information technology on city network. Scholars also studied the impacts of different information flow, including parcel, mail, internet traffic and network bandwidth, on the urban system network (Mitchelson and Wheeler, 1994; Townsend, 2001; Malecki, 2002). However, the difficulty in obtaining data of internet traffic prevented from yielding fruitful researches in this area.

As global city has become a production base for advanced producer services (Sassen, 1991), Friedmann (1986) suggested to study functional connection and changes between cities, according to the hierarchical world city network system influenced by the distribution of corporate headquarters and large banks. Taylor (2004) also investigated the hierarchical world city network system through the distribution of global production services layout. Based on above-mentioned research, on the one hand, world city network theories was proposed and recognized. The main innovation of this theory was based on the flow space, which promoted the transformation of theoretical research paradigm by employing ′relationship′ to substitute ′structure′, and replacing ′center place theory′ for ′center flow theory′. On the other hand, above research indicated that the producer services network was an effective tool to explain the intercity networking.

Ever since the world city network paradigm was introduced into geographical research field in China in recent years (Zhen *et al*., 2007; Yang *et al*., 2011), scholars have conducted empirical research on national or regional urban network system (Jin, 2010; Ning and Wu, 2011; Yin *et al*., 2011) at the enterprise level (focus on producer services), verifying the correlation between the quality of producer services and city rank in the Zhujiang River Delta Region (Zhong and Yan, 2008). Meanwhile, thoughts and methods of Taylor (2004) were employed in explaining the change of urban networks in the Changjiang River Delta and Chengdu-Chongqing region (Zhang and Wang, 2008; Tang and Zhao, 2010; Tan *et al*., 2011), as well as the influence of financial service sector in the Chinese urban network system (Yin *et al*., 2011). These empirical studies suggest that the distribution of producer services can adequately explain the changes of Chinese city networks under the influence of globalization and information technology.

China's urbanization is still under rapid development. In the shadow of global financial crisis, the country's economic growth mode has been changed, coupled with the transformation and upgrade of urban industrial structure, as well as advancement of manufacturing industry. This trend makes service industry especially producer services become an important driving force of regional economic growth and urbanization. With the construction of high-speed regional railway transportation, the spatial and temporal distance among cities is greatly shortened, which in turn induces spatial development of regional integration. The development of producer services and their spatial layout plays an increasingly important role in Chinese city networking at both national and regional level. However, current domestic studies focus more on the regional level and central cities. There has been lack of exploration into urban network pattern based on the influence of producer services on national scale.

Due to the above-mentioned reasons the paper tries to analyze and explain the spatial development characteristics of China′s urban network system by constructing the main producer services enterprise network. From a business perspective, this paper proposes an analytical framework of the ′enterprise-enterprise networks-city networks′ to explain the distribution of producer services in different cities and construct the enterprise network simulating the connection flow among the different cities. This study has two specific contributions for the research of Chinese city network. First, by uncovering the spatial development characteristics of China′s urban network system based on the data of nationwide producer services enterprise network, it is facilitate for a better understanding of the pattern and mechanism of Chinese city network. Second, it offers guidance for urban authorities to develop policies and plans with respect to the distribution of producer services.

2 Materials and Methods

2.1 Data collection

It is very important to choose the right type of producer service for studying intercity networks. In order to accurately reflect the growing economic ties between cities, eleven different types of producer services are selected, namely banking, securities, insurance, accounting, law, management consulting, advertising, logistics, real estate (agents), architectural design, and IT.

Selected producer service enterprises must meet the following requirements of owning a strong strength across the country, and many subsidiary branches in different cities. Data were collected from industry association websites and industry rankings in the period from February 8 to 20, 2012. According to annual ranking of enterprises in the industries of accounting, law, management consulting, advertising, logistics, real estate agent, architectural design, IT and other sectors, 193 enterprises in 11 industries were first selected, and then information about geographical distribution of the corporate headquarters and branch offices throughout the country was obtained by browsing enterprise websites. Enterprises were measured by a three-point scale in light of the institutional significance (3 = headquarter; 2 = local branch; 1 = no enterprise). Then, the distribution data of the 11 producer services industries in 267 cities across the country were figured out. Given that most of the cities got lower scores, only cities scoring 10 points and above were selected to do further analysis.

As shown in Table 1, selected 64 cities can be broadly divided into three categories in accordance with total service value. The first type of cities is of higher administrative level, including the capital city, munici-

Table 1 Top 64 cities ranked by total service value across 193 enterprises

Rank	City	Total service value	Rank	City	Total service value
1	Beijing	362	33	Guiyang	54
2	Shanghai	261	34	Lanzhou	47
3	Shenzhen	175	35	Foshan	39
4	Guangzhou	167	36	Wuxi	38
5	Chengdu	129	37	Yinchuan	35
6	Wuhan	127	38	Xining	31
7	Nanjing	123	39	Dongguan	31
8	Tianjin	119	40	Zhuhai	27
9	Hangzhou	117	41	Yantai	24
10	Chongqing	110	42	Lhasa	21
11	Changsha	104	43	Wenzhou	20
12	Xi′an	104	44	Nantong	20
13	Shenyang	102	45	Zhongshan	19
14	Dalian	93	46	Shantou	18
15	Jinan	91	47	Changzhou	17
16	Qingdao	89	48	Quanzhou	17
17	Zhengzhou	87	49	Huizhou	17
18	Fuzhou	85	50	Shaoxing	16
19	Kunming	83	51	Yichang	16
20	Hefei	81	52	Wuhu	13
21	Nanning	78	53	Jinhua	13
22	Xiamen	78	54	Jiaxing	13
23	Nanchang	73	55	Yangzhou	12
24	Harbin	72	56	Baotou	11
25	Taiyuan	72	57	Zhenjiang	11
26	Urumqi	68	58	Jiangmen	11
27	Changchun	67	59	Xuzhou	10
28	Ningbo	65	60	Tangshan	10
29	Shijiazhuang	63	61	Lianyungang	10
30	Suzhou	56	62	Zhanjiang	10
31	Hohhot	54	63	Taizhou	10
32	Haikou	54	64	Qinhuangdao	10

palities and provincial capital cities. The second type is economically developed coastal cities such as Shenzhen, Xiamen, Ningbo, Suzhou. The third type is the relatively developed cities in inland areas, such as Baotou, Yichang and Xuzhou.

2.2 Methods

The Interlocking Network method proposed by Taylor (2004) has been extensively applied to studying intercity connection at different scales. Taylor *et al*. (2010) put forward the center flow theory as a complemental and extended central place theory. Based on the world city network method, this paper builds the service matrix by 64 cities and 193 producer service enterprises.

2.2.1 Calculation of network connectivity

According to the Interlocking Network method, firstly, the network connectivity between city *a* and city *b* for enterprise *j* is computed by Equation (1):

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

where $R_{ab,j}$ is network connectivity between city *a* and city *b* for enterprise *j*; V_{aj} is score value of enterprise *j* in city *a* and represents the important degree in the entire network for the enterprise *j*; V_{bj} is score value of enterprise *j* in city *b* and represents the important degree in the entire network for the enterprise *j*.

Secondly, to establish a network connectivity matrix for 64 × 64 cities, the total network connectivity between city *a* and city *b* is figured by Equation (2):

$$R_{ab} = \sum_{j=1}^{n} R_{ab,j} \tag{2}$$

where R_{ab} is the total network connectivity between city *a* and city *b*.

Thirdly, connectivity for a single city and all other cities is calculated by Equation (3),

$$N_a = \sum_{i=1}^{n} R_{ai} \tag{3}$$

where N_a is the network connectivity rate of city *a*; R_{ai} is the network connectivity between city *a* and city *i*.

Next, based on the city with highest network connectivity rate, relative network connectivity rate for a single city is obtained according to Equation (4):

$$P_a = N_a / N_h \tag{4}$$

where P_a is relative network connectivity rate of city *a*; N_h is the highest network connectivity rate.

2.2.2 Calculation of impact index of central cities

To characterize the dependence of the other cities on a central city, this paper employs the concept of ′impact index′, from which we could further analyze the influence sphere of each central city.

The calculation equation of impact index is as follows:

$$K = y_1 - ax_1 - b \tag{5}$$

where *K* is the impact index of a city; y_1 is the relative network connectivity rate of a city to the central city; x_1 is the connectivity rate of a city to the national network; *a* is the regression coefficient of the function; *b* is the regression slope of the function.

According to the different value of *K*, the sphere of influence is divided into three categories: 1) *K* is greater than 0.2, indicating the close contact and high impact index; 2) *K* is between –0.2 and 0.2, showing the medium connection and the general impact index; and 3) *K* is less than –0.2, suggesting the weak connection and low- impact index.

3 Results

After the completion of corporate network matrix construction, the spatial characteristics of the China′s city networks based on the producer services could be analyzed from the following four aspects.

3.1 Relationship between relative city network connectivity and city significance

The city′s total network connectivity N_a is the sum of all connections with the city as the endpoint. The closer the connection is, the more important node role the city plays in the whole network system. As Fig. 1 shows, to the linear relationship between relative city network connectivity and total service score, Beijing, Shanghai and Shenzhen obviously rank top three in terms of the city network connection.

3.2 Hierarchical structure of city networks

As indicated in Fig. 2, 64 points representing the relative network connectivities of 64 cities approximately shapes likes a downward curve and some points with similar value tend to group within a certain range.

In accordance with their position in the mutation area of the curve slope, all 64 cities could be divided into

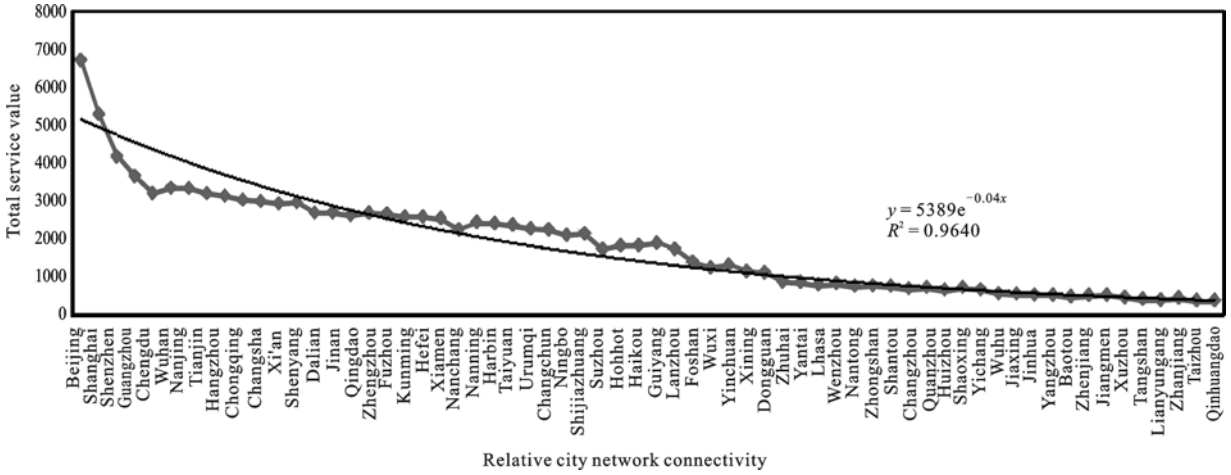

Fig. 1 Relationship between city significance and relative city network connectivity

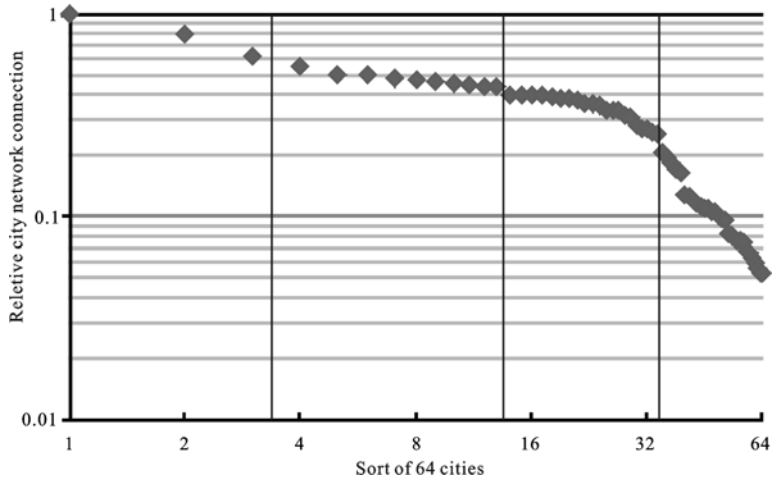

Fig. 2 Scatter diagram of relative city network connectivity of 64 cities

four different groups (Table 2). Group 1 has the highest relative city network connectivity, consisting of national central cities like Beijing, Shanghai, Shenzhen. Group 2 are regional central cities, including Guangzhou, Wuhan, Nanjing, Chengdu, Tianjin, Hangzhou, Chongqing, Changsha and Shenyang. Group 3 are sub-regional central cities, such as Xi′an, Ji′nan, Dalian, Zhengzhou. Group 4 are local central cities, including provincial capital cities of Guiyang, Haikou, Hohhot, Lanzhou, Yinchuan, Xining, Lhasa and prefecture-level cities.

3.3 Overall pattern of Chinese city networks based on producer services

To further illustrate the distribution of producer services network at the national level and the main direction of intercity economic flow, 34 cities whose network conne-

Table 2 Hierarchical distribution of Chinese city networks

Group	Relative city network connectivity	Number of cities	Cities
1	0.621–1.000	3	Beijing Shanghai Shenzhen
2	0.439–0.620	9	Guangzhou Wuhan Nanjing Chengdu Tianjin Hangzhou Chongqing Changsha Shenyang
3	0.311–0.438	17	Xi′an Jinan Dalian Zhengzhou Fuzhou Qingdao Kunming Hefei Nanning Nanchang Harbin Taiyuan Urumqi Changchun Xiamen Shijiazhuang Ningbo
4	0.052–0.310	35	Guiyang Haikou Hohhot Suzhou Lanzhou Foshan Yinchuan Wuxi Xining Dongguan Zhuhai Yantai Wenzhou Lhasa Zhongshan Nantong Shantou Shaoxing Quanzhou Changzhou Yichang Huizhou Wuhu Jinhua Jiaxing Jiangmen Yangzhou Zhenjiang Baotou Xuzhou Zhanjiang Tangshan Lianyungang Qinhuangdao Taizhou

ctivity (N_a) exceeding 82 were extracted and divided into three levels according to the connectivity intensity. City networks at national level clearly shows that the three cities of Beijing, Shanghai and Shenzhen are important national nodes, constituting the basic framework of China′s urban network based on the producer services, together with other levels of city nodes (Fig. 3). However, the networking range of different cities is different. National city networks radiate from Beijing in all directions, while Shanghai is the main networking center of eastern coastal area and the Changjiang River Basin, and Shenzhen works as the main networking center of the southern region of China.

According to the impact index calculated through Equation (5), the influence sphere maps (Fig. 4) of the four central cities, Beijing, Shanghai, Shenzhen and Wuhan were drawn respectively. In combination with Fig. 3, the position status of the central cities in the whole networks can be observed more clearly. As the national capital, Beijing has the highest network connectivity, accounting for 35.1% of the total network cities. As far as the influence sphere is concerned, Beijing has covered Shanghai, Guangzhou, Chengdu, Shenyang and other regional central cities, as well as the main cities in North China. Thus, it can be concluded that more than one-third of the main economic flow is directed to Beijing. In addition, the premier economic flow of all other cities points to Beijing except Suzhou′s orientation to Shanghai. In summary, Beijing is obviously the most important node of China′s city networks, and the management and control headquarter of national producer services.

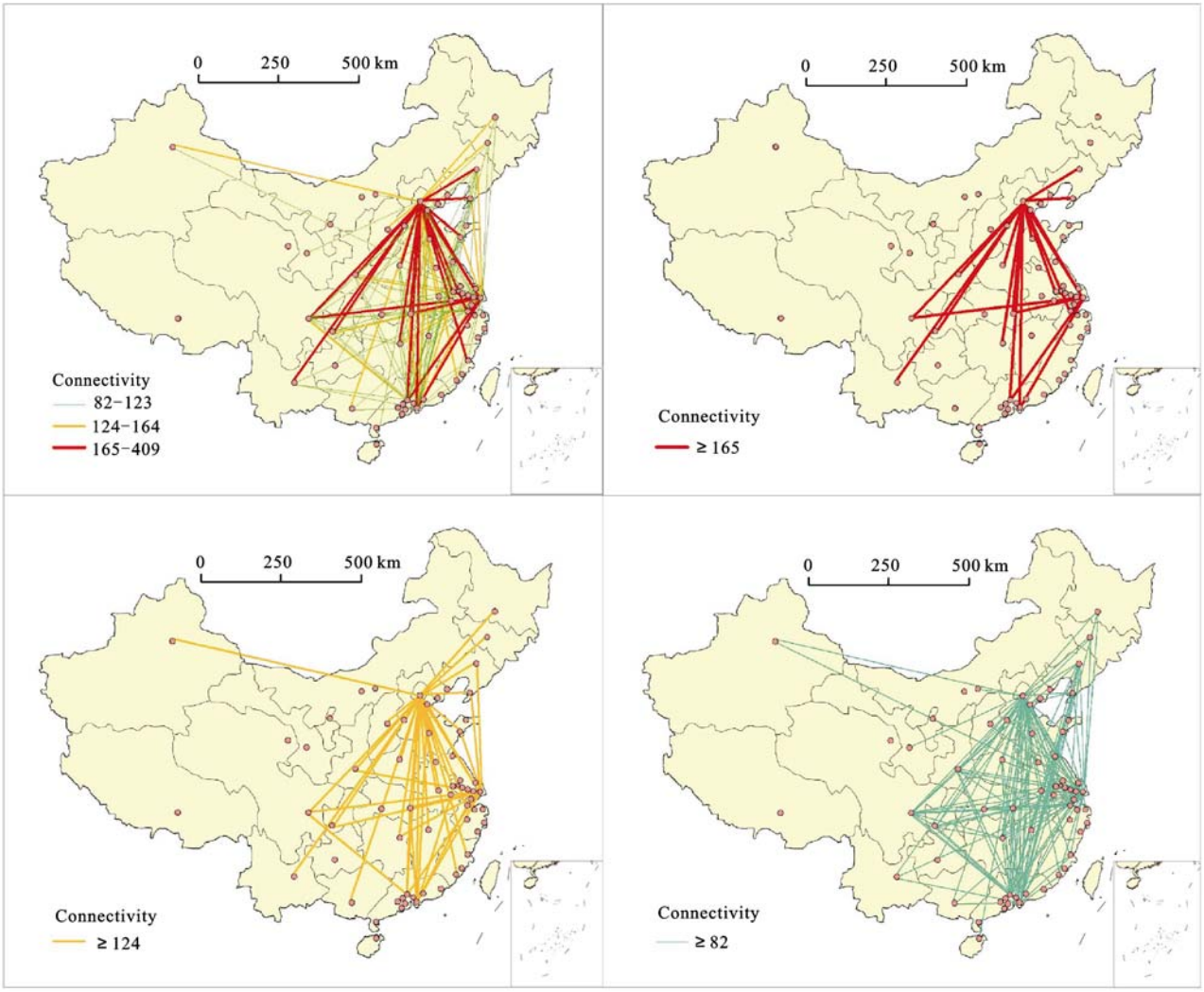

Fig. 3 Flow analysis of 34 cities based on producer services

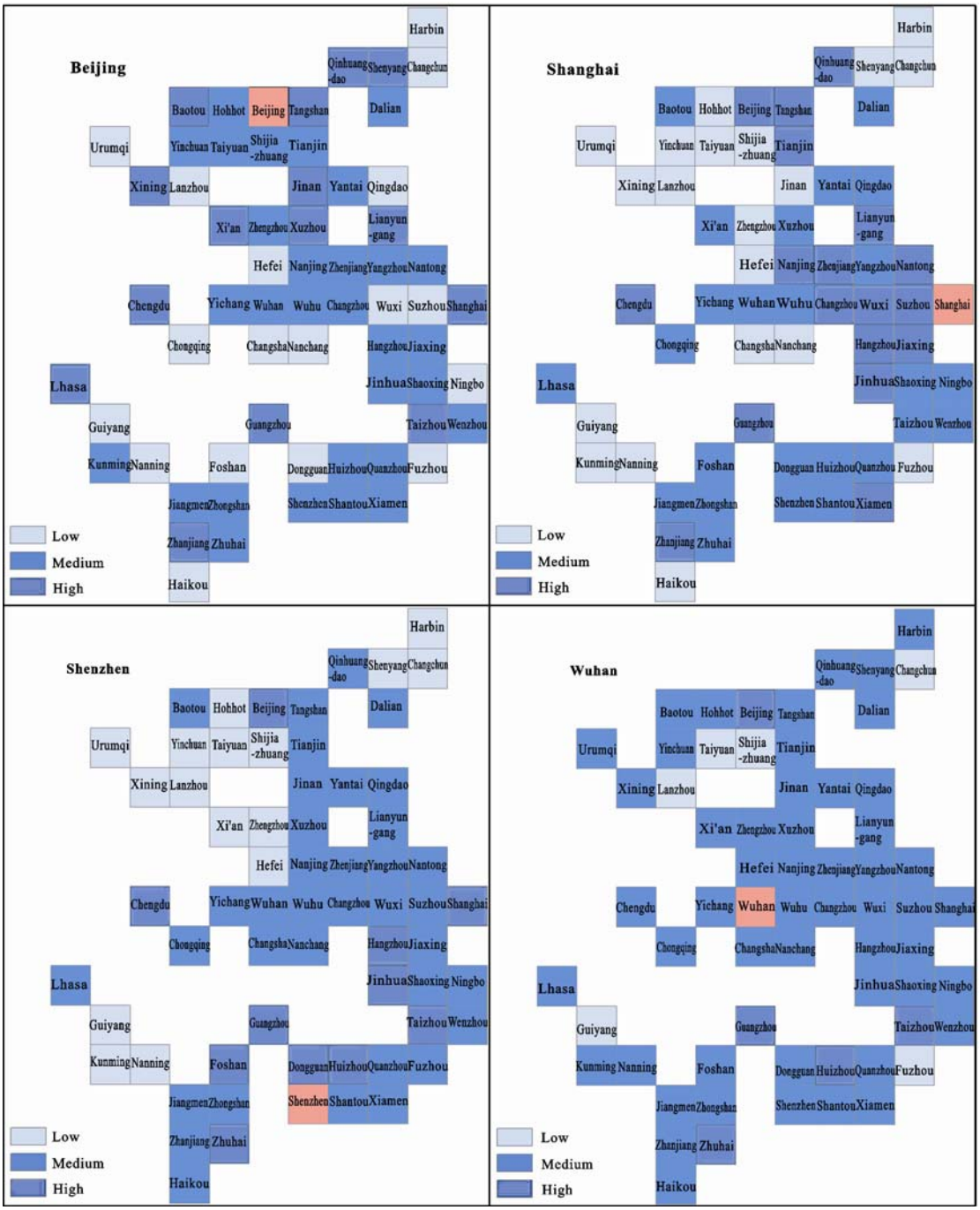

Fig. 4 Spatial influence sphere analysis of four central cities

As a national central city and leading city of the Changjiang River Delta, Shanghai has witnessed the rapid development in producer services since 1992 when the municipal government proposed the international financial center strategy. As Shown in Table 2 and Fig. 3, the network connectivity of Shanghai is very high with big traffic flow. The city′s influence sphere covers not only most cities in the Changjiang River Delta, but also other major cities such as Beijing, Guangzhou, Chengdu. Thus, Shanghai is undoubtedly the center of the country′s producer services. However, compared with Beijing, Shanghai has a relative weaker influence on the Northeast, Northwest and Southwest China.

Shenzhen enjoys the advantage of geographically adjacency to Hong Kong, the special economic development zone institution, and national policy support, which

provides good conditions for the development of producer services. Just because of these advantages, the network connectivity of Shenzhen is higher than that of Guangzhou. Although the influence sphere of Shenzhen mainly concentrates in the Zhujiang River Delta, it also extends to other national or regional cities such as Beijing, Shanghai, Guangzhou, and Chengdu. In sum, there exist three spheres in order of the connectivity intensity with Shenzhen: Zhujiang River Delta, eastern and central regions of China and northeastern, northwestern and southwest regions of China. Though Wuhan is located in the geographic centre of China, it does not fulfill the role of central node in the national network of producer services. The high rank flow directed to Wuhan is relatively small. Apart from the close connection with Beijing, Guangzhou and Zhuhai, Wuhan lacks connection with neighboring cities.

In order to directly reflect the spatial agglomeration of producer services enterprises of China in 2012, the kernel density estimation in the ArcGIS software is used to measure the spatial distribution of producer services enterprises and to draw the nuclear density estimation (Fig. 5). Obviously, the distribution of country′s producer services shows the tendency of spatial agglomeration, mainly concentrated in the Changjiang River Delta, the Zhujiang River Delta, and Beijing-Tianjin-Tangshan Economic Zone. Changjiang River Delta, with Shanghai as the center, has become the largest producer services agglomeration in China, occupying a very important position in China′s producer services network. Shandong Peninsula and the Western Shore Economic Zone of Fujian Province have also shown a concentrating pattern. However, the spatial distribution of producer services in other provinces or regions usually scatter around.

3.4 Network analysis of cities among different producer services

Different types of producer services show a striking distribution disparity in different cities where regional and urban economic level, and infrastructure have an influence on spatial layout of producer services, The following radar analysis charts displays and compares the relative network connectivity of cities ranking top 15 in 11 different producer services, respectively (Fig. 6).

Cluster analysis shows the networking resemblance of different industries, which can be classified into three

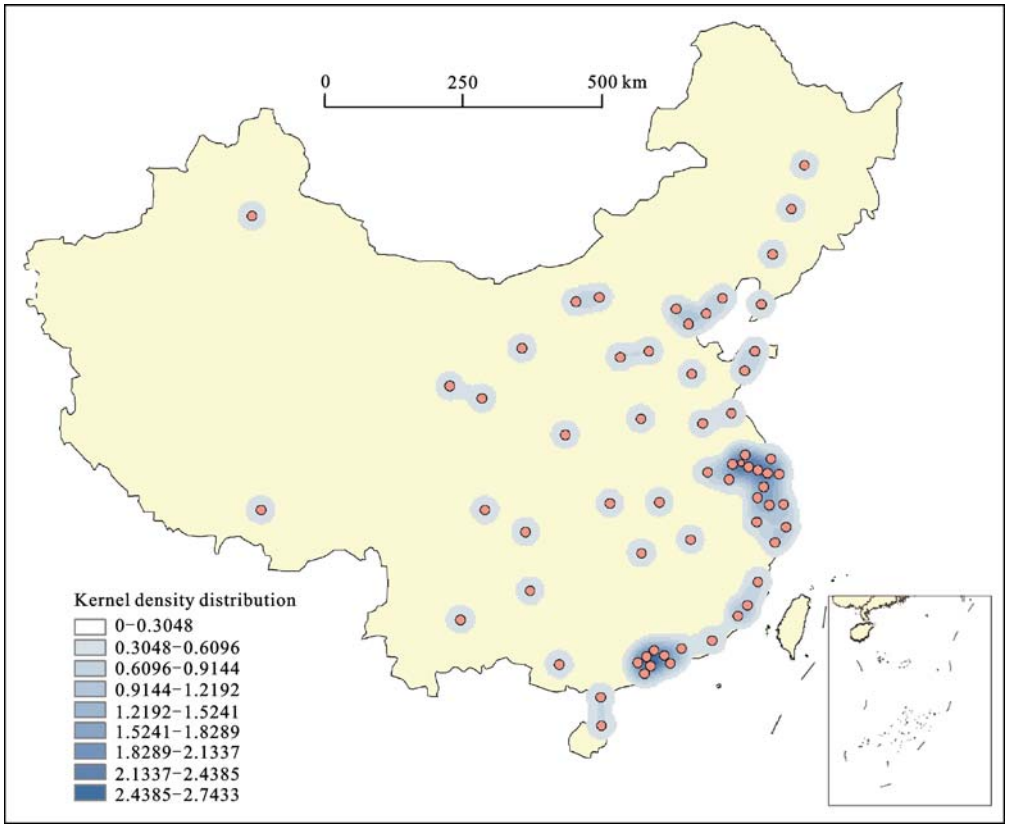

Fig. 5 Kernel density estimation of China′s producer services network distribution

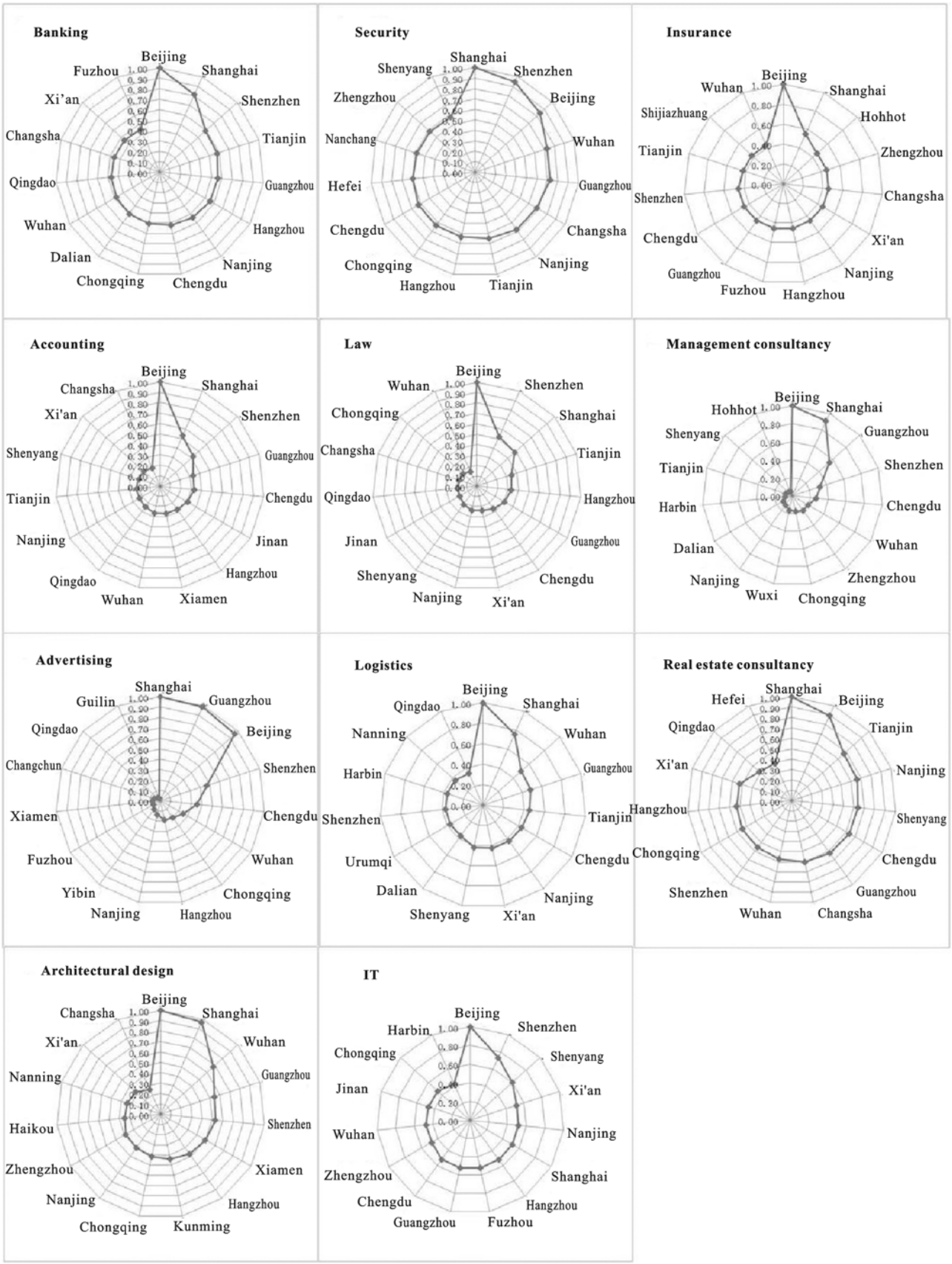

Fig. 6 Comparisons of city network connectivity in terms of producer services

categories (Table 3). With relatively mature networking, the first type of producer services has basically built up a nationwide industrial network with certain hierarchical system, including banking, insurance, logistics, real estate consulting, and IT industry. Despite of wide network coverage and densely distributed branches, the second type of securities bears less obvious hierarchy among cities, influenced by the intensity of security company branches. The third type of industries includes accounting, law, management consulting, advertising, and architecture design, which are mainly located in the national central cities and economically developed coastal cities.

4 Conclusions and Discussion

Economic globalization and informatization has accelerated city-region networking process over the world. Producer services play an increasingly important role in adding an impetus to the process. Within the framework of world city networks, it is necessary to ponder over the interaction between producer services and urban, regional economic and social development. Since the introduction of opening-up and reform policy in 1978, China′s national economy has undergone fast growth, which in turn promotes remarkable industrialization and urbanization. With the economic restructuring at national and local level, urban producer services has stepped into a rapid development stage, which not only strengthens economic links between cities, also affects the development of the networking pattern of Chinese cities. The paper employs the methodology of the world city network to analyze the development characteristics and spatial pattern of Chinese city networks through spatial distribution of producer services enterprises.

Results of analysis show that the distribution of producer services network has a positive effect on the development of Chinese city networks. This further verifies the results of relevant theoretical studies, such as Zhong and Yan′s study (2008) on the correlation between the development level of producer services and urban hierarchy in Pearl River Delta. It is found that city network connectivity has strong connection with significance of city in producer services, and the former will decline gradually with the drop of the latter, thus exhibiting distinct hierarchical characteristics of city networks in China. Accordingly, the 64 cities can be divided into the national central cities, regional central cities, sub-regional central cities and local central cities in terms of their position and role in the nationwide producer services network. ′Flow′ analysis of producer services clearly indicates that Beijing, Shanghai, Shenzhen are three national nodal cities of producer services, constituting the basic framework of Chinese city networks, together with other different hierarchical nodal cities. However, the networking connection sphere varies from city to city. Beijing is the most important and biggest node in the network of cities based on producer services,

Table 3 Cluster analysis of different types of producer services network

Type	Industry	Central city	Network pattern	Characteristics
1	Banking	Beijing, Shanghai	Obviously double centers with the highest relative network connectivity	Well developed network with a hierarchical system
	Insurance	Beijing	Single center	
	Logistics	Beijing, Shanghai	Double centers, slow decline of the relative network connectivity of the other cities	
	Real estate consulting	Shanghai, Beijing	Double centers, slow decline of the relative connection of the other cities indicates the network of real estate consulting develops well	
	IT	Beijing, Shenzhen	Double centers, slow decline of the relative connection of the other cities	
2	Securities	Shanghai, Shenzhen, Beijing	Three centers, other cities also have high relative network connectivity (between 0.58 and 0.73) depending on the density of security company branches	Wide network coverage with no obvious hierarchical system
3	Accounting and law	Beijing	Single center except Shanghai and Shenzhen, the relative network connectivity rate of the other cities is rather low (below 0.4)	Undeveloped network and the agglomeration of advanced producer services in few cities
	Management consulting	Beijing, Shanghai	Double centers, except Guangzhou, the relative network connectivity rate of the other cities is rather low (below 0.4), indicating large consulting corporations concentrate in few high-grade cities alone	
	Advertising	Shanghai, Guangzhou, Beijing	Three centers, except Shenzhen, other cities have low relative network connectivity	
	Architecture design	Beijing, Shanghai	Double centers	

as well as the national management and control center for producer services. Shanghai and Shenzhen are other two national centers of producer services; however, influence sphere of Shanghai is more concentrating in the Changjiang River Delta and the Changjiang River Basin, Shenzhen on Zhujiang River Delta and South China. As a regional central city located in central China, Wuhan plays an especially important role for national economy and regional spatial organization, but in addition to the close connection to Beijing, Shanghai, Shenzhen and other regional central cities, it lacks its own hinterland, impeding further development of producer services.

It is found that high-grade cities with quality producer services dominate the pattern of Chinese city networks. There are emerging three spatial agglomerations of producer services enterprises in the Changjiang River Delta, the Zhujiang River Delta and Beijing-Tianjin-Tangshan Economical Region, which indicates that in these areas there are not only national central cities with high network connectivity, but also advanced and interlocking networks of producer services. Although the network connectivity of Shanghai in the whole city networks is lower than Beijing, Shanghai still spearheads producer services in the Changjiang River Delta, playing a very important role in the national network pattern of producer services. The above conclusion verifies recent research result by Huang *et al*. (2011) that the Changjiang Delta centering around Shanghai is the largest producer services area in China, followed by Shandong Peninsula, the Economic Zone of Taiwan Strait′s Western Shore, and scattered regions in other provinces. The solid manufacturing foundation in coastal areas can partially account for the spatial agglomeration of producer services enterprises in the coastal regions of China.

The paper explores spatial distribution of different producer services industry in major cities, and their characteristics of network development. Relatively speaking, banking, insurance, logistics, real estate consulting, IT industry, the securities industry have established a hierarchical structure over the country, while accounting, law, management consulting, advertising and design industry highly concentrate in developed coastal cities. This indicates that the gap of economic development among cities or regions affects the growth of producer services, which also enlightens city government to make preferential policies to encourage the development of advanced producer services such as accounting and law.

The paper demonstrates that the study of producer services can and will continuously serve as an effective tool to interpret the pattern of current Chinese urban networking. Given that city networking is a complex, changeable and sustainable process, a more rigorous study should take account of network layout, stream of money, fund flow direction and so on. Only an overall consideration of various factors can yield more accurate results about the developmental characteristics of producer services-based network of cities. In addition，the paper is static analysis based only on the 2012 national production services network. It focuses on the investigation into the morphological changes of producer services network, while the driving mechanism is not explained in detail. These above-mentioned inadequacies are our future research directions.

References

Batty M U, 1991. Urban information networks: The evolution and planning of computer communications infrastructure. In: Brotchie J *et al*. (eds.). *Cities of the 21st Century New Technologies and Spatial System.* New York: Halsted Press, 65–72.

Castells M, 1989. *The Informational City*: *Information Technology*, *Economic Restructuring and the Urban-Regional Process.* Oxford: Blackwell Publishing.

Castells M, 1996. *The Rise of the Network Society*. Cambridge: Blackwell Publishers.

Friedmann J, 1986. The world city hypothesis. *Development and Change*, 17(1): 69–83. doi: 10.1111/j.1467-7660.1986.tb00231.x

Goetz A R, 1992. Air passenger transportation and growth in the US urban system 1950–1987. *Growth and Change*, 23(2): 218–2421. doi: 10.1111/j.1468-2257.1992.tb00580.x

Huang Fanhua, Cheng Jia, Wang Jingjing, 2011. An empirical study of producer service agglomeration in Yangtze River Delta region. *Journal of Nanjing University of Posts and Telecommunications* (*Social Science*), 13(4): 9–15. (in Chinese)

Ho Shin K, Timberlake A, 2000. World cities in Asia cliques, centrality and connectedness. *Urban Studies*, 37(12): 2257–2285. doi: 10.1080/00420980020002805

Jin Zhongfan, 2010. On structural properties of transnational urban network based on multinational enterprises network in China: As the case of link with South Korea. *Geographical Research*, 29(9): 1670–1682. (in Chinese)

Malecki E J, 2002. The economic geography of the Internet's infrastructure. *Economic Geography*, 78(4): 399–424. doi: 10.1111/j.1944-8287.2002.tb00193.x

Mat Sumoto H, 2004. International urban systems and air passenger and cargo flows: Some calculations. *Journal of Air*

Transport Management, 10(4): 239–247. doi: org/10.1016/j.jairtraman.2004.02.003

Mitchelson R, Wheeler J O, 1994. The flow of information in a global economy：The role of the American urban system in 1990. *Annals of the Association of American Geographers*, 84(1): 87–107. doi: 10.1111/j.1467-8306.1994.tb01730.x

Ning Yuemin, Wu Qianbo, 2011. *Corporate Spatial Organization and Urban-regional Development*. Beijing: Science Press. (in Chinese)

Sassen S, 1991. *The Global City: New York, London, Tokyo*. Princeton NJ: Princeton University Press.

Taylor P J, 2004. *World City Network*: *A Global Urban Analysis*. New York: Routledge.

Taylor P J, Hoyler M, Verbruggen R, 2010. External urban relational process: Introducing central flow theory to complement central place theory. *Urban Studies*, 47(13): 2803–2818. doi: 10.1177/0042098010377367

Tan Yiming,Yang Yongchun, Leng Bingrong, *et al*., 2011. Urban network system in chengdu-chongqing region in the perspective of advanced producer service. *Progress in Geography*, 30(6): 724–732. (in Chinese)

Tang Zilai, Zhao Miaoxi, 2010. Economic globalization and transformation of urban system in the Yangtze river delta region: interlocking network and value-added hierarchy. *Urban Planning Forum*, (1): 29–34. (in Chinese)

Townsend A M, 2001. Networked cities and the global structure of the Internet. *American Behavioral Scientist*, 44(10): 1698–1717. doi: 10.1177/00027640121957998

Yang Yongchun, Leng Bingrong, Tan Yiming *et al*., 2011. Review on world city studies and their implications in urban systems. *Geographical Research*, 30(6): 1009–1020. (in Chinese)

Yin Jun, Zhen Feng, Wang Chunhui, 2011. China′s city network pattern: An empirical analysis based on financial enterprises layout, *Economic Geography*, 31(5): 754–759. (in Chinese)

Zhang Xiaoming, Wang Chun, 2008. Analysis of urban pattern of mega city-region in Yangtze River Delta: Advanced producer services perspective. *Urban and Regional Planning Research*, 1(2): 44–59. (in Chinese)

Zhen Feng, Liu Xiaoxia, Liu Hui, 2007. Regional urban network influenced by information technology: New directions of urban studies. *Human Geography*, 22(2): 76–80, 71. (in Chinese)

Zhong Yun, Yan Xiaopei, 2008. Relationship between producer services developing level and urban hierarchy—A case study of Zhujiang River Delta. *Chinese Geographical Science*, 18(1): 1–8. doi: 10.1007/s11769-008-0001-0