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Research on China's Urban Network Based on the Relations between Micro-Blog Users: a Case Study of Sina Micro-Blog

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1 ABSTRACT

The change of urban regional spatial structure influenced by information technology has become a hotspot of foreign and domestic scholars' research. This study tries to analyze China's city network characteristics from the social network space perspective, by using Sina Microblog as an example. The result showss that China's city network based on the Micro-blog social space has a clear hierarchical structure and level distinction. Firstly, the result shows the existence of regional characteristics, performance as a visible regional development pattern which contains "Three Main-regions and Four Sub-regions" according to the analysis of the level distinction in the city network and the connection rate between cities. Specifically speaking, the three main regions contains the Beijing- Tianjing- Hebei region represented by Beijing, Pearl River Delta region presented by Guangzhou and Shenzhen, the Yangtze River Delta region represented by Shanghai, Hangzhou and Nanjing. The four sub-region contains Chengdu- Chongqing region, Hercynian region represented by Fuzhou and Xiamen, Wuhan region presented by Wuhan and Changsha, Northeast region represented by Shenyang, Harbin and Changchun. Secondly, the result shows a significant difference of the network links among the Eastern, Central, Western China. Links within the Eastern region and the links between Eastern region and Central region, Western region constitute almost all of the current network system. The result also finds that the high-level cities has an absolute dominance in the city network pattern, Beijing is the contact center in China's city network, with an overwhelming advantage. Shanghai, Guangzhou and Shenzhen is the sub contact center in China's city network.

2 INTRODUCTION

Spatial relationship between cities has always been a key research topic of urban and economic geography. Since 1990s, information technology, represented by the Internet, has developed rapidly and globally, which not only changed the human social system and economic structure, but also reconstructed the structure of the global physical and virtual space (Graham S, Marvin S., 1996). Considering globally, nationally or regionally, the development of cities has crossed their own boundaries. Cities and their facilities are closely linked to each other through a variety of high-speed network to form a diversified global or regional urban network (Zhen Feng, Liu Xiaoxia, 2007). With the growing impact of information technology, many scholars began to take information factors into consideration in the study of urban network, and network paradigms based on the complex links between cities also emerged (Batty M., 1991). From then on, urban network under the influence of globalization and informatization has become the main research field of urban and regional spatial relations. The Space of Flow proposed by Castells emphasizes the value of urban nodes in shaping the entire network system (Castells M., 1996), which provides an important theoretical frame for the urban network research at home and abroad. For the shaping of information flow on the relationship between cities, western scholars have studied parcel mail, Internet traffic, network bandwidth and other information flow (Mitchelson R., Wheeler J O., 1994; Townsend A M., 2001; Malecki E J.,2002), as well as the influence of traffic flows like flights and cargo volume, port throughput, highway and railway traffic flow on urban network system (Goetz A R.,1992; Ho Shin K , Timberlake A, 2000; Mat sumoto H, 2004). Later, western geographers represented by Zook, Townsend and Moss, based on the data of Internet domain names and network capacity, Internet names and IP addresses, conducted lots of meaningful studies on network information space from the global, national or regional, and inner city levels (Zook M A., 1998, 2000, 2001; Castells M., 1999; Townsend A M., 2001; Moss M L, 1997, 1999, 2000).

In recent years, Shoko et al (2011) collected more than ten million Twitter data with geographical tags through the geographical collection system of Twitter, constructed the Japanese social geographical boundaries, and simulated the urban characteristics based on social urban crowds according to the Vironoi

diagram and the geographical laws of human activities in daily life. Croitoru et al (2012) conducted a systematic study of the urban or regional characteristics by constructing the social geographic analysis platform (G-SAW). This shows that, current studies on urban characteristics reflect the activities and local characteristics of the entire city and made quantitative representations on the relatively qualitative geographical features mainly through the research on the network activities of a large number of residents. Gautier et al (2009) adopted the communications information of 25 million users provided by the Belgian mobile phone operator, established urban social network based on the corresponding zip codes of the mobile phone billing addresses of the users, and studied the communication activity between cities and found the urban structure in the communication network. Seeing from the existing research results, the way of employing users' communication information to carry out studies on urban structure is in its infancy and has a relatively single method. Although its data acquisition is difficult, the research results are found to be accurate and thus should be paid more attention to. At the same time, as the flow data are often difficult to obtain, many western scholars attempt to analyze the network links between cities through urban function contacts. The impact of globalization makes the global city become a production base of advanced producer services (Sassen S., 2001). Based on it, some scholars judged the function contacts and changes between cities, and the distribution of corporate headquarters, large banks and other global producer services have been used to analyze the structure of these world cities (Friedmann J., 1986; Taylor P J., 2004).

Since 2000, Chinese scholars also have become concerned about the urban network system and achieved lots of results. Similar to the western research ideas, Chinese scholars mainly interpreted the development pattern of urban network on the national level and its changes based on the infrastructure networks of air transport and railway (Jin Fengjun, Wang Chengjin, 2005; Xue Junfei, 2008; Wu Wei, et al., 2009). In recent years, the network paradigms of western world cities were comprehensively introduced to China (Yang Yongchun, et al., 2011). Some scholars studied the national or regional urban network system from the perspective of enterprises (especially producer services) (Zhang Xiaoming, 2006; Jin Zhongfan, 2010; Yin Jun, Zhen Feng, et al., 2011; Ning Yuemin, Wu Qianbo, 2011), while others also studied from the relationship between Internet facilities (Wang Mingfeng, Ning Yuemin, 2006; Sun Zhongwei, et al., 2010), both of which explained the changes in Chinese urban network system under the influence of globalization and informatization.

The network constructs a new human social form, while the spread of network logic substantially changes the operation and results in production, experience, power and culture. In addition to the emphasis on the roles of information infrastructure and information nodes, in the theory of Space of Flow constructed by Castells, there is another important content, that is, "spatial organizations of the work, games, and sports of the world's elite. However, in the research literature of world and national urban network, the power of social network space is seemingly ignored, while it is playing an increasingly large spatial influence. Currently, the research on China's urban network from the perspective of interpersonal networks is rare. The emergence of social network sites like micro-blog not only enriches and expands the social relation network, but also provides a new perspective for the interpretation and analysis of urban network structure. Micro-blog, a system similar to blog, can release real-time news. Its text content is limited to 140 words and can achieve real-time sharing. By the end of June, 2011, the total number of netizens in China has amounted to 485 million and Internet penetration rate has reached 36.2 %. The number of micro-blog users has increased to 195 millions, while the netizen utilization rate has been expanded to 40.2 % from 13.8 %, becoming the fastest-growing Internet application.[1] From the world's first micro-blog of Twitter to the Sina Micro-blog and Tencent Micro-blog in China, micro-blog has gradually become an influential social media platform. The return of voice to the public rebuilds the social space. More importantly, compared to the point-to-point contact characteristics of the previous network communities like BBS and QQ, micro-blog itself is a completely open and civilian interactive network platform. It gets a lot of people involved and has strong social mobilization ability, making it ideal for the utilization of fragmentized time and space under the influence of information technology (Liu Yang, 2010; Zhan Zihua, 2011). As a result, this paper tries to study China's urban network architecture and its spatial characteristics with the help of this emerging network media and interactive platform of micro-blog.

[1] China National Network Information Center (CNNIC), "The 28th Statistic Report of China Internet Network Development Status", 2011

3 RESEARCH METHODS

According to the survey data of "White Paper of Sina Micro-blog in 2010", Sina Micro-blog is a mainstream micro-blog with the highest market visibility and highest user utilization rate.[2] Therefore, this paper selects Sina Micro-blog as the research object, analyzes the social relation network from the perspective of the relationship between network users, and then interprets the changes in China's urban network system.

3.1 Research ideas

Sina Micro-blog has a wide range of national influence and adequate user distribution, so we can use the relationship between micro-blog users to effectively support and reflect the linkages between cities. In Sina Micro-blog, the relationships between users include three types, namely, follower, following and friend. As we can see in Figure 1, follower and following reflect the unidirectional information transfer between users. A follows B, meaning that A is willing to accept B's updated real-time information and make comments as well as exchange ideas. Under this circumstance, for A, his relationship with B is the "following"; for B, his relationship with A is the "follower". Compared to the relationships of followers or followings, the users with the relationship of "friend" can accept the updated real-time information from each other and make comments as well as exchange ideas. It is better to achieve the bidirectional transfer of information. From the geographical perspective, the cities can be understood as the nodes in the network communities, and the friend relation between cities can be interpreted as the information flow between nodes in the network communities. These understandings will facilitate the analysis of the state in which strong and weak relationships exist, so as to construct a city's network system based on network community. As a result, if more friend relation between the micro-blog users in City(A) and the micro-blog users in City(B) exists, then more closely related information contact can be found in the network systems of City(A) and City(B); if more friend relation between the micro-blog users in City(A) and the micro-blog users in other cities exists, then City(A) enjoys a higher degree of importance in the whole network system as well as a higher hierarchy.

According to the current status of China's urban network system, this paper first selects the cities which are economically powerful and highly informatized and likely to become the backbone notes in micro-blog space as the representative cities based on certain screening criteria, then uses Sina Micro-blog site to make a statistics of the micro-blog users of each representative city. Then, we collect the data of friend relation between the selected micro-blog users and other geospatial data, and construct a matrix of the network community friend relation between the representative cities referring to the research method of world city networks proposed by P. Taylor. Finally, with the help of Arcgis analysis software, we reflect the network community friend relation in the geographic space, and analyze China's urban network system

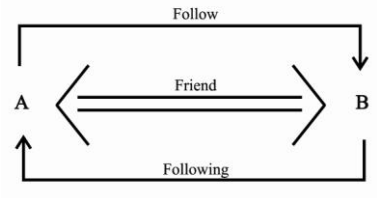

Fig. 1: The relationship between users based on user A

3.2 Data collection

This paper selects several representative cities in Mainland China as the research units, and reflects the friend relation between Sina Micro-blog users of each research unit in the geographic space.

(1) The selection of urban network notes in social network space

According to the indicator of "Number of the Internet Users" in the China City Statistical Yearbook of 2011, we select the top 100 cities. Combined with the existing study of China's urban hierarchical scale (Gu Chaolin, 1990; Gu Chaolin, Hu Xiuhong, 1998), we finally select 51 note cities and build a urban network framework in social network space (Table 1).

[2] Sina Micro-blog neice was made on August 14, 2009. It became the first portal website which provided micro-blog service. Currently, greater than 3 million micro-blogs are released each day, and nearly 40 micro-blogs are released in a second.

City name	The rankings of the number of Internet users in China	The rankings of GDP in 2010 in China	City name	The rankings of the number of Internet users in China	The rankings of GDP in 2010 in China	City name	The rankings of the number of Internet users in China	The rankings of GDP in 2010 in China
Shanghai	1	1	Dalian	18	14	Xuzhou	48	35
Tianjin	2	6	Chengdu	19	13	Liuzhou	53	92
Beijing	3	2	Xi'an	22	29	Daqing	61	40
Kunming	4	51	Jinan	24	22	Hefei	64	41
Wenzhou	5	32	Shijiazhuang	25	26	Wulumuqi	66	88
Guangzhou	6	3	Handan	26	45	Lanzhou	69	107
Changchun	7	28	Ha'erbin	29	24	Guiyang	72	98
Shenzhen	8	4	Taiyuan	30	64	Jilin	74	66
Chongqing	9	7	Fuzhou	31	31	Huhehaote	85	62
Suzhou	10	5	Nanchang	33	50	Baoji	90	121
Hangzhou	11	8	Changsha	35	20	Haikou	92	206
Wuhan	12	12	Tangshan	38	18	Xiangfan	99	77
Qindao	13	10	Yantai	40	21	Changzhi	129	130
Ningbo	14	15	Nanning	42	65	Sanming	166	124
Nanjing	15	17	Xiamen	44	55	Xining	172	205
Zhengzhou	16	23	Lianyungang	45	101	Yinchuang	185	182
Shenyang	17	16	Guilin	46	103	Lasa	-	280

Table 1: The 51 selected node cities

(2) The selection of micro-blog users of each note city in urban network

With the selected 51 representative cities as the strongholds, we choose 20 users from each city as the research samples. These samples should meet the following three conditions: (1) The user lives in the selected city; (2) The user is the "grassroots", but not a "celebrity",[3] which helps to reflect the real social network relations and excludes those relations without actual communication but for influence expansion or celebrity worship; (3) The user is active, has 400 followers and followings respectively, and releases more than 6 micro-blogs every day. Finally, with the help of the application module of "Finding Someone" in Sina Micro-blog, we collected data on December 4, 2011, and obtained 1020 samples from the 51 representative cities for Sina Micro-blog research.

(3) The acquisition of friend relation of the micro-blog research sample

Due to the large amount of data, we collected the micro-blog IDs of the followers and follow users of the 1020 research samples through the establishment of a crawler program,[4] find out the micro-blog users with friend relations and recorded their geographic information data. Finally, by running the program, we got 243451 effective friend relation data (excluding the friend relations of overseas, Hong Kong, Macao and Taiwan regions and default data). There are 183597 friend relation data among the 51 research samples, accounting for 75.41 % of the total data, which also verifies the reasonability of the city selections in data collection.

3.3 Data calculation

The data calculation includes four steps. The first step: standardize the collected friend relations data of the 51 note cities, and construct a matrix of the number of friends of the 51 cities. The formula is as follows:

$$V'_{ij} = V_{ij} / \sum_{j} V_{ij} \quad (1)$$

[3] In Sina Micro-blog, the users can be generally divided into "celebrities" and "grassroots". Compared to "celebrities", the words and deeds of the "grassroots" are usually the information communication with other users and play the role of maintaining the social relations between users, so they can reflect the links between cities more truly.

[4] A crawler program can enter the Sina Micro-blog web page of each user, and calculate the numbers of the user's followers, followings and friends automatically, making the data collection more convenient and feasible.

Where V_{ij} is the number of the friends of the collected $City_{(i)}$ in $City_{(j)}$; $\sum v_{ij}$ is the sum of the numbers of $City_{(i)}$ in each $City_{(j)}$ (51 note cities); V_{ij}' is the standardized number of the friends of $City_{(i)}$ in $City_{(j)}$.

The second step: on the basis of the above calculation, calculate the city's external connectivity index in the network system. The formula is as follows:

$$N_i = \sum_j V_{ij}' - V_{ii}' \quad (2)$$

Learning from the Central Place Theory proposed by W. Christaller, we use the external connectivity index to represent urban hierarchy. In the formula, N_i is a city's external connectivity index, reflecting the sum of the ratios of the friend relations of $City_{(i)}$ in other cities; V_{ij}' is the standardized number of the friends of $City_{(i)}$ in $City_{(j)}$; V_{ii}' is the standardized number of the friends of $City_{(i)}$ in the same city.

The third step: calculate the network connectivity between cities to reflect the closeness of contact information between cities in the network. The formula is as follows:

$$R_{ij} = V_{ij}' * V_{ji}' \quad (3)$$

Assume that =100, we adopt the maximum standardization:

$$R_{ij}' = \frac{R_{ij}}{Max(R_{ij})} * 100 \quad (4)$$

Where V_{ij}' is the standardized number of the friends of $City_{(i)}$ in $City_{(j)}$; V_{ji}' is the standardized number of the friends of $City_{(j)}$ in $City_{(i)}$; R_{ij} is the network connectivity between $City_{(i)}$ and $City_{(j)}$; $Max(R_{ij})$ is the maximum of the calculated network connectivity; R_{ij}' is the standardized network connectivity between $City_{(i)}$ and $City_{(j)}$.

The fourth step: calculate the network connectivity of each city to reflect the contact intensity of the city in the network system. The formula is as follows:

$$M_i = \sum_j R_{ij}' - R_{ii}' \quad (5)$$

Where M_i is the network connectivity of City I; R_{ij}' is the standardized network connectivity between $City_{(i)}$ and $City_{(j)}$; R_{ii}' is the network connectivity of the inner $City_{(i)}$.

4 CHINA'S URBAN NETWORK CHARACTERISTICS FROM THE PERSPECTIVE OF MICRO-BLOG SOCIAL SPACE

Based on the above methods, we analyzed and calculated the friend relations of the micro-blog users of the selected 51 representative cities. Combined with the geospatial urban network patterns, we made the following analysis of China's urban network system based on the micro-blog social space.

4.1 Analysis of the Overall Structure of Urban Network System

The micro-blog social space itself should be flat and without centers. However, the analysis of the micro-blog friend relations shows that, the urban network system in the network space is obviously influenced by the urban network relations in real life, exhibiting the following characteristics.

4.1.1 The relative consistency of network connectivity and urban structure in the network

In Figure 2, the abscissa is the city ranking based on its external connectivity index ( ) with a descending order and a lower ranking suggests a lower hierarchy in the network system; the ordinate is the corresponding network connectivity of each city ( ), reflecting the contact intensity of the city in the network system. It can be drawn that, a city's network connectivity is positively correlated with its hierarchy and shows a downward trend with the decreasing of the urban hierarchy, which means, the higher the urban hierarchy is, the higher the city's network connectivity will be. However, the inconsistency between network

connectivity and urban hierarchy also exists in cities like Shenzhen, Chengdu, Tianjin, Fuzhou, Zhengzhou, Qingdao, Nanjing and Harbin, while these cities are often the network node center of the small region where it belongs. For example, the network connectivity in Chengdu and some western cities is relatively high. This suggests that, although some cities have a low hierarchy, they have relatively higher network connectivity due to its strong network connectivity in the small region.

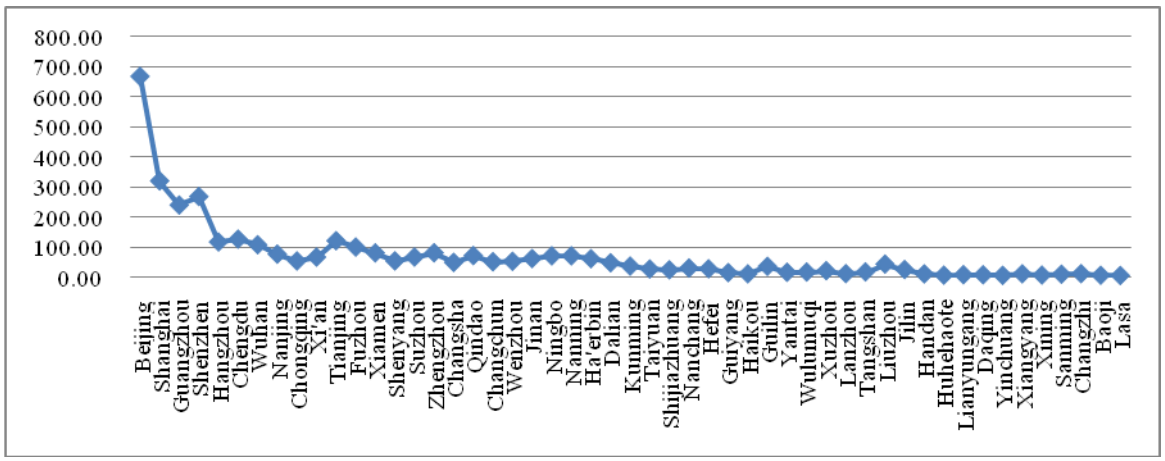

Fig.2: The relationship between the connection rate and the hierarchy system of the cities in the network

4.1.2 City-level distribution in urban network

In order to further subdivide the city level, we sequenced the cities' network connectivity ( ). As shown in Figure 3, the ordinate is the ranking sequenced according to the city's network connectivity; the abscissa is the corresponding city. The lower the ranking is, the weaker the city's contact role in the network will be. According to K-means clustering analysis, these 51 research cities are divided into 6 levels (Table 2). Beijing is in the first level: its network connectivity is more than 600, being the contact center of the national network; Shanghai, Guangzhou and Shenzhen are in the second level: their network connectivity is between 200 and 600, being the sub-centers of the national network; Chengdu, Tianjin, Hangzhou, Wuhan and Fuzhou are in the third level: their network connectivity is between 100 and 200, being the contact centers of regional networks; Zhengzhou, Xiamen, Nanjing and Qingdao etc. are in the fourth level: their network connectivity is between 50 and 100, being the contact centers of sub-regional networks; Changsha, Dalian, Liuzhou and Kunming etc. are in the fifth level: their network connectivity is between 10 and 50, being the contact centers of local networks; Lianyungang, Daqing, Xining and Huhehote etc. are in the sixth level: their network connectivity is less than 10, being the contact nodes of local networks and having the weakest contact roles in the network.

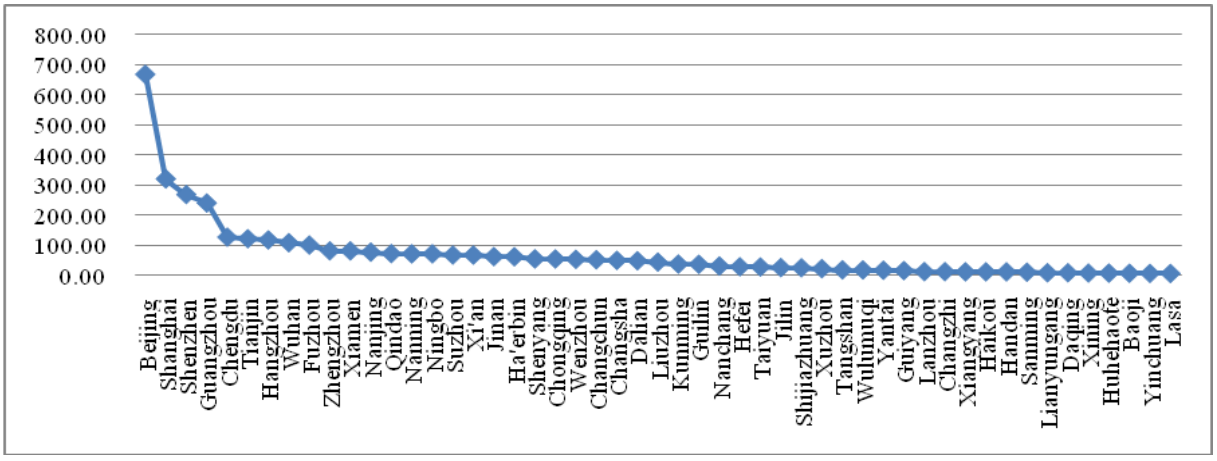

Fig.3: The rank of the connection rate of cities in the network

Considering from the six levels, several cities like Chengdu, Fuzhou, Nanjing, Harbin, Lanzhou and Kunming only play the roles of regional network contact sub-centers or local network contact center, totally inconsistent with the existing urban system-level characteristics related to the entity economies or infrastructure, especially for the regional, sub-regional and local levels. This reflects to some extent that the

spatial expansion of the micro-blog network is not in full compliance with the existing based geospatial. The hierarchy of a city in the network system is not entirely determined by the level of economic development, but the result under the influence of socio-economic level and geo-culture.

Level	Network connectivity	Cities
Center of the national network	＞600	Beijing
Sub-center of the national network	200-600	Shanghai, Guangzhou, Shenzhen
Center of the regional network	100-200	Chengdu, Tianjin, Hangzhou, Wuhan, Fuzhou
Sub-center of the regional network	50-100	Zhengzhou, Xiamen, Nanjing, Qindao, Nanning, Ningbo, Suzhou, Xi'an, Jinan, Haer'bin, Shenyang, Chongqing, Wenzhou, Changchun
Center of the local network	10-50	Changsha, Dalian, Liuzhou, Kunming, Guilin, Nanchang, Hefei, Taiyuan, Jilin, Shijiazhuang, Xuzhou, Tangshan, Wulumuqi, Yantai, Guiyang, Lanzhou, Changzhi, Xiangyang, Haikou, Handan, Sanming
Node of the local network	＜10	Lianyungang, Daqing, Xining, Huhehaote, Baoji, Yinchuang, Lasa

Table 2: Level distribution of the city network

4.1.3 City contact intensity partition in urban network system

Sequencing the network contact intensity ( ) of the 1275 ( ) groups of contact between each two cities from low to high, we found that significant levels exist in these data. Specifically speaking, there are 984 groups of contact between two cities whose network connectivity is between 0 and 1, accounting for 77.17 % of the total number; there are 149 groups of contact between two cities whose network connectivity is between 1 and 3, accounting for 11.69 % of the total number; there are only 112 groups of contact between two cities whose network connectivity is greater than 3, though only accounting for 8.78 % of the total number, the sum of all the network connectivity of these 112 groups reaches 1254.72 which accounts for 70.59 % of the total urban network connectivity. This reinforces that there is a greater level in the network contact intensity between cities. We sequenced the network connectivity of these 112 groups from small to large and also found a significant level. As shown in Figure 4, with the increasing of sequence, the network intensity between cities shows a growth trend similar to an index.

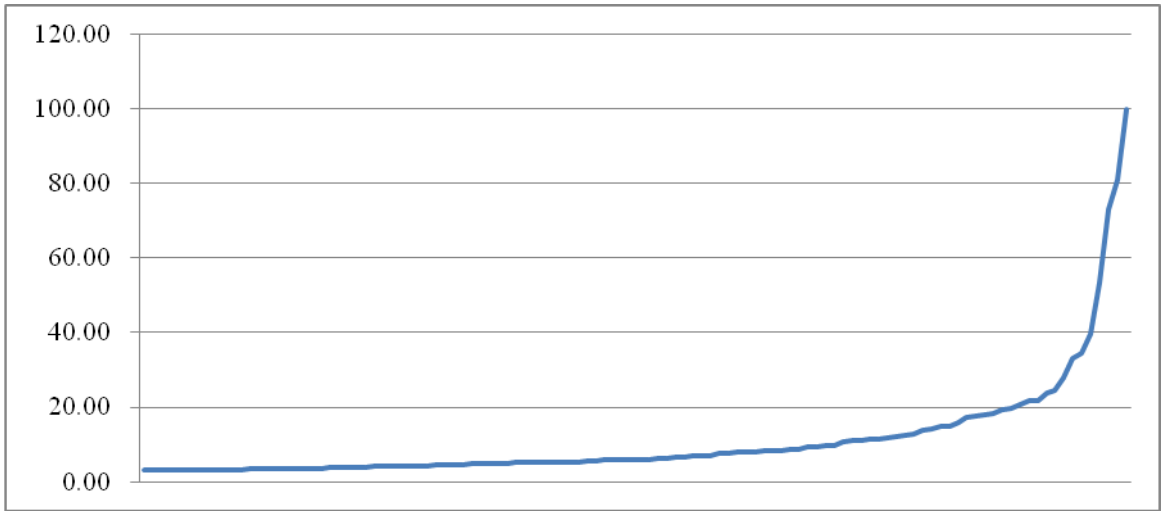

Fig.4: The rank of the connection rate(＞3) between cities

4.2 Spatial Analysis of Urban Network System

With Arcgis analysis software, we prepared the thematic maps about the urban hierarchy in urban network system and the network connectivity between cities to further analyze the spatial characteristics of urban network system. We also divide the network connectivity of the 112 groups of contact between each two cities into six levels.

4.2.1 Significant difference between Eastern China and Midwest China

According to the traditional division method of three regions, namely, Eastern China, Central China, and Western China, we conducted a geographic division of these 51 node cities. As shown in Figure 5, the horizontal axis is divided into three major regions of Western China, Central China, and Eastern China from left to right. We then sequenced the cities in each region according to their network connectivity. The

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analysis showed that, although cities with higher city levels also exist in Western China and Central China, the average city level in Eastern China is significantly higher than those of Central China and Western China. However, the difference between Central China and Western China is not so significant. The 29th Statistic Report of China Internet Network Development Status newly released by China National Network Information Center (CNNIC) also pointed out that, the provinces and cities whose Internet penetrations are above the national average level are mostly concentrated in the eastern coastal areas. This suggests that, the difference in the Internet development level directly affects the city's network connectivity and further widens the development gap between Eastern China and Midwest China.

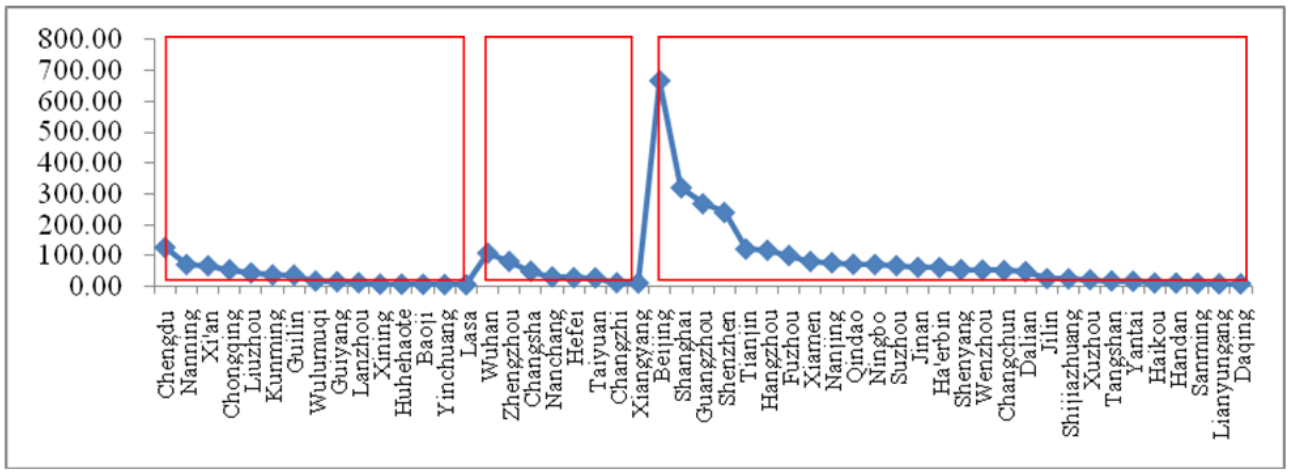
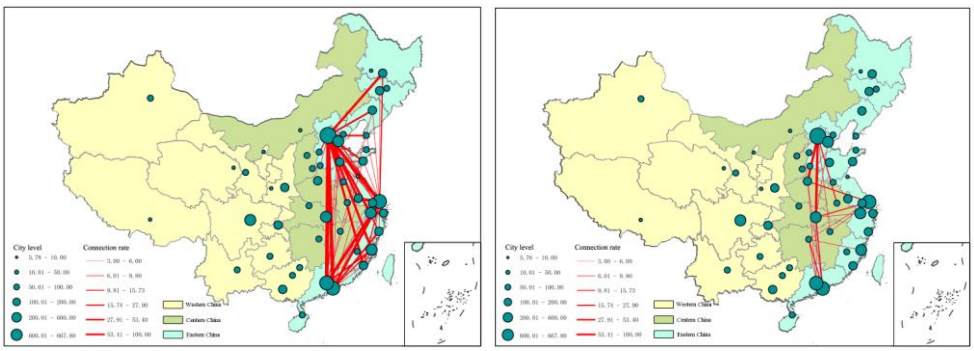
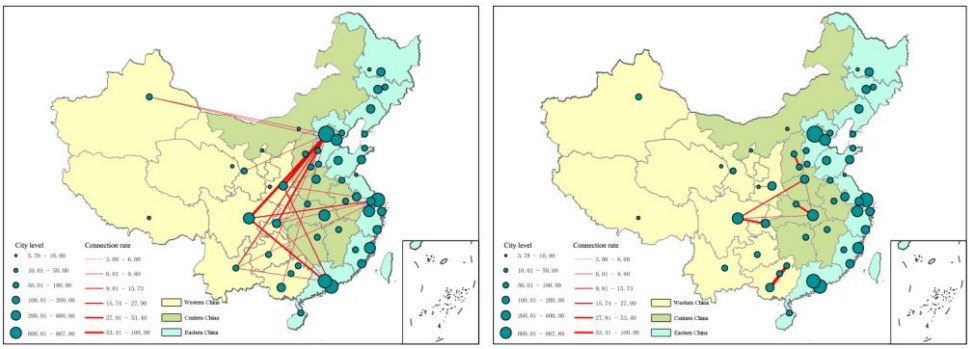


Fig.5: The rank of city level distribution in the Western, Central, Eastern China

We further made a comparative analysis of the information contact intensity and geographical characteristics in the internal Eastern China, between Eastern China and Central China, Eastern China and Western China, Central China and Western China. It can be seen from Figure 6 that, the internal relations in Eastern China is still the main body of current network system. In the statistics of the network system topology whose network information contact intensity is greater than 3, there are 59 connections in the internal Eastern China, accounting for 52.68 % of the total number. The network connectivity totals 846.56, accounting for 67.4 % of the whole network. Secondly, the contacts between Eastern China and Central China, Eastern China and Western China are relatively close. In the network system topology, each has 18 connections, accounting for 16.07 % of the total number respectively. In the cumulative network connectivity, they are nearly the same, which are 132.4 and 138.38 respectively, accounting for 10.54 % and 11.03 % in the entire network respectively. Meanwhile, the network contacts in the internal Central China, in the internal Western China, and between Central China and Western China are obviously weaker. As a result, we can conclude that, the contacts in the internal Eastern China, between Eastern China and Central China, Eastern China and Western China constitute almost all of the current network systems. Besides, the network contacts in the internal Eastern China are the strongest, which reflects the levels of Internet development and economic ties. At the same time, there is no significant difference between Central China and Western China and the contacts between them are also weak.



The internel network connection in Eastern China (left). The network connection between Eastern and Centern China (right).



The network connection between Eastern and Western China (left). The network connection between Centern and Western China (right).

Fig.6: The network connection among Western, Central, Eastern China

4.2.2 Hierarchical agglomeration in urban network

Analyzing the urban network pattern from the perspectives of city level and network contact intensity (>3) between cities, we can found that, hierarchical agglomeration exists in China's urban network system, the specific performance of which is the spatial pattern of "Three Majors and Four Smalls". Figure 7 directly shows the important roles of the three major regions of the Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta in the entire network system. It shows a great similarity with the urban network system pattern in the geographic entity space, especially the emergence of three gathering areas of the Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta in the entire network system.

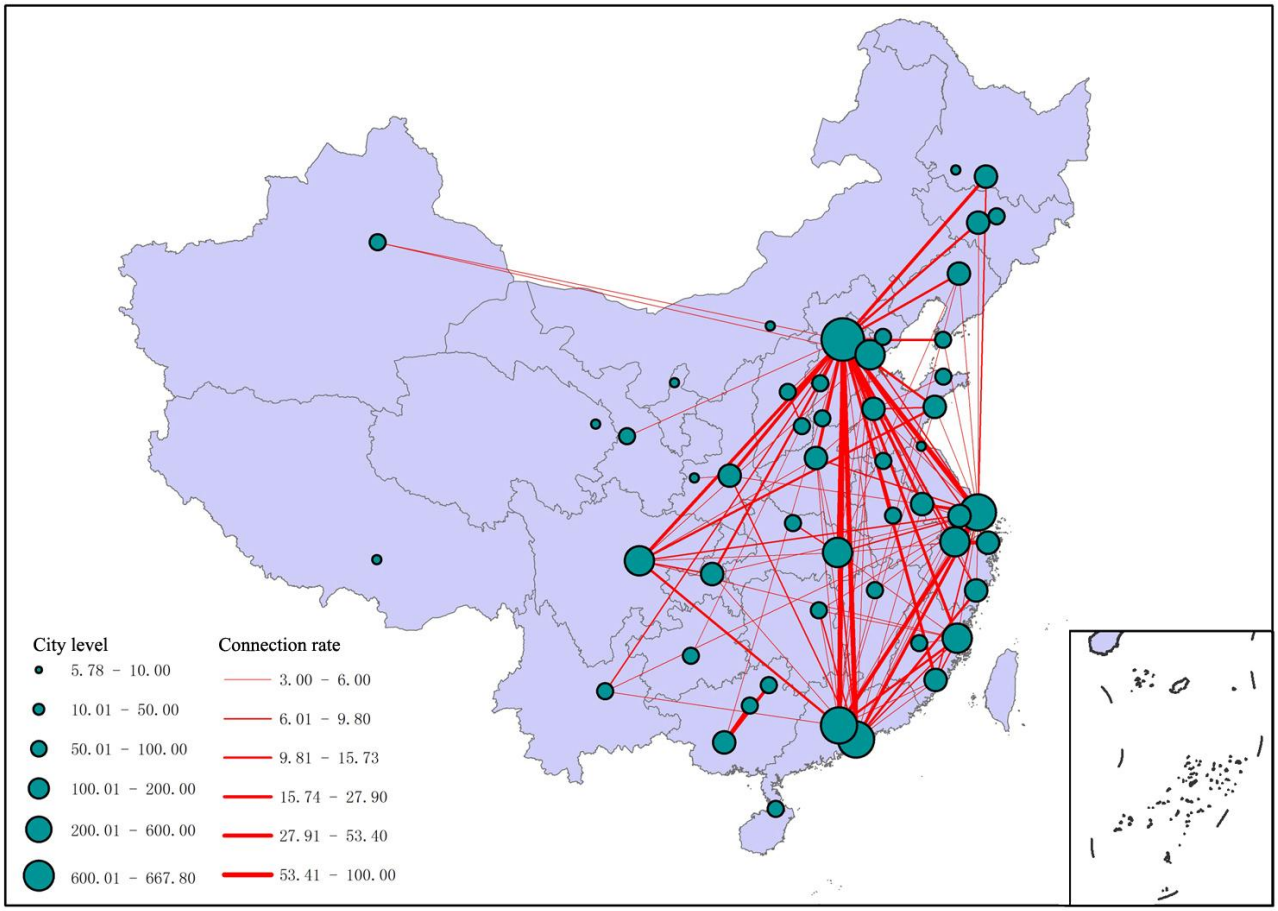


Fig.7: The pattern of China's cities network based on the social network space

Specifically speaking, the "three majors" include the Beijing-Tianjin-Hebei region (Beijing, Tianjin, Shijiazhuang, Tangshan), the Pearl River Delta (Guangzhou, Shenzhen), the Yangtze River Delta (Shanghai, Hangzhou, Nanjing, Ningbo, Suzhou, Wenzhou); the "Four Smalls" include Chengdu-Chongqing region (Chengdu, Chongqing), Hercynian region (Fuzhou, Xiamen, Sanming), Wuhan (central) region (Wuhan,

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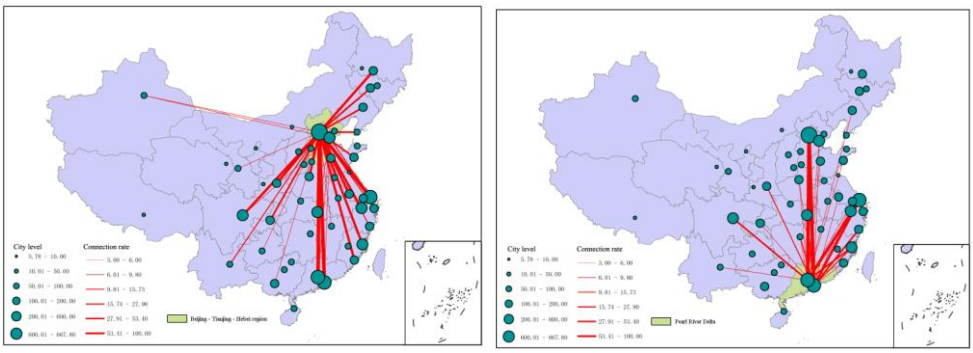
Changsha, Nanchang, Hefei, Changzhi, Xiangyang), Northeast China (Shenyang, Harbin, Changchun) (Table 3). Table 3 is based on the statistical analysis of the network levels of the note and key cities in the seven regions and the network contact intensity between them and the outer world, elaborating the urban network architecture characteristics and division basis more detailedly. The hierarchical agglomeration in China's urban network structure based on network communities is still significant. However, combined with the previous analysis on the characteristics of city level distribution, as an interactive network platform, micro-blog still strengthens the "horizontal contacts" between cities, especially in the local level. This can also explain the emergence of the localized agglomeration of the "Four Smalls" regions.

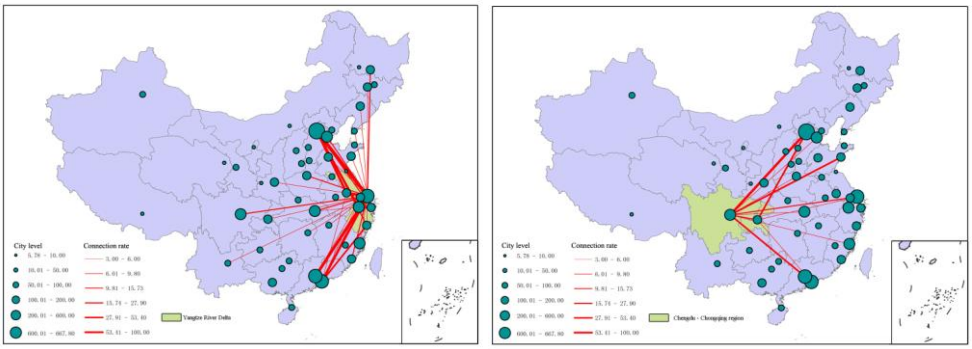
City-region	Node cities	City level	Connection rate of cities (>3)
Beijing-Tianjin-Hebei region	Beijing, Tianjing, Shijiazhuang, Tangshan	Beijing is the center of the natioanl network;Tianjing is the center of the regional network; Shijiazhuang and Tangshan are the centers of the local network;	There are 39 connections between these four cities and other cites, accounting for 32.0 % of the total of connections; and the commulativeconnection rate of these four cities are 675.94, accounting for 53.87 % of the total.
Pearl River Delta	Guangzhou, Shenzhen	Guangzhou and Shenzhen are the sub-centers of the national network	There are 31 connections between these four cities and other cites, accounting for 25.4 % of the total of connections; and the commulativeconnection rate of these four cities are 384.33, accounting for 30.63 % of the total.
Yangtze River Delta	Shanghai, Hangzhou, Nanjing, Ningbo, Suzhou, Wenzhou	Shanghai is the sub-center of the national network; Hangzhou is the center of the regional network; Nanjing, Ningbo, Suzhou and Wenzhou are the sub-centers of the regional network;	There are 39 connections between these six cities and other cites, accounting for 32.0 % of the total of connections; and the commulativeconnection rate of these six cities are 448.06, accounting for 35.71 % of the total.
Chengdu-Chongqing region	Chengdu, Chongqing	Chengdu is the center of the regional cetwork; Chongqing is the sub-center of the regional network;	There are 13 connections between these two cities and other cites, accounting for 10.7 % of the total of connections; and the commulativeconnection rate of these two cities are 104.28, accounting for 8.31 % of the total.
Hercynian region	Fuzhou, Xiamen, Sanming	Fuzhou is the center of the regional network; Xiamen is the sub-center of the regional network; Sanming is the Center of the local network;	There are 12 connections between these three cities and other cites, accounting for 9.8 % of the total of connections; and the commulativeconnection rate of these six cities are 102.07, accounting for 8.13 % of the total.
Wuhan (central) region	Wuhan, Changsha, Nanchang, Hefei, Changzhi, Xiangyang	Wuhan is the center of the regional network; Changsha, Nanchang, Hefei, Changzhi and Xiangyang are the centers of the local network;	There are 18 connections between these six cities and other cites, accounting for 14.8 % of the total of connections; and the commulativeconnection rate of these six cities are 108.22, accounting for 8.63 % of the total.
Northeast China	Ha'erbin, Shenyang, Changchun, Jilin	Ha'erbin, Shenyang and Changchun are the sub-centers of the regional network; Jilin is the center of the local network;	There are 9 connections between these four cities and other cites, accounting for 7.4 % of the total of connections; and the commulativeconnection rate of these six cities are 81.21, accounting for 6.47 % of the total.

Table 3: The overall city network structure

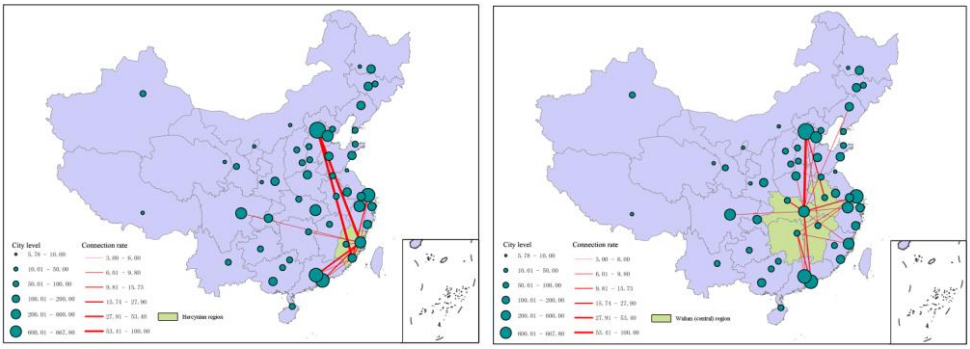
Figure 8 further shows the status of the regions of "Three Majors and Four Smalls" in the national urban network system. Beijing-Tianjin-Hebei region enjoys a widest coverage in the network system and covers the whole country, bearing the status of the country's center. The coverage of the Pearl River Delta region and the Yangtze River Delta region in the network system is less than that of Beijing-Tianjin-Hebei region. There is a certain correlation between the coverage and the geographical entity pattern. The Pearl River Delta region shows obvious characteristics of the network system center in South China, while the Yangtze River Delta region shows the characteristics of the network system center in East China. At the same time, the network contacts between the three major regions dominate the entire network system. In addition, Chengdu-Chongqing region, the Hercynian region, Wuhan region, and Northeast region also occupy a certain position in the whole network system. In addition to reflecting the characteristics of local contacts, each region of the "Four Smalls" shows a unified spatial directivity towards the three cities of Beijing, Shanghai and Guangzhou. It is worth noting that, the geometric center of Wuhan region in the network system is obvious, showing the central characteristics of the blending of North and South, East and West and a significant regional advantage.



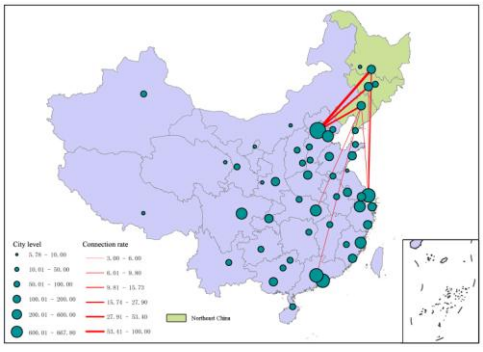
The connection of Beijing-Tianjin-Hebei region in the network (left). The connection of Pearl River Delta in the network (right).



The connection of Yangtze River Delta in the network (left). The connection of Chengdu-Chongqing region in the network (right).



The connection of Hercynian region in the network (left). The connection of Wuhan (central) region in the network (right).



The connection of Northeast China in the network.

Fig. 8: The position of different region in China's city networks

4.2.3 High level city-dominated urban network system

In order to analyze the importance degree of the core cities in the network system, we extracted the first four cities in the urban network system, which are the national network contact center---Beijing and the three national network contact sub-centers---Shanghai, Guangzhou and Shenzhen. The study shows that, cities with high hierarchy dominate the urban network system. It differs from the previous study of China's urban system based on aviation network, railway network and Internet in that the difference between Beijing and

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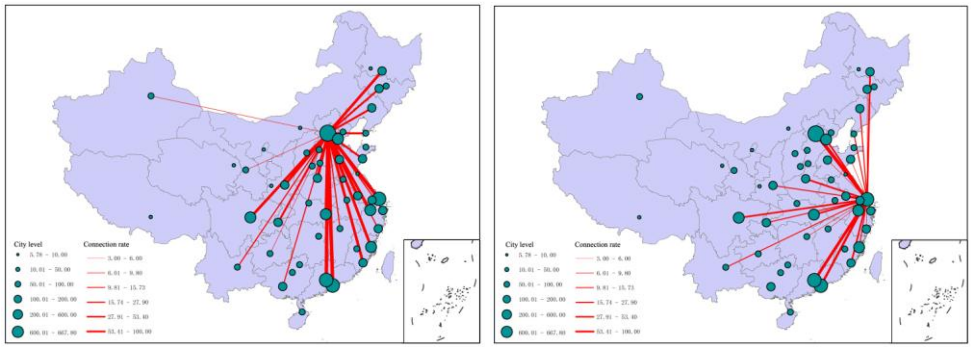
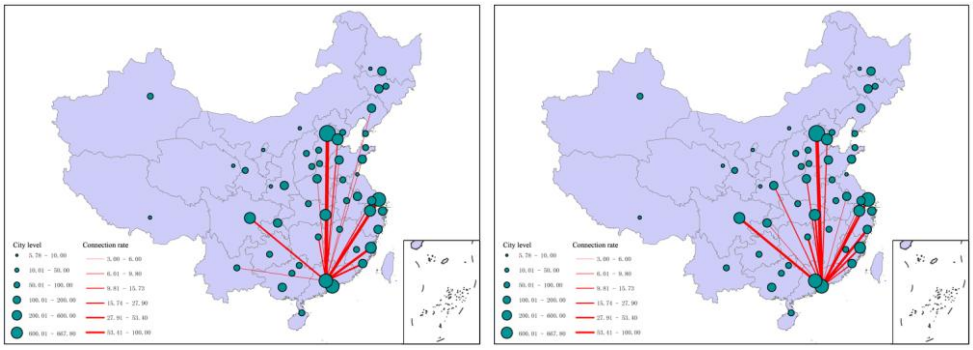
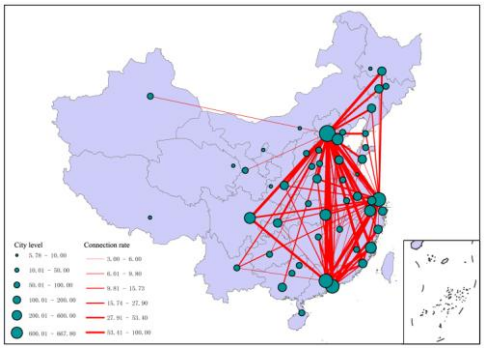
Shanghai, Guangzhou, Shenzhen are significant and they cannot by measured in the same level. In the national level, Beijing has the strongest network connection directivity and involves the most widely (Figure 9). Beijing's network contacts nearly cover the whole country, including 33 connections with other cities and accounting for 29.46 % of the total number. The cumulative network connectivity reaches 645.43, accounting for 75.66 %. It is not difficult to see from the figures that the urban network systems constructed between the four cities of Beijing, Shanghai, Guangzhou, Shenzhen and other cities are basically consistent with the national urban network system, which further reflects the dominance of the four cities in the network.



The network connection between Beijing and other cities (left). The network connection between Shanghai and other cities (right).



The network connection between Guangzhou and other cities (left). The network connection between Shenzhen and other cities (right).



The network connection between Beijing, Shanghai, Guangzhou, Shenzhen and Shenzhen to other cities

Fig.9: The network connection between Beijing, shanghai, Guangzhou and Shenzhen to other cities

5 CONCLUSIONS AND DISCUSSIONS

Information technology has an increasing influence on the development and changes of China's urban network system. From the perspective of social space, with the help of the social relation network reflected in micro-blog friends, this paper studies the patterns and characteristics of urban network system in the social network space. This is a new attempt of the urban network research under the influence of globalization and informatization. The result analysis also proves the effectiveness of the relations between micro-blog users in the study of urban network system.

Based on an empirical analysis of Sina Micro-blog, from the perspective of micro-blog social space, the paper finds that significant hierarchical relationship and level distinction exist in China's urban network. A city's network connectivity is positively correlated with its comprehensive strength and hierarchy, which means that, the higher urban hierarchy is, the higher its network connectivity will also be. The city's network connectivity shows a downward trend with the decreasing of its hierarchy. It is worth noting that, the social network space itself has no center and level, but the social relations of its participants-human beings, reflect the geospatial characteristics of the socio-economic and cultural ties. This result has a great similarity with the urban network system pattern of the geographic entity space. But it does not mean that, the urban network in the social network space is a simple projection of the geospatial urban network. This paper finds an inconsistency exists in the hierarchies of cities like Chengdu, Fuzhou and Xiamen in the urban network system based on micro-blog space and in actual entity urban system, suggesting that the spatial expansion of micro-blog network is not in full compliance with the existing based geospatial.

Based on the city's network level and network contact intensity, the research results show significant spatial differences between the three major regions of Eastern China, Central China and Western China, but the difference between Eastern China and Midwest China is more significant. Hierarchical agglomeration exists in China's urban network system, the specific performance of which is the spatial pattern of "Three Majors and Four Smalls". They are the Beijing-Tianjin-Hebei region (Beijing), the Pearl River Delta (Guangzhou, Shenzhen), the Yangtze River Delta (Shanghai, Hangzhou, Nanjing); Chengdu-Chongqing region (Chengdu, Chongqing), Hercynian region (Fuzhou, Xiamen), Wuhan (central) region (Wuhan, Changsha), Northeast China (Shenyang, Harbin, Changchun). This further verifies the domestic scholars' research on China's urban network system. It can be said that the emergence of micro-blog network space promotes the further agglomeration of the original geospatial urban network system. Its main performance is to accelerate the development of the densely urbanized areas formed by surrounding the cities with high hierarchy. This also shows that, the economic factor and the original urban structure still play their roles in shaping the urban network pattern. However, when gathering together, as an interactive network platform, micro-blog social space still strengthens the horizontal contacts between cities. The roles of the hierarchy of some cities are weakened a bit, especially in the regional and local levels. For example, the emergence of the Hercynian region and the Northeast region as regional network space, not only shows the equilibrium of network information diffusion, but also reflects the local characteristics in the social network space like micro-blog.

Of course, as a newly emerging network community, micro-blog is still in its infancy. Its influence on the geographic entity space remains to be verified. But undoubtedly, the spatial "flow" and "viscosity" brought by this powerful social dynamics will have a positive impact on the reconstruction and networking of national and regional urban systems. For the mechanisms behind it, further studies should still be conducted.

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