Research Paper

Space of flow including capital and information shape the megacity groups：

based on the example of Chengdu-Chongqing city groups in China

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Abstract

With globalization,space of flow ,such as capital, information and talent are moving around the world, which combine separated cities into influential urban groups. This research takes Chengdu-Chongqing urban agglomeration in China as an example, whose GDP exceeded 900 billion dollars in 2018.From this example ,we are concerned about its formation process and future planning. As for theory, this study utilizes Castel's theory of Network Society, which holds that "space of flow", such as, capital and information create "space of place" (cities) under globalization. Meanwhile, the key point to urban development is the information and capital. The key point to Urban planning is the attraction of external information(including talent and news) and capital. As for the method, focusing on the information and capital, this paper build the analyzing network model among 27 cities of Chengdu-Chongqing urban groups . For the information model,the intensity of information flow among cities is simulated and measured by using Baidu Index big data, in order to reflect the information attractiveness. We can find the the character of this city group network and space organization of the city groups under the view of "space of flow.As for the results, firstly,it is found that the flow factors of capital and information are positively correlated with the level of economic development, which means that the cities with high GDP ,such as Chengdu and Chongqing, have a strong flow of capital and information. Secondly, the status of cities in urban groups are determined by the value section of their enterprises. For example, Chengdu and Chongqing at the highest level, mainly hold companies with high economic value such as finance, trade and law firms, while sub-level areas share companies with slightly lower value such as manufacturing, medicine and so on. The higher the value of the company occupied by the city, the more power of the city. If the city owns multinational corporations, it can influence the world by global capital. Thirdly, cities are likely to form group development, because capital and information have agglomeration effect. As long as capital and information can flow to the region, this city can participate in the operation of urban groups. Finally, for future planning methods, under the influence of globalization, capital and information will flow more frequently, and cities will develop in groups. The core of planning is to highlight the characteristics and advantages of the city to attract the space of flow such as new companies and talents, so as to enhance its own competitiveness for better development.

Keywords

Space of flow,Chengdu-Chongqing urban agglomeration,information model

1. Theoretical research

1.1. Space of flow

With the development of economic globalization, cities have formed economic activities that combine geographically highly diffusive and functionally deeply integrated activities (P. Dicken, 2011), and form collaborative and complementary relationships through industrial chains, thus forming interrelated production networks and urban networks. The networked urban system is the advanced form of urban agglomeration development. (J. Friedmann, 1986). In 1996, M. Castelles (1996) put forward the theory of "social network" to explain the essence of urban network. He believed that cities, as "space of place", are hubs or nodes of global urban network, while "space of flow" such as capital flow, information flow and people flow, is the "space of flow". It has created a network of links between cities around the world. In the empirical aspect, there are three main research perspectives: infrastructure research, enterprise organization research, virtual network research. Infrastructure research is mainly based on Derudder (2008), Burns (2008) and other scholars through highways, railways, aviation and other carriers to study the flow of people and goods between cities.For enterprise links, Professor Peter Taylor created Locking network method,which is used to measure global urban links and is represented by GaWC's chain network model. For the researches of information flow network ,are represented by virtual network (Krings, et al. 2009; Zhenfeng, et al. 2016), especially using the data from social media and microblog .

1.2. Urban network under the perspective of information flow

The essence of urban network is the relationship between cities reflected by the factors of folw.,and information is an important supporting condition in the form of urban network (Mingfeng, Gaofeng, etc.2007). Because information flow is faster and more dynamic than other flow elements which need "actual carrier" such as enterprise organization and infrastructure.Furthermore it can better reflect the potential changes and the latest developing demand of urban network. At the same time, the Internet itself does not have a strict hierarchy of urban information exchange, so it reflects the characteristics of urban network more objectively to a certain extent, and complements other urban network studies with "actual" carriers, providing new perspectives and opportunities for the development of cities around the world.

Scholars have done a lot of research on this: Mitehelson(2002) and others use information flow such as telephone to describe the links between metropolitan areas; Zhenfeng (2012) and others, taking Sina Weibo as an example, have explored the characteristics of Chinese urban network based on cybersocial space. Xiong Lifang (2014) and Cao Ziwei (2016) used Baidu Index to interpret the the city hierarchy of Yangtze River Delta city network.

1.3. Urban Space in network form

With the rapid transmission of information and other flow elements, the relationship between cities is gradually weakened by the influence of proximity. Traditional research on urban regional spatial organization is based on the principle of spatial proximity, following the logic of "core, side and edge" spatial organization and the traditional paradigm of "central place" theory. However, professor Castel's "space of flow" gave birth to a new form of spatial organization - Urban network, which refers to the networking urban system. The shorter distance between cities will not reflect the strong connection .The importance of the distance between cities tends to weaken, and the urban system has evolved into a multi-

center, complex network and flat open system (Tang Zilai, 2010). The spatial study of urban agglomeration has also turned to how to quantitatively calculate and visualize the information flow, transportation flow, enterprise connection flow and the urban system represented by them. The status of a city is also determined by its proportion in various "flow elements" and the frequency of its connections (Xiong Lifang, Zhenfeng, etc.2013). Then under the network city organization, how to layout the urban regional space and how to attract the “space of flow have become important factors for the future development of the city.

2. Rearch subject and methods

2.1. Chengdu-Chongqing city groups

The area of Chengdu-Chongqing urban agglomeration was determined by the <Chengdu-Chongqing Urban Agglomeration Development Plan>in 2016 from central government (Fig. 1). The total area is 185,000 square kilometers,including 27 districts,such as Yuzhong, Wanzhou, Qianjiang, Fuling, and parts of Kaixian and Yunyang, as Chengdu and Ziyang in Sichuan Province. Gong, Luzhou, Deyang, Mianyang (except Beichuan County and Pingwu County), Suining, Neijiang, Leshan, Nanchong, Meishan, Yibin, Guangan, Dazhou (except Wanyuan City), Ya'an (except Tianquan County, Baoxing County), Ziyang and other 15 cities .It has a total area of 185,000 square kilometers, with a permanent resident population of 900,940 in 2014 and GDP of 376 trillion yuan, accounting for 1.92%, 6.65% and 5.49% of the country respectively.

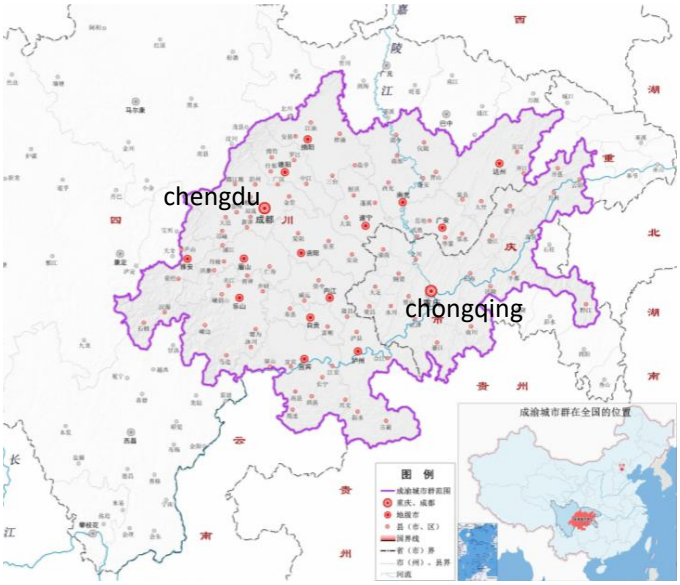


Figure 1 Research area

2.2. Data——Baidu Index

Baidu Index is based on the search volume of one city's residents for another city. According to the report released in October 2017 by StatCounter Global Stats, the proportion of Baidu search engine usage in China is as high as 82.99%, accounting the largest part. Therefore, Baidu Index can reflect the degree of concern of urban people to another city (which can be

called "attention"), and simulate the information flow between cities. At the same time, based on the current research of "Baidu Index" to simulate the information flow between cities, it is confirmed that Baidu Index reflects the economic and social links among cities to a certain extent, and reflects the comprehensive strength of cities (Xiong Lifang, etc., 2013). In order to study the development of Chengdu-Chongqing urban agglomeration before and after the publication of "Chengdu-Chongqing Urban Agglomeration Plan" in 16 years, and considering the availability of data.This paper takes the average of user search index in 2015and2018.

2.3. Research method

Referring to previous scholars'methods (Xiong Lifang, et al., 2013), the algorithm is as follows: The information flow intensity between two cities is calculated by the **Rab** formula of network attention product between cities A and B.

$$Rab = Ab * Ba$$

(Among them, **A**. For the user attention of City A in City B, **B**. For city B in city A user attention.

If the total amount of information flow in city A is N, it is the sum of information flow in city A and other cities in core area.

$$Na = Rab + Rac + ... + Raz$$

The relative attention (relative information flow) of a city is expressed by **P**, which is the relative position of the total information flow of the city in the core area in the region. Calculating formula:

$$P = Nk/Nh$$

(Among them, **Nk** is the total amount of information flow of a city, and **Nh** has the corresponding value of the largest amount of information flow of a city in the study area.)

3. The network character of Chengdu-Chongqing city group under the view of information flow

3.1. The variation character with year

From 2015 to 2018, the total amount of information flow of Chengdu-Chongqing urban group increased, and the increase was larger. The total amount of information flow in each city has risen from 7151724 to 9648844, and the average amount of information flow in each city has risen from 446982 to 603052, an average increase of 35%. At the same time, the annual variation of the total information flow in Chengdu-Chongqing urban agglomeration is measured by the variation coefficient C (the relative amount of standard deviation relative to the average size). The C value in 2015 is 1.223, which is less than 1.344 in 2018. It can be seen that the information links between cities are becoming closer and closer, and the stability of urban network based on information flow is becoming stronger and stronger (Figure 2).

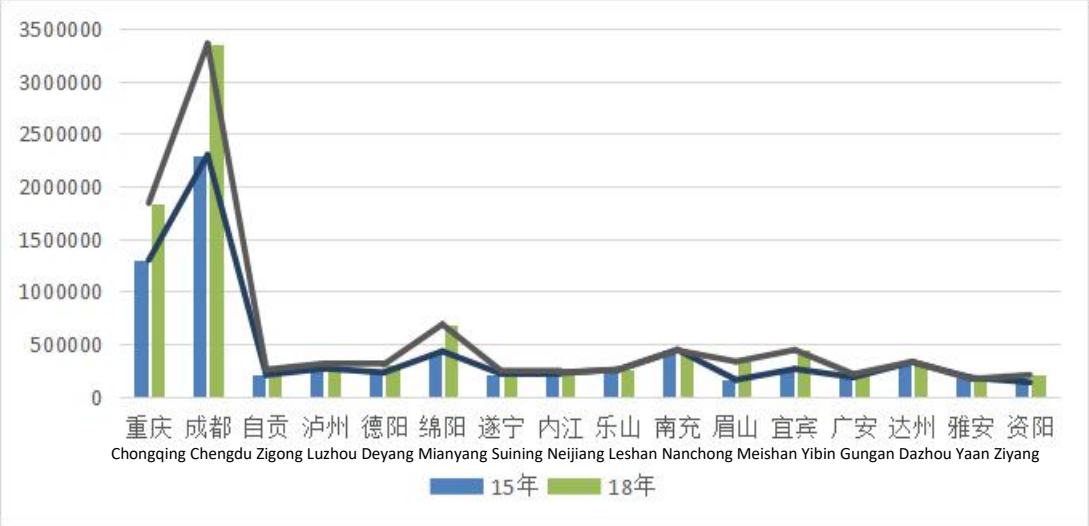


Figure 2 Change of Information Total Amount in Chengdu-Chongqing Urban group

3.2. Hierarchical character

The urban network levels of Chengdu-Chongqing urban agglomeration in 2015 and 2018 were obtained by clustering method with spss method. (Table 1).

Table 1 Information Network Hierarchy

Level	city (2015)	city (2018) (the change of the ranking)
1st	成都 chengdu	成都 chengdu
2st	重庆 chongqing	重庆 chongqing
3st	南充 nanchong、绵阳 mianyang、达州 dazhou、泸州 luzhou、宜宾 yibin、乐山 leshan、德阳 de yang、内江 neijiang	绵阳 mianyang (+1) 、宜宾 yibin (+3) 、南充 nanchong (−2) 、眉山 me shan (+9) 、达州 dazhou (−2) 、泸州 luzhou (−2) 、德阳 deyang
4st	遂宁 suining、自贡 zigong、广安 guangan、雅安 yaan	自贡 zigong (+2)
5st	眉山 meishang、资阳 ziyang	乐山 leshan (−3) 、遂宁 suining (−1)、内江 neijiang(−3)、广安 guangan(−1)、资阳 ziyang(+1)、雅安 yaan(−2)

(1) The urban network presents the development trend of "double core". Chengdu and Chongqing occupy the core position of the network, with the strongest directivity of network information links, exceeding one million in both cities, and their linformation amount are over 50% in the total network. Further, they are still in the rising stage,from 50% (15 years) to 53.8% (18 years). Among them, Chengdu has a more prominent position, accounting for 34.7%, which is 1.82 times that of Chongqing.

(2) The network presents a distinct hierarchical development trend. The first three cities developed well, while the latter two cities lagged behind. In 2015, the network level of Chengdu-Chongqing urban agglomeration was "1+1+8+4+1", and in 2018, it was "1+1+7+1+6" (fig. 3). It shows that the information of the first three cities develops rapidly

(information accounts for more than 80%) and the gap between the first three cities and the second one is increasing, which leads to the increase of the number of the last series cities.

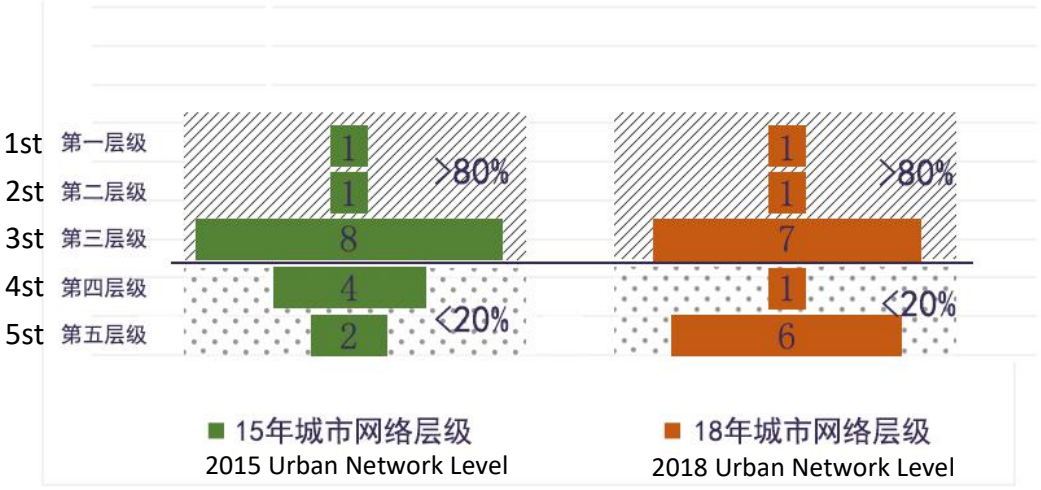


Figure 3 Image example_ISOCARP logo

(3) In the network, Yibin and Meishan have achieved good development, of which Yibin has risen by 3 places, with the increase of information amount reaching 118%, and Meishan has risen by 9 places more rapidly, with the increase reaching 207%. The status of Leshan and Neijiang has declined considerably, falling three places respectively, and from the third level to the last level.

3.3. The variation character with year

In order to further compare the structural characteristics of Chengdu-Chongqing urban agglomeration network, the influence before and after the establishment of Chengdu-Chongqing urban agglomeration is analyzed. From the perspective of space-time evolution, urban network maps are drawn based on the information flow intensity matrices of Chengdu-Chongqing urban agglomeration in 2015 and 2018 respectively (fig. 4), and a backbone network with information flow intensity more than 50,000 between cities is selected (fig. 5). At the same time, considering the status of Chengdu-Chongqing urban agglomeration network in the country, and also based on the intensity of information flow, the structure of Chengdu-Chongqing urban agglomeration in the national layout is drawn (fig. 6).

(1) From an external perspective, Chongqing-Chengdu has a prominent core position and upgraded urban links. As the dual core of Chengdu-Chongqing urban agglomeration, Chongqing and Chengdu have frequent exchanges of information elements between cities, which has leaped to become the second strength connection similar to Beijing-Tianjin and Guangzhou-Shenzhen . At the same time, the status of the two places as information nodes in the West has been strengthened, and their links with the Yangtze River Delta, the Pearl River Delta, Tianjin, Beijing and Hebei have been further strengthened. The status of Chengdu (5 links) is better than Chongqing (3 links).

Figure 4 Structural Map of National Backbone Information Network

(2) From an internal perspective. The overall network structure of Chengdu-Chongqing city has been continuously optimized and gradually matured. The information links between cities in 18 years were stronger than those in 15 years. The network shows the frequent interaction structure between Chengdu and Chongqing, and the increasing interaction between Chengdu and Chongqing as the core city and other cities.

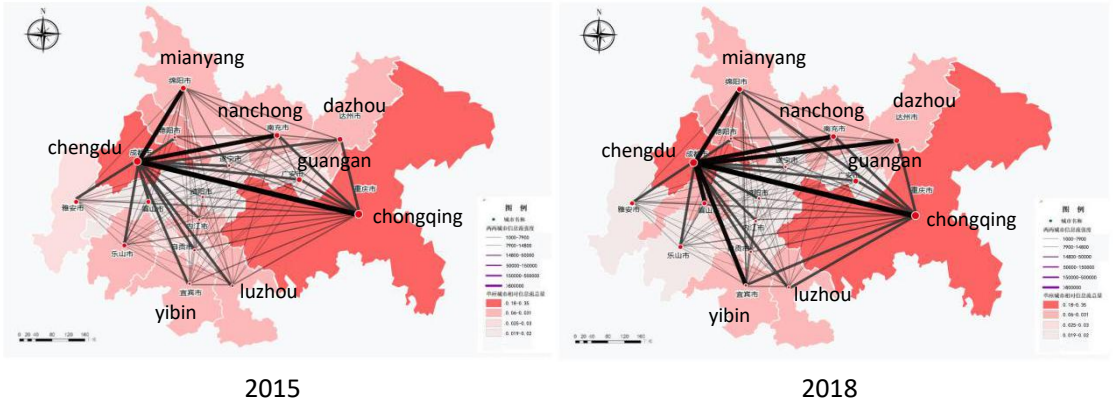


Figure 5 Chengdu-Chongqing Information Network Structure Map

(3) As far as the backbone network is concerned, the secondary nodes have been developed and the whole structure is diamond-shaped. Chongqing has broken through the administrative boundary and expanded its influence in Sichuan. Reflected in Chongqing and Sichuan provincial cities, the amount of information has increased, and interaction is more frequent. Chongqing's main links include Dazhou, Nanchong and Guang'an, with the addition of Yibin, Luzhou and Mianyang.

The network has also expanded from a single northern triangle connection to a diamond-shaped network structure with Mianyang, Nanchong and Dazhou as the core in the South and Yibin and Luzhou as the core in the north. Correspondingly, in the planning of Chengdu-Chongqing Urban Agglomeration, Yibin and Luzhou in the south are regarded as the core cities of the region, and the regional transportation links are strengthened. Therefore, the southern cities are closely connected with Chongqing's information network.

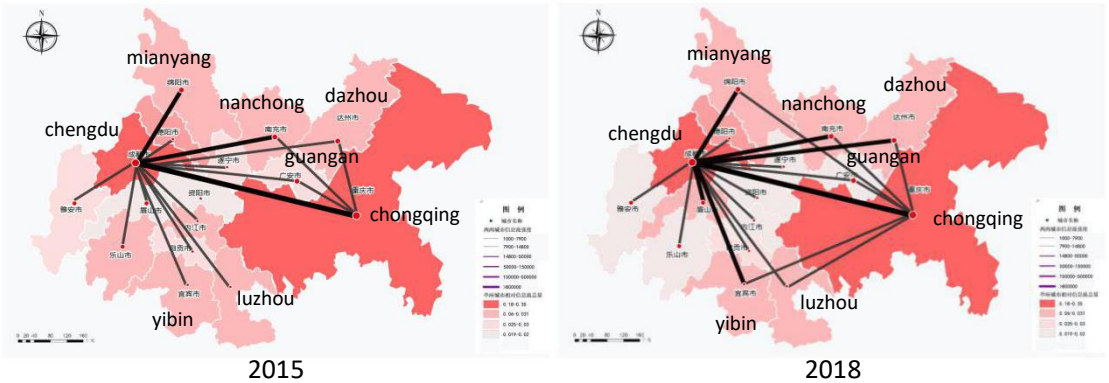


Figure 6 Structural Chart of Chengdu-Chongqing Backbone Information Network

4. Re-recognition of Chengdu-Chongqing Urban Space from the Perspective of Information Flow

4.1. Development of urban groups relying on gateway cities

In 2016, the State Council's approval document for the development plan of Chengdu-Chongqing urban agglomeration (State Letter No. 68, 2016) clearly pointed out that "by 2030, the radiation-driven role of Chongqing, Chengdu and other national central cities will be significantly enhanced, and the integrated development of urban agglomeration will be fully realized." From the perspective of information flow, it is found that Chongqing and Chengdu, as "information portals" in the west, play a two-way role in connecting the national network and radiating the urban agglomeration inward. Externally, the second and third largest cities in Chongqing and Chengdu are Beijing and Shanghai, and the top ten cities all come from the outside of the urban agglomeration (Table 3).

Table 3 Priority of Chongqing-Chengdu Urban Linkage in 2018

city	Connectivity	Relative correlation value	city	Connectivity	Relative correlation value
chongqing	1. chengdu	74. 35	chengdu	1. chongqing	74. 35
	2. beijing	41. 36		2. beijing	67. 38
	3. shanghai	37. 01		3. shanghai	56. 26
	4. shenzheng	24. 46		4. xian	55. 32
	5. xian	24. 33		5. shenzheng	36. 81
	6. guangzhou	21. 39		6. hangzhou	29. 81
	7. hangzhou	19. 33		7. guangzhou	27. 38
	8. suzhou	16. 37		8. wuhan	20. 95
	9. wuhan	15. 63		9. nanjing	20. 49
	10. kunming	8. 52		10. suzhou	17. 86

Internal aspect: From the analysis of the relationship network within the urban agglomeration, it is shown that the first and second first cities of Chengdu-Chongqing urban agglomeration are Chengdu and Chongqing, and are the dominant flow direction of the city (Figure 7 takes Luzhou and Guang'an as examples). From the analysis of both external and internal sectors, it can be concluded that Chongqing and Chengdu play a portal role in Chengdu-Chongqing urban agglomeration, and they are important media inside and outside the urban agglomeration and information hub inside (Figure 8).

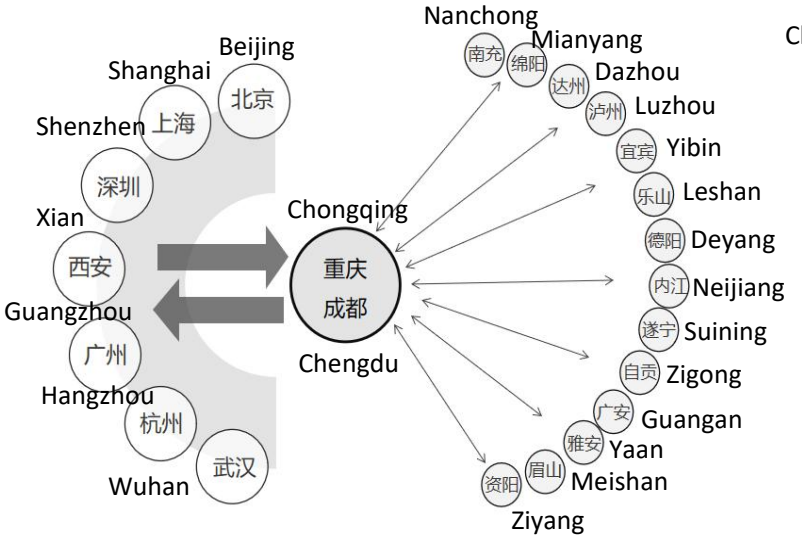


Figure 7 Chongqing and Chengdu as two sectors of information portal

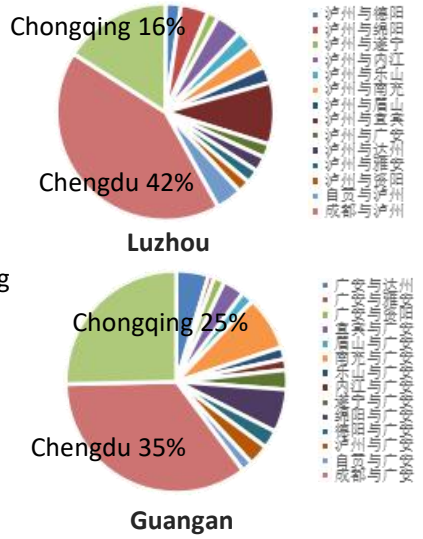


Figure 8 Analysis of the First City in Urban Agglomeration

4.2. Spatial Economic Basis Behind Information Flow

In today's highly informationized global economy, invisible information network has a great impact on urban areas, but information flow will not exist in isolation. The development of information network is often influenced by the level of urban development. It will gather and disperse with capital, labor force, and other factors of production in the geographic space (Hall, 2009). Therefore, the economic development foundation and labor force of the city itself are the important influencing factors of the development of Chengdu-Chongqing network pattern.

This paper chooses 16 cities of Chengdu-Chongqing urban agglomeration in 2018 to analyze the correlation between the Gross Regional product, the number of permanent residents and the total information flow of these cities in 18 years. The results show that the correlation is significant at 0.01, and the correlation coefficient is greater than 0.7 (Figure 9), which means that the total urban information has a relationship with the total regional urban value and the permanent population. Significant and strong correlation. At the same time, by means of SPSS regression analysis, it is found that there is a positive correlation between the amount of information and GDP, permanent population respectively (Figure 9).

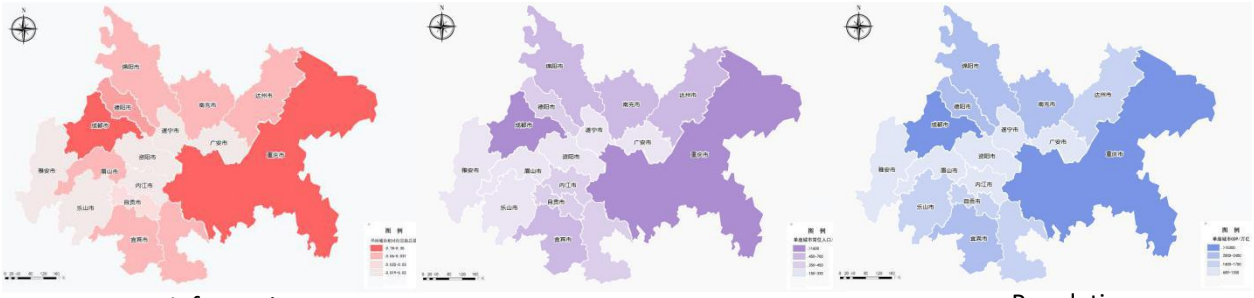
		info	peo	gdp
info	皮尔逊相关性	1	.751**	.868**
	显著性（双尾）		.002	.000
	平方和与叉积	1.008E+13	6456558888	5.925E+10
	协方差	7.752E+11	496658376.0	4557996655
	个案数	14	14	14
peo	皮尔逊相关性	.751**	1	.973**
	显著性（双尾）	.002		.000
	平方和与叉积	6456558888	7332189.724	56694789.27
	协方差	496658376.0	564014.594	4361137.636
	个案数	14	14	14
gdp	皮尔逊相关性	.868**	.973**	1
	显著性（双尾）	.000	.000	
	平方和与叉积	5.925E+10	56694789.27	462920281.6
	协方差	4557996655	4361137.636	35609252.43
	个案数	14	14	14

**. 在 0.01 级别（双尾），相关性显著。

		GDP /万元	常住人口 /万人
城市信息总量	模型 R 方	0. 753	0. 564
	显著性	0. 001	0. 002
	t	6. 024	3. 941
	未标准系数	128	880. 577
	标准系数	0. 868	0. 751

Figure 9 Analysis Table of Relevance between Information Quantity and GDP and Population

To sum up, in Chengdu-Chongqing urban agglomeration, the amount of urban information is highly related to the regional gross domestic product and the permanent population, and will grow with the growth of the gross domestic product and the permanent population. The information network between cities is not only the reflection of people's attention to the city, but also the economic and demographic basis of the city as an important support. On the one hand, only when a city has a strong economic foundation and talent gathering, can it produce more information exchange. On the other hand, cities can stimulate more elements of information flow, which also indicates opportunities for urban economic and labor growth. In the 18-year Chengdu-Chongqing urban agglomeration, we can see that economic development, population density and information activity have a high degree of overlap in space (Figure 10). Information flow network also represents the economic and demographic basis behind it to a certain extent. Therefore, paying attention to the change of information flow and becoming the core of information flow can often be a city. Bring good opportunities for development.



Information GDP Population

Figure 10 Information, GDP and Population Distribution of Chengdu-Chongqing Urban group

4.3. Gradually break through the traditional "core-edge" level of network development

Different from the spatial organization logic based on "central place" theory, which determines the location of center or periphery, the degree of connection between urban node and other nodes in urban network determines the location of the urban node at the core or periphery of the network (Doreen Massey, 2010). Using NetDraw to further abstractly analyze the information network structure of Chengdu-Chongqing urban agglomeration, we can clearly see that the information flow links between secondary cities

are constantly strengthened, and the overall trend of network urban system is presented (Fig. 11, 12).

In 2015, Chengdu and Chongqing are in the absolute core leading position, presenting obvious "core-edge" secondary structure, and Chengdu has a slightly stronger position. Secondly, the status of nodes in Nanchong, Yibin, Mianyang and Luzhou has been improved, which can also produce stronger networks in other areas, such as Yibin and Luzhou, Mianyang and Suining, Mianyang and Dazhou, which change the previous situation of radiation from Chengdu and Chongqing alone and show the trend of flattening network characteristics. From the evolution of the network, we can see that the free flow of information between cities is not bound by administrative and regional constraints. Not by the traditional administrative hierarchy of "municipalities directly under the Central Government, provincial, prefectural and county-level cities", but homogenization for all cities. The development of urban agglomeration also has the relative edge of the city to enhance the status of contact, strengthen information interaction with other cities, so that the network from a single core to network development.

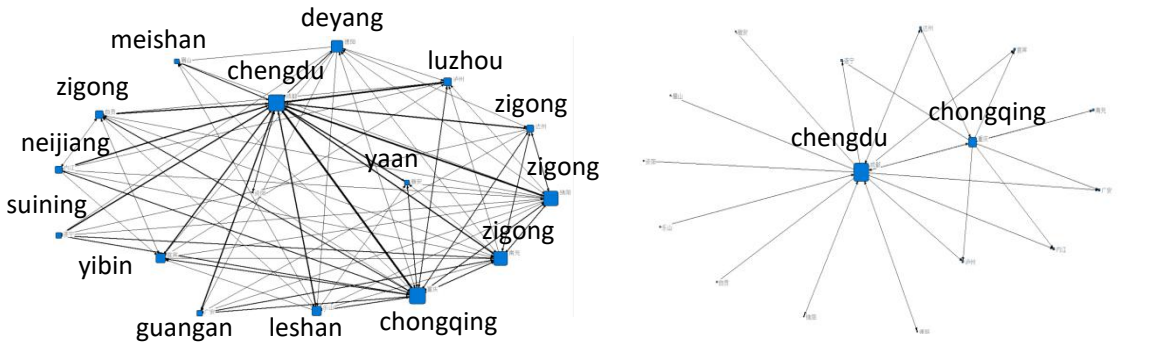


Figure 11 The obvious "core-edge" secondary structure in2015

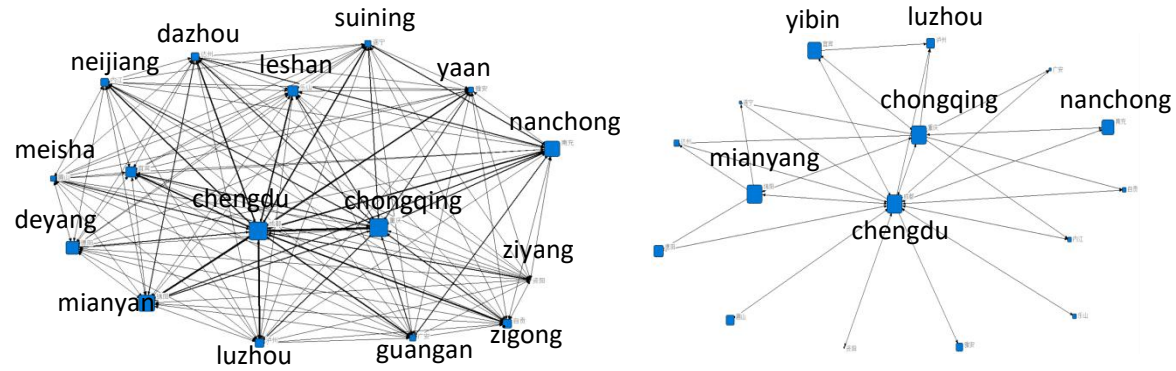


Figure 12 The obvious trend of network structure in 2018

5. Conclusions

Spatial flow promotes the reorganization of the spatial structure of urban areas (Ravetz, 2016). The focus of urban agglomeration has shifted from the traditional urban material structure and urban form itself to the social network beyond spatial perception (Davoudi,

2008), and from the "flow element" to consider the "place space" carrying the flow element. This research is from the perspective of information flow elements, using "flow data" to construct urban network relevance. On this basis, the author reflects on the "Chengdu-Chongqing Urban Agglomeration Planning" put forward in 16 years, hoping to provide more scientific technical support and a new perspective for the future Chengdu-Chongqing Urban Agglomeration Planning:

(1) Chengdu-Chongqing Urban Agglomeration refers to the full play of the dual-core driving function of Chongqing and Chengdu, giving play to its advantages of communicating East and West, and speeding up the development of the western region, which is fully based on. Chongqing and Chengdu are "information portals" in the western region, and they are important external media and internal information hub of urban agglomeration. The relationship between Chongqing and Chengdu has been growing steadily, and has risen to the second level of information connection intensity in the whole country, similar to that between Beijing and Tianjin, Guangzhou and Shenzhen. The strengthening of the core city links has brought a better information base for Chengdu-Chongqing urban agglomeration, and is also conducive to enhancing the intensity of information links within the urban agglomeration, which is conducive to the development of other node cities in the region.
(2) Planning the connection channel between urban entity and virtual entity will become an additional part of the new planning. The elements of information flow do not exist alone, but are related to the mixed elements of urban economic flow and human resource flow. Therefore, on the one hand, cities should pay attention to marketing and promotion effects in their development. For example, Chengdu-Chongqing urban agglomeration has been approved as a national-level central city group, and the overall urban information attention has been greatly enhanced. For the city itself, the enhanced information attraction contains the potential of economic and human attraction; on the other hand, new urban development. It is to enhance the information connection with other nodes and promote information exchange. In addition to network attention, convenient links such as physical transportation and enterprise communication will also be conducive to the dissemination of information and promote the development of the city.

(2) Networked urban agglomerations have open boundaries and interactive breakthroughs in administrative hierarchies. Therefore, the new planning encourages cross-regional cooperation, builds a shared and efficient infrastructure network, and allows flow elements to flow freely. From the perspective of network, the energy level of a city depends more on its network capability than on the population size and administrative level that most traditional planning considers. We find that the open and interactive relationship between the networked urban agglomerations, such as the rapid increase of the links between Chongqing and Sichuan cities, especially in Neijiang, Luzhou and Nanchong. At the same time, the urban network has broken the original single radiation structure of Chongqing and Chengdu, and the secondary radiation nodes such as Nanchong, Yibin, Mianyang and Luzhou have appeared, especially the upgrading of Yibin and Luzhou, which has expanded the whole network from the original "triangle" to the "diamond" type, and the development of secondary nodes is no longer affected. Because of the hierarchical system, future planning cities should focus on building their own links with foreign cities, and not restrict themselves by traditional planning languages such as administrative boundaries, metropolitan boundaries and axle belts, so as to carry out multi-regional cooperation and free circulation of flow elements.

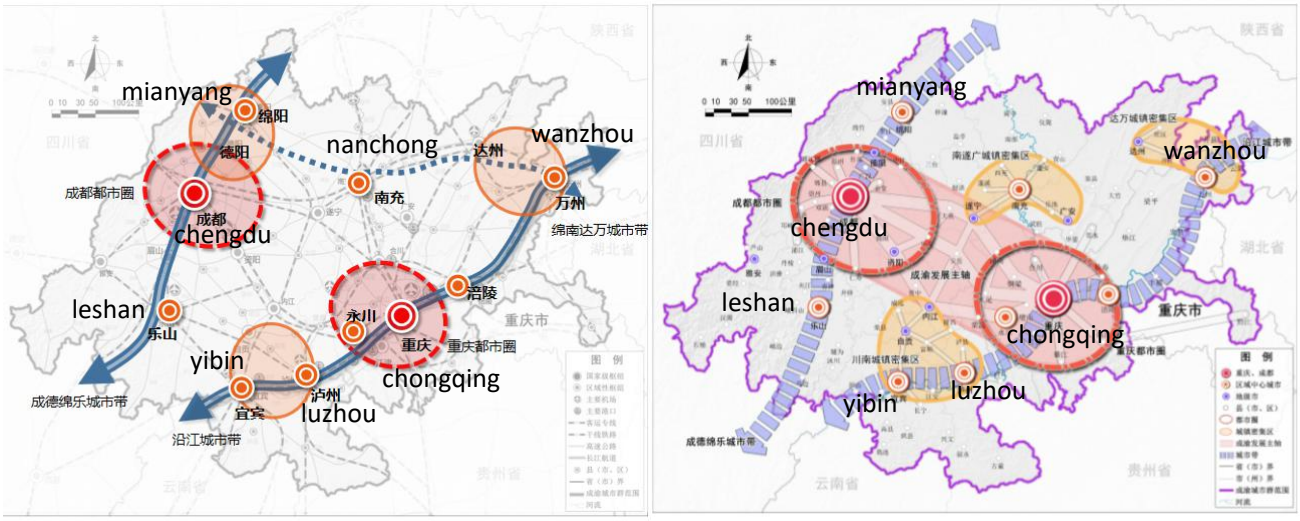


Figure 6 Image example_ISOCARP logo

6. References

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