RESEARCH ON THE REGIONAL SPATIAL STRUCTURE AND CHARACTERISTICS FROM THE SPACE OF FLOWS PERSPECTIVE BASED ON BIG DATA: TAKE GUIZHOU PROVINCE IN CHINA AS AN EXAMPLE (1154)

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Abstract. From the perspective of Space of Flows, taking Take Guizhou Province in China as an example, this paper explores the regional city network from population flow connection (physical connection) and economic flow connection (non-physical connection) by mainly using mobile signaling migration data and enterprise big data. The following conclusions can be drawn: 1) The overall pattern of the city network in Guizhou Province presents a multi-level Core-Periphery structure. 2)Top two cities in Guizhou Province have formed a strong economic link, but the actual population flow needs to be strengthened. 3)The network hinterland of Guiyang covers the whole province, but the network hinterland of Zunyi is mainly concentrated in its city and has not had a radiation effect on other areas of the whole province.

Keywords: Space of Flows, City Network, Guizhou Province, Population Flow, Economic Flow.

1. Introduction

In the 1990s, Manuel Castells(1996) proposed the theory of Space of Flows, believing that various types of flows have built our society and created a global city network system. Cities cannot exist independently in the network, and are increasingly interfered with by flow factors. He argues that "space of flows" rather than "space of places" has created the global urban system, and emphasizes the value of cities as nodes in shaping the entire network system after "de-spatialization", and that information-based cities are a symbol of future livability.This theory has changed the research perspective of regional city research, and it has gradually shifted from the static space inside the city to the dynamic connection outside the city. Based on the types of the composition of flow space elements, existing studies can be broadly classified into four categories: studies of enterprise networks based on the composition of enterprise investment or service relationships, studies of networks focusing on individual travel behavior, studies of networks based on infrastructures such as logistics or transportation, and network measurement based on the perspective of social activities such as information flow.

The remainder of this paper is organizedas follows.Thenext sectionintroduces the study area, data, and research methods. The third section critically evaluates the spatial structure and connections of Guizhou province through network analysis and spatial analysis via ArcGIS, and Navicat, using mobile signaling migration data and enterprise big data, after which we conclude the main findings, and provide a viewpoint for planners and policymakers concerning the overall spatial layout of Guizhou province.

2. Research method

2.1. The study area

Guizhou province, which is powerful support for China's western development strategy, is selected as the primary research object. It is locatedinthe southwest of China and consists of five municipalities: Guiyang, Zunyi, Tongren, Bijie, Liupanshui, and three Autonomous Prefectures, Q ian'nan,Qiandongnanand Qianxi'nan.It covers an area of 176167 km2 with a total population of about 38.5 million. The real GDP in 2021 is 1958.64 billion, accounting for 2% of China's.

Figure 1.The location of Guizhou province

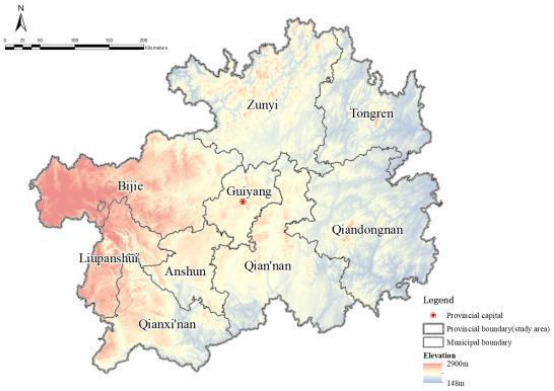


Figure 2.The layout of Guizhou province

2.2. Data

From the perspective of Space of Flows, this paper exploresthe regional city network from population flow connection (physical connection) and economic flow connection (non-physical connection) by mainlyusing mobile signaling migration data and enterprise big data. The former data can well reflect the temporal and spatial law of crowd flow behavior, representing the links and dependence of society, business, and travel between cities. Thedatawas obtained from China Unicom in December

2019[1].Enterprises are the direct actors of economic links between cities(Taylor &Derudder, 2004). Theanalysis method based onenterprise big data is themainstream method representingeconomic links between cities(Derudder, 2004). Enterprise data was obtained from the database of Chinese industrial and commercial enterprises in December 2018.

2.3. Network analysis andmeasures of centrality

2.3.1 Citynetworkapproach based on"Headquarters-branch" corporatelink

Referringtothe "headquarters-branch" approach (Cheng Yao,Zhang Yishuai &Zhao Min,,2016; Zhang Yishuai&Zhao Min, 2018), we define Sij as the association of m enterprises *p* with headquarters in city i and branchesin city j, Sji as the association of n enterprises *q* with headquarters in city j and branches in city i, Tij as the association of all enterprises with headquarters in city i and branches in city j, Tji as the association of all enterprises with headquarters in city j and branches in city i, and Vij or Vji as the total value of association between two cities (called "network association degree"), theformula is:

$$Tij = \sum_{1}^{m} Sij = \sum_{p=1}^{m} kp$$

$$Tji = \sum_{1}^{n} Sji = \sum_{q=1}^{n} kq$$

$$Vij/Vji = Tij + Tji$$

Tij and Tji are directional, and the total inward correlation ("Inbounddegree") Ii and the total outward correlation ("Outbounddegree") Oi of a city node represent the ability of city i to take in external factors and control regional production factors in that city network, respectively. ") Oi represent city i's ability to take in external factors and control regional productionfactors in that city network,respectively, while the city i's aggregate total correlation ("Degree centrality") Ci expresses its "network position", the formula is:

$$Ii = \sum_{j=1}^{r} Tji$$

$$Oi = \sum_{j=1}^{r} Tij$$

[1] Considering the exclusion of the impact of the new crown epidemic on population movement, data were collected for the month before the new crown epidemic, i.e., December 2019.

2.3.2 City network approach basedon intercity travel

With the popularity of mobile communication in urban and rural areas, by virtue of its wide coverage, high holding rate and good dynamics, mobile phone signaling data provides new data support for regional and urban research. Cell phone signaling data is alarge sample with wide coverageand a high user holding rate, which can better reflect the spatial and temporal patterns of human behavior; cell phone signaling data is anonymous data with good security, without any personal attributeinformation and no personal privacy; cell phone signaling data is involuntary data, users passively provide information and cannot interfere with the survey results; cell phone signaling data has dynamic real-time and continuity, which can accurately reflect the results in It can accurately reflect the spatial location of cell phone users at different points of time in a continuous time period, which provides the possibility to quantitatively describe the flow trajectory of people in the region(Yao Kai &Niu Xinyi,2016). The dynamic mobility demand of the crowd comes from business connections, tourism connections, etc., which can objectively reflect the direct economic and social connection demand and dependency of the city from the side, thus providing a new perspective for the cognition of urban networksand spatial structure.

Measuring the intensityof pedestrian travel is similar to the calculation method of the enterprise-associatedurban network approach, i.e., the urban network linkage model aggregates and statistically analyzes the cell phone user flowtrajectory data across counties within the metropolitan area to obtain the linkage direction and linkage intensity between towns in the study area, characterizes the urban network linkage system, and then quantitatively evaluates the urban network linkage. POi is the amount of travel from city i tothe outside world. PIii the travel volume from other cities to cityi, and the sum of the two is the total population travel volume of city i. Theformula is:

$$PO_i = \sum_{j-1}^{r} T_{ij}$$

$$PI_i = \sum_{j-1|}^{r} T_{ji}$$

3. Analyses and results

3.1. Economic flow connection features

Based on the previous research method and the "headquarters-branch" data ofenterprises, the data are organized and calculated by using SQL statements to obtain the spatial structure of cities in Guizhou province. From the figure, it is obvious that Guiyang city has the highest centrality and shows the dominant role in the economic connection of enterprises in the province, followed by Zunyi, Bijie, Xinyi and Liupanshui.

At the district and county level, the top 20 districts and counties are shown in the table below. The first tier is Yunyan District (3596) and Nanming District (2103), with centrality greater than 2000; the second tier is Xinyi City, Guanshan Lake District, Honghuagang District and Huichuan District, withcentrality greater than 1000; the third tier is Zhongshan District, Huaxi District, Qixingguan District and Xixiu District, with centrality greater than 850. it can be found that the ranking 8 of the top 10 districts and counties are located in the two metropolitan areas, and the centrality of Yunyan District and Nanming District is far ahead of the rest of the districts and counties, and the out-degree is obviously greater than the in-degree, indicatingthat a large number of corporate headquarters in Guizhou Province are set up in these two districts. In addition, the center degrees of Xinyi City in Qianxinan Prefecture and Zhongshan District in Liupanshui City are 1232 and 921 respectively, and the out-degree is similar to the in-degree, which indicates that these two districts have a good level of economic development and have gathered a certain number of enterprises, and have similar ability to accept radiation and drive the surrounding area.

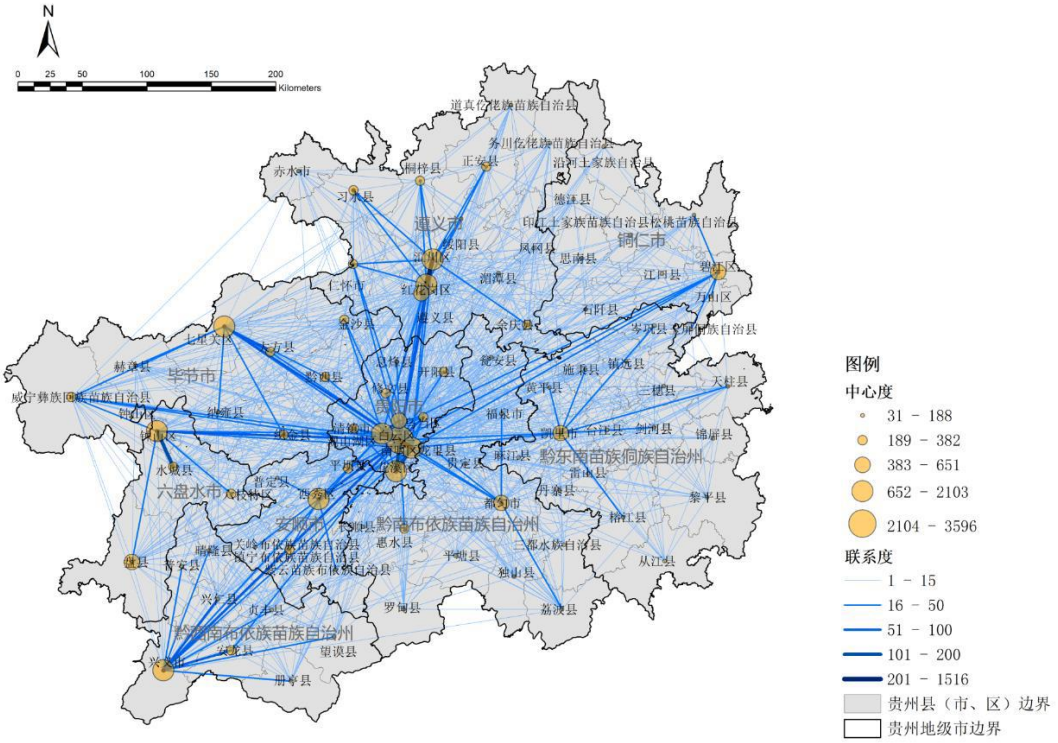


Figure 1. Spatial structure of cities at county level in Guizhou province (based on business linkages)

Table 1. City network centrality at district and county level in Guizhou province (based on enterprise linkages)

Number	County	City	Inbound degree	Outbound degree	Degree centrality
1	Yunyan	Guiyang	2398	1198	3596
2	Nanming	Guiyang	1339	764	2103
3	Xingyi	Qianxi'nan	639	593	1232
4	Guanshanhu	Guiyang	774	435	1209
5	Honghuagang	Zunyi	592	540	1132
6	Huichuan	Zunyi	576	479	1055
7	Zhongshan	Liupanshui	491	430	921
8	Huaxi	Guiyang	490	413	903
9	Qixingguan	Bijie	441	452	893
10	Xixiu	Anshun	468	420	888
11	Kaili	Qiandongnan	381	270	651
12	Pan county	Liupanshui	259	324	583
13	Duyun	Qian'nan	305	247	552
14	Zunyicounty	Zunyicity	228	299	527
15	Bijiang	Tongren	273	225	498
16	Baiyun	Guiyang	261	220	481
17	Xishui	Zunyi	156	226	382
18	Wudang	Guiyang	211	165	376
19	Zhijin	Bijie	147	209	356
20	Qingzhen	Guiyang	145	207	352

A separate analysis of the corporate ties in Guiyang City, from the branch ties headquartered inGuiyang City, reveals that the closest ties with Guiyang City are Qixingguan District in Bijie City, followed by Huichuan District and Honghuagang District in ZunyiCity, as well as Xixiu District in Anshun, Xinyi City in Qianxinan Prefecture, Qingzhen City in Guiyang City, Zhongshan District in Liupanshui, Kaili City in Qiandongnan Prefecture, Bijiang District in Tongren City, Qiannan Duyun City, most of

which are the seats of prefecture (city) governments inGuizhou Province. In addition, it can be foundfrom the headquarter organization links in Guiyang's municipal district that the core area of Gui'an New Area (Qingzhen City), Anshun City and Zunyi City's municipal district have certain headquarter-branch relationship for Guiyang, which also receives radiation and factor flow from the rest of the cities with more developed economy or higher degree of specialization. In the future planning, while pushing forward thefive-year action of "strong provincial capital", we should also pay attention to the differentiated and specialized development of the rest of the central cities in the prefecture, so that they can radiate and drive each other to form a modern economic development pattern with complementary advantages.

A separate analysis of the corporate tiesin Zunyi City, from the branch ties headquartered in Zunyi City jurisdiction can be found that the closest ties with Guiyang City jurisdiction is Xishui County of Zunyi City, followed by Tongzi County, Suiyang County, Renhuai City, Zheng'an County, Yuqing County, etc. The top 11 are all within the city limits of Zunyi, indicating that the radiation range of Zunyi City jurisdiction is basically restricted to the city.In addition, the stronger ties include Jinsha County, Qixingguan District, Bijie City and Yunyan District, Guiyang City. It can be found from the contact of the headquarter institutions branching out in Guiyang Municipal District that Zunyi City is widelyradiated by Guiyang Municipal District and has acloser contact with Guiyang Municipal District.

3.2. Population flow connection features

3.2.1 Based on all-purpose travel data

Based on the previous research method with the all-purpose travel data of Unicom cell phone signaling in December 2019, the data are organized and calculated using SQL statements and visualized and drawn based on GIS platform to obtain the spatial structure of cities in Guizhou province. From the figure, it is also obvious that Guiyang city district has the highest centrality, followed by Zunyi city, Anshun city, Bijie city Kaili city, Liupanshui city, and Xinyi city. Implemented to the district and county level, the top three ranked Yunyan District, Nanming District, Guanshan Lake District, are located in Guiyang City, followed by Zhongshan District, Qixingguan District, Huaxi District, Honghuagang District, Xixiu District, Huichuan District, Xinyi City, travel to the higher degree of the region is also the location of the local state (city) government. From the point of view of the degree of contact, Huichuan District travel to Honghuagang District has the highest volume of 400634, Honghuagang District travel to Huichuan District (393379) ranked second, followed by Nanming District -Yunyan District (300212), Yunyan District -Nanming District (299949), Yunyan District -Guanshan Lake District (180105) , Guanshan Lake District -Yunyan District (174452), Shuicheng District -

Zhongshan District (161390), Zhongshan District-Shuicheng District 160178, Honghuagang District-Baoxu District (153551), Baoxu District-Honghuagang District (151856), indicating that Zunyi City, Guiyang City and Liupanshui City are more closely linked in terms of pedestrian flow, and the amount of population travel within the district is higher.

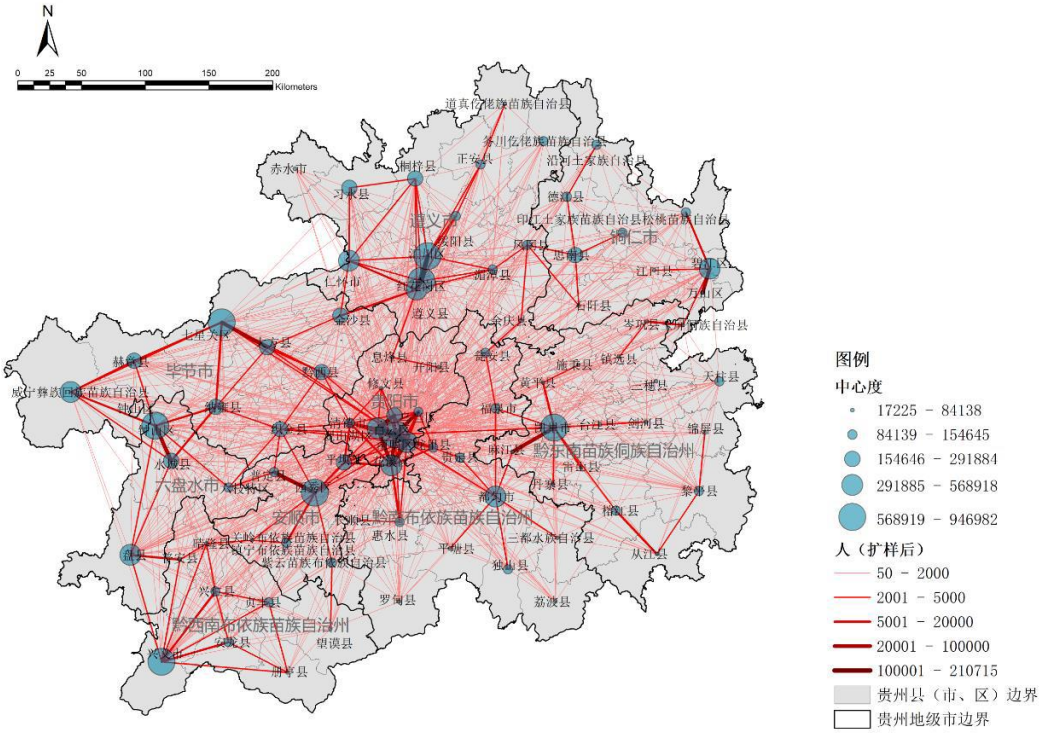
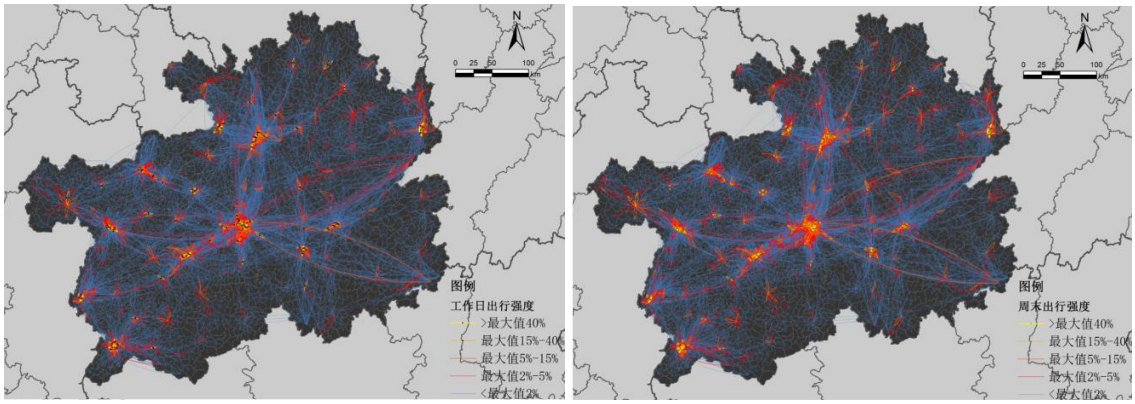


Figure 3-3. Urban spatial structure at the district and county level in Guizhou province (based on all-purpose travel links).

The cell phone signaling travel data are extracted and travel intensity is calculated accordingto two time periods: weekdays and weekends, and it can be found that weekday travel is mainly concentrated within the city area or within the central city area of the city (county),and the travel volume is the largest in Guiyang and Zunyi city districts;the cross-city travel volume increases significantly on weekends, such as Guiyang city district and Anshun, Zunyi city district and Tongzi county, etc.



Guizhou All Purpose Travel Contact Network (weekdays)

Guizhou All Purpose Travel Contact Network (Weekend)

Figure 3-4. Analysis of the all pu rpose travel linkage network in your province

A separate analysis of the travel links of people in Guiyang city shows that the top two district s (cities) in terms of linkage are Qingzhen city and Longli co unty, no matter from Guiyang municipal district or to Guiyang city. This indicates that the daily travel links between Qingzhen City and Guiyang Municipal District are already relatively close a nd have a strong demand for connection. Therefore, the city of Qingzhen can be continuously promoted to be abol ished and incorporated into the Guiyang municipal district, expanding the spatial scope of the Guiyang municipal district, optimizing the scope of affairs and approval rights of the Qingzhen area, and promoting further economic development of Guiyang. At the same time, Longli County, as the bridgehead of Qiannan State connecting Guiyang, actively cooperates with Guiyang City in industry, infrastruc ture and public services (especially Huaxi District), providin g strong supporting guarantee for the development of Guiyang.

Longli Express Logistics Park has become the largest express logistics distribution center in the southwest. Now the development of Huaxi Longli co location should be actively promoted.

Second ly, the districts and counties with strong ties t o Guiyang city district are Xiuwen County, Kaiyang County, Xifeng County, Huishui County, Guiding County, Pingba District, Xixiu District, Honghu agang District, Tongzi County, Qianxi County, Yuping C ounty and so on. Among them, Xiuwen County, Kaiyang Count y, Xifeng County, Guiyang City, the county within the scope of the city, should continue to promote the northern three counties of Guiyang to abo lish the county, expanding the spatial scope of Guiyan g City. In addition to Longli County, Huishui County and Guiding County are strategic areas in Qiannan State linked to Guiyang, and should be actively integrated into the development

of Guiyang, togethe r with Longli and Changshun, to create a modern storag e and logistics undertaking area around Guiyang, and a co nsumer goods preservation area around Guiyang city, to enhance factor concentration and carrying capacity, and improve economic strength and industrial competitiveness. Pingba District and Xixiu Dist rict are important areas of Gui'an New Area, which means that the integrated development of Guiyang Gui'an has begun to bear fruit. In the future, the cooperation and exchange between Guiyang and Gui'anin industry, ecology and infrastructure should be continuously promoted to form provincial growth poles and drive the economic development of Guiyang-Gui'an-Anshun metropolitan area as well as the province. Honghuagang District, Tongzi County, Qianxi County and Yuping County are located in Zunyi City, Bijie City and Tongren City, respectively, and should continue to strengthen the interconnection between Guiyang City and regional central cities on the existing basis, as well as cooperation in various aspects such as economic industries, to achieve a win-win situation and promote the high-quality development of Guizhou.

3.2.2 Based on occupational and residential travel data

Similarly, using SQL statements with the GIS platform, the data of occupational and residential trips were analyzed. It can be found that the overall and all-purpose travel analysis presents relatively similar results, with Guiyang city district having the highest centrality, followed by, Zunyi city district, then Duyun, Xinyi, Zhongshan district (Liupanshui), and Qixingguan district (Bijie city). However, it should be noted that the workplace travel is mostly concentrated in the municipal district or within the county, long-distance cross-city travel is relatively small. For example, in Guiyang City, work and residence travel is concentrated in Nanming District, Yunyan District, Huaxi District, Wudang District, Baiyun District, Guanshan Lake District, followed by a certain intensity of work and residence contact with Qingzhen City, Longli County. For example, in Zunyi City, work and residence trips are mainly concentrated in Huanghuagang District, Huichuan District and Buzhou District within the city's jurisdiction.

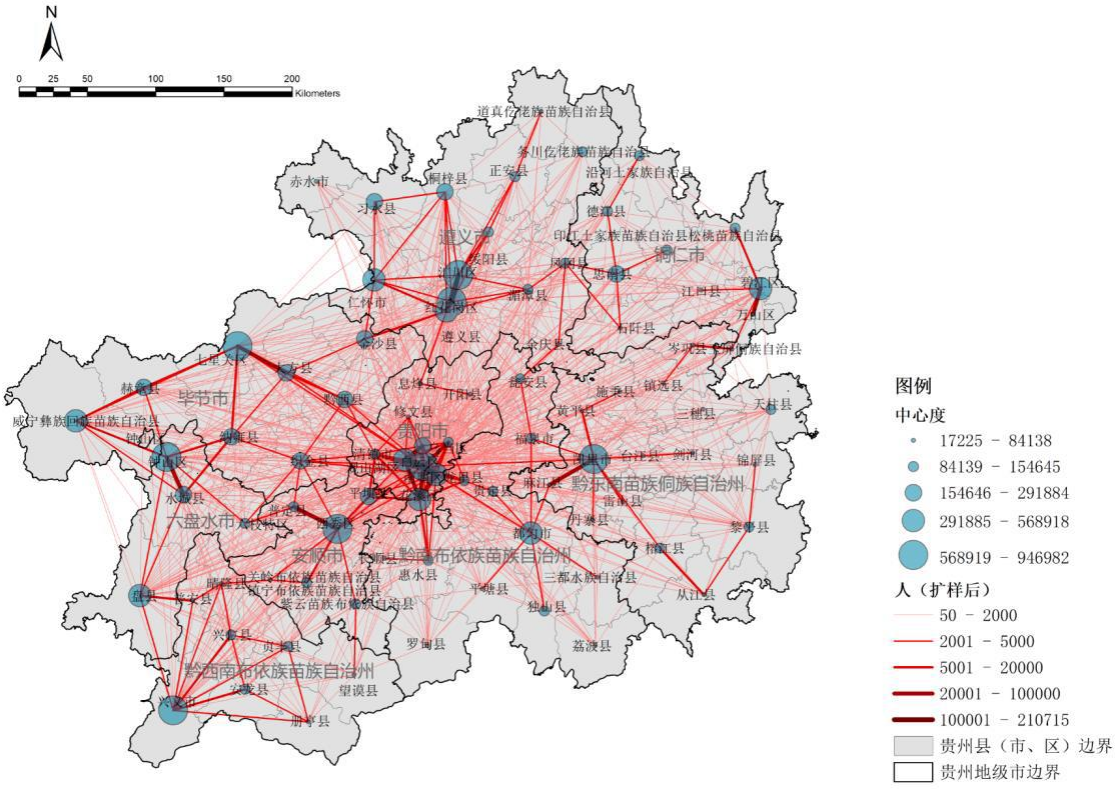


Figure 3-5. Urban spatial structure at the district and county level in Guizhou province (based on occupational and resident ial travel links)

4. Conclusion and policy suggestion

The following conclusions can be drawn from this study: 1) The o verall pattern of the city network in Guizhou Province pre sents a multi level Core Periphery structure. Within the province, Guiyang, the provincial capital, is the core and other regions are the peripheries, showing the dominant role in the economic links of enterprises in the province; Within the area, a networ k structure with regional central cities as the core and surrounding cities and towns as the peripheries is mainly formed. At the same time, from the perspective of population flow, it can be found that Guizhou Province presents the characteristics of init ial networking. 2)Compared with the higher enterprise network link degree betwee n Guiyang and Zunyi, the link degree of population flow is lower, which shows that Guiyang and Zunyi, as the top two c ities in Guizhou Province, have formed a strong economic l ink, but the actual population flow needs to be strengthened. 3)The network hint erland of Guiyang covers the whole province, but the network hinterland of Zunyi is mainly concentrated in its city and has not had a radiation effect on other areas of the who le province. At the same time, while receiving the radiation of

Guiyang, other r egional central cities also play a leading role in the surrounding small and medium sized cities and towns.

Based on the characteristics of Guizhou's mountainous area, the city is in line with the trend of urban development and population concentration in Guizhou Province, and responds to the national policy guidance to promote the cluster with the circle, strengthen the center and drive the periphery. Combining the above analysis of the spatial structure of cities and towns, th e spatial scope of the Guiyang Gui'an Anshun metropolitan area and Zunyi metropolitan area, and the spatial scope of Qianzhong urban cluster, and d rawing on the networked "galaxy" development pattern of "corridors + nodes" in the metropolitan areas of the Unit ed States, we propose the construction of the Qianzhong urban cluster as the main body, with the main city of Guizhou as the main city. The mai n body of the city cluster is Qianzhong, with Guiyang Gui'an as the leader, Guiyang Gui'an Anshun and Zunyi as th e core growth poles, Biji e, Liupanshui, Tongren, Kaili, Duyun and Xinyi as the focus, several county node cities as the important support, and small towns as the basis of the "one core group, two circles and six centers". The spatial pattern of Guizhou's mountainous town system is based on a core group, two circles, six centers, multiple branches and multiple points.

With the continuous promotion of regional coordination strategy, th e cooperation between cities has been strengthened. As the main platform platform, megapolitan clusters and m etropolitan areas composed of multiple cities and towns gradually replace individual cities to participate in global c ompetition, and their internal will in evitably form a close and reasonable city network. Then, how identifying the city network and relate d characteristics has become the key point. This study will help to identify and understand the characteristics of cit y networks from Space of Flows and the irimportance to regional coordinated development, aiming at providing a reference for relevant simi lar research and decision making.

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