

Study on the Spatial Structure of Urban Networks in Henan

Province

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Abstract: With the coming of the Internet information age, interactive information contact has become an important means of intercity element flow. Based on the attention data of Baidu users in Henan in 2013, 2017 and 2021, a city network in Henan province based on information flow is constructed. The Louvain algorithm is used for network community mining, and the spatial distribution and structural structure of Baidu users in Henan province are summarized. Louvain algorithm is used for network community mining, and the spatial distribution and structural characteristics of the city network in Henan Province are deeply analyzed. The results show that: 1) the urban network in Henan province is closely connected, and the total amount of information flow presents a rapid growth trend. The results show that: 1) the urban network in Henan province is closely connected, and the total amount of information flow presents a rapid growth trend. Zhengzhou city has a very obvious agglomeration effect, and it is in the core position of the whole network with great development potential. The core position of the network will be further enhanced in the future. 2) The grade distribution of urban network shows "5+19+32+30+34". +30+34". During 2013-2021, the connection of urban network in Henan Province has been strengthened obviously. Wuzhi County, Zhongmou County, Gongyi City, Wen County and other low-grade cities rely on the urban network of Henan Province. Wuzhi County, Zhongmou County, Gongyi City, Wen County and other low-grade cities rely on Zhengzhou to realize their own transition, and the distribution of urban hierarchy has a reasonable trend. 3) The spatial distribution of community groups has been strengthened in Henan Province. The spatial distribution of community groups divided by Baidu Index information flow is consistent in urban agglomerations in the province, basically in line with the urban development pattern of the city. The spatial distribution of community groups divided by Baidu Index information flow is consistent in urban agglomerations in the province, basically in line with the urban development pattern of one main region and one sub-region. From 6 community groups in 2013 to 4 community groups in 2021, the city From 6 community groups in 2013 to 4 community groups in 2021, the city structure of community groups has changed from scattered and fragmented to more clustered board development, and the number of isolated cities has decreased. The stability of urban networks has been enhanced.

Keywords: Urban Network; Community Structure; Information Flow; Baidu Index; Spatial Structure

Introduction

Since the 1970s, new technologies and theoretical paradigms in the West have continuously influenced the development of cities. The Spanish sociologist Castells firstly put forward the theory of "flow space", which laid a solid theoretical foundation for the study of urban network, and scholars at home and abroad have carried out research on the relationship of traffic flow, capital flow, information flow and other elements between cities on this basis, and explored the influence of these elements on the development of urban agglomerations and the evolution of spatial structure. The influence of these elements on the development and spatial structure of urban agglomerations has been explored. Especially after 2000, with the rapid development of information network and the acceleration of regional integration process, the spatial connectivity between cities has been increasing and tends to be flattened, and the channel of information circulation between cities has changed from traditional information bearing media such as telephone and newspaper and physical transportation such as trains and

airplanes, to virtual network data such as cell phone signaling index and microblogging, with the new Internet as the medium of information bearing, and the communication between cities is dominated by virtual network data. Network data is the main focus, the communication and connection between cities are getting closer and closer, and the influence of virtual flow space is expanding, gradually replacing the original local space and becoming an important part of the socio-economic system. Each city is an independent node, and all kinds of elemental flows become the links connecting them, together constituting a huge network diagram, the development trend of urban virtual networkization is more and more obvious, and the connection is more and more close, exploring the study of urban network structure under the perspective of flow space has become a hotspot of the new generation of academic research.

Based on the theory of flow space, this paper constructs the city network of Henan Province in 13, 17 and 21 years and analyzes its evolution characteristics with Baidu's user attention as the inter-city information flow link, explores the spatial structure characteristics of the city network of the 17 prefectural-level cities and 105 county-level cities within the scope of Henan area under the perspective of information flow, and explores the impact of information flow on the spatial pattern of cities in Henan area, so as to provide certain reference for the coordinated urban development in the Internet era.

1. Research Sources and Research Directions

1.1 Overview of the study area:

Henan urban agglomeration is located in the central region of China, located in the North China Plain, the whole area including 17 prefectural-level cities and one county-level city under the jurisdiction of the province. It is a high level of economic development in the central region of China. In 2021, the state issued the Fourteenth Five-Year Plan and Vision 2035 Outline, which proposed to promote the development of Henan urban agglomeration, and to determine the spatial layout for the development of urban agglomeration in Henan Province according to the location conditions of the prefectural cities, resource endowment, industrial foundation and other actualities, combined with the economic spatial pattern of the urban agglomeration of the province, and regarded the Zhengzhou Metropolitan Area as the new economic growth pole of central China, adding a new economic growth pole for Henan Province as well as the central region and even the whole country. Zhengzhou Metropolitan Area is regarded as a new economic growth pole in the central region, adding new economic vitality to Henan Province, the central region and even the whole country. Therefore, realizing the high-quality development of Henan urban agglomeration plays a significant role in economic and cultural exchanges, ecological civilization construction, and safeguarding and improving people's livelihood.

1.2 Research methodology and data sources

In today's society, human beings have entered the era of Internet of Everything, and the Internet has a great role in promoting the development of human life and productivity. According to the Statistical Report on the Development Status of China's Internet Network, the number of Internet users in China reached 1.031 billion in 2021, and the Internet penetration rate reached 73%, of which Baidu, as the head company of the Internet, accounted for 71% of China's search engine market, so Baidu index data based on Baidu's big data as a support is of great significance as a reference for the study of the spatial structure of the city.

Baidu Index is based on the Internet search volume, through scientific weighted statistics and operations, to calculate the precise attention value. In this paper, the information flow data from the Baidu index website (<https://index.baidu.com/v2/index.html#/>), through the comparison of the index of different regions, in order to Henan Province, 17 prefecture-level cities, 21 county-level cities, 82 counties of the name of the keyword search, to obtain the 2012-2021 10 years between 120 cities two and two user attention overall daily average data.

1.3 Research methodology

1.3.1 Information flow intensity method

In this paper, three time periods (2017, 2019, 2021) were selected to obtain the information linkage matrix of Baidu index for all cities in Henan, and the strength of the information linkage between a and b. The strength of the information linkage between a and b is expressed in the form of the numerical product of Baidu users' attention, which is given by the formula

$$R_{ab} = V_{ab} \times V_{ba} \quad (1)$$

Where. V_{ab} is the search index of city a for city b; and V_{ba} is the search index of city b for city a.

1.3.2 Community structure

Based on topological relationships and attributes, the nodes embedded in the network are identified and organized into "clusters" or "groups" based on the tightness and sparseness of the connections between the nodes. Overall, urban information flows within the same community are more tightly connected, while the strength of information flows between different communities is relatively sparse. Community structure is also known as "community mining", and there are many mainstream community mining algorithms, including CAM algorithm, Walktap algorithm, Infomap algorithm and GN algorithm. According to the characteristics of the study area, this paper adopts Louvain large-scale community discovery algorithm, which is an algorithm based on multilevel optimization Modularity, with the advantages of fast, accurate and retaining the network weights and other attribute information, Louvain algorithm is one of the best network community mining methods at present. In order to evaluate the importance of different communities in the overall network, we introduce the Pagerank algorithm to evaluate the connection status of each node in the information network, and feedback the external connectivity of community groups according to the total value of PR in the divided community, and judge the importance of the community groups in the overall network according to the level of external connectivity. The formula is as follows:

$$Q = \sum_c \left[\frac{\sum \text{in}}{2m} - \left(\frac{\sum \text{tot}}{2m} \right)^2 \right]$$

$$= \sum_c [e_c - a_c^2]$$

2. Analysis of the spatial structure of urban information linkage network in Henan Province

2.1 Increase in total information flow and strengthening of interconnections between cities in Henan Province

From the perspective of flow analysis, the city flow from 13 to 17 years of flow growth is huge, and then tends to stabilize, indicating that the connection between the cities is strengthened, the influence of each other is gradually expanding, and the exchange of information between the cities is also getting closer and closer. Zhengzhou is in the absolute center of the city group in Henan Province, showing a high degree of single-core characteristics, and has a strong radiation-driven role, slip county, Suoi County, Zhongmou County, Fan County, etc. are because of Zhengzhou's radiation-driven and thus the information flow increases year by year.

2.2 Gradual optimization of the urban network structure

The spatial distribution of urban information linkage network in Henan Province is not balanced, showing the phenomenon of prominent central axis and concave sides, with the characteristics of decreasing from the center to the north and south sides. The skeleton of the urban network structure in Henan Province is radiating distribution centered on Zhengzhou, indicating that other cities within the urban agglomeration are more closely linked to Zhengzhou, and the backbone of the network is a single-core distribution centered on Zhengzhou. From the viewpoint of the spatial and temporal evolution of the city network in Henan Province, on the whole, the city network structure in Henan Province is undergoing adjustment and optimization, and is gradually maturing. From 13 to 17 to 21 years, the information connection of each city is obviously strengthened. In 2013, the city network map presents Jiaozuo, Luoyang, Hebi, Pingdingshan. In 2013, the city network map shows a "big" structure with Jiaozuo, Luoyang, Hebi, Pingdingshan, and Pingdingshan as support points, but in 2021, new cities such as Nanyang and Xinyang have been added to form a "meter" structure, and sub-center nodes such as Luoyang, Xinyang, and Nanyang have appeared. These cities become the dominant information cities in the information linkage skeleton of Henan Province. The skeleton links can be divided into two parts: prefecture-level city-to-prefecture-level city links and prefecture-level city-to-county-level city links. For example, the skeleton links between prefecture-level cities are Zhengzhou-Xuchang, Zhengzhou-Luoyang, and Zhengzhou-Kaifeng, all focusing on Zhengzhou, while the links between

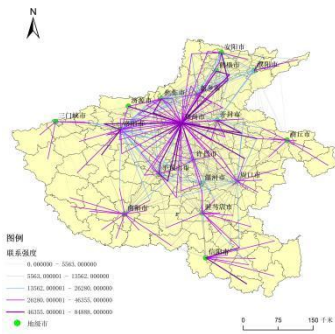
other prefecture-level cities are relatively weak.

To summarize, the core cities in Henan Province play a leading role in the information exchange between cities and counties, and the backbone network of the city mainly relies on Zhengzhou City to connect to other prefecture-level cities, and most of the information flow in the province is also concentrated between the central and sub-central cities, such as Zhengzhou, Luoyang, Nanyang, and so on.

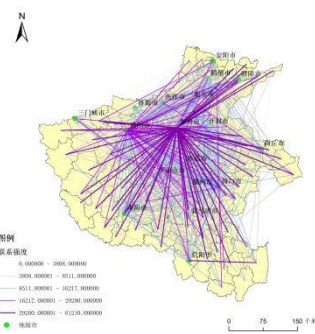
3. Analysis of urban network evolution in Henan Province

3.1 Mapping the spatial structure of urban networks in Henan Province

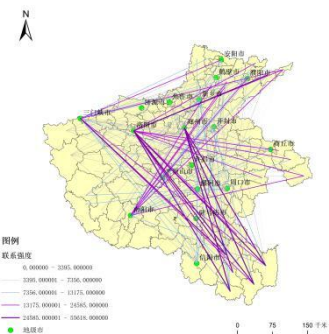
Cities at all levels in Henan Province will be analyzed according to straight-line distance for medical CT scanning multi-level, wide-scale analysis, spatial straight-line distance in accordance with the less than 150, 150 ~ 300, 300 ~ 500km section for division, corresponding to the county, city, province three more detailed spatial scale, its spatial structure mapping as shown in Figure.



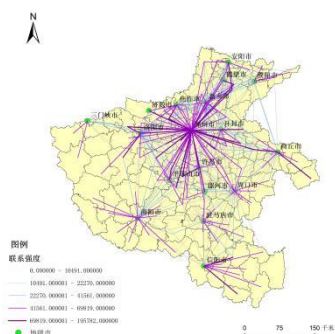
Schematic of 0-150km in '13



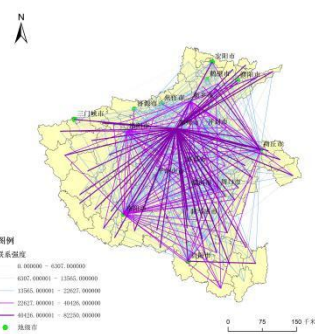
Schematic of 150-300km in '13



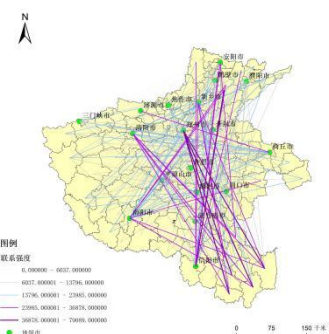
Schematic of 300-500km in '13



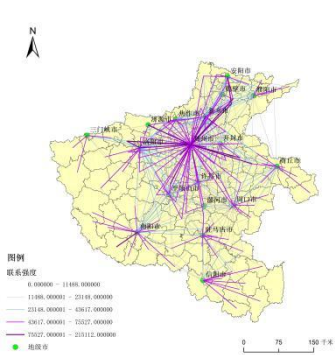
FY17 0-150km Schematics



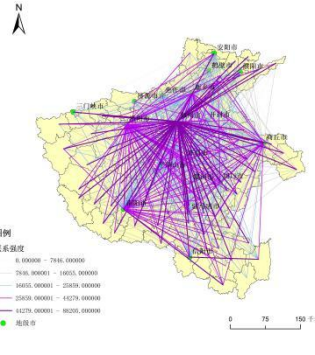
Schematic of 150-300km in '17



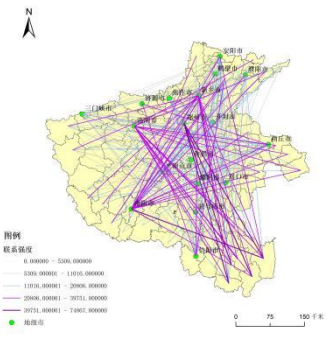
Schematic of 300-500km in '17



Schematic of 0-150km in 21 years



Schematic diagram of 150-300km in 21 years



Schematic diagram of 300-500km in 21 years

The spatial division structure of information flow changes as well as closeness in three distance segments in Henan Province is quite different. Taking the information flow intensity connection in Henan Province in 2017 as an example, the traffic connection section within 150km accounts for 33%, presenting the characteristics of obvious center radial spatial

distribution, i.e. the municipal administrative center and the local center of the surrounding counties are dominant. That is to say, the municipal administrative center and the local center of the surrounding counties are the main contact, and the "core-edge" feature is clearly reflected. 300km above the traffic contact section accounted for 19%, with the increase of distance, the intensity of the information flow between the county cities is gradually weakened, the radiation effect of Zhengzhou's provincial central city has decreased significantly, and the traffic contact is mainly concentrated in the higher level of Henan Province, and the traffic contact is mainly concentrated in the higher level of Henan Province, and the traffic contact is mainly concentrated in the higher level of Henan Province. Zhengzhou's role as the provincial central city of radiation decreases significantly, and the traffic links are mainly concentrated in the higher-level prefecture-level cities in Henan Province, such as Luoyang City, Nanyang City, Xinyang City, Anyang City, Shangqiu City, etc., with the rest of the prefecture-level cities having weaker links. Information flow links are mainly concentrated in the central region of Henan Province, and its radiation to remote areas in the northeast, northwest and south, the spatial structure of information flow in Henan Province shows a more obvious "oblique triangle" structure.

In summary, the regional 'core-edge' structure of information flow intensity is obvious, with a single-core to multi-core structure gradually spreading from the center to the periphery of Henan Province. On a more distant scale, there is a uniform "core-edge structure" across the province, and a "diagonal triangle" spatial structure is formed by Sanmenxia City, Xinyang City, Shangqiu City and Xinxiang City.

3.2 One main, two secondary and three regional city network patterns emerging

The community spatial distribution of major communities in 2013-2021 has a strong spatial proximity characteristic in the city administrative divisions and the geographic location of the node cities, etc. There is a greater connection. Taking the division of community clusters in Henan Province in 2021 as an example, the distribution characteristics of communities based on the information flow of Baidu index are as follows: Community 1 contains cities mainly distributed in the central and northern parts of Henan Province, including 45 county-level cities and 9 prefecture-level city districts; Community 2 is dominated by the Luoxi urban agglomeration, including 18 county-level cities and 3 prefecture-level city districts; and Community 3 is mainly distributed in the southwestern part of Henan Province, with Nanyang and Xinyang urban agglomerations dominating, containing 19 county-level cities and 2 prefecture-level cities. and Xinyang urban agglomerations, containing 19 county-level cities and two prefecture-level city municipal districts; Community 4 is mainly located in the eastern part of Henan Province, dominated by Shangqiu, Zhoukou, and Zhumadian, and contains 23 county-level cities and three prefecture-level city municipal districts. Municipal administrative boundaries have a strong influence on the delineation of urban subordinate community clusters, with strong intra-municipal connections and weak inter-municipal connections at the prefecture level in Henan Province on the surface.

There is a large coupling between the distribution of communities and the distribution of urban agglomerations in Henan Province. Comparing the distribution of major communities in Henan Province and the spatial distribution of urban agglomerations in Henan Province, it is found that there is a spatial correlation between the two. Specifically, Henan Province has a spatial pattern of "one main city, two secondary cities and three regions", and the results of the 2021 community clusters are basically consistent with it. Community one corresponds to one main, that is, the central city of Henan Province, Zhengzhou City, Hebi, Puyang, Anyang, Xuchang and other cities geographically close, and with the Zhengbei urban agglomeration between the population, materials, information flow is increasingly strengthened to produce a close connection.

Conclusion and discussion

This paper obtains the information flow data of 122 cities and counties in Henan Province for three years in 2013,2017,2021 with the help of Baidu index platform, constructs the urban information network of Henan Province, analyzes the characteristics and evolution law of urban network in Henan Province, and finds that:

(1) In 2021, based on Baidu index data, the city network structure of Henan Province presents the following characteristics: the overall city cluster network shows stable growth, the total amount of information flow of each city increases year by year, the information network connection between city clusters is closer, the clustering effect of big cities is

obvious, the information flow connection is highly concentrated in the central region of Henan Province, and the overall network presents a 'meter' shape structure. ' zigzag structure.

(2) The division of community clusters in the watershed is greatly influenced by spatial distance and administrative divisions, and most of the information links of county-level cities are concentrated in their own prefecture-level cities, with poor overall connectivity.^{13,17} Communities show a more dispersed and fragmented, with a low degree of integration.

Based on the above analysis, the following suggestions are made for the future development of cities in Henan Province: Firstly, we should vigorously develop the provincial central cities, take into account the sub-centers and regional centers, improve the transportation network construction and infrastructure network construction of the remote and backward cities, and set up an interconnected intercity information network between the cities to promote the circulation of multiple factors, so as to form the development pattern of the regional information network. Secondly, we should be guided by the national policy, set the province's efforts to enhance the status of Zhengzhou City's transportation and information hub, so as to promote the urbanization of Henan Province's city clusters, better promote the integrated development of Henan Province, and balance the development of cities, weakening the "Matthew effect". Thirdly, we should give full play to the advantages of cities with regional characteristics or functional positioning, and create brand cities through policy support to expand the city's popularity.

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