Research on the Development of Guanzhong Plain City Group in Shaanxi Province Based on the Economic Relation Network Model

Yuan Zhang*
e-mail address: 342945117@qq.com

Xijing University Changan District, Xi'an City, Shaanxi Province

Abstract—In this paper, core cities such as Xi'an, Tongchuan, Baoji, Xianyang, Weinan, and Yangling were selected as research subjects in the Guanzhong Plain area of Shaanxi Province. Economic operating data were collected from 2017 to 2020. With the help of the gravity model and the economic relation membership grade model, this article measures the economic relation degree of city group and the radiation capacity intensity of the central city of Xi'an to the economic development of other cities. It is combined with the social network analysis method, to identify the economic relation network characteristics of urban agglomeration. By analyzing the network structure of Guanzhong Plain city group, which provides countermeasures and suggestions to find ways to shorten the economic development gap of Guanzhong plain city group.

Keywords- city group; economy relation degree; gravity model; social network analysis method;

1 INTRODUCTION

The Guanzhong Plain has located in the center of inland China. It is an important birthplace of Chinese civilization and a starting point of the land Silk Road, and an important gateway for the western region to connect the eastern region. Improving the new urbanization level of the Guanzhong Plain city group is conducive to leading and supporting the development of the western region and promoting the construction of "Belt and Road" in depth. Compared with the Yangtze River Delta, the Yangtze River Delta, and other Beijing-Tianjin-Hebei urban agglomerations, the urbanization level of the Guanzhong Plain city group is still relatively lagging. The Guanzhong Plain has profound historical and cultural deposits, remarkable location and transportation advantages, a complete modern industrial system, and strong comprehensive innovation strength. Relying on the core leading role of Xi'an, the Guanzhong Plain city group is the only megacity in northwest China, which has great potential for development.

In research on the degree of city economic relation, scholars generally adopt the gravity model and the economic relation membership grade model, which is of great significance to constructing a reasonable spatial pattern and coordinated developing urban system. This paper takes Guanzhong plain city group as the research object. Through the measure of the urban economy linkage degree and the social network analysis method, the imbalance of the economic development degree among the cities in Guanzhong plain is found for the economic

ICEMME 2022, November 18-20, Nanjing, People's Republic of China

DOI 10.4108/eai.18-11-2022.2327177

development gap. And it provides theoretical support for the new situation of economic growth poles between Guanzhong plain city group jointly driving the high-quality economic development of Shaanxi.

2 RESEARCH METHOD AND DATA SOURCES

2.1 Research method

2.1.1 Gravity model

Jefferson and Zipf introduced the law of gravity in physics into the interaction of cities, as in [1-2]. The subsequent researchers improved the flow, took the traffic flow, trade flow, and material flow as the economic contact indicators, and analyzed the economic connection of the city. The classical formula for calculating urban economic relations is shown in Equation (1)

$$R_{ij} = \frac{\sqrt{P_i V_i}\sqrt{P_j V_j}}{{D_{ij}}^2} \tag{1}$$

Among these, P represents the population in the city, V represents the economic development of the urban agglomeration, while D refers to the distance between the two cities. Moreover, the economic relation between cities are unidirectional, even if the total population of the two cities is similar to the economic size, their interaction power is different. Therefore, corrections to the classical gravitational model are needed.

This paper introduces the parameter δ to represent the one-way characteristic index of the city's economic connection, δ is the ratio of the city's GDP to the sum of the GDP of the two related cities. The improved gravity of the economic relationship between the two cities is shown in formula (2), and the calculation of the parameter δ is shown in formula (3)

$$R_{ij} = \delta_{ij} \frac{\sqrt{G_i P_i}\sqrt{G_j P_j}}{{D_{ij}}^2} \tag{2}$$

$$\delta_{ij} = \frac{G_i}{G_i + G_j} \tag{3}$$

Among them, G represents the urban GDP, and P represents the urban population size. D represents the shortest traffic distance between the two associated cities.

The shortest traffic distance measurement method is roughly divided into three treatment methods. The first method is to directly choose the straight-line distances between cities, but the terrain factors and traffic infrastructure are generally not consistent with the straight-line distance. The second method is to use the average value of highway mileage, railway mileage, and spatial linear distance. At the same time, some scholars aim to increase their objectivity. The probability of people choosing the transportation mode is determined according to the passenger turnover of urban road transport and railway transport and then weighted average. However, the turnover is only one of the indirect manifestations of the choice of traffic mode, and it does not represent people's preference for the choice of traffic mode between the specific two cities. This mode of empowerment lacks theoretical support. The third approach is to use the modified gravitational coefficient. The substance is similar to the mean value method. With the development of intercity traffic, the absolute spatial distance between cities has changed to

the relative distance in time. Therefore, the shortest road transportation distance is chosen to measure the shortest traffic distance between cities in this paper.

This article calculates the strength of regional economic relations based on the measurement of regional economic relation quantity. The magnitude of the urban economic radiation intensity is measured using the economic membership model. The evaluation is an index to compare the size of the economic connection between regions, which reflects the closeness of the economic relations between cities and the coordinated development degree of the regional economy. The economic relation membership grade model is calculated as shown in Equation (4).

$$F_{ij} = \frac{R_{ij}}{\sum_{j=1}^{n} R_{ij}} * 100\% \quad (4)$$

Among them, F_{ij} is the membership degree of economic connection and n is the number of economic radiations in the central city.

2.1.2 Overview of the social network model

The social network model is mainly used to analyze the characteristic relationship between networks, determine the types of network members, and explore the role of members on the network. Social network research methods provide excellent tools for analyzing the network layout between cities, making the process of optimizing the network structure of urban agglomerations visualized, and the effect of quantitative evaluation is more obvious, as in [3-7]. Regarding the structural analysis and measurement of urban networks, this article draws on the main concepts of "relationship and location orientation" in social network theory.

2.1.2.1 Network Density.

Network density refers to the degree of closeness among all members of the network. It is obtained using the relative ratio of the number of connections in the network and the number of relationships in the concept. The proof shows that the deeper the relationship between the members, the greater the network density. The network density between cities is calculated as shown in Equation (5) and Equation (6)

$$D = \sum_{i=1}^{n} d_i\,(c_i)/n(n-1) \quad (5)$$

$$d_i(c_i) = \sum_{i=1}^{n} d_i\,(c_i, c_j) \quad (6)$$

Among them, n represents the size of the urban network or the number of cities. If there is a connection between city I and city j, thus the $d_i(c_i)$ value is 1 or otherwise 0.

2.1.2.2 Network center degree

Network center degree is mainly a measure of the centralization level of the whole network. In urban networks, cities located in central locations have easier access to information and resources, with a strong agglomeration effect, and have a greater impact on other cities. Point degree centrality is an indicator of the location of cities in an important center in the network of spatial economic relations. This metric can be represented by the size of the direct association between the two associated cities. According to the different directions and strengths of urban economic relations, the center of point degree can be divided into point degree and point degree. The calculation of point centrality is shown in Equation (7)

$$C_D(c_i) = \frac{d(c_i)}{n-1} \quad (7)$$

2.2 Data Sources

This paper studies the Guanzhong Plain, which includes six cities in the Guanzhong Plain area of Shaanxi Province. They include Xi'an, Tongchuan, Baoji, Xianyang, Weinan, and Yangling. The Development Plan of Guanzhong Plain Urban Agglomeration was then implemented beginning in 2018. Therefore, considering the dynamic trends of economic relations between cities and the availability of data, this paper selects the data from four cross-sections for 2017, 2018, 2019, and 2020. GDP, population, and other economic operation data are from the "Shaanxi Statistical Yearbook", and the shortest time distance of road transport is obtained from the AutoNavi map calculation.

3 Analysis of the Network Structure of Guanzhong Plain Urban Agglomeration

3.1 Regional Economic Connection Analysis

Using a modified gravity model, the strength of the economic relations between cities in Guanzhong Plain of Shaanxi Province is shown in Table 1 and Table 2.

From the perspective of the intensity of economic relations between cities in Guanzhong Plain of Shaanxi Province, the economic relations between cities grow year by year and are characterized by gradient distribution. From 2017 to 2020, the intensity of economic relations grew year by year. For example, the economic relations between Xi'an and Xianyang have increased from 1,585.27 in 2017 to 2,128.98 in 2020. The economic relations between Xi'an and Baoji grew from 128.87 in 2017 to 174.38 in 2020. Xi'an City and Xianyang City are located in the regional economic center of Guanzhong Plain, with the closest economic relations, which is in line with the integrated development trend of the integration of Xi'an City and Xianyang City.

TABLE 1. The intensity of the economic Relations between cities in Guanzhong Plain, Shaanxi Province in 2017

City	City					
	XA	TC	BJ	XY	WN	YL
Xi'an	-	121.59	128.87	1585.27	725.16	29.4
Tongchuan	5.67	-	0.9	3.91	4.37	0.64
Baoji	37.8	5.66	-	38.20	19.50	9.3
Xianyang	486.39	25.73	39.96	-	117.41	20.1
Weinan	194.07	25.08	17.8	102.41	-	4.5
Yangling	0.54	0.25	0.58	1.2	0.31	-

TABLE 2. The intensity of the economic Relations between cities in Guanzhong Plain, Shaanxi Province in 2020

City	City					
	XA	TC	BJ	XY	WN	YL

Xi'an	-	157.4	174.38	2128.98	905.92	46.26
Tongchuan	6.00	-	0.86	3.90	4.16	0.71
Baoji	39.62	5.13	-	35.40	17.04	10.33
Xianyang	468.44	22.51	34.27	-	96.61	21.7
Weinan	168.72	20.32	13.96	81.77	-	4.52
Yangling	0.7	0.28	0.69	1.49	0.37	-

The economic membership between cities in Shaanxi Guanzhong Plain is shown in Table 3. The economic links between cities in Guanzhong Plain in Shaanxi Province are mainly concentrated in Xi'an and Xianyang. As a regional central city, Xi'an has its economic relations with most of the cities in the Guanzhong urban agglomeration in Shaanxi province by more than 30% of its total economic relations. In 2020, Xianyang's economic relations with Xi'an reached 72.79% of its total economic relations. The economic relations between Weinan and Xi'an reached 58.32% of its total economic relations. Yangling is limited by its size of cities and has weak economic connections with other cities. From 2017 to 2018, the economic membership grade between other cities showed a fluctuating trend. This explains that the economic links between non-central cities are in dynamic development.

TABLE 3. THE ECONOMIC MEMBERSHIP BETWEEN CITIES IN SHAANXI GUANZHONG PLAIN IN 2020

City	**City(acronym)**					
	XA	**TC**	**BJ**	**XY**	**WN**	**YL**
Xi'an	0.00%	4.61%	5.11%	62.38%	26.54%	1.36%
Tongchuan	38.39%	0.00%	5.50%	24.95%	26.60%	4.55%
Baoji	36.86%	4.77%	0.00%	32.92%	15.85%	9.61%
Xianyang	72.79%	3.50%	5.33%	0.00%	15.01%	3.37%
Weinan	58.32%	7.02%	4.83%	28.27%	0.00%	1.56%
Yangling	19.83%	8.00%	19.48%	42.28%	10.40%	0.00%

3.2 Social network analysis

Using social network correlation theory analyzes network structure, network density, and network centrality on the network of Shaanxi Guanzhong Plain. Using social network correlation theory analyzes network structure, network density, and network centrality on the network of Shaanxi Guanzhong Plain.

3.2.1 Analysis of network structure

The city network is composed of a certain number and scale of cities, and the network structure enables cities to better divide and cooperate with each other and give play to the synergy of urban agglomerations. Through the analysis of the urban agglomeration network structure, it can more intuitively reflect the economic radiation effect, contact strength, and collaborative behavior between cities. This paper uses UCINET software to generate a network structure diagram of the urban agglomeration in the Guanzhong Plain, Shaanxi, as shown in Figure 1 and Figure 2. It can be seen that the spatial economic relations of the Guanzhong Plain urban agglomeration in Shaanxi has obvious network characteristics, the development of the urban

network is complicated, and the degree of closeness of the urban spatial connection is getting higher and higher.

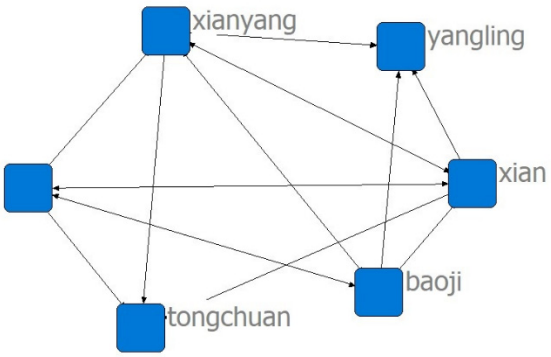

Figure 1 Network Structure of Economic Relations in Guanzhong Plain, Shaanxi province in 2020

3.2.2 Analysis of network density

The network density trends of Shaanxi Guanzhong Plain urban agglomeration were calculated using UCINET software, as in [8]. As shown in Figure 2, from 2017 to 2020. The urban spatial and economic connection of Guanzhong Plain is getting higher and higher, with an increase of nearly 19.18% year on year. Network density reflects the increasing impact of the central city of Xi'an on the whole region, and the increasing economic connection between cities. In 2020, the network density of Guanzhong Plain cities in Shaanxi Province was 149.081. The process of integrated regional economic development was accelerated. Economic activities and cross-regional transaction behaviors increase between cities. The network density of Guanzhong Plain urban agglomeration in Shaanxi Province is increasing year by year, and the advantages of urban clusters are shown. The city network density is not the higher the better. As transactions between cities will generate costs, which will affect the utilization rate of resources. Only with the appropriate network scale and density can the urban agglomeration be developed steadily.

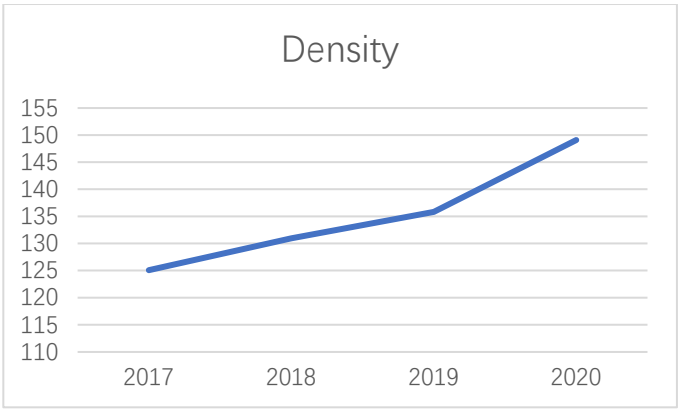

Figure 2 Network Density Trends from 2017 to 2020

3.2.3 Analysis of network centrality

Due to the unidirectional characteristics of urban spatial economic connection, the connection direction and strength of different cities are different. Using improved gravity model and UCINET software to calculate the center of spatial economic connection network in Shaanxi Guanzhong Plain. The following changes are found by the comparison of point degree centrality. The out-degree increased from 2590.28 in 2017 to 3 412.938 in 2020, and the in-degree was reduced from 724.463 in 2017 to 6 83.491 in 2020. The in-degree of other cities has seen large-scale growth, indicating that the economic radiation capacity of Xi'an to other regional cities is increasing.

The absolute value of the difference between in and out-degree is the comprehensive influence of the city. According to the comprehensive influence of the city, we can judge the size of its influence and the direction of economic connections. It can be seen that the comprehensive influence of Guanzhong Plain cities in Shaanxi ranges from large to small to Xi'an, Xianyang, Weinan, Tongchuan, Baoji, and Yangling. As a regional central city, Xi'an has the largest comprehensive influence as shown in Table 4.

TABLE 4. NETWORK DEGREE OF GUANZHONG PLAIN CITY GROUP IN SHAANXI PROVINCE FROM 2017 TO 2020

City	2017		2018		2019		2020	
	Outdeg	Indeg	Outdeg	Indeg	Outdeg	Indeg	Outdeg	Indeg
Xian	2590.283	724.463	2808.795	703.997	3021.805	645.036	3412.938	683.491
Tongchuan	15.49	178.315	13.761	177.675	14.939	189.298	15.621	205.637
Baoji	110.65	188.107	112.969	201.275	110.341	210.726	107.512	224.166
Xianyang	689.591	1730.993	706.947	1898.571	634.533	2016.711	63.541	2251.540
Weinan	343.859	866.753	282.814	877.305	289.411	938.077	289.295	1024.081
yangling	2.88	63.937	3.264	69.728	3.817	74.997	3.532	83.524

4 CONCLUSION AND SUGGESTION

This paper shows that Xi'an, as a core city, has a strong scale effect. The economy is growing faster than that in other cities. The hierarchical structure of economic relation strength of Guanzhong Plain urban agglomeration is unbalanced, and it is necessary to constantly change the intensity of economic relation between central cities and surrounding cities. This paper proposes the need to speed up the trend of the integration of Xi'an City and Xianyang City and promote the rapid development of the central city of Xi'an. We will expand the influence and economic relations of the Guanzhong urban agglomeration. Through the integrated development of urban agglomeration, the development level of space, industry, facilities, ecology, culture, system, and other dimensions can be improved. By promoting the integrated development of urban and rural areas, we will comprehensively promote the efficient utilization of regional resources.

Acknowledgement. 1. Supported by special scientific research plan project of education department of Shaanxi province (Grant No: 18JK1187) “Research on the Development Model of Guanzhong Urbanization in the New Period”.

2. Supported by Xijing University level scientific research fund project (Grant No: XJ150231) “Research on the Development Model of Guanzhong Urbanization in the New Period”.

REFERENCES

[1] M Jefferson. The law of the primate city[J]. Geographical Review, 1939(29): 226-232.

[2] G K Zipf. The hypothesis: On the intercity movement of persons[J]. American Sociological Review, 1946, 11(6): 677-686.

[3] D C Zhao, R Xie, X Y Lu. The Metrical Analysis of Economic Integration in Jiangxi Province Based on the Gravity Connection Model[J]. Modern Urban Research,2015(5),pp.84-88,118.

[4] Y Q li. Research on Coordinated Development Strategy for Chengdu Chongqing City Agglomeration at New Era[J]. West Forum, 2018, 28(3), pp94-99.

[5] L Zou, G Zeng, X Z Cao, S Y Chen. Reseaech on Spatial Characteristic of the Economic Relation Network of Yangtze Economic Zone[J]. Economic Geography, 2015,35(6), pp.1-7.

[6] J K Yu, J Q Ma. Spatial Pattern Evolution of Economic Links in Shandong Peninsula Urban Agglomeration[J]. Scientia Geographica Sinica,2018,38(11):1875-1882.

[7] G J Mulgan. Communication and Control: Networks and the New Econ-omies of Communication[M]. New York: Guilford Publications, Inc,1991.

[8] S P Borgatti, M G Everett. and Freeman, L.C. 2002. Ucinet 6 for Windows: Software for Social Network Analysis.