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Study on Economic Relations and Spatial Pattern Evolution of Hunan Province

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Abstract

Based on the modified gravity model, this paper conducts a analysis of the evolution of the spatial pattern of economic linkages in 13 prefecture-level cities in Hunan Province from 2008 to 2020, and uses the social network analysis method to further verify the conclusions. The study found that: (1) The overall level of economic connection in Hunan Province has been greatly improved, but the spatial differences in regional economic connections are obvious. The densely connected areas are mainly concentrated in the Chang-Zhu-Tan area, and there is a lack of obvious sub-center cities in the network to connect the fringe areas; (2) The structure of the economic connection network in Hunan Province tends to be balanced, and the overall network no longer relies too much on the intermediary role of Changsha and Hengyang.

Keywords

Gravity Models; Social Network Analysis; Economic Linkages; Spatial Patterns.

1. Introduction

Regional economic linkage is a comprehensive concept, which is expressed as the exchange of goods, labor services, capital and information in the relevant regions. In-depth study of regional economic connections is of great significance for optimizing the industrial layout and resource allocation in the region and promoting the coordinated development of the region[1]. Existing research shows that the economic connection network takes the region as the carrier and the economic activity as the basis, and accelerates the flow of elements in the network through agglomeration and radiation effects, thereby promoting the coordinated development of the regional economy[2]. It can be seen that studying the economic connection network of Hunan Province, clarifying the characteristics of economic space connection, and grasping the evolution law of the economic space pattern are of great significance for promoting the integrated development of the Changsha, Zhuzhou and Tianjin region and its surrounding cities and forming a new development pattern of regional coordination.

2. Literature Review

The proposal of "spatial interaction theory" and "spatial diffusion theory" in the metrology revolution that emerged in the 1950s established a sufficient theoretical basis for the study of regional economic linkages. At the same time, with the acceleration of economic globalization, this horizontal interregional Contact research has gradually become a frontier field of regional geography research[3]. The current research on regional economic linkages shows the following trends:

(1) From the perspective of research objects, with the development of the trend of regional economic integration in the international economy since the second half of the 20th century, the scope of research on regional economic linkages has gradually expanded from the initial analysis of radiation flows inside and outside a single city[4]to Measurement of the strength of

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economic ties in adjacent areas[5]and analysis of the spatial pattern of economic ties in urban agglomerations and national strategic areas [6,7].

(2) From a research perspective, there are many entry points for regional economic linkage research, ranging from trade flow[8]and aviation flow[9]in early foreign research to the current domestic tourism economy[10], high-speed rail network[11], etc. are involved.

(3) From the perspective of research methods, most of the existing studies have used traditional gravity model[12], urban flow intensity[13] and passenger and cargo flow[14]to measure the strength of economic links. Gravity models have been improved to varying degrees[15,16]. Later, with the in-depth development of various disciplines, the research methods of geography and management disciplines have been gradually adopted and promoted in the related research on regional economic relations. Among them, ArcGIS spatial analysis[17] and social network analysis method [18]are more Popularity.

(4) In addition, many domestic scholars have also conducted in-depth research on the main economic links in the region. Zhou Xing[19]proceeded from theoretical analysis and believed that under the background of spatial heterogeneity of regional development, there is a certain regularity between the spatial structure of the urban system and the direction of main economic connections, and based on this, he proposed the theory of main economic connection directions. Meng Deyou and Lu Yuqi[20] started with empirical research, and by measuring the strength and direction of regional economic linkages in Henan Province, they investigated the formation mechanism of the Central Plains urban agglomeration and the spatial structure characteristics of the urban system in Henan Province, and further verified and improved what Zhou Xing proposed. theory.

Although domestic and foreign scholars have made useful explorations on the research on regional economic linkages, there is still room for improvement in measurement methods and research objects. First, the traditional gravitational model has a single measure of the strength of economic ties, which cannot comprehensively reflect the economic ties between regions from multiple aspects, and most scholars only start with a single variable in the revision of the gravitational model, lacking a comprehensive and multi-angle approach. correction plan. Second, most of the research on the spatial pattern of economic linkages takes Beijing-Tianjin-Hebei, Yangtze River Delta, Guangdong-Hong Kong-Macao and other important urban agglomerations and national-level strategic areas as research objects, mainly analyzing the economic linkages between inter-provincial regions, and for regional economic linkages within the province. There are relatively few studies on it, and the coordinated development of regions within a province is an important basis for ensuring the coordinated development of inter-provincial regions. The study of regional economic connections within a province can enrich the relevant research on coordinated regional development to a certain extent and has practical significance. As the ninth largest province in China and the third largest province in central China, Hunan Province has a relatively developed economy as a whole, but its development pattern is not balanced, with obvious regional differences. In view of this, this paper modified the gravity model based on the comprehensive quality of the city and the perspective of time distance, made a visual analysis of the evolution of the spatial pattern of economic linkages in Hunan Province, and used the social network analysis method to further verify the conclusions obtained.

3. Data Sources and Research Methods

3.1. Data Sources

This paper uses the improved gravity model to measure the economic connection strength of 13 prefecture-level cities in Hunan Province from 2008 to 2020. The original data for calculating the comprehensive quality of the city in the gravity model comes from the "Hunan

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Statistical Yearbook" over the years, and some data from the Xiangxi Tujia and Miao Autonomous Prefecture are temporarily unavailable, so they are not included in the research scope, and the missing data of other prefecture-level cities use the average ratio. Complement the law. The time distance between local-level cities refers to most literatures, and the time data of recommended driving routes in Baidu Maps shall prevail.

3.2. Gravity Model Correction

The existing literatures mainly use three methods to measure the strength of economic linkages: the gravity model, the urban flow strength and the passenger and cargo flow. Among them, the traditional gravity model data acquisition is relatively simple, and the operability is strong, but only the urban population size and economic aggregate cannot fully reflect the comprehensive quality of the city, and the shortest geographical distance cannot reflect the actual traffic cost between cities[21]. The urban flow intensity can evaluate its outward function by calculating the influence of the external agglomeration and radiation of each city in the region, but it cannot reflect the strength of the economic connection between the two cities. Although passenger and cargo flow can assess the strength of economic links between cities to a certain extent, it is difficult to comprehensively reflect the characteristics of economic links between cities from the single aspect of passenger and cargo flow. Therefore, this paper selects a gravitational model with strong operability as a method for measuring regional economic connections, and corrects the traditional gravitational model by establishing a comprehensive urban quality evaluation system and introducing time distance. The specific correction process is as follows:

3.2.1. Establishment of a Comprehensive Urban Quality Evaluation System

This paper refers to the indicator system and existing literature developed by the Urban Department of the National Bureau of Statistics and the Urban Statistics Branch of the China Statistical Association and the existing literature, combined with the principles of data authenticity and availability, and proposes a comprehensive economic strength, social development level, basic Urban comprehensive quality evaluation system including 4 first-level indicators and 15 second-level indicators of facility construction and population size (see Table 1).

Table 1. Urban comprehensive quality evaluation system

Primary indicator	Secondary indicator	Weight
Comprehensive economic strength	Gross Regional Product (100 million yuan)	0.1019
	Fixed asset investment (100 million yuan)	0.1121
	Per capita disposable income of urban residents (yuan)	0.0230
	The added value of the tertiary industry as a percentage of GDP (%)	0.0075
Degree of social development	Total retail sales of consumer goods (100 million yuan)	0.1184
	Total number of beds in health institutions (pieces)	0.0465
	Number of full-time teachers in colleges and universities (person)	0.2372
	Education expenditure (10,000 yuan)	0.0625
	R&D intensity (%)	0.0679
infrastructure	Total post and telecommunications business (100 million yuan)	0.1233
	Public transport vehicles per 10,000 people (benchmark)	0.0276
	Per capita park green space (square meters)	0.0085
	Daily domestic water consumption per capita (liters)	0.0110
Population size	Total permanent population at the end of the year (10,000 people)	0.0203
	Urban population (10,000 people)	0.0325

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3.2.2. Time Distance Correction

In the traditional gravity model, the distance between two cities generally adopts the geographic distance, but this distance only measured from the perspective of space cannot fully reflect the difficulty of interaction between cities. With the development of road facilities and transportation, the distance between cities has been gradually replaced by the time cost and currency cost of transportation between the two places. Time has become an important factor in regional economic relations. Therefore, this paper replaces the traditional geographic distance with the time distance that can more accurately reflect the potential energy of interaction between cities, and uses the time data of the recommended driving routes in Baidu Maps to get the time distance between various cities in Hunan Province.

3.2.3. Modified Gravity Model Form

The traditional gravitational model is modified from the perspective of comprehensive urban mass and time distance, and the calculation formula is:

$$F_{ij} = k_{ij} \frac{M_i M_j}{D_{ij}^2}, (k_{ij} = \frac{M_i}{M_i + M_j}) \quad (1)$$

$$TF_i = \sum_j F_{ij} = \sum_j k_{ij} \frac{M_i M_j}{D_{ij}^2} \quad (2)$$

This study assumes that the economic connection strength between cities is directional. In formula (1) F_{ij} is the economic connection strength of city i to city j; k_{ij} is the contribution rate of city i to city; M_i and M_j is the comprehensive quality of cities i and j measured by the evaluation system; D_{ij} is the time distance between city i and city j; in formula (2) TF_i is the total economic connection of city i.

4. Analysis on the Evolution of Economic Contact Strength

4.1. Economic Ties Strength Measure

Using the 2008-2020 "Hunan Provincial Statistical Yearbook" data and the time distance matrix of prefecture-level cities in Table 2, according to the entropy method and formulas (1) and (2), the comprehensive urban quality M_i and economy of prefecture-level cities over the years were calculated. Contact the total amount TF_i, select 2008, 2014 and 2020 as the representative years, and the results are shown in the following table.

It can be seen that on the whole, the comprehensive quality and total economic linkages of prefecture-level cities are on the rise. There are significant differences between them, showing obvious non-equilibrium distribution characteristics. Changsha is far ahead of other cities, and surrounding cities such as Zhuzhou, Xiangtan, Yueyang, Hengyang, etc. are also performing relatively well, but Zhangjiajie, Huaihua and other cities far away from Changsha, Zhuzhou and Tan have low overall quality and total economic connections, and the growth rate is not obvious . At the same time, it can be found that the cities with the highest economic linkages are generally more developed, while the lower ranked cities are generally lagging behind, which indicates that there is a certain positive correlation between the total economic linkages of cities and their economic development level, which is consistent with the current situation. Studies have come to the same conclusion.

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Table 2. Urban Comprehensive Quality and Total Economic Connections

City	2008		2014		2020	
	M_i	TF_i	M_i	TF_i	M_i	TF_i
Changsha	0.44970	0.12940	0.67298	0.28400	0.91792	0.53696
Zhuzhou	0.15023	0.04268	0.21771	0.08942	0.30011	0.16927
Xiangtan	0.13935	0.04305	0.19637	0.08697	0.26130	0.15720
Hengyang	0.15370	0.02364	0.22949	0.05208	0.33192	0.10789
Shaoyang	0.10900	0.01205	0.16423	0.02681	0.25006	0.06042
Yueyang	0.14172	0.01253	0.21092	0.02754	0.27400	0.04812
Changde	0.13117	0.01397	0.19908	0.03146	0.26734	0.05825
Zhangjiajie	0.05321	0.00156	0.06887	0.00269	0.09515	0.00517
Yiyang	0.09696	0.01502	0.14491	0.03330	0.21438	0.07100
Chenzhou	0.11291	0.00571	0.18365	0.01433	0.24260	0.02597
Yongzhou	0.10451	0.00935	0.14696	0.01891	0.22937	0.04434
Huaihua	0.10317	0.00376	0.13150	0.00648	0.20098	0.01468
Loudi	0.09497	0.01344	0.13692	0.02810	0.19241	0.05584
average value	0.14158	0.02509	0.20797	0.05401	0.29058	0.10424

5. Analysis on the Evolution of Economic Contact Network Structure

In the entire economic connection space of Hunan Province, each city is a "node", and the economic connection between cities is a "line", which together constitute a complete economic connection network. This paper is based on the directed matrix of the economic connection strength of various cities in Hunan Province measured by the improved gravity model, and refers to the “means principle method” adopted by Li Lin and Niu Tingyu[22]. The average value of economic connection strength in 2008 is used as the connection. Threshold binarizes the calendar year matrix. After calculation, the mean value of economic ties in the base year is 0.00193. Therefore, economic ties greater than or equal to 0.00193 are considered to have economic ties, and the value is assigned 1; In order to avoid the appearance of closed sub-rings in the network, it is assumed that city i has no economic connection with itself, and the value is 0. After the above data processing, the Ucinet software is used to analyze the evolution of the economic connection network structure in Hunan Province.

5.1. Analysis of the Evolution of Network Centrality

Network centrality can reflect the status and role of each city node in the economic network, and it mainly has three forms: point centrality, betweenness centrality and proximity centrality[23]. Since the closeness centrality analysis has very strict requirements on the completeness of the network, and its conclusion is basically the same as that of the point degree centrality analysis, this paper mainly examines the characteristics of each city node in the network through the point degree centrality and betweenness centrality. The three time sections 2008, 2014 and 2020 are used as representative years.

5.1.1. Point Degree Centrality Analysis

Point-degree centrality can be divided into point-out degree and point-in degree. Point-out degree represents the radiation effect of city i on other cities in the region, and point-in degree represents the radiation effect of city i by other cities in the region. The larger the point degree centrality, the higher the core status of the city node in the entire network, and the stronger the

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ability to gather and radiate resources. The calculated point centrality data are shown in the following table.

Table 3. Economic connection network point degree centrality

City	2008			2014			2020		
	click-out	click-in	sort	click-out	click-in	sort	click-out	click-in	sort
Changsha	10	6	1	12	8	1	12	10	1
Zhuzhou	4	3	4	8	7	2	10	10	3
Xiangtan	5	3	3	8	8	3	10	10	4
Hengyang	6	4	2	8	7	4	11	10	2
Shaoyang	2	4	5	5	6	8	10	10	5
Yueyang	1	1	9	5	5	9	8	7	8
Changde	2	2	7	7	5	5	9	8	6
Zhangjiajie	0	0	11	0	2	12	0	2	13
Yiyang	2	3	6	6	7	6	8	8	9
Chenzhou	0	1	13	1	2	11	6	6	11
Yongzhou	2	3	8	2	3	10	7	7	10
Huaihua	0	0	12	0	1	13	2	3	12
Loudi	1	5	10	6	7	7	9	11	7
average value	2.69	2.69	—	5.23	5.23	—	7.85	7.85	—

The study found that: (1) The average point-degree centrality of the economic connection network from 2008 to 2020 has been greatly improved. Among them, the three cities whose point-out degree and point-in degree are higher than the average value of the year are Changsha, Zhuzhou, Xiangtan, Hengyang shows that these cities have a strong ability to gather and radiate resources, and among them, Changsha and Hengyang are more prominent. (2) On the whole, Changsha surrounding cities such as Zhuzhou, Xiangtan, Changde, etc. have a more significant increase in point centrality than southern and western cities. This is mainly due to geographical proximity and other reasons. These cities are driven by the radiation effect of Changsha. bigger. By 2020, the top-ranked cities in Diandu centrality are basically located in the Changsha-Zhuzhou-Xiangtan area, with significant spatial differentiation characteristics.

5.1.2. Betweenness Centrality Analysis

The betweenness centrality reflects the bridge and intermediary role of city nodes in the economic connection network. The greater the betweenness centrality of city i, the greater the dependence of other city nodes on its intermediary role in the network. The calculated betweenness centrality data are shown in the table below.

The study found: (1) In 2008 and 2014, the betweenness centrality of Changsha and Hengyang was far greater than the average and far ahead of other cities. Especially in 2008, there were as many as 6 cities with a betweenness centrality of 0, and there were still 5 cities in 2014. These two cities strictly controlled the flow and direction of regional resources during this period, and other cities were extremely dependent on their bridge and intermediary roles. The network structure at this time is very unstable, and the absence of these two important city nodes can easily lead to the paralysis of the entire economic connection network. (2) Compared with 2008 and 2014, the intermediary centrality of Changsha and Hengyang dropped significantly in 2020, and the intermediary centrality of surrounding cities increased, indicating that the overall economic development was less dependent on the intermediary role of Changsha and Hengyang. The city's ability to control resources is gradually increasing.

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Table 4. Betweenness centrality of economic connection network

City	2008		2014		2020	
	Centrality	Sort	Centrality	Sort	Centrality	Sort
Changsha	46.67	1	31.53	1	11.54	1
Zhuzhou	0.00	8	3.70	5	2.71	7
Xiangtan	2.50	5	5.53	3	2.71	6
Hengyang	23.17	2	21.33	2	5.54	4
Shaoyang	9.50	4	4.17	4	8.93	2
Yueyang	0.00	9	0.00	10	0.00	10
Changde	0.00	13	2.20	6	4.14	5
Zhangjiajie	0.00	11	0.00	9	0.00	11
Yiyang	0.50	7	2.03	7	0.14	9
Chenzhou	0.00	10	0.00	13	0.00	13
Yongzhou	16.00	3	0.00	11	0.33	8
Huaihua	0.00	12	0.00	12	0.00	12
Loudi	0.67	6	1.50	8	6.94	3
average value	7.62	—	5.54	—	3.31	—

5.2. Core-periphery Structure Evolution Analysis

The core-periphery structure is a special structure that reflects the importance of a city node in the economic connection network. It divides each city node into tightly connected core members and sparsely scattered non-core members. Through the core-periphery absolute model to analyze the economic connection network of Hunan Province (see Table 6), it can be seen that the number of cities in the core area is increasing steadily, from Changsha, Zhuzhou, Xiangtan and Hengyang in 2008 to 2020. Changsha, Zhuzhou, Xiangtan, Hengyang, Shaoyang, Changde, Yiyang, Yueyang, Loudi, it can be seen that the densely connected areas of the network are gradually expanding. There is increasing spatial dominance in contact networks. Further, the core degree calculated by the core-edge continuum model is used for analysis, and Table 7 is obtained. It can be seen from the table that the core degree of Changsha in 2008 was 0.71, while the core degree of most other prefecture-level cities in the same period was much lower than that of Changsha. The overall network showed the instability of Changsha's obvious core position and the lack of network sub-center cities. structure. By 2020, the core degree of Changsha will be greatly reduced, and the core degree of the urban agglomeration around Changsha, Zhuzhou and Tan will generally increase, indicating that the network is less dependent on a single core city, Changsha, and the urban agglomeration around Changsha, Zhuzhou and Tan has gradually grown into a new core to promote economic development. , the new growth pole. In addition, there are still a few cities, such as Zhangjiajie, whose core degree has always been low or even zero, indicating that it is necessary to find new "intermediary cities" to promote the coordinated development of such cities.

Table 5. Core-Edge Absolute Model Analysis

Year	fit	No.	City
2008	0.782	1	Changsha, Zhuzhou, Xiangtan, Hengyang
		2	Shaoyang, Yueyang, Changde, Zhangjiajie, Yiyang, Chenzhou, Yongzhou, Huaihua, Loudi
2014	0.593	1	Changsha, Zhuzhou, Xiangtan, Hengyang, Shaoyang, Yueyang, Changde, Yiyang, Loudi
		2	Zhangjiajie, Chenzhou, Yongzhou, Huaihua
2020	0.850	1	Changsha, Zhuzhou, Xiangtan, Hengyang, Shaoyang, Changde, Yiyang, Yueyang, Loudi
		2	Zhangjiajie, Chenzhou, Yongzhou, Huaihua

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Table 6. Core-Edge Continuity Model Analysis

City	2008		2014		2020	
	Core degree	sort	Core degree	sort	Core degree	sort
Changsha	0.71	1	0.42	1	0.35	1
Zhuzhou	0.34	4	0.40	2	0.34	3
Xiangtan	0.39	2	0.40	3	0.34	4
Hengyang	0.36	3	0.32	4	0.35	2
Shaoyang	0.02	9	0.21	9	0.31	6
Yueyang	0.15	7	0.26	8	0.28	7
Changde	0.19	5	0.31	5	0.28	8
Zhangjiajie	0.00	11	0.00	12	0.00	13
Yiyang	0.19	6	0.31	6	0.28	9
Chenzhou	0.00	12	0.04	11	0.20	11
Yongzhou	0.08	8	0.07	10	0.24	10
Huaihua	0.00	13	0.00	13	0.06	12
Loudi	0.00	10	0.30	7	0.31	5

6. Conclusions and Countermeasures

The main research conclusions are as follows: (1) The overall level of economic linkages in Hunan Province has been greatly improved, but regional economic linkages still have obvious spatial differentiation characteristics. The densely connected areas are mainly concentrated in the Chang-Zhu-Tan area, and the economic connection strength between most of the other cities is at a low level. At the same time, there is no obvious sub-center city in the network, which cannot have a strong radiation and driving effect on the peripheral areas. (2) The structure of the economic connection network in Hunan Province tends to be balanced. The centrality of the surrounding cities of Changsha, Zhuzhou and Tan has improved significantly, and the ability to control resources and economic connections between them has been greatly improved. The pattern of two important cities in Hengyang has changed, and a pattern of promoting the province's economic development with the regional integration of Changsha, Zhuzhou and Tan has gradually formed.

In view of the above research conclusions, the following policy suggestions are put forward to optimize the economic connection network of Hunan Province and promote the coordinated development of regions. First, guide cities to rationally deploy industries based on their own resource endowments, and improve urban economic levels through industrial development. At the same time, it is necessary to establish an industrial synergy mechanism to promote the coordinated development of inter-regional industries and form high-quality high-quality products with distinctive features and complementary advantages. development pattern. Specifically, Chang-Zhu-Tan can rely on its strong economic strength and relatively complete innovation system and mechanism to focus on the development of advanced manufacturing and modern service industries; Loudi, due to its energy advantages, can vigorously develop steel and chemical industries as leading industries. Second, speed up the construction of interconnection infrastructure such as the "3+5" intercity railway network, and build a "half-hour commuting circle" and "one-hour economic circle" in the Changsha-Zhuzhou-Xiangtan region to promote the efficient flow of resource elements and enable them to Better radiation to drive the development of surrounding areas.

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References

[1] H.H. He, B. Lv. A study on the measurement of economic linkages in the Chang-Zhu-Tan urban agglomeration. Economic Geography, Vol. 34(2014) No.7, p.67-74.

[2] Y.X. Zhong, X.H. Feng, Y.Z. Wen. Research on the evolution of economic network structure in the Yangtze River Economic Belt and its driving mechanism. Geography, Vol. 36(2016) No.1, p.10-19.

[3] C.F. Li. Interregional connections-Recent Frontiers of Regional Geography. Acta Geographica Sinica, Vol. 16(1995) No.1, p.491-496.

[4] S.M. Yao, D. Wang, F. Ye. The economic radiation function and development trend of Xiamen Special Economic Zone. Acta Geographica Sinica, Vol. 2(1989) No.26, p.140-146.

[5] S. Qian, F.H. Tang, Y. Tang. An economic tie network-structure analysis of urban agglomeration in the middle reaches of Changjiang River based on SNA. Journal of Geographical Sciences, Vol. 25(2015) No.6, p.117-125.

[6] S.Y. Wang, Y.N. Song, H.W. Wen, et al. The network structure of urban agglomeration in the Yangtze River Economic Belt from the perspective of two-way connection: Based on time distance and social network analysis methods. Economic Geography, Vol. 39(2020) No.2, p.73-81.

[7] Y. Huang, T. Hong, T. Ma. Urban Network Externalities, Agglomeration Economies and Urban Economic Growth. Cities, Vol. 28(2020) No.8, p.107-118.

[8] Simeon Djankov, Caroline Freund. Trade Flows in the Former Soviet Union, 1987 to 1996. Journal of Comparative Economics, Vol. 30(2002) No.1, p.76-90.

[9] Hidenobu Matsumoto. International urban systems and air passenger and cargo flows: some calculations. Journal of Air Transport Management, Vol. 10(2004) No.4, p.239-247.

[10] Q.B. Shi, Y.S. Xie, Z.L. Han, et al. The Spatial Structure and Development Model of Tourism Economic Connections between Northeast Cities. Economic Geography, Vol. 38(2018) No.11, p.211-219.

[11] H.L. Yan, Q. Wang, H. Xiong, et al. The impact of China's "four vertical and four horizontal" high-speed rail on the accessibility of cities along the line and its economic connection. Economic Geography, Vol. 40(2020) No.1, p.57-67.

[12] B. Wang, A. Sun, Q.X. Zheng, et al. Spatio-Temporal Characteristics of Green Development Cooperation Network among Belt and Road Initiative Regions and Countries Sustainability, Vol. 13(2021) No.20, p.34-46.

[13] C. Liang, J. Zeng. The measurement of network connections in the Beijing-Tianjin-Hebei urban agglomeration from the perspective of urban flow. Urban Issues, Vol. 25(2020) No.1, p.78-83.

[14] Miller J, Horowitz E. Algorithms for real-time gathering and analysis of continuous-flow traffic data. Intelligent Transportation Systems Conference, Vol. 25(2006) No.8, p.1454-1459.

[15] X.M. Liu, X.H. Hu Ye, N.Y.Liu. Analysis of tourism economic linkages in Beijing-Tianjin-Hebei urban agglomeration: Based on an improved gravity model. China Circulation Economy, Vol. 34(2020) No.2, p.121-128.

[16] Y.Q. Ou, Y.S. Qian, J.W. Zen, et al. Research on the spatial pattern of traffic accessibility and economic connection in Guanzhong urban agglomeration. Vol. 28(2021) No.16, p.136-149.

[17] L. Li, L.J. Cai. The spatiotemporal evolution characteristics of urban economic connections in the middle delta urban agglomeration. Urban Issues, Vol. 25(2015) No.7, p.62-70.

[18] R.J. Zhang, H.W. Tai, K.T. Cheng, et al. Analysis on Evolution Characteristics and Dynamic Mechanism of Urban Green Innovation Network: A Case Study of Yangtze River Economic Belt. Sustainability, Vol. 14(2021) No.1, p.86-97.

[19] Y.X. Zhou. The main economic connection direction. Urban Planning, Vol. 13(1998) No.2, p.3-5.

[20] D.Y. Meng, Y.Q. Lu. Strength and direction of regional economic connection in Jiangsu based on gravity model. Advances in Geography, Vol. 28(2009) No.5, p.697-704.

[21] J.K. Yu, J.Q. Ma. Research on the evolution of the spatial pattern of economic connections in Shandong Peninsula urban agglomeration. Geographical Sciences, Vol. 38(2018) No.11, p.1875-1882.

ISSN: 2692-7608 DOI: 10.6981/FEM.202207_3(7).0018

[22] L. Li, T.Y. Niu. The evolution of spatial correlation network structure of regional innovation output based on SNA. Economic Geography, Vol. 37(2017) No.9, p. 19-25+61.

[23] J. Liu:Lecture Notes on Overall Network Analysis(Gezhi Publishing House, China 2014).