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Research on the spatial pattern of Hefei metropolitan area based on improved urban gravity model

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ABSTRACT. *This paper improves the urban gravity model in terms of economic quality and economic distance, and measures the economic connections between cities in the Hefei metropolitan area in 2018. The results show that: Hefei has the highest economic quality and far ahead, followed by Wuhu City and Ma'anshan City; the highest gravitational value between Hefei City and Lu'an City, Ma'anshan City and Wuhu City, Hefei City and Wuhu City ranked second and third; Hefei City as a "leading" city, other cities The gravitational force is much greater than the gravitational forces of other cities, and its radiation driving effect is more significant.*

KEYWORDS: *Urban gravity model, Hefei metropolitan area, entropy method*

1. Introduction

The metropolitan area is composed of one or more large cities or mega cities with relatively developed economies and strong urban functions in a specific geographical area, and is composed of a series of small and medium-sized cities of different nature, scale and grade. Regional spatial organization with similar geographical locations, closely related functions, and economic integration [1]. In 2006, Anhui Province put forward the concept of "Hefei Economic Circle" for the first time, and promulgated "Several Opinions on Accelerating the Construction of Hefei Economic Circle" in the same year; in 2016, the State Council formulated the "Development Plan of the Yangtze River Delta City Cluster", Hefei Metropolitan Circle Became one of the five metropolitan areas in the Yangtze River Delta urban agglomeration. [2] The Hefei metropolitan area includes 7 prefecture-level cities including Hefei, Huainan, Lu'an, Chuzhou, Wuhu, Ma'anshan and Bengbu, with 41% of the province's area and 43.2% of the province's population. As the core city of the metropolitan area, Hefei can play a leading role in radiation and promote coordinated regional development.

Interregional economic relations are often measured by the strength of the

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interaction, and the gravity model is a relatively mature measurement method. In the early stage of the study, population and gross national product were generally used as the measurement standards of urban quality, and the spatial distance or highway mileage was used as the distance between the two places. Wang Haijiang et al. used data from 2000 and 2009 to estimate the national provincial economic links. The spatial pattern shows that the strengthening of economic links between cities promotes the development of urban agglomerations [3].With the deepening of research, scholars believe that the indicators such as urban population and GDP are relatively single, and cannot comprehensively measure the quality of the urban economy. At the same time, with the advancement of transportation methods, the inter-city accessibility continues to increase, and the traditional geographic distance is not being able to measure the "economic distance" between regions, based on this, the gravity model has been continuously improved. Qian Chunlei, etc. selected five first-level indicators such as economic development, social development, and residents' quality of life to measure urban competitiveness, used fast railways, ordinary railways, and highways to calculate the distance between urban transportation costs, and used an improved urban gravity model to study Economic connection of Wuhan City Circle [4]; Guo Yuanyuan, etc. built an index system to improve the "city quality" and "inertia index" in the gravity model, and measured the attractiveness of 14 cities in Hunan [5].

In summary, this article uses the improved urban gravity model to select the relevant data of each city in 2018, the railway query network and the bus ticket query network data in Hefei Metropolitan Area, to measure the economic gravity between the cities in Hefei Metropolitan Area, and to study the inter-city Reasons for the strength of radiation driving.

2. Research methods and data sources

2.1 City gravity model

The classic urban gravitational model expresses the strength of the economic connection I_{ij} between region i and region j as:

$$I_{ij} = G\frac{M_i M_j}{d_{ij}^b}$$

In the formula: I_{ij} is the strength of economic connection between city i and city j, M_i and M_j are the economic quality of city i and city j, d_{ij} is the distance coefficient between the two places, b is the distance friction coefficient, G is the empirical constant, Usually assigned a value of 1.

2.2 Gravity model improvement

2.2.1 Improvement of economic quality.

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In this paper, based on the research of various scholars, 15 evaluation indicators were selected from five aspects of economic development level, financial development quality, residents' quality of life, urban construction level and urban service capacity to comprehensively evaluate the urban economic quality, and the entropy method was used to calculate each The weight of each index is shown in Table 1.

Table 1 City Economic Quality Evaluation System of Hefei Metropolitan Area

Target layer	Criterion layer	Indicator layer	Weights
Economic quality of cities in Hefei metropolitan area	The level of economic development	GDP（X_1）	0.0767
		Local fiscal revenue（X_2）	0.0757
		Total industrial assets above designated size（X_3）	0.0493
		The total retail sales of social consumer goods（X_2）	0.0661
	Financial development quality	Total deposits and loans of financial institutions（X_2）	0.1224
	Resident quality of life	Number of employees（X_2）	0.0347
		Disposable income（X_2）	0.0355
		Number of family cars（X_2）	0.0521
		Electricity consumption of urban and rural residents（X_2）	0.0592
	City construction level	Urban road area per capita（X_2）	0.0493
		Park area per capita（X_2）	0.0421
		Built-up area（X_2）	0.0810
	Urban service capacity	Number of universities（X_2）	0.1339
		Number of medical and health institutions（X_2）	0.0346
		Total passenger traffic（X_2）	0.0872

It can be seen from Table 1 that the weights of the total deposits and loans of financial institutions and the number of colleges and universities both exceed 0.1, indicating that there are large differences in finance and education among cities in

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the Hefei metropolitan area. From the criterion level, the weight of economic development level is the largest.

2.2.2. Improvement of economic distance

The concept of urban spatial distance can not really reflect the spatial interaction between cities. It is necessary to comprehensively consider the time cost (T_{ij}) and currency cost (C_{ij}) between cities [6], the formula is as follows:

$$D_{ij} = \sum_{k=1}^{n} \lambda_k T_{ij}\, C_{ij}$$

In the above formula, D_{ij} is the economic distance between city i and city j, λ_k is the weight of transportation mode k; T_{ij} is the time between two cities in transportation mode k as time cost, and C_{ij} is the fare between two cities in transportation mode k as currency cost.

2.3 Data sources

This article takes 7 prefecture-level cities in the Hefei metropolitan area as research objects. The urban economic quality data comes from the "Anhui Statistical Yearbook 2019". The currency cost and time cost in economic distance are from the 12306 train ticket query website and the bus ticket query website.

3. Research results of the spatial pattern of Hefei metropolitan area

3.1 City economic quality calculation

According to the weight of each indicator, the comprehensive score of economic quality of each city in the Hefei metropolitan area is calculated, see Table 2.

Table 2 Economic quality values of cities in Hefei Metropolitan Area

project	city						
	Hefei	Bengbu	Huainan	Chuzhou	Lu'an	Maanshan	Wuhu
Economic quality	0.9121	0.1197	0.0758	0.1715	0.1307	0.1768	0.2435

The economic quality of Hefei City is 0.9121, much higher than other cities, and all kinds of resource elements are relatively concentrated. This is consistent with Hefei's status as a core city in the metropolitan area, and can play a regional leading role and radiation role. The economic quality of Wuhu City and Ma'anshan City ranks second and third. These two cities developed earlier in the province, and the economic quality is at the forefront. At the same time, Wuhu City and Ma'anshan

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City are closer to Nanjing City. The city is affected by the economic radiation of Nanjing City. The effect is stronger, and the transportation level of these two cities is also higher.

3.2 City gravity analysis

According to the improved urban gravity model, the gravity value in Hefei metropolitan area is measured. The results are shown in Table 3.

Table 3 City Comprehensive Gravity Matrix of Hefei Metropolitan Area

	Hefei	Lu'an	Huainan	Chuzhou	Wuhu	Maanshan	Bengbu
Hefei		0.2919	0.1497	0.0924	0.1884	0.1178	0.1006
Lu'an	0.2919		0.0137	0.0102	0.0112	0.0076	0.0094
Huainan	0.1497	0.0137		0.0106	0.0841	0.0995	0.0398
Chuzhou	0.0924	0.0102	0.0106		0.0404	0.0420	0.0220
Wuhu	0.1884	0.0112	0.0841	0.0404		0.2754	0.0125
Maanshan	0.1178	0.0076	0.0995	0.0420	0.2754		0.0011
Bengbu	0.1006	0.0094	0.0398	0.0220	0.0125	0.0011	

It can be seen from the above table that the gravity value between Hefei City and Lu'an City reached 0.2919, which is the highest; followed by Ma'anshan City and Wuhu City, the gravity value is 0.2754; the gravity value of Hefei City and Wuhu City ranked third, Is 0.1884. However, the gravitational values between other cities are all less than 0.15. The smallest gravitational values are Ma'anshan City and Bengbu City, which is only 0.0011, which is close to 0, indicating that the interaction between these two cities is small.

Hefei and other cities occupy two seats in the top three cities of gravitational value, indicating that Hefei has a significant radiation effect as a core city. Hefei and Lu'an have the closest economic ties, which is in line with the original idea of the Hefei metropolitan area to include Lu'an City. The gravitational value of Wuhu City and Ma'anshan City ranked second, thanks to the higher economic quality value of these two cities. The gravitational values of Wuhu and Bengbu Hefei and Wuhu are relatively high, which shows that it is scientific and reasonable for the "Yangtze River Delta Urban Cluster Development Plan" to include them in the construction of the Hefei metropolitan area. According to the gravitational value between cities, ARCGIS is used to draw the comprehensive gravitational network of Hefei metropolitan area, as shown in Figure 1.

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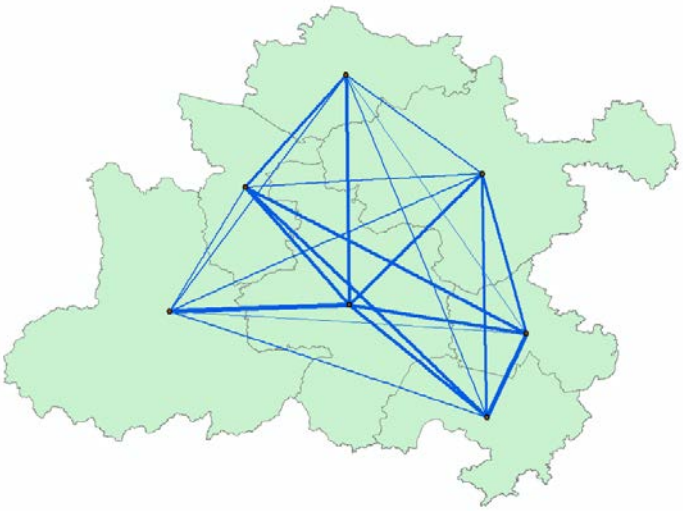

Figure 1 Hefei City Comprehensive Gravity Network

As can be seen from the above figure, as a "leading" city, Hefei has a greater attraction to other cities than other cities. This shows that Hefei plays a role in driving the development of other cities in the metropolitan area. The connection is weak. Wuhu City and Ma'anshan City are two important economic development areas. Improving the urban functions and economic development status of the two cities in the Hefei metropolitan area is an important direction for the future development of the Hefei metropolitan area.

4. Conclusion

This paper uses the improved urban gravity model to measure the economic connection between cities in the Hefei metropolitan area. The results show that Hefei has the highest economic quality and is far ahead, followed by Wuhu and Ma'anshan; between Hefei and Lu'an The highest gravitational value, the gravitation among Ma'anshan City and Wuhu City, Hefei City and Wuhu City ranked second and third; Hefei City as a "leading" city, the gravitational force of other cities is much greater than the gravitational force of other cities, and its radiation The driving effect is more significant. In this regard, this article believes that Hefei, as the core city in the metropolitan area, needs to further strengthen its economic radiation effect, and the cohesion of the cities in the Hefei metropolitan area needs to be improved. Each city should give full play to its own advantages, complement each other's advantages and disadvantages, and divide labor reasonably to jointly promote the Hefei metropolitan area. The improvement of economic strength requires strengthening cooperation between cities and promoting the realization of regional integration [7].

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