Research on Interaction among Cities in Urban Agglomeration

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Abstract: Aiming at the interaction intensity problem of cities in urban agglomeration, the gravity model of interaction among cities in urban agglomeration is set up to find the influence factors of the interaction and put forward the efficient method to promoting the interaction among cities in urban agglomeration. Firstly, analyzing the manifestation of the interaction and introducing traditional gravity model. Then, improving the city quality and distance measurement method and determine model. In the end, the interaction among cities in HuBaoOr urban agglomeration is obtained based on related data. The result indicated that with the repaid development of society, economic, transportation and communication, the contact of cities has been strengthened and the space interaction also increasing. The interaction is the requirement of cities’ normal operation and it also is the foundation of cities to achieve mutual benefit and seek further professional development. In this way, the researches on interaction among cities in urban agglomeration is very meaningful.

1. Introduction

With the acceleration of urbanization, aggregation of cities is strengthening and urban agglomeration will be an important trend of cities development in our country. At the same time, the interaction among cities in urban agglomeration play an important role in building and developing the economy relation between cities and urban agglomeration. On the one hand, the interaction can strengthen the contact between related cities and agglomeration. On the other, it can cause the vicious competition of cities in resources, elements and develop opportunity but it might cause damage to cities and agglomerations. The researches on interaction among cities in urban agglomeration is meaningful.

There has been some related research at the determination of cities interaction in urban agglomeration. Literature [1] put forward space interaction to introduce contact degree between two places. The study on the interaction among cities can be concluded as: First, the study methods renovate increasingly. Most researches use qualitative analysis [2], quantitative analysis [3] and combination of qualitative and quantitative analysis [4]. Due to the traffic OD data is difficult to get, theoretical model in literature [5] is relatively simple. It can be concluded that the study methods renovate increasingly with the deepening of research. Secondly, the data types are diverse in the research and they can be divided into static data and dynamic data. Static data in literature [6-9] which made up of city attribute, as GDP, population, investment, city space, time distance etc. usually be...
chosen. Thirdly, the measurement model is diversified. The frequently used method is the gravity model in literature [10-12], the urbanization curve in literature [13], traditional gravity model and reachability model.

In conclusion, aiming at determining the interaction among cities, many study have been made by domestic and overseas scholars, but most of them are limited in cities, very little on the interaction among cities and urban agglomeration. The interaction among cities in urban agglomeration closely affect the culture, transportation communication, so, improving the interaction force of cities’ interaction of urban agglomeration is imminent. Interaction among cities model is built by study the mechanism of cities interaction in urban agglomeration to judge interaction degree of cities and analyze the image factor of cities’ interaction intuitively. Providing the theoretical basis for promoting the communication among cities in urban agglomeration.

2. Traditional gravity model
There are many theory models on cities’ interaction, and Riley model, Converse model, gravity model and potential model are used more applied. This paper applies gravity model and improve the model. In the long-term study, scholars found that space interaction attenuate with distance and they try to use universal gravitation to describe it. The base gravity model is [5-13]

\[ I_{ij} = \frac{m_i \times m_j}{d_{ij}^b} \] (1)

In this equation, \( I_{ij} \) is the gravitation between city \( i \) and city \( j \); \( m_i, m_j \) is the quality of city \( i \) and city \( j \); \( d_{ij} \) is the distance between city \( i \) and \( j \); \( b \) is distance attenuation coefficient.

3. Improving of gravity model

3.1 Improving of measurement of city quality
The quality of the city in gravity model shows the comprehensive strength of the city, which shows the importance of the city in agglomeration, including population, materials, capitals, information and technology. Three sub-indexes in statistical yearbook are used to measure the overall quality of cities based on five factors of space interaction. The overall quality of cities is used to show cities’ comprehensive strength and measure the interaction among cities. As overall quality of cities is a comprehensive value, to comprehensively and systematically show the strength of the city and simplify data, principal components analysis is used to change the multiple variables that affect city strength into a few integrated factors. Use equation (2) to express the city strength in gravity model.

\[ m_i \times m_j = \sqrt{q_i \times q_j \times q_i G_j \times q_j G_i} \] (2)

In this equation, \( q_i \) is the population of city \( i \) in the end of the year, \( q^{NA}_i \) is non-agricultural population of city \( i \); \( q_j \) is the population of city \( j \) in the end of the year. \( G_i \) is the GDP of city \( i \); \( G_j \) is the GDP of city \( j \).

3.2 Improving of city distance measurement
The distance among cities reflect the interaction tendency among cities. It is wrong that just define \( d \) as the space distance between two cities. Simply use space distance cannot reflect the interaction between two areas, on the condition of market economy, distance has dissimilated to a concept that consist of economic cost and time cost. Therefore, transportation cost and time cost is used to measure the transport distance among cities, as equation (3) (4).

\[ d_{ij} = \sum_{k=1}^{n} X_k \sqrt{p_i p_j T_{ij}} \] (3)

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In equation (3) and (4), $d_{ij}$ is the comprehensive distance coefficient between i and j; $X_k$ is the weight of traffic mode k; $p_i$ is the radiation force of city i, $p_j$ is the radiation force of city j; $r_i$, $r_j$, $r_k$ are GDP, gross industrial output value and fixed assets investment of the city; $T_{ij}$ is the time cost of traffic mode k from city i to city j. In the model, running speed is 80 km/h for highway and 100 km/h for railway referring to Highway Engineering Technique Standard [4].

3.3 Determination of model

The value of $b$ is difficult to determining, and theory consider it as 1 or 2 [6]. However, research suggests that the value of $b$ is changing from 0.5 to 3. Considering relevant research results, we comprehensively consider distance attenuation coefficient as 1. Equation (5) can be used to calculate the strength of interaction action among cities in urban agglomeration.

$$F_{ij} = \sum_{k=1}^{n} X_k \sqrt{p_i p_j T_{ij}}$$

In the equation, $F_{ij}$ is the gravity between city i and j, $q_i$ is the population of city i in the end of the year, $q_{ni}$ is non-agricultural population of city i; $q_{nj}$ is non-agricultural population of city j, $q_j$ is the population of city i in the end of the year. $G_i$ is the GDP of city i, $G_j$ is the GDP of city j. $X_k$ is the weight of traffic mode k (k are 1 and 2 refer to highway and railway). $p$ is the radiation force of city i. $T_{ij}$ is the time cost of traffic mode k from city i to city j.

4. Space interaction calculation and characteristic analysis of HuBaoOr

4.1 Data source

Taking 26 cities, banners and counties in HuBaoOr urban agglomeration as research object, related data is obtained from Inner Mongolia Autonomous Region Yearbook of 2009; Getting the shortest distance of highway and railway among cities and taking the shortest time as time cost, in which running speed is 80 km/h for highway and 100 km/h for railway referring to Highway Engineering Technique Standard [4]. On this foundation, the spatial interaction of HuBaoOr urban agglomeration is studied.

4.2 Calculating of cities’ comprehensive strength

Using entropy method to conclude that the weight of highway in traffic system is 0.833, weight of railway in traffic system is 0.167 [4]. The comprehensive index of Hohhot, Baotou and Ordos stand for the value of the cities. It can be concluded that the comprehensive strength of Hohhot is 21655.89, the influence value is 8332002330; the comprehensive strength of Baotou is 32399.21, the influence value is 27901421168; the comprehensive strength of Ordos is 21640.19, the influence value is 32498030674. Total mileage of highway from Baotou to Hohhot is up to 163, railway is 106; total mileage of highway from Baotou to Ordos is up to 107, railway is 118; total mileage of highway from Hohhot to Ordos is up to 431, railway is 236 (The above data is from the Inner Mongolia Statistical Yearbook of 2014). By substitution of the data to equation (3), the traffic distance that reflect the interaction degrees among cities are concluded.
Table 1 HuBaoOr urban agglomeration of important city mutual distance

|               | Hohhot | Ordos     | Baotou     |
|---------------|--------|-----------|------------|
| Hohhot        | --     | 30606675405 | 28359645510 |
| Ordos         | 30606675405 | --       | 56008588602 |
| Baotou        | 28359645510 | 56008588602 | --         |

4.3 Calculation and analysis of space interaction

On the foundation of the analysis of cities’ comprehensive strength and transport distance, substitute the result into equation (5), the comprehensive indexes of cities are used to represent the value in urban agglomeration to calculate the interaction strength. In the end, the interaction values among cities and urban agglomeration that reflect the interaction strength are concluded in table 2.

Table 2 HuBaoOr urban agglomeration city important interaction value

|          | Hohhot | Ordos | Baotou |
|----------|--------|-------|--------|
| Hohhot   | --     | 0.0153| 0.024  |
| Ordos    | 0.0153 | --    | 0.013  |
| Baotou   | 0.024  | 0.013 | --     |
| Total    | 0.0393 | 0.0283| 0.037  |

As can be seen from table 2, the contribution rate to urban agglomeration space interaction of the interaction strength values of Hohhot, Baotou, Ordos are 0.48, 0.39, 0.13. It is obvious that the interaction strength between Hohhot and Ordos and the interaction strength between Baotou and Ordos are same and both of them are weak. The interaction strength between Hohhot and Baotou is the strongest but not much different. It follows that the space interaction system of HuBaoOr urban agglomeration is mainly distributed as zonal and well-distributed. The interaction strength among cities of urban agglomeration distribution of a pyramid-type structure, the maximum value of interaction strength is 0.024 and the minimum value is 0.013. Interaction strength values reduce with distance.

4.4 Analysis of the factors that influence economic space interaction strength of HuBaoOr urban agglomeration

It can be concluded from gravity model that two factors influence the interaction among cities in urban agglomeration and the one is the quality of urban agglomeration, the other is the distance among cities. The quality of urban agglomeration reflects the comprehensive of urban agglomeration and the distance among cities reflect the tendency of space interaction. The quantity of interaction factor and the interaction strength increase with the comprehensive strength getting high [11]. Except traffic location, politics, culture and industry etc. also affect the space interaction of urban agglomeration. The influence of industry is complementary industrial structures in urban agglomeration. Complementary industrial structures play an important role in improving agglomeration and dispersion of resources to reach its maximal effect and avoiding disorderly competition. There are two aspects of political influence, the one is the separation of administrative division and cultural
difference on the flow of resources in urban agglomerations, the other is the promotion of administrative power and cultural identity accelerating the flow of resource elements.

5. Conclusion
Cities are interacting with cities and urban agglomeration in space like the exchange of population, materials, capitals and technical information. The interaction combines the cities with a special relation and forming a certain structure and function of the organic whole. The gravity model of HuBaoOr urban agglomeration is built by analyzing the urban agglomeration. It concluded that in HuBaoOr urban agglomeration, the centralities of Hohhot and Baotou are obvious and Ordos need to be strengthen. An interaction link bond has been built among Hohhot, Baotou and Ordos and it strengthen the contact among cities in the urban agglomeration. The interaction expands with the bond and decrease with distance. The interaction strength inversely proportional to distance and is proportional to population, GDP and non-agricultural population. The problem of HuBaoOr urban agglomeration is that the overall strength is not powerful and the structure system is not perfect. It is suggested that HuBaoOr urban agglomeration should strengthen its comprehensive strength, expand it scale and optimize the urban agglomeration structure. And optimize the industrial division by optimizing business investment, industrial output value and information technology. Developing fast traffic, building a rapid transportation network, strengthening the accessibility of urban agglomeration, building an urban agglomeration with strong interaction among cities can promote the development of regional.

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