Study on the Spatial Connection of Beijing Tianjin Hebei Urban Agglomeration

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Abstract. The importance of close cooperation among cities can be seen from the development experience of mature urban agglomerations in the world. Compared with the Yangtze river delta and the Pearl River Delta urban agglomeration, cities in Beijing Tianjin Hebei urban agglomerations are in poor connection. This paper studies the internal linkages of Beijing Tianjin Hebei Urban Agglomerations, and finds that: in recent years, the overall spatial linkages of the urban agglomerations have been several times higher than that in 2007, but they show the characteristics of geographically "dense in the South and sparse in the north"; the main connection tracks within the urban agglomerations are roughly "inverted L", that is, the connection of "Beijing-Tianjin", "Beijing-Baoding-Shijiazhuang" and "Xingtai-Handan".

1 Introduction

The formation and healthy development of world-class urban agglomerations with different development modes all convey a truth: the importance of close cooperation among cities in urban agglomerations[1].The gap between Beijing Tianjin Hebei Urban Agglomeration (Hereinafter referred to as “BTA Agglomeration”) and the other two urban agglomerations (Yangtze river delta and Pearl River Delta urban agglomeration) is reflected in many aspects, such as economic level, evolution stage, integration state, and competitiveness of BTH Agglomeration is also weaker correspondingly. The important reason for these situations lies in the unreasonable spatial connection structure of urban agglomerations [2].The essential attribute of regional economy is spatial dependence[3]. Scientific quantification and improvement of intercity linkages promote the coordinated development of urban agglomerations and the process of regional integration[4]. The main linkages between cities can be divided into five types: nature, economy, technology, society and administration, each of which can be divided into various forms. The secondary classification of economic linkages includes linkages of infrastructure, trade, industry and capital. This paper focuses on linkages of economy[5].

This paper innovatively selects the data of 2007(No high-speed rail), 2013(High speed railway began service) and 2017(After the coordinated development of Beijing, Tianjin and Hebei has become a national strategy, Anyang has been included in the scope of BTA Agglomeration) to study the spatial connection structure of urban agglomeration. In addition, this paper selects the provincial capital cities around the city cluster, and brings them into the research scope, thus breaking the idea of only limiting the perspective within the city cluster, and can more directly show the importance of administrative divisions.

2 Research area and research method

2.1 Research area

In February 2016, The national economic and social development plan of Beijing, Tianjin and Hebei during the 13th Five Year Plan period specified that Beijing Tianjin Hebei Urban Agglomeration covers Beijing, Tianjin, 11 cities in Hebei province and Anyang in Henan province. This is the basis to determine the scope of this study. The specific study area is shown in Figure 1.

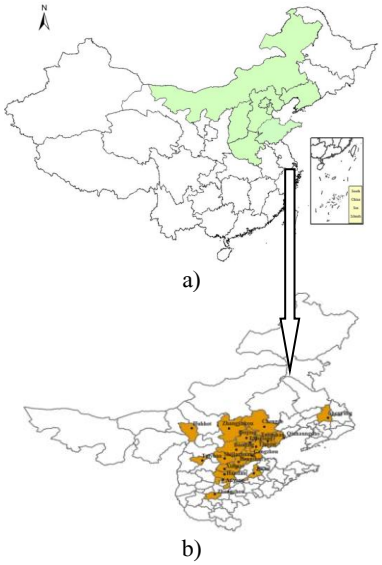

Fig. 1. Distribution of Beijing Tianjin Hebei Urban Agglomeration and its surrounding areas.

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2.2 Research Methods

The research methods of intercity connection mainly include urban flow model and gravity model6-8. In this paper, the improved gravity model is selected according to the actual content.

Gravity model is often used in the study of economic geography. The traditional gravity model of economic connection is shown in formula (1):

$$R_{ij} = \frac{\sqrt{(P_i V_i)(P_j V_j)}}{d_{ij}^2} \quad (1)$$

R_{ij} is the economic connection volume of region i and j; P_i、P_j represent the population of the corresponding regions; V_i and V_j represent the total amount of regional economy respectively, generally expressed in GDP; d indicates the distance between the two cities.

In order to measure the spatial connection of BTH Agglomeration more accurately, this paper revises the economic quality and distance respectively, and adds the economic connection coefficient in the formula.

The calculation formula of the strength of the connection between cities is modified with reference to the universal gravity formula, as follows:

$$R_{ij_i} = k_{ij}\frac{M_i \times M_j}{{d_{ij}}^2}, \quad R_{ij} = R_{ij_i} + R_{ij_j}, \quad k_{ij} = \frac{M_i}{M_i + M_j} \quad (2)$$

R_{ij} indicates the strength of intercity connection, R_{ij_i} is the economic effect intensity of i city on j City; M_i and M_j indicate the comprehensive development quality of cities; d_{ij} is the economic distance between the two cities, "2" in denominator is distance attenuation coefficient.

3 Calculation and analysis of connection volume

3.1 Quality of urban comprehensive development

The traditional indicators to measure the quality of urban development are modified. In this paper, from the three aspects of population quality and structure, economic scale and structure, and social development, 14 indicators are selected to measure the quality of urban comprehensive development9. According to the principal component analysis10, the weight of each index is calculated as shown in Table 1. Limited to space, the specific calculation process is not listed.

Table1. Index weight of economic quality

Index	Weight
Total urban population (10000)	0.055
Proportion of employees in the tertiary industry (%)	0.083
Urbanization rate （%）	0.074
GDP (100 million yuan)	0.084
Fixed assets investment (100 million yuan)	0.083
General budget revenue of local finance (100 million yuan)	0.080
Proportion of secondary industry (%)	0.034
Proportion of tertiary industry (%)	0.067
Per capita year-end deposit balance (yuan)	0.072
Total number of hospital beds	0.081
Number of doctors per 10000 people	0.070
Number of college students per 10000	0.054
Added value of transportation, warehousing and post and Telecommunications (100 million yuan)	0.081
Total social consumption (100 million yuan)	0.083

According to the values and weights of indicators in Table 1, the comprehensive development quality of each city is calculated and shown in Table 2. It can be seen that the level of economic development of BTA Agglomeration is highly polarized. Beijing and Tianjin are far ahead in the development, while most other cities are relatively backward and low in economic quality, showing a condition of overall imbalance.

Table2. Economic quality of Beijing Tianjin Hebei Urban Agglomeration and its surrounding provincial capitals

City	2007	2013	2017
Beijing	1.878	3.319	4.085
Tianjin	1.193	2.189	2.582
Shijiazhuang	0.656	1.206	1.639
Chengde	0.260	0.458	0.593
Zhangjiakou	0.251	0.511	0.800
Qinhuangdao	0.547	0.678	0.872
Tangshan	0.435	1.013	1.397
Langfang	0.346	0.446	0.862
Baoding	0.224	0.514	1.007
Cangzhou	0.246	0.627	1.070
Hengshui	0.261	0.452	0.797
Xingtai	0.199	0.433	0.778
Handan	0.272	0.615	1.046
Anyang	0.065	0.288	0.530
Shenyang	0.883	1.517	1.755
Huhhot	0.543	1.013	0.991
Taiyaun	0.847	1.517	1.712
Zhengzhou	0.838	1.459	2.120
Jinan	0.877	1.404	1.699

3.2 Distance between cities

The distance here is calculated based on highway and railway time and money costs. First, calculating the weight of each mode according to the volume of passenger and freight traffic, then calculating the time and fare of the two transportation modes, and finally calculating the economic distance. The calculation results of weight are shown in Table 3:

Table3. Weight of railway and highway transportation

Mode of transport	2007	2013	2017
railway transport	0.118	0.139	0.146
road transport	0.882	0.861	0.854

Limited to the space, the calculated economic distance matrices are not listed.

3.3 Connections between cities

3.3.1 Calculation of connection volume

Based on the above calculation results, the amount of economic ties between cities and the total amount of external economic ties of each city can be get, as shown in Table 4. The overall connection of urban agglomeration in 2017 has been several or even more than ten times larger than that in 2007.

Table4. Strength of economic ties between Beijing Tianjin Hebei Urban Agglomeration and surrounding provincial capitals

City	2007	2013	2017
Beijing	3.408	8.750	21.030
Tianjin	2.438	6.374	12.237
Shijiazhuang	0.642	2.230	4.970
Chengde	0.142	0.418	0.836
Zhangjiakou	0.137	0.682	1.229
Qinhuangdao	0.346	0.858	1.471
Tangshan	0.652	2.254	4.580
Langfang	1.895	4.824	11.667
Baoding	0.355	1.620	4.234
Cangzhou	0.403	2.046	4.792
Hengshui	0.298	0.998	2.534
Xingtai	0.316	1.531	4.383
Handan	0.306	1.705	5.323
Anyang	0.077	0.766	2.050
Shenyang	0.141	0.378	0.533
Huhhot	0.085	0.277	0.481
Taiyaun	0.302	0.943	1.874
Zhengzhou	0.181	0.699	1.601
Jinan	0.373	1.414	2.487

According to Table 4, we can make specific analysis on the amount of connection, and Figure 2 shows the change trend of the total amount of connection of BTA Agglomeration. It can be seen that the growth rate among the three periods is relatively large, and the trend line of the proportion of the internal connection volume of BTH Agglomeration in the overall research area shows a break in 2013, which indicates that the traffic factor of high-speed rail in the surrounding provincial capitals in 2013, and the policy factor that coordinated development had not become the national strategy led to the relative decline of the internal connection volume of BTA Agglomeration in 2013.

In Table 5, the coefficient of variation of BTH Agglomeration exceeded 1 only in 2007, and has been declining since then, which shows that the gaps between the internal cities of BTH Agglomeration are narrowing, and the gaps are smaller than that of the overall research area.

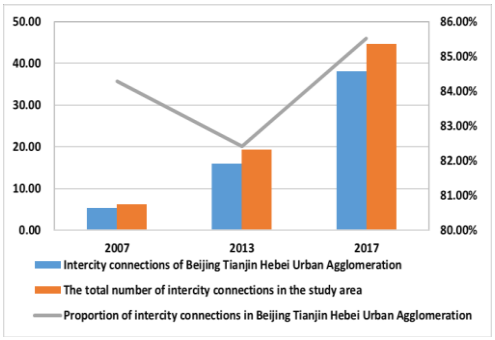


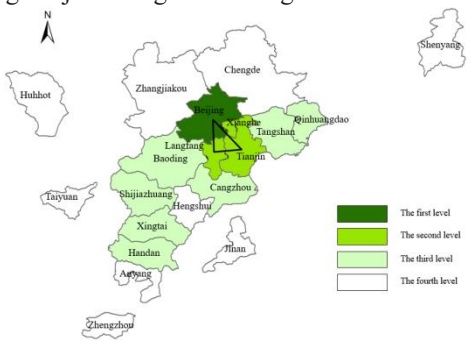
Fig. 2. Total amount and proportion of economic ties in 2007,2013and2017

Table5. Coefficient of variation

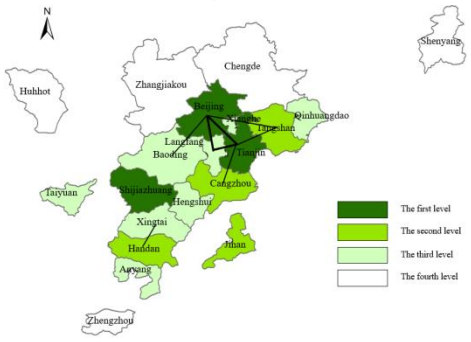
Year	Coefficient of variation	
	Beijing Tianjin Hebei Urban Agglomeration	Overall study area
2007	1.201	1.341
2013	0.941	1.067
2017	0.925	1.081

3.3.2 Level of connection volume

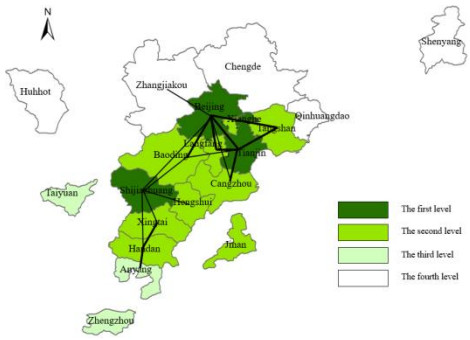
According to the natural breaks method in ArcGIS, the hierarchical distribution of connections can be obtained, and the main connection tracks can be expressed, as shown in Figure 3. The connection shows the characteristics of "dense in the South and sparse in the north"; the main connection track generally presents the "inverted L" type, namely the connection of "Beijing-Tianjin", "Beijing-Baoding-Shijiazhuang" and "Xingtai-Handan".



a)2007



b)2013



c)2017

Fig. 3. Distribution of economic ties

3.3.3 Connection direction and membership

The primary and secondary radiation and receiving cities of each city are identified according to the amount of connection in 2017, so as to analyze the main connection direction of each city. The radiation effect shows a strong regional neighborhood directivity, while the accepted connection has a strong central city directivity.

Economic subordination degree is an indicator to measure the dependence of surrounding cities on the central city, and also an indicator to measure the direction of the city's external connection, which can reflect the contribution of the central city in the economic connection. The calculation formula of economic subordination degree is shown in formula (3):

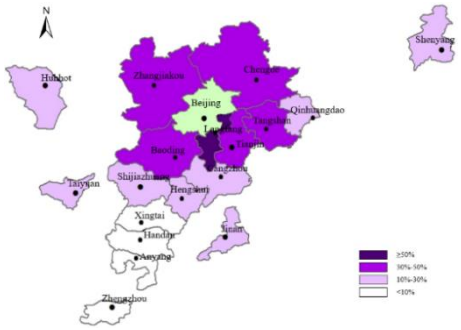
$$F_{ij} = \frac{R_{ij}}{\sum_{j=1}^{m} R_{ij}} \quad (3)$$

m represents the number of cities other than themselves, F_{ij} is the subordination degree of i city to j city.

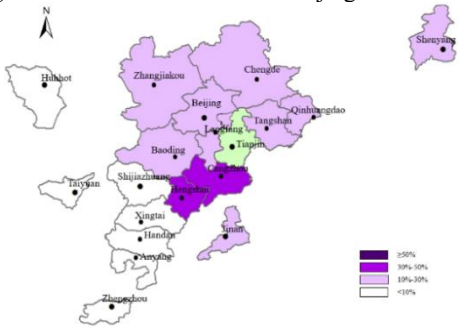
The subordination degree of each city to the central city is shown in Table 6 and Figure 4.

Table6. Subordination degree of each city

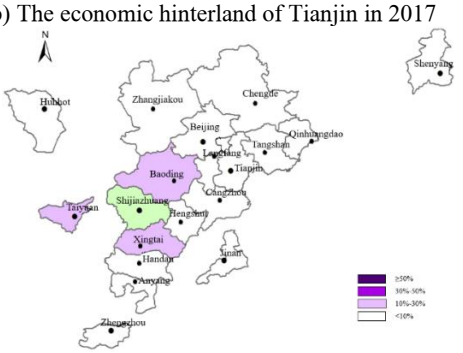
membership	Beijing	Tianjin	Shijiazhuang
Beijing	-	22.31%	3.13%
Tianjin	38.35%	-	2.69%
Shijiazhuang	13.29%	6.65%	-
Chengde	37.27%	13.41%	2.85%
Zhangjiakou	46.01%	11.27%	5.80%
Qinhuangdao	23.28%	16.43%	2.57%
Tangshan	32.54%	29.66%	2.06%
Langfang	72.35%	15.61%	1.08%
Baoding	31.41%	13.54%	15.82%
Cangzhou	19.44%	35.99%	4.57%
Hengshui	11.65%	35.99%	4.57%
Xingtai	3.76%	1.69%	15.08%
Handan	3.33%	1.88%	8.99%
Anyang	3.35%	1.83%	6.36%
Shenyang	21.77%	14.36%	4.44%
Huhhot	24.46%	8.36%	6.20%
Taiyaun	12.31%	6.67%	23.94%
Zhengzhou	8.66%	5.70%	9.05%
Jinan	13.99%	13.43%	9.37%



a) The economic hinterland of Beijing in 2017



b) The economic hinterland of Tianjin in 2017



c) The economic hinterland of Shijiazhuang in 2017

Fig. 4. Geographical distribution of economic hinterland of central city

4 Conclusions and recommendations

The main conclusions are as follows: (1) the overall spatial connections of BTA Agglomeration in 2017 have been several times higher than that in 2007, with the characteristics of "dense in the South and sparse in the north"; (2) the main central connection cities within BTA Agglomeration are Beijing, Tianjin and Shijiazhuang; (3) the main connection tracks roughly present the "inverted L" type, namely the connection of "Beijing-Tianjin", "Beijing-Baoding-Shijiazhuang" and "Xingtai-Handan".

The following suggestions are put forward: (1) Strengthen the central position of the central cities and give full play to the complementary functions of secondary central cities. (2) Establish more transportation infrastructure to strengthen the transportation tracks between the weak areas and the central cities. (3) Pay attention to the development along the connection axes, which are consistent with the existing policy planning, and can better improve the connection level.

Acknowledgements

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