Comparison of Coordinated Economic Development Trend Between Beijing-Tianjin-Hebei and Yangtze River Delta City Cluster: an Analysis Based on City-Level Electricity Consumption

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Abstract. The coordinated economic development of city agglomerations is an important part of the coordinated regional development and an important engine for China's economic growth in the next stage. Based on the analysis of the economic development of the Yangtze River Delta city cluster and the Beijing-Tianjin-Hebei City cluster, this paper constructs the economic coordination development index of the city cluster based on electricity consumption, and compares and analyzes the economic coordination trend of the two city clusters. The analysis found that the Yangtze River Delta city agglomeration needs to deepen the industrial division of labor between cities and the economic development gap between cities while promoting industrial upgrading, and the Beijing-Tianjin-Hebei metropolitan area is more important to improve the industrial function layout.

Keywords: City agglomeration; Beijing-tianjin-hebei; The Yangtze River Delta; Electricity consumption; coordinate.

1 Introduction

City agglomerations are an important carrier of population and economic factors gathering in China, a strategic space that drives the overall improvement of national economic efficiency and supports high-quality development, and accelerating the development of city agglomerationcity agglomerations is an important path to build a new dual-cycle development pattern. China's "14th Five-Year Plan" and the outline of the 2035 vision goal propose to establish and improve the integrated and coordinated development mechanism of city agglomerationcity agglomerations, focusing on city agglomerationcity agglomeration, central cities and other advantageous areas in economic development, and driving the overall improvement of national economic efficiency. In 2021, China's urbanization rate has reached 65.2%, the annual average increase rate in the past decade has slowed down compared with the previous decade, and the urbanization process is about to enter a new stage of development, and city agglomerationcity agglomerations are increasingly becoming the main driving force of urbanization development.

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The role of city agglomerationcity agglomerations is to realize the optimal allocation of resources in a wider range and enhance the radiation driving role through the interaction between large, medium and small cities within city agglomerationcity agglomerations. The level of coordinated development within city agglomerationcity agglomerations is an important content to evaluate the maturity of city agglomerationcity agglomerations. In terms of city agglomerationcity agglomeration linkages, Fang et al. calculated the spatial linkage intensity of city agglomerationcity agglomeration based on the statistical model of economic linkage intensity, urban flow intensity and urban accessibility [1]. Zhao et al. used the Baidu index of urban residents in Internet search to analyze the pattern of urban network connections [2]. Gong and Lu et al. calculated the indicators for assessing city agglomerations through special data and model calculation methods of inter-city traffic flow [3]. In terms of integrated development, Gu and Zhang constructed an evaluation index system of internal and external forces of regional economic integration, and then applied it to the analysis of the Yangtze River Delta（YRD）city agglomeration, and found that the integration index showed an inverted U-shaped trend from 2010 to 2015 [4]. Wang and Zhou constructed a market integration index, including commodity integration, labor market integration and capital integration, to evaluate the integration characteristics of target city agglomerations [5].

In terms of the development of city agglomerations, Wei conducted a comparative study on the BTH（BTH）and YRD city agglomerations from the perspective of economic linkages, and found that the economic development echelon of the latter and the economic linkages of the central cities were superior to the former, and based on this, proposed countermeasures to solve the development problems of the BTH city agglomerations[6]. Zhang and Xu et al. applied fractal theory and methods to analyze the characteristics of the BTH city cluster from the perspective of low-carbon economy, and analyzed the coordinated development of the BTH region[7]. Zhao and Bai believe that regional division of labor to form synergy is an important symbol of realizing regional coordinated development. They measure and compare the level of functional division of labor in city agglomerations in China by using spatial functional division index[8].

By combing and summarizing the existing analysis techniques, it is found that the data used in the evaluation of collaborative development of city agglomerations is relatively rich, but there are some problems such as random selection of data, difficult to obtain data or difficult to ensure data quality. Therefore, it is of great practical value to carry out the evaluation of coordinated economic development of city agglomerations based on electricity consumption data.

2 Economic comparisons between Beijing-Tianjin-Hebei city cluster and Yangtze River Delta city cluster

The BTH region and the YRD region play an important role in China's regional spatial pattern with their huge economic volume, vast regional area and high-quality resource endowment. According to the geographical division of city agglomerations in the 14th Five-Year Plan, the Outline of BTH Coordinated Development Plan, the Outline of YRD Regional Integration Development Plan and other documents, the research scope of this paper is defined as follows: The BTH city agglomerations, with Beijing and Tianjin as the core and Shibao Corridor as the

node city, covers 2 municipalities directly under the Central Government (Beijing and Tianjin) and 11 prefecture-level cities in Hebei Province; The YRD city cluster includes Shanghai, Jiangsu, Zhejiang and Anhui provinces, with a total of 26 cities at prefecture level and above.

The YRD city group is the most developed economic region in the east of China, and also the largest city group among the seven major city groups in China. Since 2020, the overall economy of the YRD city cluster has maintained growth, playing a key role in supporting the national economic growth. Overall, the total GDP of the YRD city cluster is maintained at about 20% of the national total. For a long time, the total economic volume of the YRD region has maintained positive growth, but in recent years, the GDP growth has fluctuated strongly, but the GDP growth is generally on a downward trend.

The BTH city cluster is the political, cultural and economic center in the north of China, which contributes a lot to the national GDP, but its influence on the national economy is significantly lower than that of the YRD city cluster. On the one hand, the BTH cluster accounts for about 10% of China's total GDP, which is 10 percentage points lower than that of the YRD cluster. On the other hand, since 2017, the proportion of BTH in the national GDP has shown a downward trend, falling to 8.3% in 2022, reflecting the widening economic development gap between the North and the South to a certain extent. Compared with the YRD city cluster, the GDP growth rate of the BTH city cluster has fluctuated more sharply, especially since the economy entered the "new normal" in 2012, and the economy experienced negative growth in 2018.

The YRD city cluster has a developed economic base and advanced manufacturing industry, and its per capita GDP is relatively high, especially in Shanghai, Zhejiang and Jiangsu. In 2021, the per capita GDP of the YRD region will reach 117,400 yuan, about 1.45 times the national level. However, the problem of unbalanced development within city agglomerations still exists. Although compared with the BTH region, the per capita GDP gap among cities in the YRD city cluster is smaller, with a data difference of 113,000 yuan in 2022. However, since 2017, the gap between Shanghai and Jiangsu, Zhejiang and Anhui has further widened, and the development level gap within urban agglomerations still exists.

Compared with the YRD city cluster, the per capita GDP of the BTH city cluster is relatively low. Beijing and Tianjin have relatively high per capita GDP, but some areas in Hebei province have relatively low per capita GDP and still face the problem of unbalanced development. The development gap between Beijing and Hebei is very large. In 2022, the per capita GDP of Beijing and Tianjin will reach 19.3 yuan and 119,000 yuan respectively, while the per capita GDP of Hebei Province will only reach 57,000 yuan, less than half that of Tianjin and one-third that of Beijing.

The industrial structure of the YRD city agglomeration is relatively diversified. While the tertiary industry maintains its dominant position, the growth rate of the secondary and tertiary industries tends to be synchronized, and the growth rate of the secondary industry in many regions overtakes the tertiary industry. Overall, the growth rate of the tertiary industry in the YRD region is still better than that in the BTH region, and its output value will reach 1.14 times that of the BTH region in 2022.

As a whole, the proportion of primary and secondary industries in the BTH city cluster is declining and the proportion of tertiary industries is rising. In 2022, the added value of the

tertiary industry in the BTH metropolitan area is about 6.4 trillion yuan, far exceeding the added value of the primary and secondary industries. This shows that the industrial structure of the BTH city cluster is changing from the traditional heavy chemical and resource-based industries to service and high-tech industries. Among them, the dominant position of Beijing's tertiary industry is very obvious, and the High-tech service industries and cultural industries are increasingly clustered. The early economy of Tianjin and Hebei relied on industry and manufacturing, and the growth of the tertiary industry in both places is relatively slow, especially in Hebei, the tertiary added value only accounted for 29.4% of the city agglomeration in 2022. In general, the industrial layout of the two provinces and cities has a large space for adjustment, and the industrial structure gap within the BTH city cluster is still obvious.

3 Thoughts and methods of evaluation of coordinated economic development of city agglomerations

3.1 Evaluation thought

City agglomerations are the main carrier and driving force of regional economic development, and the coordinated economic development of city agglomerations is the core part of regional coordinated development. Therefore, China attaches great importance to the development of city agglomerations in recent years. For example, in 2019, the National Development and Reform Commission issued the Guiding Opinions on Cultivating and Developing Modern Metropolitan Areas. Following promulgation of the plans for the BTH, YRD, Guangdong-Hong Kong-Macao, Chengdu-Chongqing city clusters, the plans for Nanjing, Fuzhou, Chengdu, Changzhutan, Xi 'an, Chongqing, Wuhan, Hangzhou and other city clusters have been approved one after another. The 14th Five-Year Plan points out that it is necessary to develop and expand city agglomerations and metropolitan areas, guide the development direction and construction priorities of large and small cities by categories, and form a spatial pattern of urbanization with balanced distribution, division of labor and cooperation and complete functions. From the perspective of economic development and urban economics, "dense and harmonious" is to form an orderly city system according to different functions. "Division of labor" refers to the formation of industrial chains with different divisions within city agglomerations, rather than industrial homogenization. The degree of division of labor in city agglomerations is constantly increasing, which is embodied in the agglomeration of research and development, management, finance and other links in the central city, and the agglomeration of production and manufacturing links in small and medium cities. The modern service industry is mainly concentrated in big cities, and the manufacturing industry is more concentrated in peripheral cities. Different cities bear different functions and have specialized division of labor[9-10]. "Functional perfection" means that the infrastructure within the city agglomeration is more perfect and the link is closer, so as to realize the free circulation and allocation of various production factors, promote the more balanced economic development of different cities in the city agglomeration, and the economic development level is more converged. According to the principle of market resource allocation, the more fully resources and factors flow within city agglomerations and the more extensive economic connections between different cities, the smaller the average income gap between people.

Therefore, aiming at the three core requirements of "harmonious density, division of labor and cooperation, and perfect function", the evaluation method of coordinated economic development of city agglomerations is constructed, which can be used to evaluate the level of coordinated economic development of different city agglomerations.

3.2 Evaluation method

Based on the above analysis, the coordinated development index of city agglomeration can be divided into three aspects: power law index of city agglomeration, industrial division index and per capita gap index. The three indexes are equal weights to synthesize the coordinated development index of city agglomerations. The closer the index is to 1, the more mature the coordinated economic development of city agglomerations is.

(1) Power law index of city agglomeration (PL). From the perspective of size, the size distribution of large, medium and small cities in city agglomerations basically follows Zipf's Law, which means that the size distribution of a domestic economic activity phenomenon follows a power law index of 1 power law distribution, and the relationship between the ranking of city population size and population size in the city system is very typical[11]. Here, the electricity consumption of city service industry (Size) is selected, the Rank is carried out, and the logarithm lnRank and lnSize are taken, and then regression is fitted. The coefficient of lnSize is the actual power law index (see formula 1). To show the difference between the actual power law exponent and the ideal power law exponent 1, and to consider the case where the actual power law exponent is greater than or less than 1, 1 is used here minus the absolute value of the difference between the actual power law exponent and the ideal exponent.

$$\ln Rank_t = \ln c + \ln Size_t \tag{1}$$

(2) Industrial division of labor index (ID). The formula 2 is used to calculate the degree of division of labor of manufacturing industries between the two cities:

$$ID_{jk} = \sum_{i=1}^{n} \left| \frac{q_{ij}}{q_j} - \frac{q_{ik}}{qk} \right| \tag{2}$$

Where, the subscripts j and k represent different regions, i indicates the industry and n indicates the number of industries. q_{ij} and q_{ik} represent the electricity consumption of industry i in the two regions respectively. q_j and q_k are respectively the manufacturing electricity in the two regions[12]. Then, the division of labor index between the two cities is weighted to synthesize the industrial division index of city agglomerations.

(3) Per capita gap index (PCG). In this paper, per capita household electricity consumption is taken as the proxy variable of urban economic development level. In 2020, per capita household electricity consumption in OECD countries will be about 2,400 KWH, non-OECD countries will be about 530 KWH, and China will be 878 KWH. It can be seen that per capita household electricity consumption can better reflect regional economic development level. The specific calculation process is to normalize the electricity consumption per capita in each city, then calculate the standard deviation, and finally subtract the standard deviation from 1 to get the per capita gap index. The larger the result value of the index, the smaller the difference of per capita domestic electricity consumption between cities. The above calculation process is shown in the following formulas 3-5 respectively.

$$x_i = \frac{x_i - x_{\min}}{x_{\max} - x_i} \tag{3}$$

$$s_t = \sqrt{\frac{\sum_i^n (x_i - \bar{x})}{n-1}} \tag{4}$$

$$PCG_t = 1 - s_t \tag{5}$$

3.3 Data source

In this paper, the coordinated economic development index of city agglomeration mainly uses electricity consumption data to give full play to the advantages of more accurate and objective electricity consumption statistics. The electricity consumption of the cities in the BTH city cluster and the YRD City cluster comes from the statistical system of "one library and three centers" of the State Grid Corporation; In the calculation of per capita household electricity consumption, the population is the permanent population, and the data is from the Wind Financial information database. In 2019, the population data of Baoding and Langfang in Hebei Province were missing, and interpolation processing was carried out.

4 Comparative analysis of coordinated economic development trend of two city agglomerations

Through calculation, it is found that since 2006, the degree of coordinated economic development in the YRD city agglomeration has generally shown an upward trend, and the coordinated development index has risen from 0.79 to 0.82, with an overall increase of 3.8%. The overall trend of coordinated development in the YRD is similar to the YRD Regional Coordinated Innovation Index (2011-2020) jointly released by Shanghai, Jiangsu, Zhejiang and Anhui, with a correlation coefficient of 0.85, as shown in Figure 1 below.

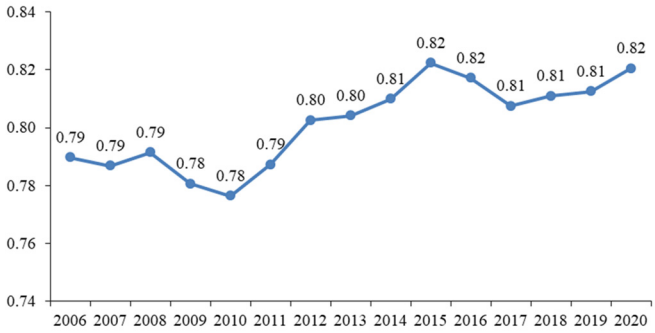

Fig. 1. Change trend of the coordinated development index of the YRD city agglomerations.

Since 2017, the YRD city coordinated development index has fluctuated, mainly due to a large degree of fluctuations in the division of labor index. In the period from 2017 to 2019, the division of labor index showed a downward trend, decreasing by 1.8% year-on-year, and in

2020 the index recovered to 0.915, still lower than the 0.922 in 2017. The industrial division index reflects the regional division and coordination ability of city agglomerations. This is related to the re-layout of industries in the stage of economic transformation, and is the result of industrial structural adjustment. Under the influence of international trade and the development environment of the domestic market, a considerable proportion of traditional industries have entered the stage of low growth and shrinking development, and high-tech industries represented by strategic emerging industries have become the main force of current economic development.

Since 2017, the per capita gap index has also declined, decreasing by about 1% year-on-year. This result reflects the rising trend of the per capita household electricity consumption gap in the YRD city agglomerations, which is related to the urbanization process and the speed of population growth, mainly because the urbanization level difference within the city agglomerations is still obvious. Comparatively speaking, Anhui's urbanization process is relatively backward in the YRD region, with an urbanization rate of only 60.2% in 2022, 5 percentage points lower than the national average; The urbanization level of Jiangsu and Zhejiang provinces is relatively close, 73.4% and 74.4% respectively. Shanghai is already at a very high stage of urbanization, and considering the impact of sluggish foreign trade, the population growth rate of Shanghai and Zhejiang has declined in recent years, while the population growth of Anhui and Jiangsu is relatively stable. See Figure 2.

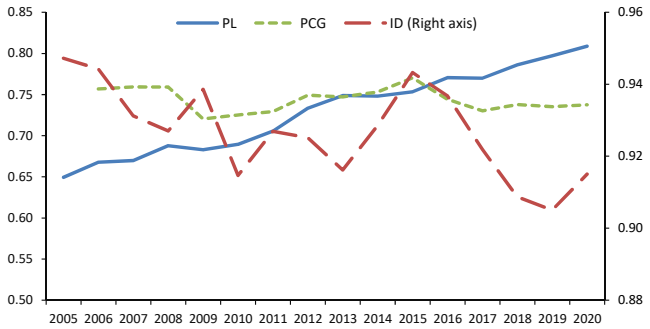

Fig. 2. Change trend of sub-index of coordinated development of YRD city agglomerations.

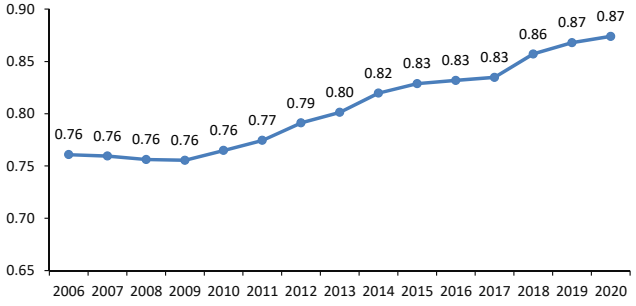

Fig. 3. Change trend of the coordinated development index of the BTH city cluster.

Since 2006, the level of coordinated development of the BTH city cluster has continued to rise, with the coordinated development index rising from 0.76 to 0.87. The change trend of the BTH Coordinated Development Index is similar to the BTH Regional Coordination Index (2014-2020) released by the Office of the BTH Coordinated Development Statistics Monitoring Coordination Leading Group, with a correlation coefficient of 0.95. Compared with the YRD region, the trend of the coordinated development index of the BTH region is steeper, with a growth rate of 15% since 2006, much higher than the YRD's 3.9%. It can be seen that, on the one hand, the degree of coordinated economic development of the BTH city agglomeration is less than that of the YRD city agglomeration, mainly due to the large differences in economic development among cities in the early stage of the region; On the other hand, with the continuous implementation of the Outline of the Plan for the Coordinated Development of the BTH Region, the major medium-term goals of the coordinated development of the BTH region have been achieved as scheduled, and the coordinated development of the BTH region has made steady progress， as shown in Figure 3 above.

Since 2006, the coordinated development of the BTH city cluster has been mainly driven by the power law index and the division of labor index, and the per capita index has improved slightly. Since 2017, the industrial division index of the BTH city cluster has shown a fluctuating rise and reached a peak in 2019, which indicates that the industrial connection and collaboration of the three regions have continued to advance; In 2020, the division of labor index has declined, which is partly related to the impact of the novel coronavirus epidemic on economic development. With the promotion of Beijing's non-capital functions, some industries in Beijing and Tianjin have been transferred to Hebei Province, strengthening the division of labor and cooperation among the three cities, clearer positioning of city industrial division, and creating new industrial clusters that complement and support each other. At present, the industrial linkage development of the BTH city cluster has made significant progress, and the development gap within the region tends to narrow, as shown in Figure 4 below..

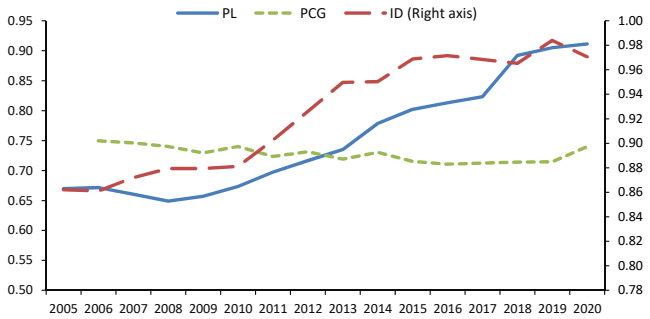

Fig. 4. Change trend of sub-index of coordinated development of BTH city cluster.

The power law indices of the YRD city cluster and the BTH City cluster both show an upward trend, reaching 0.81 and 0.91 respectively in 2020, indicating that the scale relationship between large, medium and small cities in these two city clusters is continuously optimized. This is an overall evaluation of the relationship between the size of city agglomerations, and cannot reflect the problems existing in the size of individual cities in city agglomerations, such

as whether the size of Shanghai in the YRD city agglomerations is too large, and the siphon effect of Beijing in the BTH city agglomerations is too large.

5 Conclusions

From the statistical data, the YRD city cluster and the BTH City cluster are the most important city clusters in China. Among them, the YRD city cluster has a higher level of economic development, more diversified industrial structure, more closely connected industrial chain, and a relatively stable proportion of economic scale in the country. The economic development of the BTH city cluster is not as mature as that of the YRD city cluster, and there is a large gap within the city cluster, and the proportion of the economic scale in the country is declining in recent years. According to the coordinated economic development index of city agglomerations constructed based on electricity consumption data in this paper, the degree of coordinated economic development of the two major city agglomerations is on the rise, among which the YRD city agglomerations have experienced certain fluctuations since 2015, which is largely related to the ongoing industrial upgrading and industrial layout adjustment in the region. The BTH city cluster has been promoted by the "BTH Coordinated development" policy, and the degree of industrial cooperation and division of labor has increased, and the economic development gap between cities has narrowed in recent years.

The policy implications obtained from the analysis include: the YRD city agglomeration should seize the lead advantage of industrial upgrading and the policy opportunity of the state to promote the economic integration of the YRD, give full play to the role of Anhui as part of the other three provinces and cities to undertake industries, and accelerate the optimization of industrial distribution and division of labor within the city agglomeration; in the near future, the most important thing for the coordinated economic development of the BTH city cluster is to continue to promote the coordinated development of industries, promote the layout of the manufacturing links in Beijing and Tianjin to Hebei, and deepen the level of coordination and division of labor within the city cluster. Improve transportation, communication and other infrastructure networks in city agglomerations, reduce administrative barriers, ensure the smooth flow of various production factors within city agglomerations, and realize the increasing convergence of economic development levels among city agglomerations.

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