Research on the Spatial Pattern Evolution Characteristics of Industrial Agglomeration in China's Digital Economy

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Abstract. With the maturity and industrialization of the new generation of information technology represented by cloud computing, big data, Internet of things, mobile Internet and artificial intelligence, the development of digital economy has entered a high-speed growth track. Undoubtedly, digital economy has gradually become a key force to promote the development of national economic growth. China's "fourteenth five year plan for the development of digital economy" proposes to promote the industrial cluster of digital economy, which shows that the industrial cluster of digital economy has gradually entered the implementation stage. Based on the location entropy index and Moran index, this paper analyzes the pattern evolution characteristics of China's digital economy industrial agglomeration from the perspectives of regional development imbalance, regional relevance and local conditions, and puts forward relevant development suggestions to better meet the strategic needs of cluster development.

Keywords: digital economy · agglomeration · spatial pattern · information technology

1 Introduction

In recent years, digital economy has become an important battlefield of global strategic game and a key force to change the global competition pattern. The development of digital economy characterized by the cross-border integration and application of the Internet has comprehensively promoted the upgrading and transformation of the real economy, improved economic efficiency, and accelerated the transformation of economic structure. Developed countries such as Europe and the United States have formulated strategic policies to deal with the development of digital transformation.

How to make the digital economy stronger, better and bigger is a required question for Chinese governments at all levels. The "fourteenth five year plan" for the development of digital economy in China proposes to "promote the industrial clustering of digital economy", which fully reflects that the industrial agglomeration of digital economy will be an important means for China to speed up the layout of digital economy, seize the

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commanding heights of global digital economy development, and participate in the new advantages of international economic cooperation and competition.

Industrial agglomeration brings scale effect and promotes regional economic development. Moreover, the first law of geo economics indicates that there are interaction effects between geographical neighboring areas. Economic agglomeration not only affects the high-quality development of the region, but also drives the development of the surrounding areas. For that the development of digital economy is still in the initial rising stage, the research on industrial agglomeration of digital economy in China is relatively scarce. At this stage, We need to coordinate and integrate the digital economy industry among regions to better meet the national strategic needs. The research on the overall and local evolution of the industrial pattern of digital economy will help to grasp the development characteristics of digital economy, deeply excavate its internal mechanism, and more reasonably guide the industrial agglomeration of digital economy to play a role.

2 Literature Review

2.1 Characteristics of Digital Economy

The research on digital economy began in 1996. Early scholars mainly explored its connotation, characteristics and statistical calculation. As a new economic form, the "digital economy" has not yet achieved a unified definition and accounting standard [1], but the consensus is that the essence of digital economy lies in informatization, which is an integrated economy formed through informatization [2]. Digital technologies including Internet, mobile Internet, cloud computing, big data, Internet of things, artificial intelligence (AI), virtual reality (augmented reality/hybrid reality), blockchain, 3D printing, etc. are undoubtedly the core driving technologies of the new scientific and technological revolution and industrial change. Compared with traditional industries, the innovation of digital economy has the characteristics of high innovation frequency, great influence and wide coverage. New technologies in the field of digital economy continue to mature and enter the commercialization stage, and digital technology combined with the new generation of information technology can not only be widely used in many national economic industries, but also bring about disruptive changes in the mode of production organization and labor relations [3].

In addition to technological innovation, another remarkable feature of the digital economy is the accelerated promotion of data value [4]. With the deep integration of digital economy and real economy, everything can be digitalized, and data has become a new factor of production. Decentralized data processing has derived the diversity of multiple participants and data sovereignty [5], which realizes data sharing and promoting the leap from data elements to data productivity.

2.2 Measurement and Influencing Factors

1) Influencing Factors

Yexi Zhong [6] conducted a geographically weighted regression based on the digital economy index, which profoundly clarified the strong correlation between the digital

economy and the informatization level of the Yangtze River economic belt. In addition, abundant data resources are usually the important cornerstone of the commercial operation of Internet companies. The large-scale commercial application of information technology has greatly reduced the cost of data collection, transmission, storage, analysis and other links, and the timeliness of data can also improve the synergy between labor, capital and other factors [7].

2) Measurement

Early research on industrial agglomeration focused on qualitative observation and description. With the rise of new economic geography, more and more scholars began to study how to correctly measure the level of industrial agglomeration. By combing the literature on the measurement of industrial spatial agglomeration level at home and abroad, we found that the measurement methods such as location entropy index, industry concentration, Herfindahl index, spatial Gini coefficient and EG index are the most commonly used and representative methods. The drawback of this kind of agglomeration index is that it performs poorly in the face of industries with large industrial concentration and scattered enterprise distribution [8].

The measurement method of industrial agglomeration based on distance, namely distance space measurement method, solves the problem that variable regional units cannot be measured. It is a continuous spatial function. Distance measure mainly includes reply K function, D-O index and M function. Among them, D-O index is the most widely used. It mainly makes full use of the geographical location information of enterprises to obtain the distance density distribution between enterprises weighted by economic scale and the function of industrial agglomeration degree on spatial distance. However, because the coordinate data of enterprises are difficult to obtain and the requirements for data processing ability are high, D-O index is not widely used in China.

Both the agglomeration measurement method based on overall economic activities and the distance measurement method judge the level of industrial agglomeration based on a certain region, ignoring the heterogeneity and correlation between regions. Spatial auto-correlation introduces spatial weight matrix to represent spatial adjacency, which is used to describe the relationship between adjacent regions, thus making up for this defect. In the process of practical application, the spatial auto-correlation method is simpler than the distance measurement. Chinese scholars have made a lot of discussions on economic activities by using the Moran index.

3 Spatial Evolution

3.1 Measurement of Agglomeration in Digital Economy

According to the classification of digital economy and its core industries (2021) issued by the National Bureau of statistics and the classification of national economic statistical industries, the digital economy industry fully covers the information transmission, software and information technology service, as well as the manufacturing of computers, communications and other electronic equipment manufacturing industry in the national economy industry, while other core industries are scattered in other industries of the national economy. Therefore, the article will focus on the above two industries as the

analysis object, and calculate the digital economic output value of 31 provinces and cities in China by adding the operating income of the two industries instead of the output value. Since it is difficult to obtain micro data of enterprises, the location entropy index will be used to measure the degree of industrial agglomeration.

The data in this paper are from China Statistical Yearbook 2013–2019 and statistical yearbooks of provinces and cities (excluding Hong Kong, Macao and Taiwan). Generally speaking, when the location entropy is greater than 1, it is considered that a certain industrial agglomeration level in region is high and has advantages in the country. On the contrary, when it is less than 1, it is considered that the agglomeration level is low and has disadvantages in the whole country.

3.2 Evolution Characteristics of Industrial Agglomeration Pattern

By measuring the degree of industrial agglomeration of digital economy in various regions of China, it can be seen that the current inter provincial differences in China's digital economy industries are very significant, mainly reflected the fact that the industries are concentrated in a few provinces, and the phenomenon of digital divide is obvious. Referring to Luming Yang's documents, this article analyzes the evolution characteristics from three perspectives: unbalanced regional development, regional spatial correlation and local distribution [9].

1) Imbalance of Regional Development

According to the location entropy values in 2013 and 2019, 31 provinces and cities in China are classified. If the location entropy value is greater than 1, it is a high concentration level area, if the location entropy value is between 0.5 and 1, it is a medium concentration level area, and if the location entropy value is lower than 0.5, it is a low concentration level area.

From the perspective of economic belt, in 2019, 6 of the 12 provinces and cities in the eastern coastal area were in high concentration areas, accounting for 50%, 1 was in medium concentration areas, accounting for 8.3%, and 5 were in low concentration areas, accounting for 41.6%; Among the 9 provinces and cities in the central inland region, 3 are in high concentration areas, accounting for 33.3%, and 6 are in medium concentration areas, accounting for 66.6%; The remote areas in the West include 10 provinces and cities, 1 in the high concentration area, accounting for 10%, 3 in the medium concentration area, accounting for 30%, and 6 in the low concentration area, accounting for 60%. In short, the eastern coastal areas are dominated by high concentration provinces and cities of digital economy industry, the central inland areas are dominated by medium concentration provinces and cities, and the western marginal areas are dominated by low concentration provinces and cities. The level of digital economy industry agglomeration generally shows a decreasing trend from coastal to inland.

In 2013, the high, middle and low concentration areas in the eastern coastal areas accounted for 41.6%, 25% and 33.3% respectively; The proportion of high school and low school in the central inland area is 0%, 22.2% and 77.7%; The proportion of high school and low school in the western marginal areas is 20%, 0% and 80%. It can be seen that the industrial agglomeration of digital economy in China has improved significantly

in the past six years. Although it still shows a decreasing trend from coastal to inland, the development between regions is more balanced than before.

The unbalanced development among the digital economy industrial agglomeration areas reflects the differences in the elements required for the development of digital economy in space, such as capital, talents, policies, especially technology and data. The following uses the spatial correlation and local situation analysis to further reflect the spatial evolution characteristics.

2) Global Auto-correlation Analysis

Spatial auto-correlation is a spatial statistical analysis method. Its spatial distribution characteristics can be measured by the global and local indicators of spatial auto-correlation. The global auto-correlation coefficient is used to verify the spatial pattern of the entire study area. Moran's I is the most commonly used one. When $I > 0$, it indicates that there is a positive correlation between the digital economy industry of adjacent regions, which is spatially aggregated; When $I < 0$, there is a negative relationship and a discrete distribution in space; When $I = 0$, there is no spatial dependency. We try to use spatial auto-correlation to explore whether there is correlation between digital economy industries in China.

The global Moran index test is conducted based on the unit location entropy distribution of 31 provinces and cities, and the data are shown in Table 1.

Regional spatial correlation data show that China's digital economy industry agglomeration has been showing a positive spatial correlation. That is, in space, high agglomeration areas or low agglomeration areas are always together. However, the positive correlation is not high, even that the overall spillover is slowly weakening, which reflects the insufficient cooperation and exchange, industrial transfer and technology integration in the process of developing the digital economy. All of them has not been effectively improved for a long time. We believe that the initial stage of the development of China's digital economy is an important reason for the weakening of spillover. From the location entropy value and the distribution of agglomeration level, the polar cores of the three core areas are Beijing, Shanghai and Guangdong, and the agglomeration of digital economy is gradually spreading around the three cities. In the initial stage of industrial agglomeration of digital economy, the polar core grows rapidly and even produces siphon effect

Table 1. Moran index of digital economy industry from 2013 to 2019

variable	Moran	Z value	P value
2013	0.140**	1.654	0.049
2014	0.134*	1.601	0.055
2015	0.143**	1.689	0.046
2016	0.203**	2.268	0.012
2017	0.124*	2.008	0.064
2018	0.105*	1.364	0.086
2019	0.123**	1.549	0.061

on the surrounding areas, absorbing the surrounding capital, talents, technology and other production factors, thus weakening the digital economy development ability of the surrounding areas, and finally showing a situation of low positive correlation and weak spillover.

3) Local Auto-correlation Analysis

The local Moran index statistic reflects the degree of clustering similarity between a certain region and the surrounding regions. The positive number indicates that the region is similar to the adjacent regions, in other words, high (low) values are clustered around high (low) values, while a negative number indicates that the agglomeration of adjacent regions has the opposite effect. The Moran index scatter chart is an important tool for us to further judge the high and high agglomeration or high and low agglomeration under the positive correlation between provinces and cities (Fig. 1).

The comparison chart between 2013 and 2019 shows that the provinces and cities with high concentration in 2013 still exist in 2019. Also, new provinces and cities enter, mainly including Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, Fujian and Jiangxi, which are located in the first quadrant of the Moran scatter chart. Most of the I statistics in the central inland region of China are positive, showing a positive correlation between the spaces. However, from the Moran scatter diagram, we find that most of them are concentrated in the low concentration areas, that is, the low concentration between regions, and the same is true in the western edge areas.

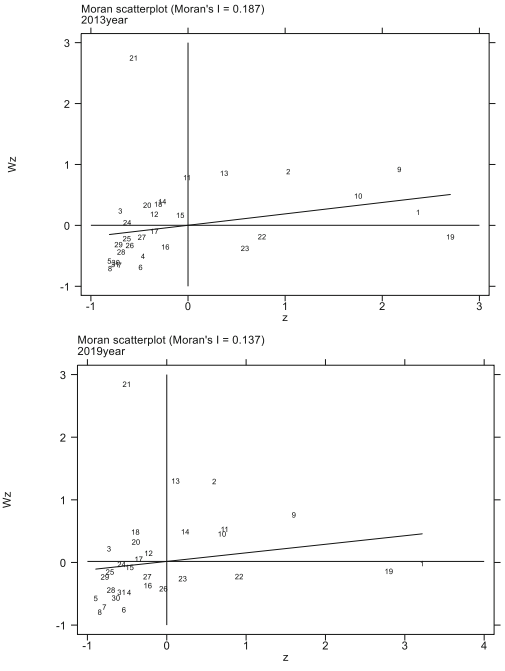

Fig. 1. Local auto-correlation scatter diagram of digital economy

As the polar core cities in the three economic zones are located in the eastern coast, they are mainly focused in this paper. From the data collection results, the I statistics in Beijing has mainly gone through three stages. From 2013 to 2015, the statistics have changed from positive to negative, indicating that there are differences in the development speed of Beijing and its surrounding areas. The speed of Beijing's digital industry agglomeration is much higher than that of surrounding provinces and cities. This conclusion is consistent with the conclusion of polar siphon effect in the above. In 2019, the I statistic has a positive trend. We speculate that the development of digital economy in Beijing is gradually maturing and can play a radiating role in the surrounding areas to a certain extent.

The I statistics of the Yangtze River Delta from 2013 to 2019 show a positive correlation, indicating that the development of the Yangtze River Delta is relatively balanced, regarded as the rapid development zone of high concentration areas, but there are still differences between individual cities. Among them, the I statistics of Shanghai and Jiangsu both show a downward trend, while that of Zhejiang Province shows an upward trend, indicating that under the characteristics of overall high agglomeration, the development of digital economy industry in Zhejiang Province is faster than that of the other two provinces and cities. We assume it as the area of digital economy industry transfer in, while the other two places belong to the area of digital economy industry transfer out.

Guangdong Province is one of the provinces and cities with the most rapid development of digital economy industry in China, but similarly, its local Moran index has remained negative for six years, and its rapid growth has not brought obvious radiation effect to the surrounding areas.

4 Conclusion

In short, the unbalanced development of digital economy still exists in China, which is mainly reflected in the fact that digital economy industries in the central and western regions are concentrated in the eastern coastal areas. In addition, China's digital economy industry agglomeration shows a positive correlation in space, but the correlation decreases in general from 2013 to 2019, and the spillover between regions weakens. What's more, the eastern coastal area is the focus of this paper. Although Beijing and Guangdong have their own rapid development of digital economy, the positive correlation radiation effect on surrounding provinces and cities is longer and weaker than the Yangtze River Delta. In view of this result, we put forward the following suggestions.

4.1 Further Narrow the Digital Divide

The industrial agglomeration of digital economy shows a decreasing trend from coastal to inland, even that the inclination of resources under market allocation will further deepen. In order to prevent the further expansion of the digital divide, the government should assume the corresponding coordination role among regions, improve the information technology infrastructure in the central and western regions, and actively guide interregional cooperation and resource and technology sharing.

4.2 Further Expand the Radiation Effect

At present, the limited radiation effect of digital economy in China is another important problem. Not only is the positive effect between regions weak, but also the radiation advantage of the eastern core region is not significant. In order to further expand the scope of radiation, the government should speed up the establishment of digital economy trading market, encourage more industries to participate in digital trading, and accelerate the formation of economies of scale. At the same time, the development of the Yangtze River Delta digital economic belt is relatively balanced, and Zhejiang Province is the country's largest digital economy industrial agglomeration transfer in six years, which is closely related to its unique digital economy development model. TIt has profound reference significance for other core areas. The surrounding areas of the polar core can actively explore the development mode of digital economy suitable for the region on the basis of accepting industrial transfer, and further promote industrial agglomeration.

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