Value, Function, Cost Volume 3 Issue 1 (2023) **doi: 10.54517/vfc.v3i1.2597**

Original Research Article

Research on the Relationship and Evolution of Regional Agglomeration of China's Construction Industry

GENG Shan-shan[1], ZHAO Li-kun[2], ZHAO Peng[3]

College of Civil Engineering，North University of Technology，Beijing 100144，China

Abstract: The research on the regional correlation of construction industry is of great significance to optimize China's construction industry structure and promote regional development. Taking 31 provinces(autonomous regions and municipalities directly under the central government) in China from 2011 to 2020 as the object, this paper studies the regional correlation and evolution of construction industry by using the methods of social network analysis and GIS spatial analysis. The research shows that: (1) in recent 10 years, there has been a social network correlation in China's construction industry agglomeration, which presents a development situation of "high in the East, low in the west, high in the South and low in the north". (2) Beijing and Tianjin are at the core of the network of construction industry agglomeration and have strong independence. (3) China presents four distinct agglomerative subgroups.

Keywords: Construction industry; Temporal and spatial evolution; Association relationship.

1. Introduction

The Opinions of the General Office of the State Council on Promoting the Sustainable and Healthy Development of the Construction Industry (State Council Office [2017] No. 19) point out that the construction industry is a pillar industry of the national economy, making significant contributions to economic and social development and urban-rural construction. From 2011 to 2020, the growth rate of the total output value of the construction industry was 9.5%, and the added value of the construction industry reached 7.3 trillion yuan[1]. However, the regional development of China's construction industry is unbalanced, and there is a large gap in competitiveness between regions, resulting in a decentralized development of the construction industry agglomeration.

At present, research on regional correlation and spatiotemporal evolution laws is mainly focused by foreign scholars on "spatial interaction", "central location" [2,3], as well as models and methods such as CA[4], SAM[5], and gravity models[6-8]. Most domestic scholars apply models and methods such as gravity models[9-11], spatial econometrics, coupling coordination, spatial distribution characteristics, spatial structure linkage, spatial agglomeration, and total factor productivity to study.

Dai Yong'an[12], Hong Jingke[13], and others used spatial econometric analysis methods to study spatial dependence and spillover effects in the construction industry. Fan Jianshuang[14], Yang Yang[15], Cao Linjian[16], and others used coupling research to study the positive spillover effects, dispersion degree of coupling coordination, and pull effects of the construction industry. Scholars often analyze spatial distribution characteristics from the perspectives of density and scale, analyzing node characteristics[17]. Mi Yang[18], Yang Guoan[19], and others conducted research on spatial distribution characteristics, focusing on spatial correlation, heterogeneity, and urban network density. The method of spatial structure linkage is often used to analyze the relationship between economy and regional agglomeration. Krugman P, Venables A[20] and Crozet M, Soubeyran P[21] applied the method of spatial structure linkage to draw conclusions on the accessibility of regional agglomeration and economic agglomeration. Li Shaolin[22] and others applied this method to the construction industry to study the relationship between urbanization rate and the construction industry. Wang Yousong[23] etal.

Received: 9 February 2023 Accepted: 17 April 2023 Available online: 20 May 2023

conducted a study on the relationship between spatial agglomeration and total factor productivity (TFP) in China's construction industry by analyzing the relationship between agglomeration and overall TFP. In addition, Hu Ying and others[24] used gravity models and urban intensity models to study outward functionality. Jia Nan and others[25] used the entropy method to study the development pattern of the construction industry.

Literature research has found that research on the regional correlation and spatiotemporal evolution of the construction industry mainly focuses on the micro perspective of a single region or a single influencing factor. The research methods mainly include Gini coefficient, spatial econometric model, and gravity model. There is relatively little research on the agglomeration of the national construction industry from a macro perspective. Based on this, this paper constructs the national construction industry cluster correlation model and evolution analysis model through the data related to the construction industry of 31 provinces (autonomous regions, municipalities directly under the Central Government) in Chinese Mainland from 2011 to 2020, conducts in-depth research on the construction industry cluster correlation, and carries out visual analysis of the time and space dimensions through Ucinet software and Arcgis. This has an important impact on optimizing the structure of China's construction industry, promoting balanced regional development, and adjusting China's macroeconomic development.

2. Data Sources and Research Methods

2.1 Data Sources

This paper takes 31 provinces (autonomous regions, municipalities directly under the Central Government) in Chinese Mainland as the research object, and the data from the National Bureau of Statistics and the Statistical Yearbook of China's Construction Industry (2011-2020) as the sample.

The spatial interaction changes over time, so it is necessary to convert static evaluation indicators into dynamic evaluation indicators. The essence of this is to add a time dimension to the indicators, which is reflected in the dimensionless transformation of the original values. The formula used is shown in (1):

$$X' = a + b \times \frac{x - \min_x}{\max_x - \min_x} \tag{Eq.1}$$

In the formula, X' represents the dimensionless value of economic and construction related indicators; x represents the original value of economic and construction related indicators; $\max_x$ is the maximum value of the indicator; $\min_x$ is the minimum value of the indicator; a , b is a constant, and a and b take 10, 100 respectively.

2.2 Research Methods

2.2.1 Gravity Model

In order to obtain the spatial correlation of the construction industry in various provinces of China, this article uses a gravity model to calculate the gravity of the construction industry agglomeration in each province and city, and constructs a provincial cluster network between each province and city. Due to the reverse distance relationship between two provinces, which has a certain impact on the strength of the connection, this article constructs a provincial network based on the revised gravity model[3]. The expression of the gravity model is as follows:

$$R_{mn} = K_{mn} \frac{\sqrt[3]{P_m G_m C_m}\sqrt[3]{P_n G_n C_n}}{\left[D_{mn} / \left(g_m - g_n \right)^2 \right]} \tag{Eq.2}$$

$$K_{mn} = \frac{C_m}{C_m + C_n} \tag{Eq.3}$$

$$C_m = \frac{B_m G_m}{B / G} \quad \text{(Eq.4)}$$

$$C_n = \frac{B_n G_n}{B / G} \quad \text{(Eq.5)}$$

In the formula, R_{mn} represents the strength of the connection between the construction industry in m province and n province and city; K_{mn} represents the contribution of m province and city to R_{mn}, which is the correction amount; P_m represents the year-end permanent population of province and city m; G_m represents the gross domestic product of m province and city; G represents the Gross Domestic Product (GDP) of the country; g_m represents the per capita GDP of province and city m; B_m represents the gross domestic product of the construction industry in province and city m; B represents the gross domestic product of the construction industry in China; C_m represents the entropy index of building location in m province and city; D_{mn} represents the geographical distance between m province and n province and city.

In order to facilitate the analysis of provincial networks, this article binarizes the elements in the network matrix of construction industry agglomeration[21], and calculates the annual mean formula as shown in (6):

$$X_m = \left(R_{m1} + R_{m2} + R_{m3} + \cdots + R_{mn} \right) / n \quad \text{(Eq.6)}$$

In the formula: X_m is the mean of the m-th row; $R_{m1}, R_{m2}, R_{m3} \cdots R_{mn}$ represents the grid matrix value in row m, and n represents 31 provinces and cities.

2.2.2 Social Network Analysis Methods

(1) Network density. Network density refers to the degree of closeness between nodes in the overall network. This article uses network density to illustrate the evolutionary trend of China's overall construction industry agglomeration from 2011 to 2020. The expression for network density is shown in (7):

$$D = \frac{L}{N \times \left(N - 1 \right)} \quad \text{(Eq.7)}$$

In the formula: D is the network density; N represents 31 provinces and cities; L is the total number of inter provincial spatial correlation relationships in the overall network.

(2) Network centrality. Centrality is used to measure the importance, independence, and controllability of nodes in a network, and is an important indicator for studying the correlation between provinces and cities.

Point centrality represents the central position of a node in the network. Formula as (8):

$$D_e = \frac{L}{N - 1} \quad \text{(Eq.8)}$$

In the formula: D_e represents the degree of point centrality; L represents the total number of spatial connections between provinces in the network; N represents 31 provinces and cities.

Proximity centrality is used to determine the degree to which a node is not controlled by other nodes, that is, the degree of independence. Formula as (9):

$$CL = \sum_{L-1}^{L} d_{mn} \quad \text{(Eq.9)}$$

In the formula, L represents the total number of spatial connections between provinces in the network, and d_{mn} represents the shortest path between m and n provinces.

The centrality in the middle represents the number of times a node serves as the shortest bridge between two other nodes, which can be used to determine the controllability of a node over other provinces and cities. The formula is as follows (10):

$$Be = \frac{\sum_{n}^{L} \sum_{i}^{L} b_{ni(m)}}{N^2 - 3N + 2} \left(n \neq m \neq i, n < i \right) \quad \text{(Eq.9)}$$

In the formula: Be is the middle centrality, and $b_{ni(m)}$ represents the number of shortest paths passing through province m between province n and province i; L represents the total number of spatial connections between provinces in the network.

(3) Condensed subgroups. Condensed subgroups are bridges that connect individual provinces and cities with the entire provincial and municipal network. When there is frequent information exchange and cooperation between provinces and cities, condensed subgroups are formed, and the interconnected condensed subgroups form the entire network.

3. Empirical Analysis

3.1 Analysis of China's Construction Industry Agglomeration Based on Time Dimension

This article uses data from various provinces in China from 2011 to 2020 to construct a network diagram of China's construction industry agglomeration. The network density of China's construction industry agglomeration from 2011 to 2020 is calculated using Ucinet, as shown in Figure 1.

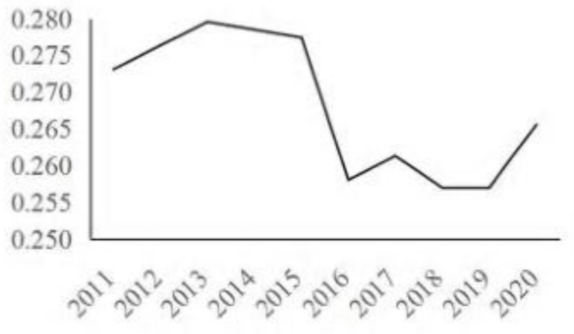

Figure 1 Network density of construction industry agglomeration.

According to Figure 1 analysis, (1) it is found that the overall network density of China's construction industry agglomeration showed a downward trend from 2011 to 2020. (2) The network density of the construction industry agglomeration showed a slow upward trend from 2011 to 2013, reaching its peak in 2013. From 2014 to 2019, the overall network density significantly decreased, with 2016 being a turning point. In 2020, the overall network density rebounded again.

The above situation is directly related to national policies, for the following reasons: (1) In August 2011, the Ministry of Housing and Urban Rural Development formulated the “Twelfth Five Year Plan” for the development of the construction industry, which reflects the government's high attention to the development of the construction industry. With the support of funds, the network density of the construction industry agglomeration has been increasing year by year from 2011 to 2013. (2) In December 2013, the Central Economic Work Conference proposed that economic development had entered a “new normal”, with four shifts leading to increased downward pressure on the economy, resulting in tight funding for the construction industry and a decrease in the network density of construction industry clusters. (3) In 2016, known as the harsh winter of the construction industry, due to overcapacity in the construction industry, a large number of enterprises suffered losses. In order to adjust the current situation and the construction industry's production capacity, the State Council issued several opinions on further strengthening urban planning and construction management in February 2016, proposing to gradually adjust the urban land structure according to the idea of strictly controlling increment, activating stock, and optimizing structure; For public services, areas outside of the pipe gallery are not allowed to build new pipelines, etc. In September of the same year, the State Council issued the Guiding Opinions on Vigorously Developing Prefabricated Buildings, mandating the elimination of building materials that do not meet energy-saving and environmental protection requirements and have poor quality and performance. (4) In April 2020, the Ministry of Housing and Urban Rural Development issued the 2020 Work

Points of the Engineering Quality and Safety Supervision Department of the Ministry of Housing and Urban Rural Development, promoting the integration and application of BIM technology in the entire process of engineering construction, and promoting the emergence of new infrastructure such as construction robots, promoting the development of the construction industry cluster. As a result, the network density of the construction industry cluster increased in 2020.

3.2 Analysis of Construction Industry Agglomeration Based on Spatial Dimension

3.2.1 Spatial Evolution Analysis

Based on the above analysis, it is concluded that national policies are an important factor affecting the agglomeration development of the construction industry. Therefore, when selecting the node years for display, this article mainly focuses on the changes in industrial policies, with the national five-year development plan as the main focus, selecting the opening and ending years for display.

This article uses ArcGIS to construct spatial evolution maps of construction industry clusters in various provinces across China in 2011, 2015, 2016, and 2020. Using the natural fracture method, the development level is divided into five levels: high development, high development, general development, low development, and low development, as shown in Figure 2.

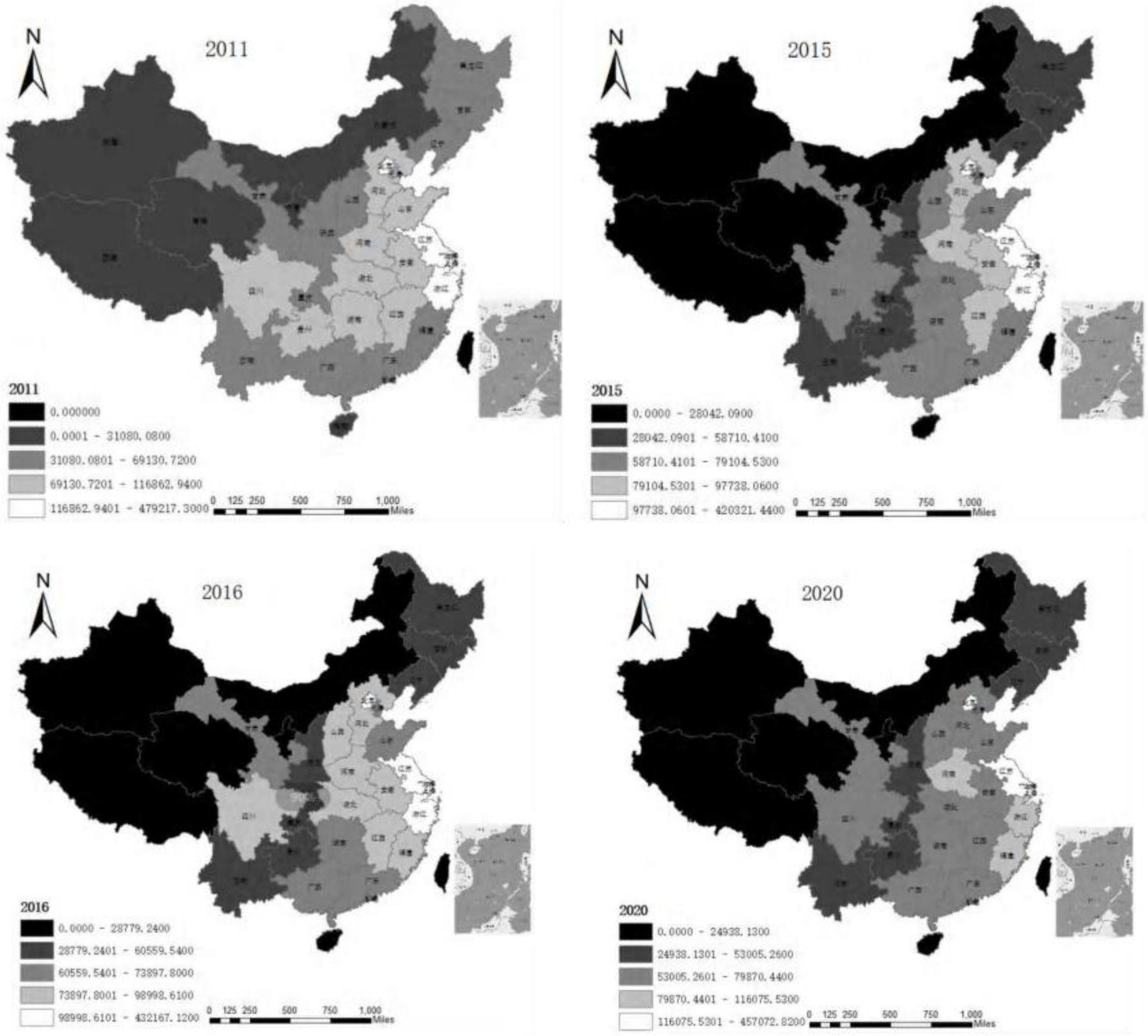

Figure 2 Evolution of National Construction Industry Development Level in 2011, 2015, 2016, and 2020.

According to the analysis in Figure 2, it is found that: (1) the development of the construction industry in various provinces and cities is uneven, with more provinces and cities concentrated in general and higher development levels. The overall situation is “high in the east and low in the west, high in the south and low in the north”, which is consistent with the trend of economic and political development in various provinces and cities in China. (2) In 2011, 2016, and 2017, the development of the construction industry was concentrated in many provinces and cities with higher development, and was concentrated in the eastern part of China. From 2012 to 2015, and from 2018 to 2020, it was concentrated in more provinces and cities with general development. From 2012, 2014 to 2020, the number of provinces and cities in lower development decreased, while the number of provinces and cities in lower development increased. (3) Most regions with high levels of development in the construction industry are located in Jiangsu, Zhejiang, Shanghai, and Beijing, while the western region of China has always shown a weak and weak level of development. The provinces and cities with high-level development in the construction industry in 2011, 2015, and 2016 are Beijing, Jiangsu, Shanghai, and Zhejiang, surrounded by higher development provinces and cities. In 2020, the number of provinces and cities with high and high-level development significantly decreased, while the difference in the development level of the construction industry between provinces and cities in the middle and high stages was relatively low.

The reasons for the above situation are as follows: (1) In 2011, the Ministry of Housing and Urban Rural Development recently released the “Twelfth Five Year Plan” for the Development of the Construction Industry, which pointed out that the main goal of the “Twelfth Five Year Plan” is to accelerate the transformation of the development mode and industrial structure of the construction industry, accelerate the transformation of the development mode and enterprise structure adjustment of the construction industry, and promote the rapid development of the construction industry in various provinces and cities. (2) The draft of the 13th Five Year Plan for National Economic and Social Development of the People's Republic of China, published by the State Council in 2016, proposed the implementation of the overall regional development strategy of western development, northeast revitalization, central rise, and eastern leadership, laying the foundation for the overall development of China's construction industry and promoting the reduction of the gap in the development level of China's construction industry.

3.2.2 Regional Correlation Analysis

The above study analyzed the changes in the development level of the construction industry in various provinces over the years and the overall development situation in China. The gravity model was introduced to study the network diagram of spatial correlation in the construction industry, as shown in Figure 3.

From Figure 3, it can be seen that: (1) The relationship between provinces and cities has undergone slight changes with 2015, 2016, and 2017 as turning points. The most prominent ones are that in 2015, Beijing's connection with Hubei Province and Guizhou Province weakened, while Tianjin's connection with Jilin Province, Hunan Province, and other provinces and cities weakened, resulting in a decrease in overall network connectivity. In 2016, the connection between Shanghai and Heilongjiang Province increased, and in 2017, the connection between Zhejiang Province and Beijing and Shandong Province increased, resulting in an overall increase in network connections. (2) From 2015 to 2016, the degree of network density decreased, indicating a decrease in spatial network connections. In 2020, network connections increased significantly, and areas with low development levels in the construction industry, driven by high development areas, accelerated their development speed. The exchange of technology and information related to the construction industry between provinces and cities was strengthened.

Calculate the strength of connections between provinces and cities using the gravity model, and construct a network co-occurrence matrix for in-depth network analysis. Due to the unequal relationships between nodes in social networks, the theory of centrality analysis was introduced to measure the status and role of each node in the social network. The correlation between provinces was analyzed from point centrality, proximity centrality, and intermediate centrality.

(1) Point degree centrality. The more connections a province or city establishes with other provinces and cities, the higher its degree of centrality, and the closer it is to the central position of the entire network, which can better lead the development of the construction industry in other provinces and cities. The centrality values of points in 2011, 2015, 2016, and 2020 are shown in Table 1. According to Table 1, the degree centrality of seven provinces and cities, including Beijing and Tianjin, is higher than the national average, indicating that these provinces and cities have established more connections with other provinces and cities. Beijing, Shanghai, and Zhejiang provinces have the highest degree centrality rankings and occupy a central position in the network, making them the main actors in the construction industry agglomeration network.

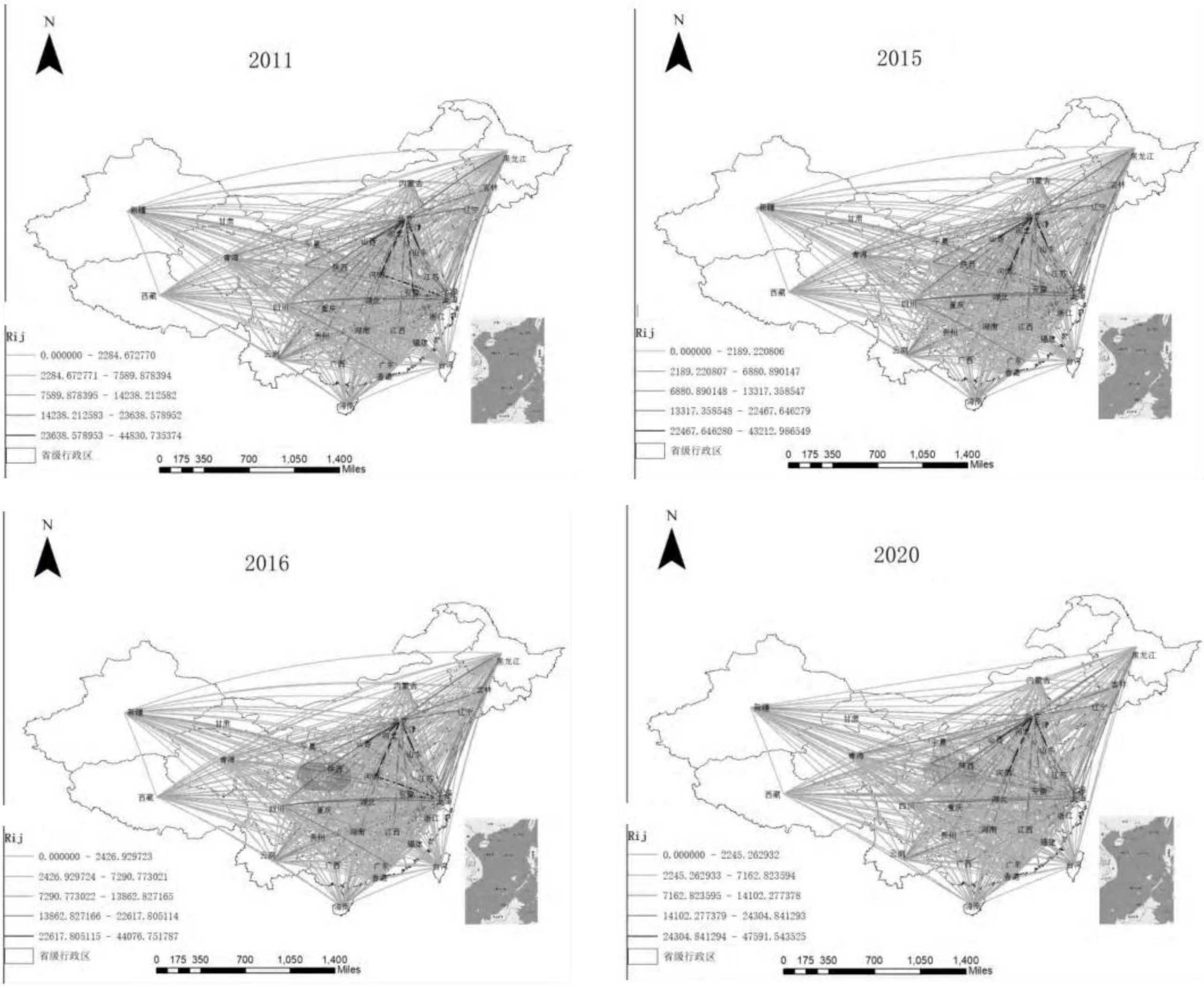

Figure 3 Network diagram of spatial correlation in the construction industry in 2011, 2015, 2016, and 2020.

Beijing and Tianjin are located in the Beijing Tianjin Hebei economic circle, with abundant talents and technological resources. Their politics, transportation, and economy are highly developed; Shanghai, Jiangsu Province, Zhejiang Province, Fujian Province, and Guangdong Province are located in the eastern coastal areas of China, with good geographical advantages. They are the financial and transportation centers of China and play a pivotal role in the development of the construction industry. They have a high spatial spillover effect and can drive the development of the construction industry in other provinces and cities.

(2) Approaching centrality. Proximity centrality reflects the degree to which a province or city is not controlled by other provinces or cities in the agglomeration of the construction industry. The closeness centrality values for 2011, 2015, 2016, and 2020 are shown in Table 1. Beijing, Tianjin, Jiangsu, Shanghai, Zhejiang, and Fujian provinces have high centrality values, and 5 provinces and cities belong to the economically developed

eastern coastal areas with strong spatial spillover effects and endogenous driving forces. The lower ranked provinces include Liaoning and Inner Mongolia, which belong to the position of marginal actors in space due to geographical location, economy, and other factors.

(3) Intermediate centrality. The intermediate centrality reflects the number of times a province serves as a bridge for communication and interaction between the other two provinces. The intermediate centrality values for 2011, 2015, 2016, and 2020 are shown in Table 2. According to Table 2, Beijing, Jiangsu Province, Shanghai City, Zhejiang Province, and Fujian Province have a high intermediate centrality ranking and can serve as intermediaries to connect with the construction industry in other provinces.

Table 1 Point centrality and proximity centrality values for each province in 2011, 2015, 2016, and 2020.

Province	2011		2015		2016		2020	
	Point degree centrality	Approaching centrality	Point degree centrality	Approaching centrality	Point degree centrality	Approaching centrality	Point degree centrality	Approaching centrality
Shanghai	28	93.75	28	93.75	28	93.75	28	93.75
Beijing	27	90.909	27	90.909	27	90.909	28	93.75
Jiangsu	26	88.235	25	85.714	24	83.333	25	85.714
Tianjin	25	85.714	16	68.182	10	60	17	69.767
Zhejiang	25	85.714	25	85.714	25	85.714	24	83.333
Guangdong	23	81.081	24	83.333	23	81.081	20	75
Fujian	16	68.182	21	76.923	20	75	24	83.333
Guizhou	9	58.824	9	58.824	7	56.604	7	56.604
Yunnan	8	57.692	7	56.604	6	55.556	6	55.556
Xizang	8	57.692	8	57.692	6	55.556	7	56.604
Qinghai	8	57.692	8	57.692	6	55.556	7	56.604
Gansu	8	57.692	9	58.824	9	58.824	9	58.824
Guangxi	7	56.604	8	57.692	7	56.604	8	57.692
Hainan	7	56.604	6	55.556	6	55.556	6	55.556
Chongqing	7	56.604	9	58.824	8	57.692	8	57.692
Hebei	7	56.604	9	58.824	8	57.692	10	60
Sichuan	7	56.604	8	57.692	8	57.692	8	57.692
Anhui	7	56.604	7	56.604	7	56.604	6	55.556
Jiangxi	7	56.604	7	56.604	6	55.556	6	55.556
Hunan	7	56.604	6	55.556	6	55.556	6	55.556
Heilongjiang	6	55.556	8	57.692	8	57.692	7	56.604
Xinjiang	6	55.556	6	55.556	6	55.556	7	56.604
Shanxi	6	55.556	8	57.692	9	58.824	7	56.604
Ningxia	6	55.556	7	56.604	6	55.556	7	56.604
Hubei	6	55.556	5	54.545	5	54.545	5	54.545
Shanxi	6	55.556	5	54.545	5	54.545	5	54.545
Jilin	6	55.556	8	57.692	7	56.604	7	56.604
Liaoning	5	54.545	5	54.545	5	54.545	6	55.556
Inner Mongolia	5	54.545	5	54.545	5	54.545	4	53.571

(4) The clustering network of the construction industry in each province consolidates subgroups. Cohesive subgroup analysis is based on the strength of the connection between provinces and cities in the construction industry, analyzing the clustering situation of each province and city within the network and the evolution of cohesive subgroups, reflecting the closeness of the connection between the construction industry. This article uses Ucinet to generate cohesive subgroups for 31 provinces and cities across the country.

Seven condensed subgroups were generated in 2011, 2012, 2015, 2017, 2018, and 2019, and eight condensed subgroups were generated in 2013, 2014, 2016, and 2020.

Table 2 Intermediate centrality values for 2011, 2015, 2016, and 2020.

Provinces	2011	2015	2016	2020	Provinces	2011	2015	2016	2020
Beijing	167.546	154.151	150.864	136.896	Anhui	3.941	3.815	4.265	2.179
Jiangsu	58.273	69.604	77.012	76.392	Shandong	3.282	5.135	2.355	1.559
Shanghai	55.653	69.736	87.199	84.938	Hubei	3.017	1.222	1.247	0.932
Zhejiang	47.48	52.887	58.846	44.945	Shanxi	2.49	9.267	17.838	5.584
Guangdong	34.787	42.502	44.899	36.106	Heilongjiang	0.807	7.075	11.039	5.584
Tianjin	77.747	17.602	3.714	23.367	Jilin	0.807	1.842	2.059	1.715
Fujian	13.982	36.096	40.346	61.199	Shaanxi	0.482	0.546	0.554	0.545
Guizhou	10.001	3.982	3.291	2.597	Inner Mongolia	0.348	0.418	0.419	0.276
Sichuan	6.766	4.065	4.765	3.822	Liaoning	0.348	0.546	1.224	3.427
Jiangxi	6.766	3.815	3.551	2.616	Chongqing	0	0	0	0
Hunan	6.766	3.451	3.551	2.616	Qinghai	0	0	0	0
Yunnan	6.251	3.058	1.93	0.443	Xinjiang	0	0	0	0
Gansu	5.825	8.078	4.887	7.416	Ningxia	0	0	0	0
Guangxi	5.742	3.321	3.291	3.088	Xizang	0	0	0	0
Henan	4.951	9.267	4.265	6.355	Hainan	0	0	0	0
Hebei	3.941	12.517	14.588	14.403					

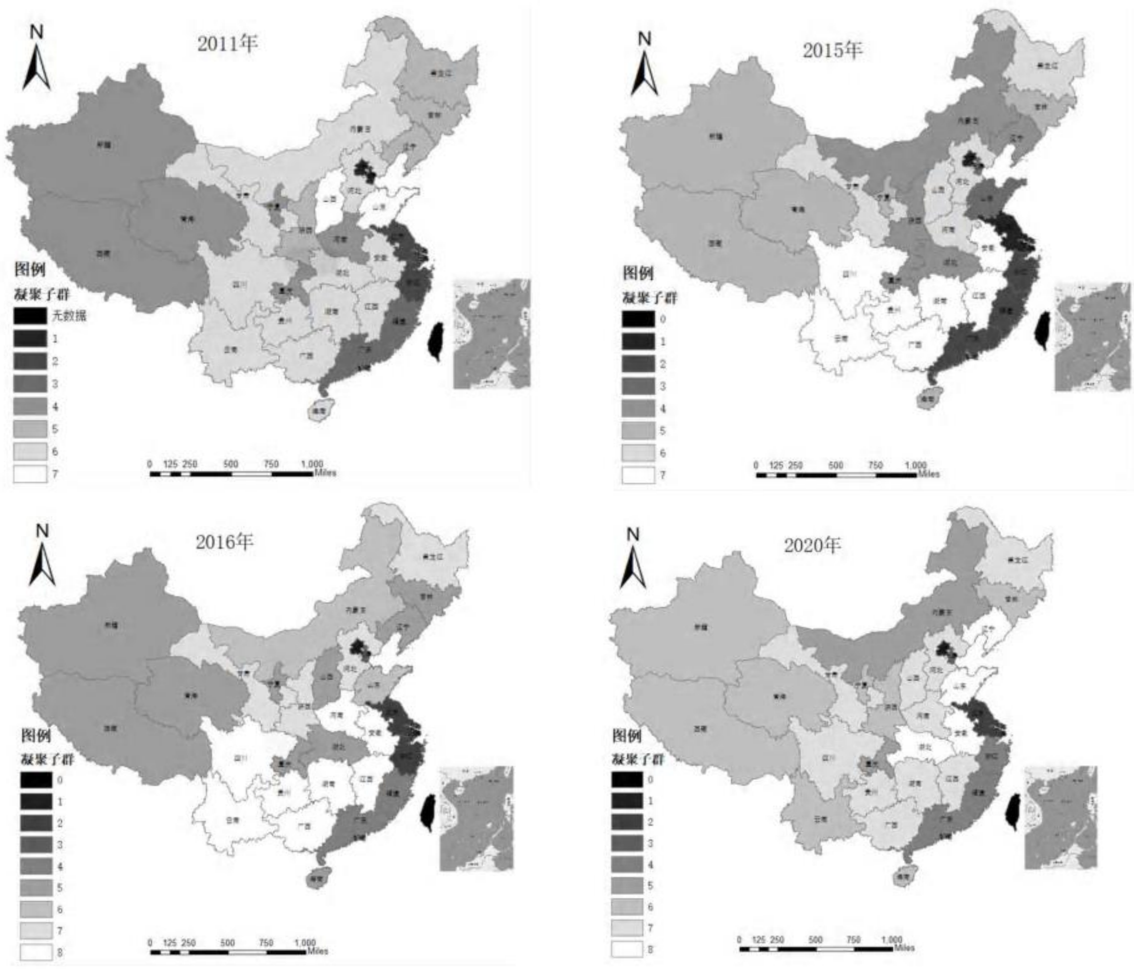

Figure 4 Condensed subgroup graphs for 2011, 2015, 2016, and 2020.

From Figure 4, it can be seen that: (1) All condensed subgroups have changed from 2011 to 2020. The frequency of changes shows that, except for Beijing, all other provinces and cities belong to two or more subgroups. The provinces and cities with the most changes in subgroups are Hubei Province and Inner Mongolia Province, indicating frequent changes in information and cooperation related to the construction industry between Hubei Province and Inner Mongolia Province and other provinces and cities. (2) Guangdong and Fujian provinces have always been in the same cohesive subgroup, with adjacent geographical locations. In 2010, the Guangdong Fujian Chamber of Commerce was established, which has established close economic relations between the two provinces. The economic connection directly promotes the common development of the construction industry. Xinjiang Province, Hainan Province, Qinghai Province and Xizang Province are geographically adjacent, closely linked and always in the same cohesive subgroup. (3) There was not much change in the subgroup members between 2011 and 2015, and there were four distinct cohesive subgroups in China, namely located in the western, northern, eastern, and southern parts of China. (4) In 2016, some provinces and cities in the cohesive subgroups of northern and southern China began to break spatial limitations and form different cohesive subgroups. The cohesive subgroup formed in the eastern region of China is composed of a few economically developed provinces, and the provinces and cities within the subgroup are constantly changing, indicating that the eastern region of China has strong endogenous dynamics and a certain degree of independence.

4. Conclusion

Based on the relevant data of 31 provinces (autonomous regions, municipalities directly under the Central Government) in Chinese Mainland from 2011 to 2020, this paper constructs the correlation model and evolution analysis model of the national construction industry cluster, and analyzes the connection strength and development level of the construction industry in all provinces of the country. The main conclusions are as follows:

(1) National policies are an important factor affecting the agglomeration development of the construction industry. For a long time, overcapacity in the construction industry has led to extensive losses for enterprises. Due to the policies introduced by the government in 2016 to adjust the industrial structure, the network density of the construction industry has significantly decreased, and from 2016 to 2019, it has been at a low agglomeration level.

(2) The development of the construction industry in various provinces presents an uneven and asymmetric phenomenon. The overall situation presents a “high in the east and low in the west, high in the south and low in the north” trend, which is consistent with the economic and political development trends of various provinces in China.

(3) The degree centrality and proximity centrality between the Beijing Tianjin Hebei Economic Circle and the eastern coastal areas of China are the highest. The provinces and cities it contains occupy the central position of the network, which can effectively control and drive the agglomeration and development of the construction industry in other provinces and cities, and play the role of a “button” to drive underdeveloped western provinces to move towards moderately developed areas.

(4) Provinces and cities in the construction industry cluster network that are adjacent or have the same level of economic development are more likely to form the same cohesive subgroup for common development. Currently, there are four distinct cohesive subgroups in China. The cohesive subgroup in the eastern region of China is composed of a few highly developed provinces and cities, and its connection with other provinces and cities is not very close.

References

1. The Development Situation of the Construction Industry during the 14th Five Year Plan Period in Our Editorial Department [J]. Installation, 2021 (05): 1-2.

2. Fik T J, Mulligan G F. Spatial flows and competing central places: Toward a general theory of hierarchical interaction. Environment & Planning A, 1990, 22(4): 527-549.
3. Meijers E. From central place to network model: Theory and evidence of a paradigm change. Tijdschrift Voor Economische En Sociale Geografie, 2010, 98(2): 245-259.
4. BATTY M. New ways of looking at cities ［J］.Nature, 1995,377(6550) :574-574.
5. SHEN G. Reverse -fitting the gravity model to inter –city airline passenger flows by an algebraic simplification ［J］.Journal of Transport Geography,2004,12(3): 219-234.
6. Matsumoto H.International urban systems and air passenger and cargo flows: some calculations. Journal of Air Transport Management, 2004,(10):241-249.
7. Peter Nijkamp，Aura Reggiani. Spatial Interaction Models and Gravity Theory a Concise Overview ［M]. Berlin:Springer Berlin Heidelberg,1992,2 -16.
8. Cheung C,Black J. A Reappraisal of the Intervening Opportunities Model of Commuter Behaviour［J］.Road and Transport Research,2008,17(2) :3-18.
9. Li Chen, Jin Xiangmu. Research on Spatial Connection Measurement of Central Towns Based on Gravity Model: Taking 25 Central Towns in Jinhua City, Zhejiang Province as an Example [J] Geographic Science, 2016 (05): 724-732.
10. Miao Hongliang, Zhou Hui. A comparison of economic connections and hierarchical structures within three major urban agglomerations in China: an analysis based on the comprehensive gravity model [J] Economic Geography, 2017 (06): 52-59.
11. Qi Mengxi, Lu Han, Cao Shisong, et al. Analysis of spatiotemporal evolution of economic spatial structure based on gravity model: A case study of Henan Province [J]. Geography Research, 2018 (05): 883-897.
12. Dai Yong'an, Chen Cai. Spatial econometric analysis of development differences in the construction industry in China's provinces [J]. Forum on Statistics and Information, 2010, 25 (05): 53-58.
13. Hong Jingke, Huang Zhijin, Yao Jiadai, et al. Research on the agglomeration and spatial spillover effects of the construction industry in the Yangtze River Economic Belt [J]. Construction Economics, 2020, 41 (12): 21-25.
14. Fan Jianshuang, Yu Xiaofen. Research on the Coupling Mechanism between Construction Industry Agglomeration and Housing Industrialization [J]. China Real Estate, 2012 (22): 12-20.
15. Qian Chunlei, Ye Jing, Lu Chao. A study on the division of the gravity pattern of Wuhan urban agglomeration based on an improved urban gravity model [J]. Progress in Geographic Science, 2015, 34 (02): 237-245.
16. Cao Linjian, Qi Zijun, Wang Lisha. A Study on the Coupling and Synergy of Urbanization and Construction Industry Development [J]. Construction Economy, 2016, 37 (11): 87-91.
17. Guangjin Tian,Zhi Qiao,Yaoqi Zhang.The investigation of relationship between rural settlement density, size, spatial distribution and its geophysical parameters of China using Landsat TM images [J]. Ecological Modelling.231(2012),25-36.
18. Mi Yang, Li Ailing, Zhang Xinghua, et al. Study on the spatial distribution characteristics of provincial construction industry output value [J]. Engineering Economics, 2018, 28 (06): 48-51.
19. Yang Guoan, Gan Guohui. Spatial distribution characteristics and changes of urban systems in China [J]. Earth Information Science, 2004 (03): 12-18.
20. Krugman P, Venables A. Integration, specialization， and adjustment [J]. European Economic Review,1996,40(3) : 959-67.
21. Crozet M, Soubeyran P. EU enlargement and the internal geography of countries [J]. Journal of Comparative Economics, 2004, 32(1) : 265-279.
22. Li Shaolin, Xiao Xingzhi. Research on the linkage between urbanization and spatial structure of the construction industry [J]. Building Economy, 2014 (01): 12-16.

23. Wang Yousong, Su Boya, Zhang Yangbing, et al. Research on the Impact of Industrial Agglomeration on Total Factor Productivity of the Construction Industry [J]. Construction Economics, 2020, 41 (12): 9-14.
24. Hu Ying, Zhang Jin, Liu Zhuanhua, et al. A study on the spatial connections of urban agglomerations in the middle reaches of the Yangtze River based on gravity models and urban flow [J]. Modern Urban Research, 2016 (01): 52-57.
25. Jia Nan. Research on the spatiotemporal evolution of the development level of regional construction industry in China [J]. Engineering Economics, 2019, 29 (02): 44-49.
26. Zhou Xumeng. Research on the Spatial Agglomeration Effect of the Construction Industry and Its Relationship with the Development of New Urbanization [D]. Xi'an: Xi'an University of Architecture and Technology, 2018.
27. Zhao Chunfeng, Yang Qingqing, Zhu Yuanyuan, et al. Spatial Connection and Spatial Organization of Hunan Regional Economy [J]. Economic Geography, 2015, 35 (8): 53-60, 67.