Evolutionary Characteristics and Influencing Factors of the Investment Agglomeration Network Structure of the Bohai-Rim Urban Agglomeration: A Perspective on Urban Planning and Based on Data of Listed Enterprises

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Abstract. The improvement of the investment network of urban agglomerations is conducive to promoting the optimization of the economic and industrial structures of cities, accelerating the social and economic integration of urban agglomerations, improving the core competitiveness of regional development, and being a significate part of urban planning and design. However, the construction methods of the urban investment network in existing studies are relatively simple, and explorations of the influencing factors of such a network are insufficient and imprecise by a lack of discussion in China's unique institutional environment. Therefore, the current research constructs the investment network of the Bohai-Rim Urban Agglomeration (BRA) based on the data of Chinese listed enterprises. This research also explores the evolution characteristics of BRA's network structure in 2010, 2015, and 2021. Lastly, this research performs multiple regression analysis to investigate the impact of different influencing factors on the investment activities of node cities. Results show that a). the overall spatial pattern of the BRA's network has gradually shifted from the core area of the Beijing-Tianjin-Hebei urban agglomeration to the core area of the high-value continuous belt of the urban agglomeration in the central part of Bohai Rim. b). the network is affected in different degrees by the administrative ranks of cities, government's ability of intervention, economic development, financial environment, and innovation level. The relevant conclusions of this research are conducive to guiding urban planning and design, providing additional effective suggestions for cities to formulate policies and strategies to improve their economies and status.

Keywords: investment network, urban agglomeration, centrality analysis, influencing factors, evolutionary

1 INTRODUCTION

With the emergence of globalization and acceleration of global capital flows, cities are

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no longer divided into traditional hierarchies but are gradually transformed into dynamic urban networks through spatial–temporal connections facilitated by frequent factor flows. Given that cities are the most important sites for economic activities, the characteristics and patterns of urban economic networks can reflect the spatial configuration and agglomeration characteristics of economic activities, which are beneficial in guiding urban layout and promoting urban economic growth [1,2]. Research on urban economic networks has attracted the attention of many scholars, like GaWC proposed "flow space" theory and the chain network model based on high-end productive service enterprises to simulate inter-city connections with the distribution relationship of headquarters, regional centers, and branches [3]. Enterprises are often regarded as the main drivers of urban economic activities, and investments of inter-city enterprises are important means to promote the economic growth of cities. Therefore, investment network research based on the enterprise perspective is one of the most important methods in studying the urban economic network. This approach is markedly able to respond to the complexities of inter-city links and is conducive to promoting the optimization of the industrial structure of the urban economy, accelerating the social and economic integration of urban agglomerations development processes, improving the core competitiveness of regional development, and guiding urban planning and design [4].

At present, the methods of network construction in studies on investment network based on the enterprise perspective are relatively simple. These methods are mainly constructed using a single element, such as the number of enterprises or investment capital as edge weight, which lack the synergistic consideration of the number of enterprises and investment capital (i.e., consideration of enterprise scale). For example, the investment network constructed by Lu et al. is based on the number of enterprises investing between cities as edge weight [5]. Alderson et al. constructed the headquarters–branch urban network based on high-end productive service enterprises for research, which is one of the most common methods for constructing urban investment networks [6]. Wang et al. used the total amount of investments from one city to a certain industry in another city as the edge weight for constructing an investment network to conduct research. Thereafter, they summarized and defined the network relationship of three major urban agglomerations [7]. The exploration of the influencing factors of investment network is conducive to national macroeconomic regulations, driving the development of the urban economy and other aspects. However, current explorations of this aspect remain insufficient. Ye et al. found the influencing factors, such as urban population density and administrative power on the outdegree and indegree, and concluded that the joint role of the market and government [8]. By contrast, Meijers et al. explored the influence of such factors as city function and city scale on the urban economic network and found a positive correlation [9]. Note that the exploration of network influencing factors is conducive to the development and maintenance of urban networks. However, the types of factors explored remain lacking in diversity, and the degree of refinement of the results is also insufficient by a lack of discussion in China's unique institutional environment.

To address the aforementioned challenges, this research introduces the enterprise scale factor. Enterprise scale integrates the number of "headquarters–branches" and registered capital of enterprises to construct an urban investment network and explores

the evolution laws and influencing characteristics of this investment network. Moreover, enterprise scale is an indispensable consideration in the research on urban networks. Cross-city investment by large enterprises is conducive to driving regional development, improving the market competitiveness of cities, and generating a scale effect attracting additional enterprises to invest in cities, thereby generating substantial economic benefits [10]. In addition, the current research enriches the investigation on the influencing factors of investment network by selecting five indicators (i.e., city's administrative rank, government's ability of intervention, economic development, financial environment, and innovation level) as influencing factors to obtain additional detailed conclusions in China's unique institutional environment. The results of this research can help guide urban planning and design and provide further effective suggestions for cities to formulate policies and strategies to improve economies and status.

2 METHODS

2.1 Research Area and Data Sources

The research area is the Bohai-Rim Urban Agglomeration (BRA) in Northern China, encompassing the vast economic region surrounding the Bohai Sea and part of the Yellow Sea coastline. BRA mainly includes the two municipalities directly under the central government, namely, Beijing and Tianjin, and the three provinces of Hebei, Shandong, and Liaoning. The region covers an area of 1,120,000 km2 and has a population of about 260 million people. BRA is known as one of the three major urban agglomerations in China, along with the Yangtze River Delta region and Guangdong–Hong Kong–Macao Greater Bay Area. BRA, with its favorable location, numerous enterprises, significant investments, strong competitiveness of the regional economy, and unique layout, is a suitable region for conducting research on issues related to regional economy.

Data of listed enterprises were obtained from the publicly available data on the China 114 Telephone Inquiry Website (https://www.54114.cn/) in 2010, 2015, and 2021, totaling 929 companies. Information includes the names, addresses, and registered capital of the enterprises. The links data between the headquarters and branches of the enterprises were sourced from Tianyancha (https://www.tianyancha.com/) and Green Shield Enterprise Credit System (https://www.11315.com/). Their branches in the research area were retrieved through data search by the names of enterprise headquarters, yielding a total of 41,486 data sets. A secondary query was conducted to eliminate anomalous information and make additional corrections to missing information. Firms' registered capital and year-to-year changes were obtained from the China Stock Market & Accounting Research Database (CSMAR) (https://www.gtarsc.com/). After screening and elimination, 8,066 rules of change of registered capital and enterprise reserves in 2010, 2015, and 2021 were obtained.

2.2 Network Construction and Centrality Analysis

This research drew on the GaWC research group's method of constructing a chain

network model based on high-end productive service enterprises to simulate inter-city linkages with the distribution relationship of headquarters and branches [3]. However, single-factor data based solely on the headquarters–branches of enterprises between different cities often cannot explain the complex investment network relationships between cities [11]. The current research integrated registered capital and enterprise scale to establish a directed weighted network based on the headquarters–branches data of enterprises between different cities. Establishing an investment network with composite indicator data can more accurately describe the investment relationship between cities. Due to the fact that larger enterprises have more branches, this research uses the ratio of the total number of global branches owned by all headquarters in the city to the number of headquarters to measure the overall enterprise size of the city [3]. This research defined the formula for linkage strength as follows:

$$X_{ij} = a_{ij}c_{ij}\frac{B_i}{H_i} + a_{ji}c_{ji}\frac{B_j}{H_j} \quad (1)$$

where X_{ij} is the linkage strength between network node i and network node j; a_{ij} is the total number of branches in node j of the enterprises, headquarters of which are in node i; c_{ij} is the average registered capital of enterprises with headquarters in node i when they register branch offices in node j; $\frac{B_i}{H_i}$ is the ratio of the total number of global branches owned by all headquarters in node i to the total number of headquarters in node i; a_{ij} and c_{ij} are the corresponding opposite vector values; and $\frac{B_i}{H_i}$ is the ratio of the total number of global branches owned by all headquarters in node j to the total number of headquarters in node j.

The social network analysis (SNA) method is an analytical method describing the characteristics and structure of the overall network [12]. In this context, centrality analysis is often used as a basic concept of SNA to assess the relative importance of nodes in the network [13]. This research analyzed the development level, complexity, and evolutionary characteristics of the investment network structure of BRA through three types of centralities: degree, betweenness, and closeness centralities (see Table 1).

Table 1. Meaning of centrality indicators and their formulas.

Indicator	Formula	Explanation and meaning of formula
Degree centrality	$C_B(m) = \sum_{j=1}^{n} \frac{X_{ij}}{n-1}$	Where $C_D(i)$ is the degree centrality of node i, X_{ij} is the linkage strength between node i and j, and n is the number of city nodes in the network It measures the importance of a node in the network [14]
Betweenness centrality	$C_B(m) = \sum_{i \neq j} \frac{\sigma_{ij}(m)}{\sigma_{ij}}$	$C_B(m)$ is the betweenness centrality of node m, σ_{ij} is the number of all the shortest paths from network node i to j, $\sigma_{ij}(m)$ is the number of all the shortest paths from network node i to j through node m.

		It measures the degree to which nodes assume the role of transit bridges in the network [15]
Closeness centrality	$C_c(i) = 1/\sum_j d_{ij}$	Where $C_c(i)$is the closeness centrality of node i, and d_{ij} is the shortest path distance between node i and j It reflects the importance of the location of nodes in the network, that is, the degree of closeness to the center of the network [14]

2.3 Multiple Regression Analysis of Influencing Factors

To further explore the differences in the influence of various influencing factors on the investment network structure of BRA, this research constructed two econometric models, with indegree and outdegree as explanatory variables. The explanatory variables include five aspects, namely, urban administrative rank, government's ability of intervention, economic development, financial environment, and innovation level. These aspects were analyzed via multiple regression analysis using Stata17. The model is as follows:

$$\ln InD_{i,t} = \alpha + \alpha_1 \ln AR_{i,t} + \alpha_2 \ln GAI_{i,t} + \alpha_3 \ln GDP_{i,t} + \alpha_4 \ln FE_{i,t} + \alpha_5 \ln IP_{i,t} + \varepsilon_1, \quad (2)$$

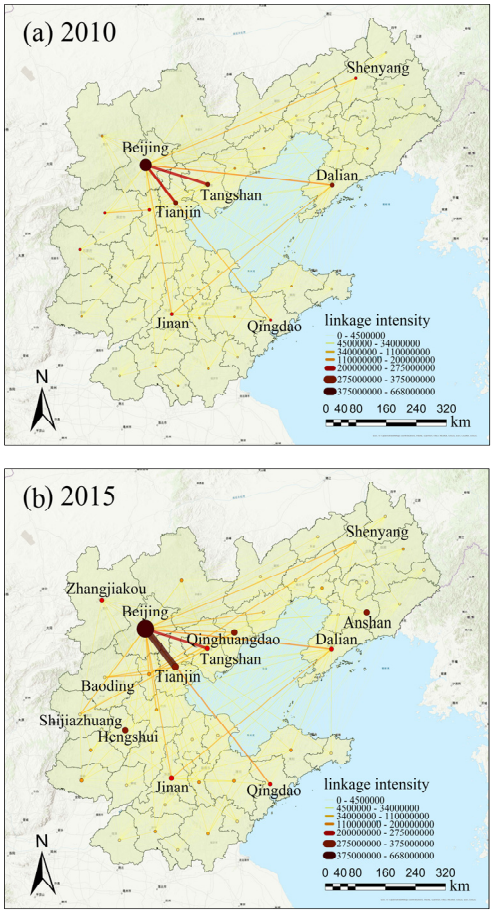
$$\ln OutD_{i,t} = \alpha_0 + \alpha_6 \ln AR_{i,t} + \alpha_7 \ln GAI_{i,t} + \alpha_8 \ln GDP_{i,t} + \alpha_9 \ln FE_{i,t} + \alpha_{10} \ln IP_{i,t} + \varepsilon_2, \quad (3)$$

where α, α_0 are constant terms; α_1, α_2, …, α_{10} are the regression coefficients of each variable; ε_1, ε_2 are the random interference terms; $\ln InD_{i,t}$ is the logarithm of the indegree of i city in t years; $\ln OutD_{i,t}$ is the logarithm of the outdegree of i city in t years; and $\ln AR_{i,t}$ is the logarithm of the urban administrative rank (see Li et al.). Weights assigned to the administrative ranks of municipalities directly under the central government, provincial capitals, Chinese municipalities with independent planning status, and prefecture-level cities are 0.59, 0.22, 0.13, and 0.06, respectively [8]. Meanwhile, $\ln GAI_{i,t}$ is the logarithm of the proportion of public financial expenditure to GDP, indicating the government's ability of intervention; $\ln GDP_{i,t}$is the logarithm of GDP; $\ln FE_{i,t}$is the logarithm of the balance of deposits and loans of financial institutions to the proportion of GDP, indicating the financial environment index; and $\ln IP_{i,t}$ takes the logarithm of the number of invention patents granted by the city, indicating the innovation level of the city.

To avoid heteroskedasticity, this research took the logarithm of each variable and used ordinary least squares to conduct regression analysis and lagged all the explanatory variables by one period.

3 RESULTS

This research used ArcGIS to visualize the investment network structure of BRA in an origin–destination (O–D) framework. The natural breakpoint method was utilized to classify the strength of investment links between city nodes, resulting in a spatial network connection topology map, as shown in Figure 1. The visualization map indicates that the investment network structure of BRA exhibited an evident point-and-shoot shape, with main connections concentrated in the Beijing–Tianjin–Hebei area. A comparison of time evolution revealed an increasing number and direction of linkage between network nodes. The overall development of the linkage strength of the network structure tended to be balanced, gradually forming a V-shaped structure consisting of three urban agglomerations: Beijing–Tianjin–Hebei, central and southern Liaoning, and Shandong Peninsula. In addition, the strength of existing links has continuously strengthened and developed vertically and deeply, with Beijing emerging with the strongest linkage during the decade.



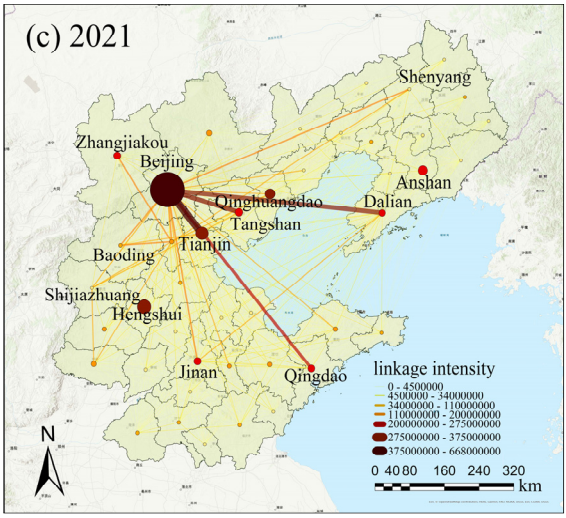


Fig. 1. Investment network structure of Bohai-Rim urban agglomeration by time period.

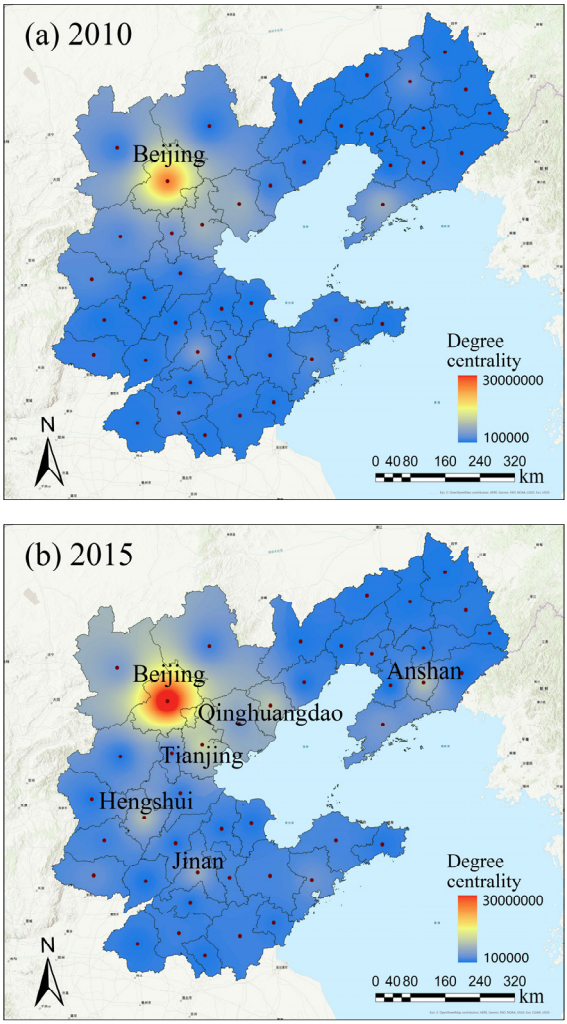
3.1 Evolutionary Characteristics of the Investment Network Structure

This research used the constructed investment network as basis to interpolate the centrality of each city node in BRA for 2010, 2015, and 2021, thereby reflecting the spatial structure of city nodes in the network. Overall, the degree, betweenness, and closeness centralities in the BRA network exhibited evident high and low value intervals. Specific characteristics were observed with evolution over time.

First, the spatial pattern of degree centrality of urban agglomerations investment network nodes is presented in Figure 2. From 2010 to 2021, the high and low value intervals under the global perspective of the network continued to diverge. However, the network structure gradually transitioned from the extreme "one super" situation, in which the spatial pattern of Beijing's degree centrality was considerably higher than that of the other city nodes, to the "one superpower and few major powers" situation, in which the gradual evolution indicated city nodes with higher degree centrality values in all provinces and Chinese municipalities directly under the central government. This situation characterizes a multilevel centrality distribution.

The degree centrality of network nodes correlates significantly with the city spillover effect, local resources, and city location and policy conditions. For example, nodes with high degree centrality were concentrated in Beijing and gradually spread to such cities as Tianjin and Qinhuangdao around Beijing, forming a high level of high degree centrality area. The reason is that Beijing, as the capital city, is the economic core of the region and attracts numerous corporate investments. Under the spillover effect [16], Beijing is gradually relocating some of its economic industries to neighboring cities, particularly transferring its non-capital functions. Tianjin and Hebei Province benefit from Beijing's radiation and absorb the spillover economy generated by Beijing, thereby emphasizing the importance of these city nodes. Moreover, Anshan relies on

its extensive iron ore resources to vigorously develop its iron and steel industries, leading to rapid industrialization and ultimately increasing its investment level in the region. Similarly, Qingdao in Shandong Province benefits from its superior coastal port location, providing vital port services for cargo transportation and logistics, which promote the development of urban commerce and industry. Qingdao was listed as a Chinese municipality with independent planning status in 1986, granting it greater economic management authority and better policy support [17]. This situation has created a markedly favorable business environment, attracting investments and increasing the importance of urban nodes in the investment network.



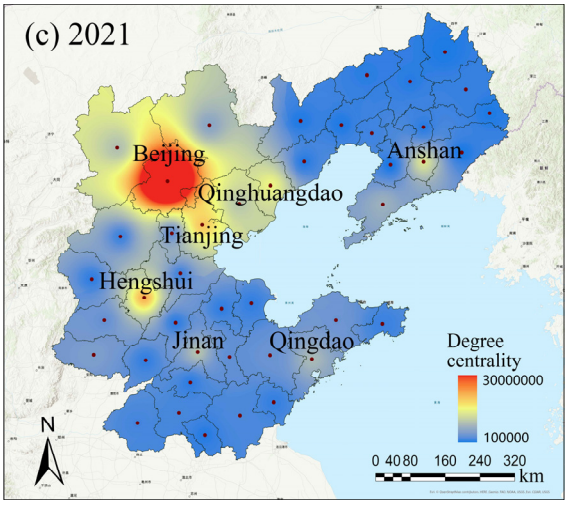


Fig. 2. Degree centrality of network nodes by time period.

Second, the spatial pattern of betweenness centrality of the investment network nodes in the urban agglomeration is illustrated in Figure 3. From 2010 to 2021, the exchange hub area of investment factors, which consists of Beijing, Tianjin, and their junction cities with high value of intermediary center in Hebei, has gradually weakened. The betweenness centrality of Dalian in Liaoning Province and Yantai, Qingdao in Shandong Province was increasing, gradually forming a bridge of cross-sea investment links. However, the betweenness centrality of the north and south poles of BRA has consistently differed from that of the central region over the past decade.

The betweenness centrality of the network nodes is highly correlated with the administrative level and external conditions of cities. For example, Beijing, as the capital city and the location of many corporate headquarters, is more likely to pool resources to attract investment to support branches around the region [2], resulting in higher betweenness centrality. However, as the number of enterprises in Bohai-Rim has increased and their distribution has gradually decentralized over the past decade, the intermediary hub advantage brought by Beijing's administrative level has diminished. The function of the Beijing–Tianjin–Hebei economic hub node area has weakened, and the betweenness centrality has reduced accordingly. However, Qingdao and Dalian have attracted numerous enterprises to settle and invest in the region owing to the significant benefits of their superior coastal port locations. This situation has enriched the number and direction of linkages in the urban investment network through these nodes, and their role as important hubs for the transmission of economic factors among the nodes has gradually increased.

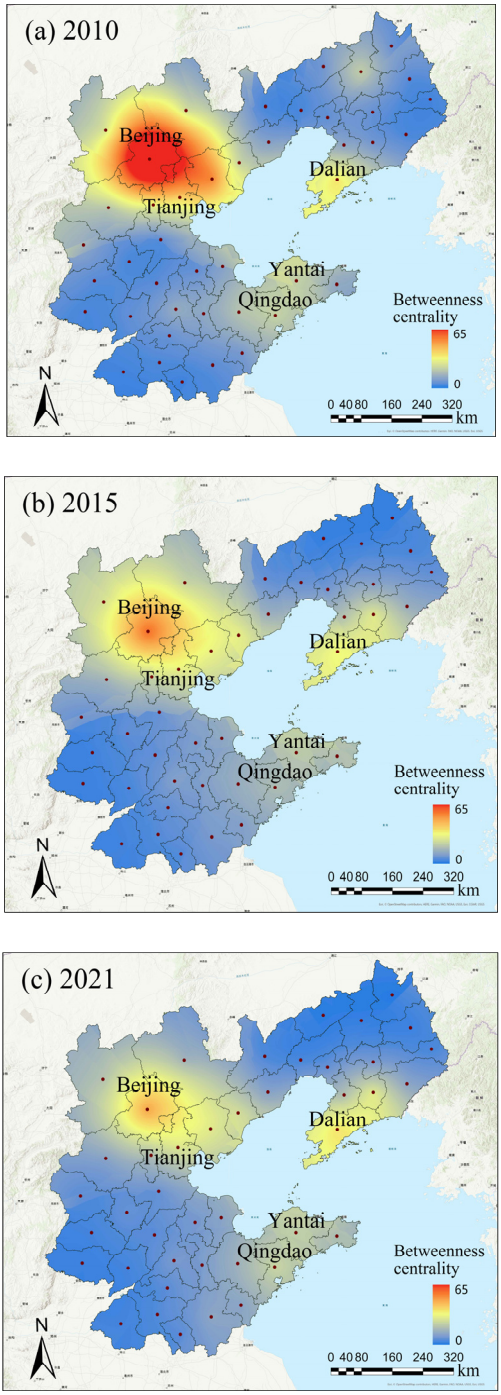
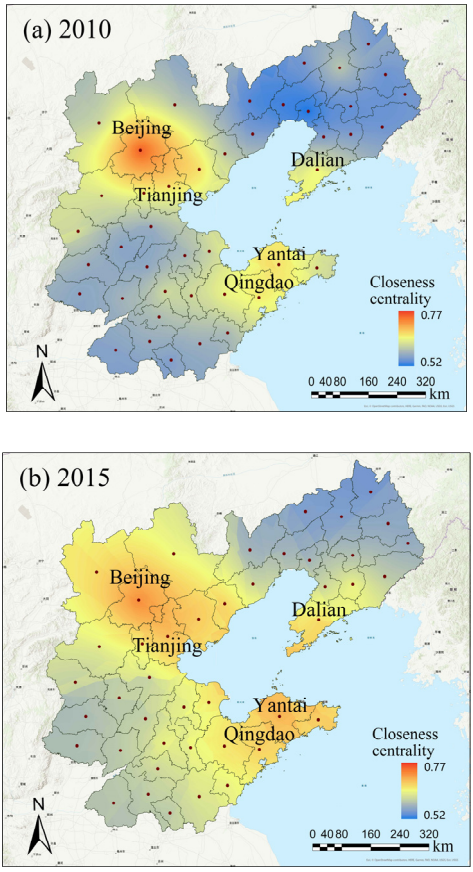


Fig. 3. Betweenness centrality of network nodes by time period.

Lastly, the spatial pattern of closeness centrality of urban agglomeration investment network nodes is shown in Figure 4. Over the past decade, the high-value zone of closeness centrality has gradually shifted from the "three powers" spatial pattern composed of the Beijing–Tianjin–Hebei, central and southern Liaoning, and Shandong Peninsula urban agglomerations to the spatial pattern of a high-value contiguous belt of the central urban agglomeration in Bohai Rim.

The evolution of network nodes' closeness centrality reflects the influence of cities' locations on the importance of their positions in the network. The high-value contiguous belt of the central BRA is increasingly important in the investment network of the Bohai-Rim region every year. This case verifies that Beijing, Dalian, Yantai, and Qingdao, as the economic core and hubs in the region, are experiencing increasing spillover and scale effects. Cities around these core cities are likely to be driven by the network [16], and they correspond to important locations in the network with high values of closeness centrality. Moreover, the aforementioned cities are predominantly coastal cities with port advantages, enabling them to considerably absorb the radiation effect from regional cores and hubs and continue the advantage of urban investment network center spillover [18].



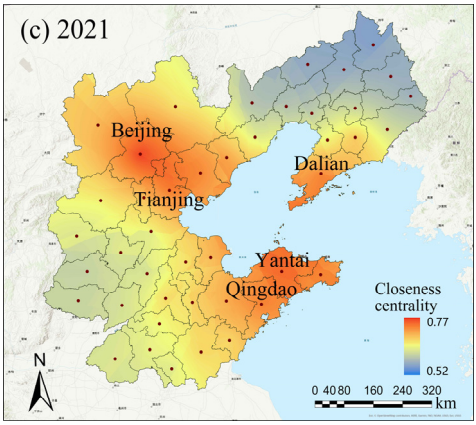


Fig. 4. Closeness centrality of network nodes by time period.

3.2 Influencing Factors of Investment Network Structure

After conducting the WHITE test, the results indicated that Pro > chi^2 = 0.3530 in Equation (5) and Pro > chi^2 = 0.2026 in Equation (6), indicating no heteroscedasticity. In addition, the variables in Equations (5) and (6) were tested separately, showing that the variance inflation factor (VIF) of all explanatory variables is below 4, with an average VIF of 2.93 and 2.94, respectively. This result suggests no serious multicollinearity between the explanatory variables. Table 2 presents the effect of each influencing factor on the outdegree and indegree to the nodes of the urban investment network. Moreover, Table 2 shows that the government's ability of intervention, the city's economic development level, and the financial environment have an impact on the outdegree and indegree of network node cities. However, the administrative rank and innovation level of cities have a certain impact on the indegree but have no impact on the outdegree. The following results are noteworthy.

First, the administrative rank of BRA has a negative impact on the indegree of node cities in the investment network of the region, with no significant correlation with the outdegree. This result indicates that high-level cities are minimally attractive in the investment network. On the one hand, this phenomenon may be attributed to the high degree of market openness in cities with high administrative grades, thereby favoring the introduction of foreign financial institutions. This situation relatively increases the entry threshold for Chinese capital and hinders the attraction of capital [19]. On the other hand, this case could be caused by the special characteristics of the administrative rank of BRA in terms of matching its economic agglomeration and primacy. Municipalities directly under the central government and provincial capitals are usually administrative core and also economic centers of the region. However, there are limitations in identifying economic centers by administrative centers. For example, although Jinan in Shandong Province and Shenyang in Liaoning Province are provincial capitals, they function more as administrative centers exercising administrative power. Their economic development and investment levels are not as high as those of Qingdao and

Dalian, which are separately listed cities in their corresponding provinces. These cities, as regional economic centers, tend to have more favorable investment policies and better trade locations [17].

Second, the government's ability of intervention has a markedly evident positive effect on the node's indegree but has a significant negative correlation with the outdegree. Given that government intervention can maximize the rationalization of the allocation of financial investment resources and enhance the efficiency of regional economic investments [20], such an intervention is conducive to cities attracting inward investment. In China's institutional background, local economic growth directly affects government performance and official promotion. To immediately gain growth advantages, local governments usually increase investments in crude production activities with short-term economic benefits [21], which is often politically selective. GDP-oriented incentives also lead to local governments preferring to intervene to attract investments from foreign enterprises and to retain enterprises to invest locally rather than outward. This situation leads to a decrease in outward investment in cities.

The level of urban economic development represented by GDP has a significant positive effect on the outdegree and indegree. That is, the higher the scale of economic development, the development of various industries in cities brings about an increase in inter-city investment behavior. The reason is that a good level of economic development can enhance economic resilience within the urban agglomerations. For example, cities can break administrative barriers through talent exchange and economic cooperation, maximize spatial proximity to connect with each other, and use technology transfer incentive policy to achieve knowledge sharing and economic synergy [22], ultimately bringing better investment and development opportunities. In addition, the rationalization of market structures, equalization of human resource levels, advanced investments in urban R&D, and technological innovations brought about by economic agglomeration [23], all of which are accompanied by economic growth, enhance the ability of cities to take the initiative and move forward vigorously in the regional investment network.

Cities' financial environment also shows a significant positive correlation with their outdegree and indegree in the investment network. This result indicates that the financial environment of cities can determine the difficulty of business operation. The more mature and perfect the financial environment, the easier for cities to carry out business, attract more capital, and generate industrial agglomeration effects [24]. The urban investment network is a new financial institutional arrangement; it is directly affected by the structure of the financial system, development of the financial market, and operational efficiency of the financial system [25]. When cities establish a good financial environment, capital becomes active, leading to an increase in the number of the cities' foreign investments and attracting inward investments.

Lastly, the innovation level of cities has a markedly significant positive correlation with their node indegree, while the correlation with the node outdegree is not significant. The reason is that when cities' innovation level increases, they have additional advantages in transforming industries into economic benefits under regional competition and cooperation. Enterprises dominate in interconnected investments, which is conducive to the entry of capital. For BRA, cities with high innovation levels, such as

Beijing, have attracted substantial inward investments in realizing the digital transformation of the economy and society and the high-quality shift in the mode of development, thereby enhancing the growth efficiency of the green economy [26]. Competition for innovation resources among cities prompts those at the innovation pole to trigger neighboring cities to follow suit in financial expenditures on science and technology, forcing neighboring cities to increase relevant expenditures. From the perspective of the proportion of increased expenditures, the increase in neighboring cities is considerably higher than that of the actual original pole [21], setting up cost obstacles for the spillover expansion of the original leading industrial enterprises. This phenomenon leads to high level of innovation in the region, possibly weakening the advantage of the spillover effect, which reduces enterprises' outward investment behavior.

Table 2. Results of multiple regression.

Variable	lnInD	lnOutD
lnAR (Urban administrative hierarchy)	-1.615*	-1.522
lnGAI (Government intervention capacity)	0.804**	-4.247***
lnGDP (Level of economic development)	1.069***	2.077***
lnFE (Financial environment)	0.513**	3.794***
lnIP (Innovation level)	0.645*	0.838
_cons	8.655***	-15.366***
R-squared	0.645	0.468
Prob > F	0.000	0.000

*** p<0.01, ** p<0.05, * p<0.1

4 CONCLUSION

This research constructed the investment network of BRA based on data of Chinese listed enterprises. We explored the characteristics of the structural evolution of the investment network using the centrality analysis method in SNA. In addition, we utilized the indegree and outdegree as dependent variables and five indicators (i.e., urban administrative rank, government's ability of intervention, economic development, financial environment, and innovation level) as independent variables. We explored the differences in the influence of these factors on the investment network structure of BRA by performing multivariate regression analysis.

The result indicates that the overall spatial pattern of the BRA's network has gradually shifted from the core area of the Beijing-Tianjin-Hebei urban agglomeration to the core area of the high-value continuous belt of the urban agglomeration in the central part of Bohai Rim. Over time, the overall network has exhibited an evident point-and-shoot shape and gradually evolved into a V-shaped structure comprising three city agglomerations: Beijing–Tianjin–Hebei, central and southern Liaoning, and Shandong Peninsula urban agglomerations. For the degree centrality analysis, the urban investment network structure has gradually shifted from the extreme spatial pattern of "one super" to the spatial pattern of "one superpower and few major powers," indicating

multi-level characteristics. In particular, cities' spillover effect, on-site resources, locations, and policy conditions are closely related to the evolution of the spatial pattern of degree centrality. For the betweenness centrality analysis, the investment factor exchange hub area comprising Beijing, Tianjin, and border cities in Hebei with high intermediary centrality is gradually weakening. By contrast, the betweenness centrality of Dalian in Liaoning Province and Yantai and Qingdao in Shandong Province is increasing, gradually forming a cross-sea investment linkage bridge. This evolution is influenced by the city administrative rank and external conditions. At the closeness centrality analysis level, the high-value zone has gradually transitioned from the "three powers" spatial pattern to the high-value contiguous belt of the urban agglomeration in the central part of Bohai Rim. Accordingly, the result of the evolution is related to the location of cities.

For the differences in the impact of different influencing factors on the structure of investment networks of BRA, this research found that the government's ability of intervention, the city's economic development level, and the financial environment have an impact on attracting investment to network node cities and encouraging enterprises to invest abroad. However, the administrative rank and innovation level of cities have a certain impact on attracting investment but have no impact on encouraging enterprises to invest abroad. the administrative rank of cities within BRA reflects the impact of market openness on their investment activities. It also illustrates the special match between the administrative and economic centers of cities within BRA. The government's ability of intervention suggests that investment activities in cities, under the influence of China's institutions, are highly correlated with the implementation of local policies at all government levels. Investment activities of cities are strongly associated with economic resilience and the various economic advantages accompanying economic growth within urban agglomerations. This situation is reflected on the impact of the economic development level of cities on their investment activities. Given that the urban investment network is a new financial institutional arrangement, urban investment activities are suggested to be closely related to cities' financial environment. Lastly, the innovation level of cities reflects the impact of the benefits of science and innovation on urban investments and the corresponding investment behavior of enterprises resulting from the competition for innovation resources among cities.

Our research still has some limitations. Due to the limitations in technology and data, we can only conduct research based on data from listed companies. However, listed companies cannot fully represent the investment activities of the city and have a certain degree of one-sidedness. In selecting the influencing factors, we lack a markedly in-depth analysis and weighting of indicators. For example, the number of granted invention patents of cities is directly used to refer to their innovation levels. We are optimistic to obtain enterprise investment data through more data sources and optimize urban investment networks in future research and improve the calculation method of the influencing factor indicators, thereby enabling these indicators to be significantly accurate and reasonable.

This research has enabled us to gain an understanding of the evolutionary characteristics and influencing factors of the investment network structure of BRA, which will help cities formulate policies and strategies. Moreover, this research helps to guide

urban planning and design, promote the rational development of important regional nodes and neighboring cities in BRA, play the role of government intervention, maximize the advantages presented by the investment network structure, activate economic vitality, and improve the status of cities.

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