

Research Article

Relationship between Urban Economic Connections and Geoeconomic Relations in Northeast China

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Using Northeast China as the research area and three time nodes (2007, 2012, and 2017), the gravitational model and Euclidean distance method were used to measure the spatial economic connections and geoeconomic relations between four regional central cities and other small- and medium-sized cities. The complexity of urban economic relations was systematically analyzed based on matching urban economic connections and geoeconomic relations. This paper provides suggestions on how to strengthen and build a benign and sustainable urban economic relations system in Northeast China. The results of the study show that, from 2007 to 2017, the economic links between the four central cities and other cities continued to strengthen. Shenyang had the highest total of economic links, and Changchun, the fastest growth rate. From 2007 to 2017, the geoeconomic relations between the four central and other cities generally improved, shifting from competitiveness to complementarity. Competition intensified for Shenyang and Dalian with cities in Liaoning province, and their complementarity strengthened with cities outside the province. The relationship between the four central cities with other cities is to strengthen cooperation and complementarity. Therefore, the cities in Northeast China need to strengthen economic ties and the complementarity of geoeconomic relations and optimize the matching relationship. They should focus on the role of regional central cities in promoting the economic integration of the entire Northeast China and jointly promote the orderly urban niche system and full coordination. The formation and stability of the developing regional cooperative community are discussed.

1. Introduction

Cities, as places of interaction and association, are defined as connections with other cities [1]. The study of the spatial interaction between cities has attracted scholarly attention from the perspectives of regional economics, urban geography, and regional geography [2, 3]. The urban economic relationship refers to the exchange of commodities, labor services, capital, technology, and information between cities, as well as the relatedness and participatory economic behaviors that occur on this basis [4]. Relevance focuses on the importance of economic ties between cities, reflecting the necessity that cities strengthen exchanges and cooperation, indicating whether the economic ties between them are frequent or occasional, and the quantitative stipulations of

the ties. A participatory focus is on the closeness of economic ties between cities, reflecting the potential of cities to strengthen exchanges and cooperation, indicating whether the economic ties between them are competitive or cooperative, and the qualitative stipulations of the ties. As the center of a region, the city maintains economic, political, and cultural ties with surrounding areas and, to a certain extent, promotes or influences the development of these surrounding areas. As such, an urban economic connection is an important indicator of regional development and maturity [5]. Against the background of the continuous deepening of China's market economic system reform and regional open cooperation, the development trend of regional economic integration centered on large cities is becoming increasingly obvious. To enhance the momentum of

urban economic growth and optimize the spatial pattern of regional development, the relationship between the central city of the urban agglomeration and peripheral cities [6] as well as the policy cooperation network between different levels of government must be strengthened [7]. Furthermore, the economic competition of urban interests has led to an increasing number of urban economic disputes, and conflicts in the economic field have become a major obstacle to the development of regional integration.

The urban economic relationship has always been a hot issue in the study of urban and regional development. The spatial connection of the urban system can be delineated as the network connection, which focuses on large-scale and long-distance connection, and regional connection, which focuses on the connection between neighboring cities. These indicate the regional global combination state and local cohesion state, respectively [8]. In Mainland China, research on economic links between cities began in the 1990s. The direction theory highlights the impact of economic links on the development of urban space and lays the theoretical foundation for the study of spatial economic links in China [9]. Research on the economic connection between cities is based on the gravitational model and uses traffic flow and product flow data [10]. Furthermore, the gravitational model is based on the analysis of regional influence, and the main direction and degree of intercity connections are determined by this influence [11, 12], which reflects a close degree of spatial economic connection between cities [13]. Therefore, many scholars have used the gravitational model and its extended models (e.g., economic membership model, urban potential model, urban flow strength model, and break point model) to measure urban economic relationships. Applied to Mainland China, based on the urban flow and urban interaction intensity models, the radiating driving intensity of the three central cities in the middle reaches of the Yangtze River is generally weak [13]. Using the gravity model, based on the strength of the spatial correlation within the nine major urban agglomerations in China, it is believed that it is more difficult for core cities to radiate to the peripheral cities [14]. Finally, the intercity economic connections in China's urban system, urban connections in the Northeast region, and Kunming and its surrounding areas were analyzed based on the gravitational model and urban flow intensity model [15–17].

Although the strength of economic ties can explain the frequent state of urban exchanges, it does not reflect whether the economic relationship between cities tends to be competition or cooperation. Geoeconomics refers to the interaction between core and peripheral areas and the impact of the flow of relevant factors on the regional economy [18]. Edward [19] proposed the concept of “geoeconomics” to represent the economic situation and economic relations gradually replacing military confrontation and political relations. For him, geoeconomics is a basic principle and “zero sum” that emphasizes the maximization of business interests. The best description of the basic logic of the “zero sum competitive game” conflict is mixed. Furthermore, geoeconomics refers to a focus on achieving the optimal allocation of personnel and other resources in a larger range.

Geoeconomic relations are mostly used in economic battles between countries [20–23]. With the deepening of economic globalization and regionalization, geoeconomics has been given a new connotation and significance, and competition between countries is becoming increasingly important [24–27]. Currently, to reflect the direction of urban economic relations or competition or cooperation, research on the geoeconomic relations of ethnic countries based on territorial boundaries has taken a microturn, providing a new perspective for urban development research [28, 29]. Geoeconomic relations are delineated as complementary and competitive. Similarity leads to competition to restrain the economic development of the two places, and complementarity leads to cooperation to promote their economic development [30]. The urban geoeconomic relationship has a significant impact on the amount of urban economic links. Under the same external conditions, the amount of economic links between complementary cities is usually greater than the amount of economic links between competitive cities [31]. Based on an urban geoeconomic relations perspective, the intercity relations between Ningbo and many prefecture-level cities in the Yangtze River Economic Belt, the intergroup relations between the Pearl River Delta urban agglomeration and other urban agglomerations, and the interpersonal relations between the three provinces and two cities in the Bohai Rim region have received much scholarly attention [32–34].

Although previous studies had diverse search purposes, methods, and viewpoints, they generally contend that strengthening urban economic ties is important in promoting the economic development and regional economic integration of cities. An analysis of the existing research revealed gaps in the following aspects. First, most research on the economic relationship between cities focuses on the amount of urban economic connections. Although some studies involve the main direction of these connections, the focus is only on primary and secondary relationships that show the importance of the contact partners, not the competition between them. The joint relationship means that the direction of the urban spatial economic connection is not specified. Second, in the urban economic connection network, the urban relationship follows the “advantage connection” rule. This research perspective neglects the role of the central city in the urban complex relationship network. Furthermore, research from the perspective of a single central city cannot reflect the complexity of the urban relationship. These types of “one-to-many” studies highlight the lack of “many-to-many” ones from the perspective of multiple central cities. Third, many urban economic linkage studies follow the analysis framework of points (urban potential)–line (economic linkage axis)–network (economic linkage network) [35, 36]; however, the analytical framework of these works does not respond positively to the development direction of the city's economic connections, and research on the complex competition or cooperation between cities is weak. Finally, while the use of high-speed rail and aviation data, online goods services, and intercompany investment data has important practical significance for the study of intercity economic links [37–42], the measurement

of urban economic links based on traffic flow, product flow, and capital flow is restricted by limited data accumulation. These data reflect the spatiotemporal evolution of urban economic relations over a long period.

Therefore, based on the urban connection theory and regional development theory, three important time nodes of 2007, 2012, and 2017 were selected. The Northeast region was selected as the research area for this study, and the four regions of Shenyang, Dalian, Changchun, and Harbin were chosen as the central cities. Then, using the urban economic connection strength model and economic connection membership model, the importance of the economic connection between the four major regional central cities and other cities in the Northeast region was measured. Following this, based on the urban geoeconomic relationship model, the direction of the economic competition and cooperation between the four major regional central cities and other cities in Northeast China was measured. Finally, based on the matching relationship between urban spatial economic connections and urban geoeconomic relations, we examined the complexity of urban economic relations in the Northeast region. This study hopes to provide a reference for the regional economic integration of Northeast China and improve the misaligned development of central and peripheral cities, and complementary advantages.

2. Materials and Methods

2.1. Study Area. Northeast China, as an important old industrial base in China [43], is also a relatively complete regional economic sector. From the perspective of the national development strategy, historical development accumulation, and geographical development environment, Northeast China has a very important strategic position. However, the region is facing structural difficulties and institutional contradictions, and the administrative system and government functions are becoming increasingly unsuitable for marketization. Furthermore, the phenomenon of a “strong government and weak market” in cities in Northeast China is very prominent [44]. The Northeast China, referred to in this paper, includes 40 prefecture-level cities (regions, autonomous prefectures, and leagues) in Liaoning Province, Jilin Province, Heilongjiang Province, and Inner Mongolia Autonomous Region, as shown in Figure 1. Some leading cities in the Chinese urban system act as command and control centers, and the unidirectional control relationship from the core city to the small- and medium-sized cities is stronger, and the horizontal connection between the cities appears slightly weaker [45]. The regional spatial development of this area is unbalanced. Shenyang, Dalian, Harbin, and Changchun, as four sub-provincial cities in Northeast China, are not only the economic centers of this area, but also the core hub cities of regional transportation. The flow of resources such as transportation and human resources has a radiating effect on other cities in the region and plays a dominant role in the region through agglomeration and diffusion effects [46, 47]. Northeast China is a complete geographical unit. Thus, the functional positioning and coordination of the development

of the four central cities involve the overall development of the region [48]. To achieve high-quality development in Northeast China, the leadership of the four regional central cities must be brought into play.

2.2. Data Sources. The administrative boundary data was derived from the national geographic information resource directory service system (<http://www.webmap.cn>). This study focuses on the spatial interaction of cities in Northeast China, where highway passenger and freight transportation account for the largest proportion of transportation modes in the region, and spatial distance changes significantly with the level of economic development [16]. Compared with the spatial distance based on the length of road mileage, the time-cost distance is a time metric for evaluating a certain city node in comparison to others. This metric is used to measure the city’s level of accessibility from a time-saving time perspective and can intuitively express accessibility and changes therein [49–51]. Therefore, to determine the distance between cities, time-cost distance was measured by converting the highway operating mileage between the urban areas of the two cities according to the highway speed in different periods. According to the highway engineering technical standards (JT/G B01-2003 and JT/G B01-2014), and the road and actual driving conditions in Northeast China, the driving speed of highway transportation in 2007, 2012, and 2017 was set and the time-cost per kilometer calculated (Table 1).

The flow and connection of factors between regions generally flow from areas with low production efficiency to those with high production efficiency, and from areas with relatively abundant factors to those with relatively few elements. With reference to previous research results [31, 52, 53], this study used the time cross-sectional data of 40 prefecture-level administrative units in the northeast region in 2007, 2012, and 2017, including regional GDP; secondary and tertiary industry regional GDP; and socio-economic data such as total fixed asset investment, year-end financial institution deposit balance, total employee wages, and annual import and export total. Five comprehensive indicators were selected to reflect the liquidity of products and resources, as shown in Table 2. Excel2019, SPSS23.0, and ArcGIS10.7 were used for the mathematical analysis, model calculation, and visual expression.

2.3. Research Methods

2.3.1. Measuring Method of Urban Spatial Economic Connection. To measure the strength of economic ties between cities, the gravitational model was used to reflect the radiation capacity of the central city and degree of acceptance of the surrounding cities [10]. Based on the first law of geography, the gravitational model further considers the dual effects of city size and spatial distance [54]. The effectiveness of the gravitational model in expressing humane economic phenomena has been confirmed, and many reasonable theoretical deductions have been obtained therefrom. The model is favored for its simple form and high



FIGURE 1: Schematic diagram of Northeast China.

generalization of spatial interaction phenomena [55]. Two indicators—urban economic connection strength and economic connection membership—were employed to quantify the central city’s ability to radiate the economy of

surrounding cities and the surrounding city’s ability to accept the central city’s radiating ability. The following are the calculation formulas for the strength of urban economic ties and membership of economic ties [16, 56]:

TABLE 1: Speed and time cost of highway transportation in different periods.

	Year 2007	Year 2012	Year 2017
Driving speed (km/h)	90	100	110
Time cost (minutes)	0.667	0.6	0.545

TABLE 2: Index system and data composition of urban geoeconomic relations.

Index	Calculation	Memo
ID	—	The serial number of the city
X	Total fixed asset investment in a certain area/gross GDP for that year	Regional capital conversion rate or the surplus or shortage of capital
Y	Deposit balance of financial institutions at the end of a year/GDP of the year	Living and consumption power of people in the region
Z	Total wages of employees in a certain area/gross GDP for that year	Regional labor efficiency
T	GDP of the secondary and tertiary industries in a certain area/GDP of that area in the current year	Regional urban economic development capacity
S	Total annual export volume of a certain area/total annual import volume of that area	Regional resources' and products' outward flow capacity

$$R_{ij} = \alpha \frac{\sqrt{P_i G_i} \sqrt{P_j G_j}}{D_{ij}^\beta}, \quad (1)$$

$$L_{ij} = \frac{R_{ij}}{\sum_{n=1}^n R_{ij}},$$

where R_{ij} is the strength of economic ties between cities i and j , L_{ij} is the degree of affiliation of economic ties between cities i and j , P_i and P_j are the population of cities i and j , respectively, G_i and G_j are the regional GDP of cities i and j , D_{ij} is the time distance between cities i and j , n represents the number of cities studied, and α is the gravitational constant with a value of 1.0. Finally, β is the distance attenuation index, and when the values are 1.0 and 2.0, respectively, it can more truly reflect the urban radiation effect at the national and provincial scales [15, 57]. Since this study focused on the Northeast region, it is closest to the provincial scale; thus, the value of β is 2.0.

2.3.2. Measuring Method of Urban Geoeconomic Relationship. The widely used Euclidean distance [17, 30, 52, 53, 58–61] is scientifically valid and has become the main method for measuring the geoeconomic relationship between cities or regions [62]. Thus, Euclidean distance was employed in this study to evaluate the geoeconomic relationship between Shenyang, Dalian, Harbin, Changchun, and other cities.

Here, “distance” does not refer to the geographic spatial distance, but the difference between cities measured by selected economic indicators. The smaller the distance, the smaller the difference between the two cities and the stronger the competition. Conversely, the larger the distance, the greater the difference between the two cities and the stronger the complementarity.

To effectively reduce dimensional differences in data processing, the five comprehensive indicators in Table 2 were standardized, and the five processed indicators were X^* , Y^* , Z^* , T^* , and S^* . The formulas are as follows:

$$X^* = \frac{X - \bar{X}}{S_X}, \quad (2)$$

$$S_X = \sqrt{\frac{\sum (X - \bar{X})^2}{n}},$$

where X^* is the standardized value of the data of X , \bar{X} is the average value of the data of X , S_X is the standard deviation of the data of X , and n is the number of each piece of data. Similarly, the standardized values of X , Y , Z , T , and S can also be obtained.

Suppose that X_0^* , Y_0^* , Z_0^* , T_0^* , S_0^* are the central cities of the study, then the formula for calculating the Euclidean distance from another city is

$$D_i = \sqrt{(X_i^* - X_0^*)^2 + (Y_i^* - Y_0^*)^2 + (Z_i^* - Z_0^*)^2 + (T_i^* - T_0^*)^2 + (S_i^* - S_0^*)^2}, \quad (3)$$

where i is the serial number of other cities except the central city, and X_i^* , Y_i^* , Z_i^* , T_i^* , S_i^* are their standardized values. To facilitate the judgment of the results, the value of the Euclidean distance is standardized, and the calculation formula is as follows:

$$D_i^* = \frac{D_i - \bar{D}_i}{S_{D_i}}, \quad (4)$$

$$S_{D_i} = \sqrt{\frac{\sum (D_i - \bar{D}_i)^2}{n}},$$

where \bar{D}_i is the average value of the Euclidean distance from the city to other cities, and S_{D_i} is the standard deviation of the Euclidean distance from the city to other cities.

3. Results

3.1. Spatial and Temporal Evolution of Urban Spatial Economic Relations in Northeast China. Using formula (1), the strength of economic ties and degree of economic affiliation of 39 cities with the central cities of Shenyang, Dalian, Changchun, and Harbin can be calculated separately. Based on the degree of economic ties between two cities, they can be divided into four categories: very strong connection type ($L_{ij} > 5\%$), generally strong connection type ($1\% < L_{ij} \leq 5\%$), generally weak connection type ($0.5\% < L_{ij} \leq 1\%$), and very weak connection type ($L_{ij} \leq 0.5\%$), as shown in Figure 2.

For economic ties, for the three time points from 2007 to 2017, Shenyang ranks first among the four major cities from the beginning to the end, followed by Changchun and Harbin, and then Dalian. However, the growth rate of Changchun's total economic ties is the fastest, followed by Harbin and Dalian, and Shenyang has the slowest. Regarding economic affiliation, of the four central cities, Shenyang and Dalian have an economic affiliation with a higher proportion of cities in the province than with those outside it, but this proportion is gradually declining. Outside the province, Changchun and Harbin have a high degree of economic affiliation. That in Changchun Province is slowly increasing, while Harbin is showing a downward trend.

For the central city of Shenyang, the total amount of economic connections is increasing, although this first increased and then decreased as follows: an increase of 2.3 times from 1358.2 million in 2007 to 3117.7 million in 2017. However, from 2007 to 2017, the membership of Shenyang with the cities in the province demonstrated a gradual downward trend. The membership at the three time points was 64.28%, 63.47%, and 59.8%, respectively, a decrease of nearly 5%. The degree of membership is increasing each year. The degree of urban membership with Jilin Province is the highest: 18.99%, 19.63%, and 22% at the three time points, respectively. Among the other 39 cities, Shenyang had the strongest ties with Anshan, Fushun, and Liaoyang from 2007 to 2012, and by 2017, the strongest ties were with Anshan, Changchun, and Fushun in that order. From a spatial viewpoint, Shenyang has relatively strong economic ties with the cities in the province, especially with the central and southern urban agglomerations of Liaoning. In addition, it is closely connected with most of the cities in Jilin Province, and few with Heilongjiang Province.

Regarding the central city of Dalian, its total economic links with other cities are gradually increasing. The city's total economic links increased 2.55 times from 564.4 million in 2007 to 1492.6 million in 2017. The subordination of Dalian and the cities in the province also gradually decreased at the three time points: 58.16%, 57.24%, and 54.23%, respectively, a decrease of about 4%. At the same time, the affiliation degree of Dalian and cities outside the province is increasing like Shenyang, and the affiliation of cities outside Jilin Province and Jilin Province is the highest. This was

19.29%, 19.96%, and 21.83% at the three time points, respectively. Shenyang, Anshan, and Changchun have always had strong links with Dalian, but in 2017 Changchun surpassed Anshan and took the second place. From a spatial viewpoint, Dalian is closely connected with the cities in the province, while outside the province it has strong ties with Changchun and Harbin.

For the central city of Changchun, the total amount of economic ties has continued to increase: from 926.3 million in 2007 to 2876.7 million in 2017, a 3.1-fold increase in 10 years. At the three time points from 2007 to 2017, the economic affiliation of Changchun and the cities in the province demonstrated a growth trend: 32.12%, 33.61%, and 33.29%, respectively. Changchun and other cities in Jilin province had a relatively low total degree of affiliation, while the total degree of affiliation with cities outside Jilin province is 66%, among which the degree of affiliation with Liaoning is the highest: 35.48%, 34.7%, and 32.83% at the three time points, respectively. Although there is a downward trend, it still accounts for a high proportion. Among the 39 cities, Harbin, Jilin, and Shenyang have always had relatively strong economic ties with Changchun. From a spatial viewpoint, except for the cities of Baicheng and Yanbian and the prefectures in Jilin Province, the links between cities and Changchun were slightly weaker, and the strength of economic links between other cities and Changchun was relatively high. In addition to the strength of the economic links between Changchun and Shenyang, Harbin, and Dalian, the cities of Daqing, Suihua, Tongliao, Anshan, Fushun, and Tieling have relatively strong economic ties. From a spatial viewpoint, Changchun has strong ties with Jilin and Songyuan in the province, economic ties with other cities in the province are relatively weak, and ties with Shenyang and Harbin outside the province are relatively strong.

For the central city of Harbin, the total amount of economic ties has increased 2.84 times in 10 years, from 916.6 million in 2007 to 2606.23 million in 2017. The affiliation of Harbin and cities in the province is declining slightly: 37.51%, 36.91%, and 37.14% at the three time points, respectively. Furthermore, the degree of affiliation with cities outside the province is relatively high: the province has the largest city subordination, followed by Liaoning, and the five cities in the Inner Mongolia District have the smallest. The top three cities with economic ties to Harbin are Changchun, Daqing, and Suihua. In 2017, Suihua surpassed Daqing to become its second-largest economically connected city. From a spatial perspective, except for the six cities of Qiqihar, Jixi, Daqing, Jiamusi, Mudanjiang, and Suihua, the economic strength of Harbin and other cities in the province is not very strong.

3.2. Spatial and Temporal Evolution of Urban Geoeconomic Relations in Northeast China. Using formulas (2)–(4), the Euclidean distance and its normalized value between Shenyang, Dalian, Changchun, and Harbin and 39 other cities in Northeast China can be calculated separately. According to the classification scheme of other scholars [63, 64], combined with the actual situation in the Northeast region and

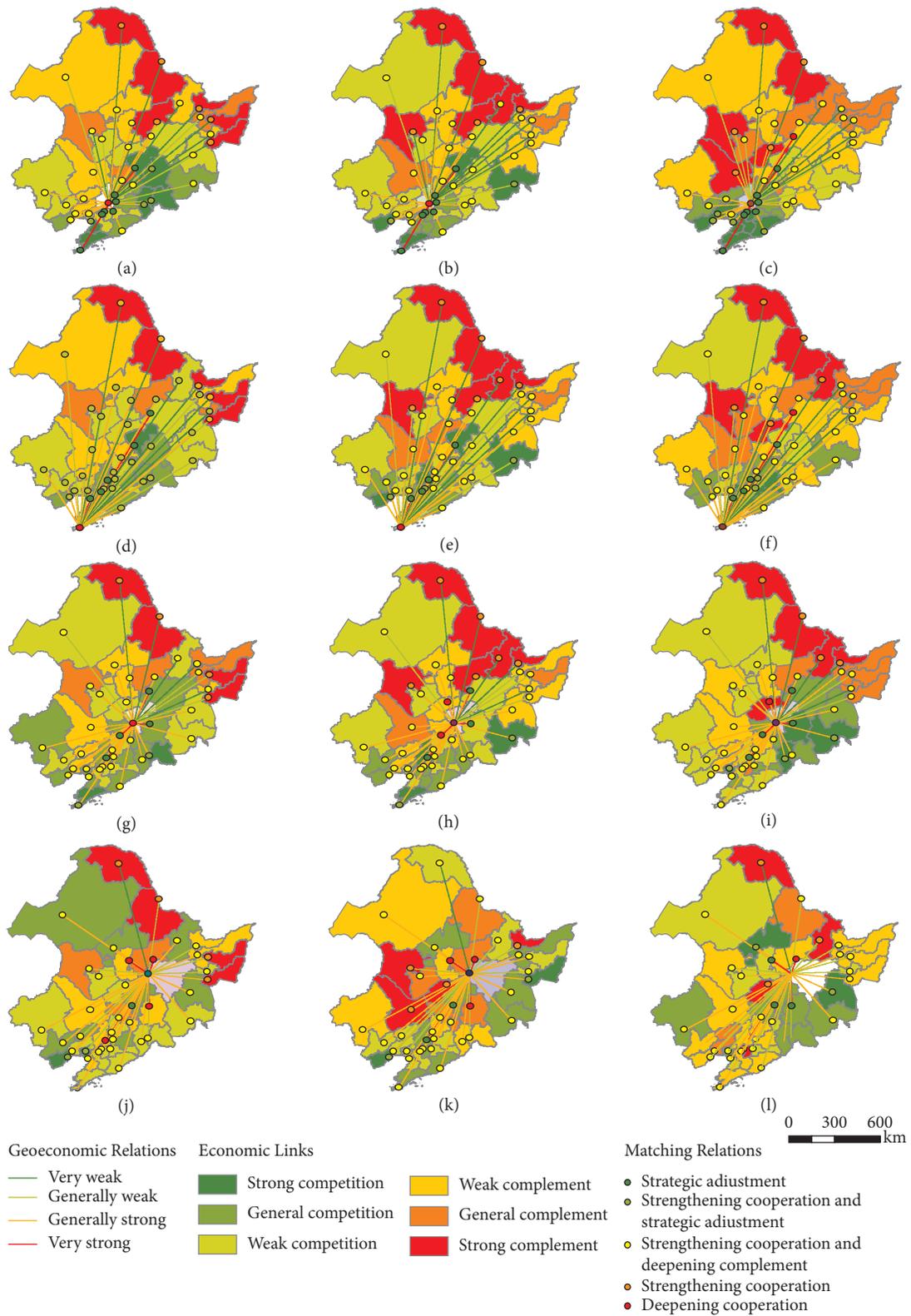


FIGURE 2: Northeast China's urban economic relations, geoeconomic relations, and their matching relations in 2007, 2012, and 2017. (a) Shenyang, the period of 2007. (b) Shenyang, the period of 2012. (c) Shenyang, the period of 2017. (d) Dalian, the period of 2007. (e) Dalian, the period of 2012. (f) Dalian, the period of 2017. (g) Changchun, the period of 2007. (h) Changchun, the period of 2012. (i) Changchun, the period of 2017. (j) Harbin, the period of 2007. (k) Harbin, the period of 2012. (l) Harbin, the period of 2017.

this study, the standardized value of the Euclidean distance is divided into six categories: strong competitive type ($D_i \leq -1$), general competitive type ($-1 < D_i \leq -0.5$), weak competitive type ($-0.5 < D_i \leq 0$), weak complementary type ($0 < D_i \leq 0.5$), general complementary type ($0.5 < D_i \leq 1$), and strong complementary type ($D_i > 1$), as shown in Figure 2. Because of the relative competitiveness and complementarity between regions, when Shenyang is the central city, the relationship to Dalian is relatively compared with the relationship between the other 38 cities. When Dalian is the central city, the relationship to Shenyang is also relatively compared with the relationship between the other 38 cities. The Euclidean distance between Shenyang and Dalian will not change, but when different cities are at the center, the standardized value of the Euclidean distance will change.

With Shenyang as the central city, from 2007 to 2017, the socioeconomic relationship between Shenyang and 39 other cities in Northeast China shifted from more competitive than complementary to more complementary than competitive. In 2007, of the 39 other cities in Northeast China, 22 favored competition with Shenyang and 17 favored complementarity. By 2017, the cities favoring complementarity increased to 23 and those preferring competition decreased to 16. From a spatial perspective, in 2007, 2012, and 2017, Shenyang's socioeconomic relations with Heilongjiang, Inner Mongolia, and Jilin provinces and regions have tended to complement each other. Of these, all cities in Heilongjiang and Inner Mongolia are in a complementary state. In addition to Changchun, Tonghua, and Yanbian, other cities in the province also tend toward complementarity; however, the competitive relationship between Shenyang and other cities in Liaoning Province is intensifying and deepening.

With Dalian as the central city, from 2007 to 2017, the socioeconomic relationship between Dalian and other cities has also shifted from more competitive than complementary to more complementary than competitive. In 2007, among the 39 other cities in Dalian and Northeast China, 25 favored competition and 14 complementarity. By 2017, the number of cities competing with Dalian decreased to 18, and those favoring complementarity increased to 21. From a spatial perspective, in 2007, 2012, and 2017, the socioeconomic relationship between Dalian and Heilongjiang and Inner Mongolia has tended to be complementary as a whole, except for Hulunbeier City. Furthermore, the socioeconomic relationship between Dalian and Jilin Province is both complementary and competitive, while Dalian and the cities in Liaoning Province are in a state of competition. Except for Liaoyang, where the competitive relationship is slightly lower, that in other cities has intensified.

With Changchun as the central city, the socioeconomic relationship between Changchun and 39 other cities from 2007 to 2017 was more competitive than complementary, but the gap was narrowing. In 2007, there were 25 competitive socioeconomic relations between Changchun and other cities, and only 14 were complementary. By 2012, the number of competitive cities decreased to 20, and complementary cities increased to 19. However, by 2017 the situation had changed again, with 22 competitive cities and 17 complementary cities. From a spatial perspective, in 2007,

2012, and 2017, Changchun's socioeconomic relations with the province and Liaoning have generally tended to compete, but the degree of competition has eased. In contrast, competition with Hulunbeier in Inner Mongolia has intensified. Although the relationship with Tongliao City is complementary, the degree is decreasing, and while the relationship with Heilongjiang is mostly complementary, the overall degree of complementarity is also decreasing.

With Harbin as the central city, the socioeconomic relationship between Harbin and other cities from 2007 to 2017 changed from being more competitive than complementary to more complementary than competitive. In 2007, 24 cities were in competition with Harbin and 15 were complementary. By 2017, the number of cities in competition with Harbin decreased to 17, and the number of complementary cities increased to 22. This shows that the socioeconomic relationship between Harbin and other surrounding cities is gradually becoming complementary, and the possibility of cooperation with other cities is increasing. From a spatial perspective, in 2007, 2012, and 2017, the socioeconomic relationship between Harbin and Liaoning Province has tended to be complementary. Except for Benxi, Panjin, and Yingkou, the other cities were complementary in 2017. The cities in Jilin Province were all competing in 2017, except for Songyuan City, which was complementary. Furthermore, the degree of competition is intensifying. The four urban areas of Inner Mongolia are both complementary and competitive, although the overall degree of competition is gradually intensifying. Finally, the degree of competition between Harbin and the cities in the province is also intensifying, except in Hegang and Yichun.

4. Discussion

To better investigate the complexity of urban connections in Northeast China, the above classification of economic connections and level of socioeconomic relations was used to match and analyze these connections and relations of the four central cities in Northeast China. Figure 2 provides the matching results. The five categories of matching relationships were as follows: Deepening cooperation type with strong economic connection and strong complementarity; adjustment strategy type with strong economic connection and strong competitiveness; strengthening cooperation type with strong complementarity and weak economic connection; strengthening cooperation adjustment strategy type with strong competition and weak economic connection; strengthening cooperation and strengthening complementarity type with weak economic connection and general competition or complementarity.

According to the matching situation of the four central cities' economic ties and socioeconomic relations, Harbin has the best matching situation, with good cooperation relationships or cooperation space with 39 other prefecture-level administrative units. Furthermore, while Shenyang has close economic ties with other regions, it has more competitive relationships, especially with other cities in Liaoning Province.

In 2017, the central city of Shenyang had a deepened cooperation with Harbin. The number of cities that

strengthened cooperation with Shenyang decreased from six in 2007 to five in 2017, and seven typified strategic adjustment with Shenyang (the number remained unchanged). Furthermore, at the two time points, the number of cities that strengthened their cooperation and complementarity with Shenyang increased from 22 to 23, respectively, and 4 cities strengthened their cooperation and adjustment strategies with Shenyang (number remained unchanged). At the three time points from 2007 to 2017, the seven cities of Dalian, Anshan, Fushun, Benxi, Liaoyang, Tieling, and Changchun had economically adjusted and had competitive strategic geoeconomic matching relationships with Shenyang. Except for Changchun, the other six cities are closer to Shenyang in terms of spatial distance and have closer economic links, but because of their similarity in industrial structure, their competition is also fierce. Harbin has a geoeconomic matching relationship with deepened cooperation as well as close economic ties with Shenyang, but there are also complementary places.

From 2007 to 2017, the central city of Dalian had no deepening cooperation relationships with any cities, and the number of cities categorized as strengthening cooperation remained similar, decreasing from five to four. Furthermore, 29 cities in 2007 and 28 in 2017 were categorized as strengthening cooperation and enhancing complementarity. Those that strengthened cooperation and had an adjustment strategy increased from zero in 2007 to four in 2012 and decreased to two in 2017. In 2007, five cities—Changchun, Harbin, Shenyang, Anshan, and Yingkou—were strategically aligned with Dalian for economic adjustment. However, with the division of labor and cooperation in the industry, the relationship between Harbin and Dalian changed from competition to complementarity, and the strategic type was adjusted. There are only four cities left, and those with strong economic ties and competition with Dalian are increasing, Yanbian, Liaoyang, and Huludao in 2012, but with the development of Shenyang Economic Zone and transfer of industries, Fushun was added in 2017. The two cities of Benxi have changed into strengthened cooperation and adjusted strategy cities.

For the central city of Changchun, no cities had deepened cooperation with Changchun in 2007, two did so in 2012, and one in 2017. Four cities strengthened cooperation with Changchun, and the number of cities categorized for the three types of strategic adjustment remained four. Cities that strengthened cooperation and adjusted their strategic strategies with Changchun increased from 2 to 3, and those that strengthened cooperation and enhanced complementarity decreased from 29 to 27. The four cities of Shenyang, Harbin, Jilin, and Siping are economically connected with Changchun and have competitively adjusted their strategic geoeconomic matching relationships. Shenyang and Harbin, as the capitals of Liaoning and Heilongjiang Provinces, are closely connected with Changchun's economic ties, and their competition is relatively strong. Songyuan and Changchun are categorized as having a deepening cooperation-based geoeconomic matching relationship. Songyuan is adjacent to Changchun and is the destination of industrial transfer in Changchun. The industrial division of labor and cooperation between the two cities is close.

For the three time points of 2000, 2012, and 2017, the number of cities that have deepened cooperation with Harbin has decreased from 4 to 2, the number of cities that have strengthened cooperation has been stable at 4, the number of cities that have adjusted their strategy has increased from 0 to 3, the number of cities that have strengthened cooperation and adjusted their strategy has remained 2, and the number of cities that have strengthened cooperation and enhanced complementarity has decreased from 29 to 28. In the three time points from 2000 to 2017, Shenyang, Changchun, Jilin, Suihua, and Daqing have had strong economic ties with Harbin, but the competitiveness of these five cities has changed greatly. Until 2017, Shenyang and Suihua had a deepened cooperation with Harbin, while the ties with Changchun, Daqing, and Jilin are categorized as the strategic adjustment type.

5. Conclusions

Based on urban spatial economic connections and urban geoeconomic relationships, as well as the matching results, the complexity of the urban economic relationship between the four central cities in Northeast China and other cities was analyzed in three dimensions. The following conclusions were drawn. For the period 2007–2017, the economic links between the four central cities in Northeast China and other cities became closer, reflecting the acceleration of regional integration in Northeast China. Shenyang had the highest number of economic links, followed by Changchun, Harbin, and Dalian. Changchun has the fastest growth rate, followed by Harbin, Dalian, and Shenyang. Shenyang's economic ties with Anshan, Fushun, and Liaoyang are important, and they are in competition with cities in the province and demonstrate complementarity with those outside the province. Shenyang has a strong competitive relationship with cities with strong ties, and weak economic links with those with strong complementarity. Dalian has prominent connections with Shenyang, Anshan, and Changchun. Its geoeconomic relationship with other cities is more complementary than competitive, and it is most competitive with cities in the province. The three cities with the strongest economic ties with Changchun are Harbin, Jilin, and Shenyang, which are central cities with more competitive than complementary cities. They also have a relatively good matching relationship with other cities; for example, Suihua, Daqing, and Changchun are the three most important cities in economic connection with Harbin. The geoeconomic relations with other cities are generally more complementary than competitive, but the strength of economic ties with complementary cities is weak. In terms of matching relationship types, Harbin is the best performer among the four central cities. Harbin and most small- and medium-sized cities are types that strengthen cooperation and complement each other.

The relationship between cities in Northeast China has obvious complexity. Among the four regional central cities, Shenyang has the most important urban economic connection status in Northeast China, while Dalian is a relatively weak regional central city. The relative importance of

Changchun and Harbin has been improved significantly over the last ten years. This is closely related not only to the geographical location of the city, but also to the strategic direction of urban and regional development. The basin-type city pattern in Northeast China embodies the new urban relationship model under the network development of the urban system. Shenyang is a resource distribution center and communication window for the entire Northeast China, with a very high degree of urban connection and a high urban system [16]. Considering Northeast China as a relatively closed geographical unit, Dalian has the characteristics of being a terminal location, making it a “Continental-driven development city” in Northeast China that “embraces the ocean” based on its location in a coastal area in China. Dalian’s future lies in the construction of an ocean-centric city and international shipping hub to stabilize the old industrial base and develop an open economy. Shenyang and Dalian serve as “land windows” and “sea windows” for interregional connections in Northeast China, and as bridges between Northeast China, the Beijing-Tianjin-Hebei region, and China’s coastal regions. As such, they continue to weaken the “siphon effect” of the city. Changchun and Harbin, as “middle-stream cities” in Northeast China, should play a leading role in the integrated development of the Kazakh-City agglomeration and north-central part of Northeast China and better connect with the Shenyang economic zone and Liaoning coastal economic zone. To this end, we propose the following three policy countermeasures and suggestions to guide the construction of a new type of urban relationship model in Northeast China and promote the optimal and coordinated development of regional central cities and peripheral small- and medium-sized cities.

The first suggestion is to conform to the laws of economic development, regulate the urban ecological potential, and operate overall regional functions. In different stages of urban economic development, the relationship between cities exhibits the evolutionary law of “antagonistic competition-dislocation competition-cooperative competition,” and out-of-date or out-of-place development concepts will cause more or less negative harmonious development between cities and regions. It is necessary to make full use of complementary geoeconomic relations and deal with competitive ones. Urban function positioning needs to advance with time, adapt to local conditions, and make strategic adjustments according to the required development factors and the environmental situation.

The second suggestion is to actively develop regional central cities and build a new model of urban relations. The formation of a reasonable division of labor system should be accelerated, a cooperative incentive mechanism implemented, comprehensive transportation networks as well as solid and solid industrial support systems optimized, and the vitality of economic development boosted in Northeast China. The focus should be on the construction and maintenance of the four regional central cities of Shenyang, Dalian, Harbin, and Changchun, and the urban group in the middle-southern part of Liaoning Province and the Harbin-Changchun urban agglomeration optimized. This is to form

a supporting and coordinated urban regional division of labor between the node and core cities. The background of geographic resources and the environment should be promoted; the flow of social and economic stocks activated; the flow of information, knowledge, and talent promoted; and the endogenous power of high-quality urban development enhanced. Finally, measures should be adapted based on the combination of matching relationships in different cities. For cities that are strategically adjusted, full advantage must be taken of the large amount of connections, and cooperation channels must be actively increased to enhance the complementarity between the two places. Furthermore, the industrial structure should be adjusted to reduce friction losses. For cities with deepened cooperation, it is necessary to actively promote industrial cooperation transfer and all-round open cooperation. For cities that are cooperation-oriented, it is necessary to increase the degree of economic ties between the two places, with a focus on strengthening cooperation in areas with higher economic ties.

This study focused on the relationship between regional central cities and peripheral small- and medium-sized cities and clarified the impact of urban economic connections and geoeconomic relations on the complexity of urban economic relations. Previous studies did not consider the overall importance and direction of urban economic links in the regional urban system by multiple central cities, especially in Northeast China. This study addresses this research gap. The complexity research has important reference value and significance. However, in terms of urban spatial economic connections and urban geoeconomic relations, the study has some limitations. The connection between cities is reflected in many aspects such as the flow of commodities, labor, capital, technology, and information. The distance between cities is not only covered by road transport, and the index of measuring city geoeconomic relationship should be improved and supplemented. For example, this study did not consider that manufacturing and service industries have different effects on the uneven development of the urban system [65]. In addition, the classification of various urban economic relations was relatively subjective in this study. Therefore, future research should improve the measurement model and evaluation criteria of urban economic connections and geoeconomic relations.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Disclosure

The funding sources had no role in the study design, data collection, analysis, or interpretation, or the writing of this manuscript.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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