Logistic Network Construction and Economic Linkage Development in the Guangdong-Hong Kong-Macao Greater Bay Area: An Analysis Based on Spatial Perspective

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Abstract: Regional logistic networks and linking urban clusters to boost high quality economic development are both key topics in sustainable development in China. In recent years, China has highlighted the significance of the logistics industry and urban cluster development, attaching practical importance to the connections between these two topics from a spatial perspective. This paper aims to discuss how regional logistic networks linking urban clusters improve economic development. This study constructs a logistic evaluation indicator system based on the multi-indicator data of 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area in 2020. This research employs the entropy-weighted-TOPSIS method to measure and rank the comprehensive logistics quality of each city in the economically linked logistic network of the Guangdong-Hong Kong-Macao Greater Bay Area. This study applies the modified gravity model to explore the logistics linkage and logistic network characteristics of each city in the Guangdong-Hong Kong-Macao Greater Bay Area. Finally, this research analyzes how the agglomeration ability of the central cities in the Guangdong-Hong Kong-Macao Greater Bay Area affects other cities from a spatial perspective. Furthermore, this spatial perspective investigates the agglomeration effect of the economic linkage logistic network through the social network analysis method. The results have the following three implications. (1) The logistic network has a high density, a stable overall structure with a strong agglomeration effect, and there is an increasingly mature logistic network development in the Guangdong-Hong Kong-Macao Greater Bay Area. (2) Agglomeration is significant in the central cities of the Guangdong-Hong Kong-Macao Greater Bay Area including Hong Kong, Shenzhen, Guangzhou, and Macao. Nonetheless, insufficient peripheral cities have been cultivated. Therefore, the government should focus on strengthening the balance of urban development in the bay area and improving the logistics access among cities to break through the barriers of regional synergistic development. (3) The economic development of cities is highly correlated with the level of logistics links. Additionally, the economy is the cornerstone to promoting the high-quality development of the logistics industry. Moreover, the economy and logistics are inseparable, mutually promoted, and developed together.

Keywords: logistic network; sustainability; spatial perspective; urban clusters; economic linkage

1. Introduction

The logistics industry plays a crucial role in linking urban clusters to boost sustainable economic development, and its development is a key indicator of modernization in a
country or region. Logistics is a large industry in China, which is transitioning to sustainable development [1]. However, traditional logistics has many drawbacks, due to the lagging development of technical means, operation mode, and standardization. Therefore, this low-quality development model is not sustainable and its role is getting weaker and weaker in upgrading regional logistics activities. At present, the development of China’s logistics industry still has the following problems: (1) high cost and low efficiency; (2) low marketability; (3) insufficient service innovation [2]. Therefore, establishing a regional logistic network along with the study of the associated characteristics between urban clusters and regional logistic networks can both pave the way for the transportation advantages of each city node in urban clusters and reduce unit transportation costs, hence forming a spatial drive and scale effect. Moreover, such a logistic network can enhance the economy, sustainability, and convenience of logistics activities in the entire region to optimize the overall transportation costs and maximize the resource utilization in the network [3].

Many studies assessed logistic networks and economic development in various regions. Typically, Mei et al. evaluated the level of digital villages and the high-quality development of rural economy using the data of 30 provinces (excluding Tibet) from 2001 to 2020 based on the entropy weight TOPSIS method and tested the effect of the digital villages on the high-quality development of the rural economy [4]. Huang et al. constructed a high-quality evaluation system for logistics enterprises, and applied the econometric model and gray spatial relevance model to study the high-quality development of listed Chinese logistics companies [2]. Yan et al. established an index system of high-quality economic development and logistics to measure their high-quality development level and analyze their coupling coordination degree using the coupling coordination model [5]. Ding et al. investigated cities in the Xijiang river basin of Guangxi and determined an indicator system for evaluating the ranking of nodes in the hub-and-spoke logistic network [6]. Hai et al. selected eight indicators with a large impact on logistics in Hubei province to determine the level of logistics nodes through city-score ranking, and optimized the related logistic network [7]. Ma et al. expanded the theory of the gravitational force model based on the characteristics of the bay area by reviewing the historical and current situation of opening up the five bay areas. In this way, these researchers measured the openness of each bay area and its cities using principal component analysis [8]. Peng et al. applied the TOPSIS evaluation method to calculate the comprehensive quality based on the multi-indicator data of 23 cities containing the Guangdong-Hong Kong-Macao Greater Bay Area and its surrounding cities in 2015. Using this method and data, they measured the role of inter-city spatial linkages based on the improved gravitational force model, and drew a spatial linkage map to visually investigate the overall spatial linkage characteristics and structure of urban clusters [9]. Tang et al. explored the dynamic linkages, network characteristics, and driving factors of the logistic network in the Yangtze river delta based on a social network perspective using a modified gravity model combined with a geo-detector [10]. Shi et al. established a comprehensive evaluation indicator system for the intelligent development of cities based on a human-centered urban system, and a resource-flow evaluation model via urban system theory [11,12]. Wang et al. pointed out that the development of regional economic industries in logistics node cities is an aggregate economic effect in central cities, characterized by the continuity of production. The development of central cities could attract more capital, technology, and labor [13,14]. Akhavan et al. constructed a European city network and analyzed the logistics linkages among cities based on the data from 722 offices of 27 global third-party logistics companies operating in Europe [15,16]. Lan et al. analyzed the essential factors of logistic and economic development using a Bayesian network model, and subsequently studied the influence of logistics-industry agglomeration on economic growth [17].

Although a large number of studies have employed various statistical methods for the logistic networks linking urban clusters to contribute to sustainable economic development, typical issues still exist in a single network research paradigm and there is insufficient
quantitative research. Some examples of these issues are the lack of exploration of the evolutionary characteristics of urban agglomerations’ spatial organization and inner laws from both spatial perspectives and economic linkage perspectives. Moreover, the research scale fails to meet the current strategic pattern of national macroeconomic development. The ambiguity of these issues is a major problem that seriously restricts the sustainable economic development of logistic-network-linked city clusters.

Therefore, this paper investigates the above important issues in the Guangdong-Hong Kong-Macao Greater Bay Area, located near the mouth of the Pearl River with a superior geographical location. This study constructs a comprehensive quality evaluation index system of city logistics. Additionally, this research applies the entropy-weighted TOPSIS method and social network analysis method to study the sustainable development of each city in the economically linked logistic network of the Guangdong-Hong Kong-Macao Greater Bay Area. It is of great value to examine the economic development and interaction behind the logistic network of the Guangdong-Hong Kong-Macao Greater Bay Area from a spatial perspective. Another contribution is the improvement of the logistics development quality in the Guangdong-Hong Kong-Macao Greater Bay Area in the context of “One Belt and One Road” to realize a mutually beneficial and complementary economic linkage development mechanism.

2. Methodology and Data

2.1. Data Sources and Indicator System Construction

The Guangdong-Hong Kong-Macao Greater Bay Area is the intersection of international window cities and the bridgehead of the New Maritime Silk Road due to its location at the frontier of China’s coastal opening. This area covers nine cities of Guangzhou, Shenzhen, Dongguan, Foshan, Zhuhai, Jiangmen, Zhongshan, Huizhou, and Zhaoqing in Guangdong Province and the two special administrative regions of Hong Kong and Macao. The secondary data for this study are obtained from the 2020 China Statistical Yearbook, Guangdong Statistical Yearbook, Hong Kong Statistical Yearbook, Macao Statistical Yearbook, Guangzhou Statistical Yearbook, Shenzhen Statistical Yearbook, Dongguan Statistical Yearbook, Foshan Statistical Yearbook, Zhuhai Statistical Yearbook, Jiangmen Statistical Yearbook, Zhongshan Statistical Yearbook, Huizhou Statistical Yearbook, and Zhaoqing Statistical Yearbook.

Some scholars have paid attention to the evaluation index system of sustainable development. These studies used five perspectives to establish an evaluation index system to measure high-quality economic development. The first perspective considers the following five aspects: innovation, coordination, greenness, openness, and sharing [5,18]. Second, for the content of sustainable development, all-factor productivity is the main measure of indicators [19]. The third perspective establishes a sustainable development evaluation index system from the viewpoints of output quality, development efficiency, and power transformation [20]. The fourth perspective develops a high-quality evaluation index system according to human input, capital input, output scale, and output quality [21]. This study combines the above approaches to develop a specific indicator, which covers diverse aspects and sub-indicators. In terms of space, this research establishes an indicator for evaluating the comprehensive quality of urban logistics for the following spatial ranges: level of integrated urban development, logistics market supply and demand situation, and level of integrated logistics facilities. Many factors at the macro and micro levels affect the construction of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area including economic development, geographical location, and logistics facilities. Table 1 represents the evaluation indicator system of this research, established by combining the qualitative and quantitative methods of the previous studies.
Table 1. Indicators for evaluating the comprehensive quality of urban logistics.

<table>
<thead>
<tr>
<th>Level 1 Indicators</th>
<th>Level 2 Indicators</th>
<th>Level 3 Indicators (Units)</th>
<th>Indicator Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of integrated urban development</td>
<td>Level of economic development</td>
<td>Regional GDP (hundred million yuan)</td>
<td>0.0716</td>
</tr>
<tr>
<td>Conditions of social reproduction</td>
<td>Total investment in fixed assets of the whole society (hundred million yuan)</td>
<td>0.0378</td>
<td></td>
</tr>
<tr>
<td>Retail market size</td>
<td>Total retail sales of social consumer goods (hundred million yuan)</td>
<td>0.0640</td>
<td></td>
</tr>
<tr>
<td>Level of economic development per capita</td>
<td>Real GDP per capita (ten thousand yuan)</td>
<td>0.0560</td>
<td></td>
</tr>
<tr>
<td>Logistics market supply and demand situation</td>
<td>Freight volume (ten thousand tons)</td>
<td>0.0796</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rotation volume of freight transport (billion tonne-kilometers)</td>
<td>0.0727</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Logistics gross (hundred million pieces)</td>
<td>0.1045</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total export-import volume (hundred million yuan)</td>
<td>0.1130</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year-end population (ten thousand people)</td>
<td>0.0385</td>
<td></td>
</tr>
<tr>
<td>Level of integrated logistics facilities</td>
<td>Number of mobile phone subscribers (ten thousand families)</td>
<td>0.0472</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of internet broadband access subscribers (ten thousand families)</td>
<td>0.0395</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mileage in highway open to traffic (ten thousand kilometers)</td>
<td>0.0630</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Civilian car ownership (ten thousand vehicles)</td>
<td>0.0354</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Business total of posts and telecommunications (hundred million yuan)</td>
<td>0.0809</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Port container throughput (ten thousand TEU)</td>
<td>0.0963</td>
<td></td>
</tr>
</tbody>
</table>

2.2. Research Process and Methodology

2.2.1. Entropy-Weighted-TOPSIS Method

The entropy-weight method is an evaluation method that determines objective weights based on the magnitude of variability of indicators, while the TOPSIS method is a distance-integrated evaluation method that defines the optimal and inferior solutions to a decision problem [22]. This research uses the entropy-weighted-TOPSIS method, a combination of both the entropy weight and TOPSIS methods. This method first employs the entropy-weight method to assign weight values to each measure for standardizing them. This study then uses the TOPSIS method to quantitatively rank the level of economic linkage and high-quality development of logistics in each city in the Guangdong-Hong Kong-Macao Greater Bay Area. The steps are as follows.

1. The analysis matrix is determined based on the evaluation-indicator system established in the previous section as follows.

   \[ X = (x_{ij})_{m \times n} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \]  

   where \( x_{ij} \) denotes the value of indicator \( j \) for city \( i \) in the Guangdong-Hong Kong-Macao Greater Bay Area.

2. Equation (2) shows the normalization of the analysis matrix.

   \[ Y = (y_{ij})_{m \times n} \]

   where \( y_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \)

3. Equation (3) represents how to calculate the information entropy of an indicator.

   \[ e_j = -k \sum_{i=1}^{m} f_{ij} \ln f_{ij} \]
where \( f_{ij} = \frac{y_{ij}}{\sum_{i=1}^{m} y_{ij}} \), \( k = \frac{1}{\ln m} \), and if \( f_{ij} = 0 \), then \( \lim_{f_{ij} \to 0} (f_{ij} \times \ln f_{ij}) = 0 \).

4. Equation (4) calculates indicator weights using indicator information entropy.

\[
 w_j = \frac{1 - e_j}{\sum_{j=1}^{n} (1 - e_j)} \quad (4)
\]

where \( w_j \in [0, 1] \), and \( \sum_{j=1}^{n} w_j = 1 \).

5. Equation (5) is a weighting matrix of indicators for measuring the quality development of economic linkages and logistics \( R \), calculating the comprehensive quality of logistics \( R_i (i = 1, 2, \cdots, m) \).

\[
 R = (r_{ij})_{m \times n} = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} = \begin{bmatrix} x_{11} \times w_1 & \cdots & x_{1n} \times w_n \\ \vdots & \ddots & \vdots \\ x_{m1} \times w_1 & \cdots & x_{mn} \times w_n \end{bmatrix} \quad (5)
\]

\[
 R_1 = r_{11} + r_{12} + \cdots + r_{1n} \\
 R_2 = r_{21} + r_{22} + \cdots + r_{2n} \\
 \vdots \\
 R_m = r_{m1} + r_{m2} + \cdots + r_{mn}
\]

6. Based on the weighting matrix \( R \), Equation (6) determines the positive and negative ideal solutions \( u_j^+ \) and \( u_j^- \), representing the optimal and worst solutions, respectively.

\[
 u_j^+ = \max(r_{i1}, r_{i2}, \cdots, r_{in}) (i = 1, 2, \cdots, m) \\
 u_j^- = \min(r_{i1}, r_{i2}, \cdots, r_{in}) (i = 1, 2, \cdots, m) \quad (6)
\]

7. Equation (7) calculates the Euclidean distance to the positive and negative ideal solutions for each evaluation object separately \( S_j^+ \) and \( S_j^- \).

\[
 S_j^+ = \sqrt{n \sum_{j=1}^{n} (u_j^+- r_{ij})^2} (i = 1, 2, \cdots, m) \\
 S_j^- = \sqrt{n \sum_{j=1}^{n} (u_j^- - r_{ij})^2} (i = 1, 2, \cdots, m) \quad (7)
\]

8. Equation (8) calculates \( C_i \), the relative closeness of each evaluation object to the ideal solution, separately. The closeness is directly proportional to the level of economic linkage and the quality development of logistics in each city.

\[
 C_i = \frac{S_j^-}{S_j^+ + S_j^-} \quad (8)
\]

where \( C_i \) ranges between 0 and 1. If \( C_i = 1 \), the evaluation object is in the most ideal state. The higher the value of \( C_i \), the stronger the economic linkage and logistics quality development of city \( i \) in the Guangdong-Hong Kong-Macao Greater Bay Area.
2.2.2. Modified Gravitational Model

The gravity model is a spatial interaction model, applied to economic geography in recent years, especially in urban spatial linkages, the regional economy, and trade. Reilly applied the gravity model for the first time in 1929 based on Newton’s law of gravitation [19]. Equation (9) shows the traditional gravitational model.

\[ F = k \times \frac{M_a \times M_b}{r^2} \quad (9) \]

where \( F \) serves as the linkage intensity of two cities, \( k \) is the modified gravitational constant, \( M_a \) and \( M_b \) are the GDP of the city as a proxy for the modified mass standard, and \( r \) is the geographical distance between the two cities.

This study investigates the traditional gravity model to clearly reflect the mutual radiation degree and attraction between a central city and its neighboring cities. Firstly, this investigation modifies the gravitational constant, which is the proportion of the comprehensive quality of logistics in a city to the sum of the comprehensive quality of logistics in two cities. This research modifies the mass standard, and measures the comprehensive logistics quality in each city based on the evaluation index system of comprehensive logistics quality of cities. Finally, the regional distance is modified, and the minimum ‘spatial distance’ and the minimum ‘temporal distance’ are multiplied in this study. Equation (10) represents a modified gravitational model.

\[
F_{ab} = \frac{R_a}{R_a + R_b} \times \frac{R_b \times R_a}{D_{ab} \times T_{ab}} \\
F_{ba} = \frac{R_b}{R_a + R_b} \times \frac{R_a \times R_b}{D_{ab} \times T_{ab}} \\
P_a = \sum_{a=1}^{m} F_{ab} \\
Q_a = \sum_{a=1}^{m} F_{ba} \\
I_{ab} = \frac{F_{ab}}{P_a} \quad (10)
\]

where \( R_a \) and \( R_b \) are the comprehensive logistics masses of cities \( a \) and \( b \), respectively, calculated as shown in the previous section. \( \frac{R_a}{R_a + R_b} \) and \( \frac{R_b}{R_a + R_b} \) are the gravitational coefficients of their gravity models, respectively. \( D_{ab} \) is the minimum ‘spatial distance’ between the two cities, i.e., the “shortest time” in road mileage from the freight mode in Gaode Map. \( T_{ab} \) is the minimum ‘temporal distance’ between the two cities, i.e., picking the shortest time for the shipment. \( F_{ab} \) and \( F_{ba} \) are the strength of the logistical linkages between the two cities. \( P_a \) is the intensity of the logistics linkages of city \( a \) to the other cities in the study area, i.e., the attraction intensity of city \( a \) in the study area. \( Q_a \) is the intensity summation of the logistics linkages of the other cities in the study area to city \( a \), i.e., the radiation intensity of city \( a \) in the study area. \( I_{ab} \) is the logistic linkage affiliation of city \( a \), which reflects the main direction of the logistic linkage of city \( a \), and its maximum value shows the city in the study area with the strongest logistic linkage to city \( a \).

2.2.3. Social Network Analysis

Social network analysis is an important research method in the new economic geography, which considers the importance of the relationships among interacting members. This method describes patterns of relationships using graphical tools and algebraic modeling techniques, and explores the impact of these patterns on the members of a structure or the whole. This method analyzes the structure from a ‘relational’ perspective. In this analysis, structures are behavioral, political, social, or economic [23,24]. Recent studies have widely used social network analysis to analyze the network characteristics, density, and structure
of urban agglomerations [9,25]. Based on this, this study analyzes the density, centrality, and cohesive subgroups of the economic linkages and logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area using UCINET 6. In this way, this method provides a comprehensive understanding of the process of high-quality economic development in the Guangdong-Hong Kong-Macao Greater Bay Area.

- Network density analysis

  Network density values reflect both the influence of the network as a whole on the individuals in the network in which it is located and the interaction among individuals in the network. The higher the network density value, the greater the likelihood of the network influencing its members and the closer the relationships among network members [26].

- Network centrality analysis

  The difference between inter-city links and the directionality of economically linked logistic networks leads to a discussion of network centrality in terms of both the whole and the individual. Centralization is a quantitative analysis of the whole network, measuring its centrality degree, while centrality is an important indicator to measure the “rights” and status of the nodes in the whole network. Centrality has three indicators: the degree, closeness, and betweenness centrality of the node cities in the network. This study uses these indicators to analyze the linkages and the role of each city in the economic linkage logistic network of the Guangdong-Hong Kong-Macao Greater Bay Area [24,27].

- Cohesive subgroups analysis

  In social network analysis, cohesive subgroup analysis is known as “clique” analysis, where several nodes are particularly and tightly connected in a network to form a clique, also called a cohesive subgroup [28]. Economic and spatial linkages are the basis for forming and developing logistic networks. The urban agglomeration logistic network has several subgroups according to the closeness of the cities, and each subgroup is closely and internally linked to organize the logistic network. Therefore, this study analyzes the logistic network and spatial organization structure in the Guangdong-Hong Kong-Macao Greater Bay Area according to four aspects: clique analysis, n-cliques analysis, k-core analysis, and lambda set analysis [9].

3. Results and Discussion

3.1. Economic and Logistics Network Linkages

3.1.1. Comprehensive Quality Level and Linkages of Logistics

**Comprehensive Quality Level of Logistics**

This study adopts the entropy-weighted TOPSIS method using the relevant statistical data of 11 core cities in the Guangdong-Hong Kong-Macao Greater Bay Area in 2020 as the sample. In this way, this method comprehensively evaluates the logistics development level of each city from three perspectives: the comprehensive development of the city, the supply and demand of the logistics market, and the comprehensive logistics facilities. Figure 1 depicts the measured comprehensive logistics quality level in each city.

Figure 1 and Table 2 show that Hong Kong has the first rank, followed by Shenzhen, Guangzhou, and Macao. After these cities, the fifth, sixth, and seventh ranks go to Foshan, Zhuhai, and Dongguan, respectively. The overall logistics quality and relative closeness of the cities are basically the same in the Guangdong-Hong Kong-Macao Greater Bay Area. The results of the entropy-weighted TOPSIS method show that the relative closeness level matches the total economic linkages, implying a logical correlation between the overall logistics quality levels of the cities and the regional economic and social development. An explanation for is that regions with high economic linkages with their neighbors have high logistics development.
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Figure 1. Overall research methodology model construction.

Table 2. Relative closeness and ranking of integrated logistics quality of cities in the Guangdong-Hong Kong-Macao Greater Bay Area.

<table>
<thead>
<tr>
<th>City</th>
<th>$C_i$</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong</td>
<td>0.717</td>
<td>1</td>
</tr>
<tr>
<td>Shenzhen</td>
<td>0.605</td>
<td>2</td>
</tr>
<tr>
<td>Guangzhou</td>
<td>0.596</td>
<td>3</td>
</tr>
<tr>
<td>Macao</td>
<td>0.550</td>
<td>4</td>
</tr>
<tr>
<td>Foshan</td>
<td>0.521</td>
<td>5</td>
</tr>
<tr>
<td>Zhuhai</td>
<td>0.459</td>
<td>6</td>
</tr>
<tr>
<td>Dongguan</td>
<td>0.424</td>
<td>7</td>
</tr>
<tr>
<td>Huizhou</td>
<td>0.360</td>
<td>8</td>
</tr>
<tr>
<td>Jiangmen</td>
<td>0.248</td>
<td>9</td>
</tr>
<tr>
<td>Zhongshan</td>
<td>0.228</td>
<td>10</td>
</tr>
<tr>
<td>Zhaoqing</td>
<td>0.223</td>
<td>11</td>
</tr>
</tbody>
</table>

3.1.2. Logistic Network Linkages

This study uses a modified gravitational model as the logistics linkage value of each city with other cities to measure the gravitational value of each city according to the comprehensive quality of logistics in the Guangdong-Hong Kong-Macao Greater Bay Area. Figure 2 displays the logistics linkage network obtained by ArcGIS spatial measurement tool in the Guangdong-Hong Kong-Macao Greater Bay Area.

Figure 3 illustrates the structure of the logistic network of the Guangdong-Hong Kong-Macao Greater Bay Area. In Figure 3, lines with the lightest grey color show the weak links, with values under 18,856 in ArcGIS. The darker the link between two cities, the stronger their logistics link. The larger the node, the more developed the city is in the overall network. Figure 2 shows significant hierarchical characteristics in the spatial linkages of the entire Guangdong-Hong Kong-Macao Greater Bay Area. According to Figure 2, regions with high spatial linkages are concentrated in the four central cities of Hong Kong, Shenzhen, Guangzhou, and Macao. In addition, Figure 3 indicates a positive relationship between the economic development of cities and the level of logistics links, i.e., cities with strong logistics links have a high level of economic development. Logistics links imply the cross-regional flow of capital and resources in the context of economic globalization and regional economic integration. The closer the links, the smoother the channels of capital and resource circulation between regions, and the higher the level of economic and social development.
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**Figure 2.** Comprehensive logistics quality of the cities in the Guangdong-Hong Kong-Macao Greater Bay Area.

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**Figure 3.** Logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area.

### 3.2. Characteristics of the Logistic Network

#### 3.2.1. Overall Spatial Characteristics of the Logistic Network

The directed multi-valued network was transformed into a binary one to explore the overall spatial characteristics of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area and further eliminate the influence of maximal and minimal values. UCINET 6 measures the closeness and density of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area [29]. Regarding Table 3, if the connection threshold is one, the network density is 0.7563, which is close to one, indicating a high network density. If the threshold is three or four (the median or mean of the secondary data), the network density drops to 0.5000 or 0.3455, respectively. In this case, the network density of the overall spatial linkage is stable, the overall level is relatively high, and the linkages
3.2. Characteristics of the Logistic Network

3.2.1. Overall Spatial Characteristics of the Logistic Network

The directed multi-valued network was transformed into a binary one to explore the overall spatial characteristics of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area and further eliminate the influence of maximal and minimal values. UCINET 6 measures the closeness and density of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area [29]. Regarding Table 3, if the connection threshold is one, the network density is 0.7563, which is close to one, indicating a high network density. If the threshold is three or four (the median or mean of the secondary data), the network density drops to 0.5000 or 0.3455, respectively. In this case, the network density of the overall spatial linkage is stable, the overall level is relatively high, and the linkages among cities within the urban agglomeration are strong in the Guangdong-Hong Kong-Macao Greater Bay Area.

Table 3. Overall density of logistic network.

<table>
<thead>
<tr>
<th>Connection Threshold</th>
<th>≥1</th>
<th>≥3</th>
<th>≥4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall network</td>
<td>0.7563</td>
<td>0.5000</td>
<td>0.3455</td>
</tr>
</tbody>
</table>

This study uses Netdraw software to generate a logistics linkage topology map to clearly describe the overall spatial characteristics of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area. In Figure 4, the connecting lines represent the logistics links between two cities, and the directional symbols of the connecting lines indicate that the city is taking the initiative in the logistics links. The more connecting lines a node has, the closer it is to the center of the topology diagram [30]. Specifically, the absolute core of the logistic network includes four cities: Hong Kong, Shenzhen, Guangzhou, and Macao, while the other cities surrounding the central city form an integrated development within the center and the surrounding cities in the bay area.

Figure 4. Topology of logistics links in the Guangdong-Hong Kong-Macao Greater Bay Area.

3.2.2. Individual Spatial Characteristics of Logistic Networks

- Centralization

Centralization is a quantitative analysis, measuring the centrality degree of the whole network [28]. The out-degree, in-degree, and betweenness centralization are 55%, 33%, and 17.09%, respectively, in the Guangdong-Hong Kong-Macao Greater Bay Area city network based on the role of urban spatially oriented linkages. From the degree of centralization,
the economic linkage logistic network has a relatively intense concentration trend in the Guangdong-Hong Kong-Macao Greater Bay Area. This intense concentration implies that the cities with the highest degree of centralization in the network (i.e., Hong Kong, Shenzhen, Guangzhou, and Macao) have an absolute core dominant position, are strongly leading, and spillover effect on the whole network. In terms of betweenness centralization, the degree of centrality is low as an intermediary medium in the Guangdong-Hong Kong-Macao Greater Bay Area. In the context of “One Belt, One Road”, the Guangdong-Hong Kong-Macao Greater Bay Area is actively building an inter-city rapid transport network with high-speed, inter-city, and high-grade highways as the mainstay, which enhances direct access to cities and makes transportation more convenient [31].

- **Degree centrality**

  Degree centrality characterizes the number of city nodes that have a direct relationship with a city node to reflect the level of economic linkages and logistics connections among city nodes. According to Table 4, Hong Kong, Shenzhen, Guangzhou, and Macao are the top four cities regarding the degree centrality and out-centrality. Based on Table 4, these four cities have stronger connections with other cities, confirming their stronger radiation capacity and core position of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area. The out-centralities of Foshan, Zhuhai, and Dongguan around the four logistics center cities are all higher than the in-centrality. This comparison implies that the radiation capacities of these cities are all greater than their receiving capacity. Additionally, these cities have a positive spillover effect on the logistic network of the Guangdong-Hong Kong-Macao Greater Bay Area.

<table>
<thead>
<tr>
<th>City</th>
<th>Degree Centrality</th>
<th>Out-Centrality</th>
<th>In-Centrality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong</td>
<td>100</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Shenzhen</td>
<td>90</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Guangzhou</td>
<td>90</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Macao</td>
<td>90</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Foshan</td>
<td>80</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Zhuhai</td>
<td>80</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Dongguan</td>
<td>60</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Huizhou</td>
<td>60</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Jiangmen</td>
<td>50</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Zhongshan</td>
<td>50</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Zhaoqing</td>
<td>10</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Mean</td>
<td>67.273</td>
<td>5.688</td>
<td>1.706</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>24.155</td>
<td>3.668</td>
<td>1.706</td>
</tr>
</tbody>
</table>

- **Closeness centrality**

  Closeness centrality characterizes the average length of the shortest path from a city node to all other city nodes, to reflect the accessibility of city nodes in the economically linked logistic network [32]. Based on Figure 5, six cities have the top closeness centrality in the Guangdong-Hong Kong-Macao Greater Bay Area: Hong Kong, Shenzhen, Guangzhou, Macao, Foshan, and Zhuhai. Hence, these cities do not rely entirely on intermediate nodes for logistics and they are able to achieve higher efficiency in logistics communication. Hong Kong has the highest out-degree closeness centrality, reflecting its central position in the logistics of the Guangdong-Hong Kong-Macao Greater Bay Area. The logistics development of the Guangdong-Hong Kong-Macao Greater Bay Area belongs to the central city-driven model, with the ports of Hong Kong, Shenzhen, and Guangzhou in the Bay Area port cluster ranking among the top 10 container ports in the world. With the staggering development of these three ports from the economic, financial, and trade perspectives, their advantages complement each other and gradually spread and radiate to the surrounding
cities [33]. Except for Jiangmen and Zhaoqing, the out-degree closeness centrality is greater than the in-degree one in the other nine cities. For the most part, their out-degree closeness centrality is twice the in-degree closeness centrality. This implication indicates that the role of Hong Kong and the other nine cities in the Bay Area to the surrounding cities is greater than their degree of influence by the logistics radiation of other cities. In other words, the logistics radiation function is greater than the logistics agglomeration function in the nine cities. Among the nine cities, Hong Kong, Shenzhen, Guangzhou, and Macao have the most significant effects on the neighboring cities. This implication also reaffirms the prominent position of Hong Kong, Shenzhen, Guangzhou, and Macau as the central cities in the logistic network.

![Closeness centrality of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area.](image)

**Figure 5.** Closeness centrality of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area.

- **Betweenness centrality**

  Betweenness centrality indicates the probability that the shortest paths need to pass through a city to connect other city nodes, reflecting the transit role of city nodes in the logistic network [32]. The betweenness centrality of Hong Kong is at the top of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area. This rank implies that the shortest paths through Hong Kong are the most central in the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area, with strong control over resources. Hence, these paths have the ability to influence the logistics communication of most city nodes in the region. After Hong Kong, the clustering analysis shows that the second group includes Shenzhen, Guangzhou, and Macao in terms of betweenness centrality, whose values are greater than three. These three cities form the secondary core of the Guangdong-Hong Kong-Macao Greater Bay Area, which plays a crucial role as a bridge in logistics communication. In the third group, betweenness centrality ranges from zero to three in Foshan, Dongguan, Zhuhai, and Zhongshan, which are general city nodes in the Guangdong-Hong Kong-Macao Greater Bay Area. Finally, betweenness centrality is extremely weak, equal to 0, in Huizhou, Jiangmen, and Zhaoqing. Most of the cities’ logistics links are established through intermediary cities such as Hong Kong, Shenzhen, Guangzhou, and Macao. Each city acts as a “broker” for logistics links 2.273 times on average. Figure 5 represents the correlation analysis of the statistics. According to Figure 6, the Pearson correlation coefficient is 0.943 between real GDP per capita and betweenness...
centrality in the Guangdong-Hong Kong-Macao Greater Bay Area. This value indicates that the logistics importance of each city node is highly correlated with the development level of real GDP per capita in each city and does not jump out of the distribution pattern of GDP development. The high growth of GDP is the basis for the logistics industry to reduce costs and increase efficiency. The logistics industry is an inherent requirement for achieving high-quality economic development in the Guangdong-Hong Kong-Macao Greater Bay Area. Additionally, the logistics industry is an important lever for improving the industrial development and investment environment, which plays a critical role in cultivating new momentum for economic development in the Guangdong-Hong Kong-Macao Greater Bay Area. In addition, the logistics industry has a strategic importance to the leading and radiation-driven role of the greater bay area.

![Figure 6](imageURL) 

**Figure 6.** Betweenness centrality of logistic networks in the Guangdong-Hong Kong-Macao Greater Bay Area.

The above three types of centrality and centralization analyses show that Hong Kong is at the center of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area. Additionally, Hong Kong has a strong ability to radiate logistics to the inner cities of the bay area, while it continuously absorbs the advantageous resources around it, complementing the inner cities of the bay area and forming a positive interaction. Hong Kong is a free port with an open economic system, which leads Shenzhen, Guangzhou, and Macao to form the core inner circle of the Guangdong-Hong Kong-Macao Greater Bay Area. Additionally, this port radiates the various resources of the core inner circle to the outer cities while it achieves significant development. In terms of degree and closeness centrality, out-centrality is greater than in-centrality in 70% of the cities, which has many implications. An indication is that the transportation system is convenient, advanced, and powerful in the Guangdong-Hong Kong-Macao Greater Bay Area. Another implication is that the cities actively exchange, cooperate, and trade in this area. These two implications pave the way for “going out”, stimulating the driving forces of economic development in the Bay Area, enhancing the complementary functions of Guangdong, Hong Kong, and Macao, and improving the people’s living standards [33]. In terms of betweenness centrality, developing the logistics industry is highly correlated with the value of real GDP per capita in the cities of the Bay Area. This correlation indicates the cornerstone characteristics of the economy for the high-quality development of the logistics industry and that the economy and logistics are inseparable, mutually reinforcing, and develop together.
3.2.3. Stability of the Logistic Network Structure

- Clique analysis

In a network graph, a clique is a maximal complete sub-graph of at least three nodes. In this definition, “complete” means that any two nodes are directly correlated with and adjacent to each other in the sub-graph, and no node is associated with all points in the faction. Nodes in the same faction are closely correlated with one another [34]. This research uses the faction (cliques) analysis function of UCINET 6 to set the clique size to five after running several trials in conjunction with the research question. Table 5 shows a total of three cliques found in this way.

Table 5. Results of clique analysis of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area.

<table>
<thead>
<tr>
<th>Clique</th>
<th>Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clique 1</td>
<td>Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Hong Kong, Macao</td>
</tr>
<tr>
<td>Clique 2</td>
<td>Guangzhou, Shenzhen, Zhuhai, Foshan, Dongguan, Jiangmen, Hong Kong, Macao</td>
</tr>
<tr>
<td>Clique 3</td>
<td>Guangzhou, Shenzhen, Zhaoqing, Hong Kong, Macao</td>
</tr>
</tbody>
</table>

According to Table 5, all the three cliques include Hong Kong, Macao, Shenzhen, and Guangzhou, implying the central and intermediary role of these four cities in the Guangdong-Hong Kong-Macao Greater Bay Area, growing their own logistic networks in the process of actively driving the logistics development of other cities. In addition to these four central cities, Clique 1 and 2 involve Zhuhai, Foshan, and Dongguan, which to a certain extent illustrates the “hard connectivity” formed by the Hong Kong-Zhuhai-Macao Bridge, the Guangfo Metro, and other transport infrastructures that are geographically connected. Hard connectivity gradually makes the economy take off and radiate widely, leading to high-quality development of the logistics industry in the Greater Bay Area. Although Zhaoqing, in Clique 3, is the most economically backward, the Guangzhou-Zhaoqing metropolitan area is gradually developing by opening transport facilities such as the Guangzhou-Foshan-Zhaoqing Intercity Railway and motorways. The central cities in the Guangdong-Hong Kong-Macao Greater Bay Area are driving Zhaoqing’s economic linkage to build a high-quality logistic network.

In addition to the clique analysis, UCINET 6 generates Figure 7, which is a clique cluster diagram according to the number of cliques shared by each city node in the logistic network. In Figure 7, the horizontal axis from left to right indicates that the number of shared cliques in each node decreases from three. The vertical axis reveals the name of each city node. The graph as a whole reflects the reciprocity between cities in the logistic network of the Guangdong-Hong Kong-Macao Greater Bay Area.

- N-cliques analysis

The concept of cliques is too complex, and the concept of n-cliques is easier for people to understand. An n-clique means that one of the subgraphs in a graph satisfies the condition that the distance between any two points in that subgraph (i.e., the length of the shortcut) does not exceed “n” at most. This study sets the maximum partition depth equal to one and the minimum value of n equal to the default value of three, using the n-cliques analysis function of UCINET 6, combined with the research problem, after several trial runs. As shown in Figure 8, there is a very clear trend of integration in the Greater Bay Area. Many core cities in the Pearl River Delta region have integrated with Hong Kong and Macao, forming several metropolitan areas. These include the Hong Kong-Shenzhen-Dongguan-Huizhou metropolis circle, which is driven by technological innovation; the Australia-Zhuhai-Zhongjiang metropolis circle, emphasizing the development of a circular economy; and the Guangzhou-Foshan-Zhaojiang metropolis circle with modern manufacturing and industrial and commercial services as its leading industries [35]. Under the “One Belt, One Road” initiative, regional industrial synergy is a prerequisite for dynamic economic
development, and the economic growth of the Guangdong-Hong Kong-Macao Greater Bay Area is an enabler for the diversity, connectivity, and sustainability of the logistic network.

### Figure 7. A clique cluster diagram of logistic networks in the Guangdong-Hong Kong-Macao Greater Bay Area.

### Figure 8. Distribution of cohesive subgroups of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area.

- **K-core analysis**

  The k-core analysis means that all points in the network are adjacent to at least k other points. The k-core is a cohesive subgroup built based on the number of point degrees [34]. The adjustment of the k-value allows one to obtain the status of the economic linkage logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area. The network is stable if the value of k is high, whereas the network is dispersed if this value is low.

Table 6 represents the results of the k-core analysis of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area with three levels and degrees of eight, seven, and four. In these three levels, the eight-core subgroup is a subset of the seven-core
subgroup, and both the eight-core and seven-core subgroups are subsets of the four-core subgroup. These three subgroups consist of Hong Kong, Macao, Shenzhen, and Guangzhou, which are the center of the entire logistic network, with the most significant contribution to it. Zhuhai, Foshan, Huizhou, Dongguan, and Zhongshan form a denser grid structure around the central city, while the remaining two cities, Jiangmen and Zhaoqing, are only sparsely connected to other cities.

- Lambda set analysis

Lambda set analysis of the logistic network is the analysis of the edge connectivity at the network level, which can measure the overall stability of the logistic network structure in the Guangdong-Hong Kong-Macao Greater Bay Area. The smaller the value of edge connectivity, the more fragmented the connections between city nodes, whereas the larger the value of edge connectivity, the closer the connections between city nodes [36].

This study uses the Lambda set analysis function of UCINET 6. The minimum edge connectivity is a concept based on the stability of network node connections. In this analysis, the horizontal axis is the Lambda value, which represents the minimum edge connectivity, and the vertical axis is the logistics node city. Figure 9 shows the Lambda set tree diagram of the logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area. Based on Figure 9, the minimum, maximum, mean, and median edge connectivity values are 4, 10, 9, and 8 between any two cities in the Bay Area, respectively. Overall, the edge connectivity of the economically linked logistic network shows a very balanced state in the Guangdong-Hong Kong-Macao Greater Bay Area, consistent with the results of the clique analysis. Regarding the sum of their edge connectivity, the top four cities are Hong Kong, Macao, Shenzhen, and Guangzhou. Hence, these four cities have the most robust logistics linkage in the Guangdong-Hong Kong-Macao Greater Bay Area logistic network, forming the first echelon, followed by the second echelon of Zhuhai, Foshan, and Dongguan. According to Figure 5 above, the real GDP per capita has exceeded 200,000 yuan in Hong Kong and Macao, and 100,000 yuan in Shenzhen, Guangzhou, Foshan, and Zhuhai since 2020. In addition, the real GDP per capita will exceed 100,000 yuan soon in Dongguan. The basic rule is that the more economically developed a region is, the higher the level of demand for logistics, and the more conducive it is to the high-quality development of the logistics industry.

![Lambda set tree diagram of logistic network in the Guangdong-Hong Kong-Macao Greater Bay Area.](image-url)
Table 6. Results of k-core analysis of logistic networks in the Guangdong-Hong Kong-Macao Greater Bay Area.

<table>
<thead>
<tr>
<th>k-Core</th>
<th>City</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Hong Kong, Macao</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, Hong Kong, Macao</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, Zhaoqing, Hong Kong, Macao</td>
<td>11</td>
</tr>
</tbody>
</table>

4. Conclusions and Significance

4.1. Conclusions

This research constructs a comprehensive urban logistics quality evaluation index system based on the multi-indicator data of 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area in 2020. To this end, this study employs the entropy-weighted TOPSIS method, the modified gravity model, and the social network analysis method to analyze the agglomeration capacity of the central cities in the Guangdong-Hong Kong-Macao Greater Bay Area to other cities as well as the spatial organization evolution characteristics and inner laws of urban clusters. The research question is how the regional logistic network can link the urban agglomerations to contribute to sustainable economic development.

(1) In terms of the logistics evaluation indicator system, the top three indicator weights are the total export-import volume, logistics gross, and port container throughput. The total export-import has the first rank of indicator weight, and is equal to 0.1130, proving that the Guangdong-Hong Kong-Macao Greater Bay Area is located at the fusion point of the three economic circles “Shenzhen-Dongguan-Huizhou”, “Guangzhou-Foshan-Zhaoqing”, and “Zhuhai-Zhongshan-Jiangmen”. This region is an intersection of international window cities and the bridgehead of the Silk Road [35]. The logistics gross has the second rank of indicator weight, and is equal to 0.1045, confirming the leading role of the Guangdong-Hong Kong-Macao Greater Bay Area in the development of China’s logistics industry and as a first-class international bay area. Hong Kong, Shenzhen, Guangzhou, and Macao are home to the headquarters of China’s multinational companies, which forces enterprises to provide global logistics services. This need increases with the continuous development of the Greater Bay Area. The port container throughput has the third rank of indicator weight, and is equal to 0.0963, indicating that the Guangdong-Hong Kong-Macao Greater Bay Area has several high-quality ports, such as Hong Kong Port, Guangzhou Port, Shenzhen Port, Zhuhai Port, Dongguan Port, and Zhongshan Port. The developments of logistics and economic prosperity are inseparable from the services of ports. Logistics, economy, and ports complement and reinforce each other.

(2) From the perspective of the comprehensive logistic quality, the entropy-weighted TOPSIS method can accurately use mathematics to quantify the indicator weights. In this way, this method reflects the level of economic linkage and logistics development of the cities in the Guangdong-Hong Kong-Macao Greater Bay Area. This research reveals that most cities enjoy a high integrated logistics quality, basically exceeding 100,000, but there is a severe polarization between different cities. For example, the integrated logistics quality reached 28,947.598 in Hong Kong, the central city, which is nearly seven times higher than that in Zhaoqing, a city on the edge of the Bay Area, with just 4239.698. The ranking trend of the comprehensive quality of urban logistics is the same as that of the relative closeness. A high comprehensive quality of logistics implies a great relative closeness and an excessive level of economic linkage, and the logistics development of a city.

(3) In the bay area, the strongest linkages are between Hong Kong and Shenzhen. These two cities play a leading role in developing the Guangdong-Hong Kong-Macao Greater Bay Area, which enhances the development of the Greater Bay Area. Hong Kong is a special administrative region and Shenzhen is a special economic zone. Hong Kong and Shenzhen have provided various expertise and features to develop the Greater Bay
Area with complementary functions and integrated resources. Hong Kong acts as an international financial center, shipping center, and international free-trade port, while Shenzhen performs as an information valley and high-end industrial base. Hong Kong has comparative advantages regarding international trade and manufacturing in the international cooperation platforms, which paves the way for the international division of labor system [37].

(4) From the perspective of the overall logistic network, the network density is high, the cohesive subgroup structure is very stable, the bay area agglomeration effect is strong, and the development of the logistic network is becoming increasingly mature. The economy is a link between the city and logistics, and plays a central role in developing the logistic network. From the perspective of individual logistic networks, the central cities of the bay area (including Hong Kong, Shenzhen, Guangzhou, and Macao) have comparative advantages in terms of centralization, degree centrality, closeness centrality, and betweenness centrality. Previous studies employed N-cliques analysis, k-core analysis, and Lambda set analysis to show that these central cities are often grouped together and appear repeatedly. This finding proves that the central city will release a large quantity of logistics, capital, and technology flow to the surrounding cities, which develops their logistics industry. Out-centrality is greater than the in-centrality in the sub-central cities such as Zhuhai, Foshan, and Dongguan. The above analysis shows the same result for those cities. They are also often combined with each other, closely following the central city, and appearing repeatedly, which indicates that they are also in a state of external radiation, absorbing the superior resources of the central city, and at the same time generating radiation capacity for the logistics of the surrounding cities. Huizhou, Jiangmen, and Zhaoqing, as cities on the periphery of the bay area, face gaps to actively create links with the central and sub-central cities, continuously improve the logistics accessibility among the cities, and break through the barriers of regional synergistic development.

4.2. Significance

First, the spatial scope of the Guangdong-Hong Kong-Macao Greater Bay Area is beyond the nine cities in the Pearl River Delta and the two special administrative regions of Hong Kong and Macao. This area should be constantly radiating outwards to include other cities in Guangdong. A world-class urban agglomeration needs not only a global innovation or financial center, but also a vast hinterland and a sizeable concentration of population. In the Guangdong-Hong Kong-Macao Greater Bay Area, the urban agglomeration depends on how one defines the spatially linked features of this area and its surrounding cities, clarifies the spatial organization structure among cities, and ultimately lands on the integrated development of the center and the surrounding cities [9].

Second, these four cities have an intense concentration, and the peripheral cities have insufficient cultivation in the Guangdong-Hong Kong-Macao Greater Bay Area in terms of logistic network structure. Hence, policy-makers should achieve a balance in urban development in the bay area, and alleviate the phenomenon of “four cities alone”. The cities in the Guangdong-Hong Kong-Macao Greater Bay Area should rationalize their division of labor and cooperation according to their respective resource endowments and levels of economic and social development. Additionally, these cities should promote heterogeneous development in each city, achieve complementary resources and functional integration among cities, increase integration efforts, and strengthen inter-city logistics links. For developing the Bay Area, policy-makers should consider the individual and idiosyncratic characteristics of each region to adapt to the local conditions, due to the diverse roles and opportunities of various regions [38].

Third, the essential strategy in the Guangdong-Hong Kong-Macao Greater Bay Area is the economic integration of Guangdong, Hong Kong, and Macao. Logistics integration is a critical part of economic integration [39]. In Guangdong, Hong Kong, and Macao, the logistic network reduces the costs of logistics and improves the spillover effects of central cities on other cities, logistics competitiveness among the sub-central cities, and accessibility
and efficiency of logistics among cities [40]. In addition, Hong Kong, Shenzhen, Guangzhou, and Macao, with developed logistics industries, should rely on their advantages to deeply explore the potential and improve the quality of their logistics development and spillover effects on the Greater Bay Area, China, and the world. Moreover, cities with relatively weak logistics industries (i.e., Zhuhai, Foshan, Dongguan, Zhongshan, Huizhou, Jiangmen, and Zhaoqing) should vigorously develop this industry. These cities should consider this industry as an economic driving force for meeting people’s needs, optimizing the logistic network structure, and improving the quality of logistic development.

Fourth, close and convenient transportation has enhanced the stability of the logistic network in Guangdong, Hong Kong, and Macao. With the completion of the Hong Kong-Zhuhai-Macao Bridge, the Guangzhou-Shenzhen-Hong Kong Express Rail Link, and the Liantang Port, nearly 70% of cities in the Greater Bay Area can be reached within roughly 1.5 h, driving from Hong Kong, the head of the central city, and almost all of the Greater Bay Area cities can be reached within 2.5 h [41]. In the future, the government should increase the density of the road and railway networks to strengthen the infrastructure for the spatial connection of the Guangdong-Hong Kong-Macao Greater Bay Area and its surrounding cities. This policy shortens the spatial and temporal distance among cities to form a complete and closed transportation loop in the east and west regions, which have long been separated by the Pearl River. By building a comprehensive three-dimensional transportation network via land, sea, and air, the Guangdong-Hong Kong-Macao Greater Bay Area will have the outstanding advantages of fast transportation and relatively low logistics costs, greatly enhancing the complementary functions of Guangdong, Hong Kong, and Macao and the convenience of people’s lives. This transportation network effectively addresses the spatial integration of logistics and economic linkages through the interconnection of developed international networks with transport interoperability and integration [42].

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