Research on the Function Development of Guangdong-Hong Kong-Macao Greater Bay Area International Transportation Hub

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Keywords: International transportation hub, Development model, Development path, Guangdong-Hong Kong-Macao Greater Bay Area.

Abstract: International transportation hub is the key point for a city to realize both internal and external development, a trans-regional transit and distribution center for people and materials, a bridge for international development factors to flow and gather, and a basic support for the international development of a city. The spatial distribution characteristics of population and transportation facilities in Guangdong-Hong Kong-Macao Greater Bay Area were analyzed by using population density, nuclear density and transportation connection degree models. The research shows that the spatial distribution of population in Guangdong-Hong Kong-Macao Greater Bay Area has obvious characteristics of agglomeration and polycentricity. The spatial distribution of traffic facilities is characterized by polycentric distribution, which is highly coupled with population distribution. Transportation degree: Guangzhou and Foshan > Shenzhen and Dongguan > Guangzhou and Dongguan > Shenzhen and Huizhou > Shenzhen and Guangzhou. The development of regional transportation has formed a development pattern with "Guangzhou+Shenzhen" as the main core, aiming at improving the functions of Guangdong-Hong Kong-Macao Greater Bay Area's international transportation hub and promoting the development of the interconnected transportation hub system.

1. Introduction

Hub is an important connection point, which is the key node of mutual connection between things, and plays a core role in controlling the two-way development. The international transportation hub is the key to the two-way development of the city from inside to outside, the trans-regional transit and distribution center for personnel and materials, the bridge for the international development elements to flow and gather, and the basic support for the development of international functions. Since Scottish urban planner Geddes put forward the concept of international metropolis in 1915, although there is no universally accepted definition of international metropolis, the concept of international first-class metropolis put forward by Peter Hall of Britain has been accepted by everyone internationally. He thinks that the world's first-class metropolis is an internationally important city function as a center of politics, trade, finance, talents, information, population, and entertainment [1-4]. With the process of economic globalization, global cities have concentrated on the elements and functions of international development and become the hub nodes of global urban development network (J. Friedmann1986) [5]. The elements of internationalization include the number of corporate headquarters, bank headquarters (Thrift1989) [6], infrastructure, international service facilities (Sassen1995) [7], international development channels, and capacity (Taylor2002) [8]. Since the reform and opening-up, Chinese scholars have also made active research on international metropolises. With the deepening of globalization and the deepening of international exchanges and cooperation, in 1990s, China began to pay more attention to the research on international functions and other related issues, and the internationalization of urban functions gradually became the research

  DOI: 10.25236/ermss.2021.021

focus in the field of urban internationalization (Chen Guangting 1993) [9]. Yao Shimou (1995) summarized the international function, modern infrastructure, highly internationalized service industry and fast accessible transportation network, and pointed out that one of the characteristics of an internationalized metropolis is that the international function of a city is very prominent [10]. Secondly, as an important promoter of urban internationalization [11], international transportation hub is a booster to promote urban socio-economic development, rational land use [12-13] and build a multi-level and integrated international transportation hub system [14-17]. The overall composition of international transportation hub functions includes hub lines and hub lines. The distribution of hub lines reflects the external connection strength of the city. Hub lines include external contact stations and lines, internal contact stations and lines. Hub stations include airports, ports, train stations, intercity rail transit stations, bus, and subway stations, etc. Hub stations reflect the basic conditions for urban development and international hub functions. The single hub function development mode, namely "single airport + urban transportation", forms a transportation hub network through the combination and connection of large international airports and urban transportation, which is the main mode of urban transportation hub development at the present stage. The functional development modes of diversified hubs are mainly "double airports + urban transportation", "airport + port + urban transportation", etc. most of these hubs are distributed in large cities along the southeast coast. The comprehensive hub mode weaves a comprehensive transportation hub system in the mode of "airport + high-speed rail + port + urban transportation", so that its hub stations can be set up at the same station of air transport, high-speed rail, subway, and bus, which greatly improves its transportation efficiency. At present, the more common operation modes are single and multiple development modes. Its airport is in a separate area, and the connection mode is also single, which is still a gap from the compound type [18-21].

In recent years, the development of core cities in Guangdong-Hong Kong-Macao Greater Bay Area is showing a trend of transformation to specialization and socialization in the early stage, and now to branding and internationalization. Transportation, as an important part of building a world-class Bay Area, accelerates the formation of inter-connected transportation networks among cities in the Bay Area, accelerates the construction and development within cities, connects different cities in the Bay Area through transportation networks, and strengthens the inter-connection between cities, aiming at building an international urban agglomeration with close ties and integration.

2. Data and methods

2.1 Research area

Guangzhou, Shenzhen, Hong Kong, and Macau are the core engines of regional development, which is one of the regions with the highest degree of openness and the strongest economic vitality in China, and plays an important strategic position in the overall situation of national development. Guangdong-Hong Kong-Macao Greater Bay Area includes Guangzhou, Shenzhen, Zhuhai, Foshan, Dongguan, Huizhou, Zhongshan, Jiangmen and Zhaoqing, and two special administrative regions, Hong Kong, and Macao. By the end of 2019, the resident population of Guangdong-Hong Kong-Macao Greater Bay Area has exceeded 72 million, with a total area of 56,000 square kilometers, and the gross domestic product of the Bay Area has exceeded 11 trillion yuan.

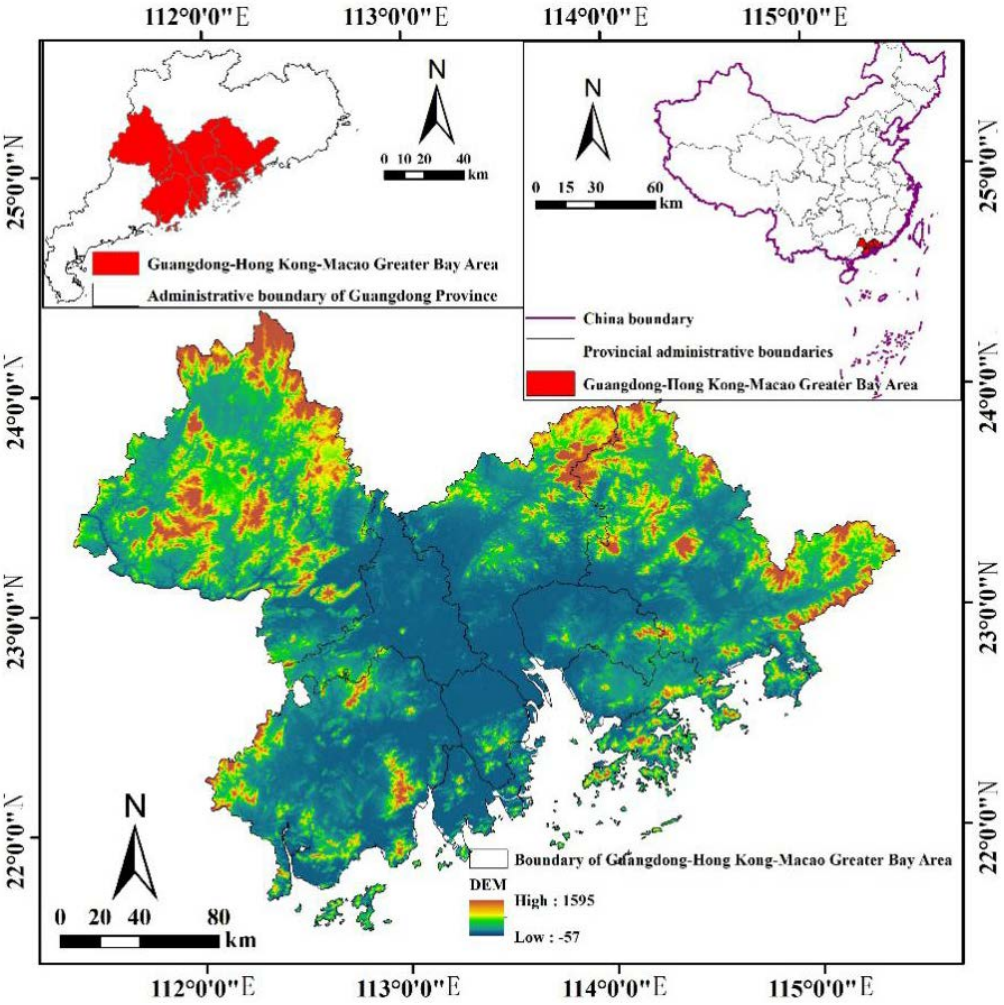

Figure 1. The Location and the research area

2.2 Data and processing

The population density data of Guangdong-Hong Kong-Macao Greater Bay Area in 2020 comes from WorldPop. Using satellite remote sensing images, land use type data, demographic data, etc., supported by various spatial numbers such as elevation and landform, the population grid data of 1 km×1 km is generated. Where, DEM_ 90m data comes from geospatial data cloud, and land use remote sensing data comes from resource and environment science data center of Chinese Academy of Sciences (http://www.resdc.cn), the data of transportation facilities are from the statistical yearbook of each city. On this basis, the characteristics are analyzed by using population density index, nuclear density analysis and traffic connection degree through ArcGIS 10.2 platform.

3. Results and analysis

3.1 Distribution characteristics of population and transportation facilities

According to the distribution of population density in Guangdong-Hong Kong-Macao Greater Bay Area, the spatial distribution of population in Greater Bay Area has obvious agglomeration and polycentricity (Figure 2). Overall, the population of Greater Bay Area is concentrated in the core area of urban agglomeration centered on Guangzhou, Shenzhen, Hong Kong, and Macau, followed by Foshan and Dongguan. Zhaoqing, Jiangmen, Huizhou, Zhongshan and Zhuhai are sparsely populated and have a relatively low degree of urbanization, which are important areas supporting the further development of Greater Bay Area's economy and society. There are many populations distribution centers in Shenzhen and Hong Kong's Greater Bay Area core, showing the characteristics of multi-center distribution of urban population.

According to GIS kernel density analysis, the spatial distribution of transportation facilities in Guangdong-Hong Kong-Macao Greater Bay Area is characterized by polycentric distribution, which is highly coupled with population distribution. Overall, the density of transportation facilities in Hong Kong, Guangzhou and Shenzhen is higher than Macao, Dongguan, Foshan, Zhongshan and Zhuhai, and Jiangmen, Huizhou and Zhaoqing. The transportation facilities in Greater Bay Area have gradually formed a hub transportation development pattern with Hong Kong, Macao, Guangzhou and Shenzhen as the core hub nodes, supplemented by other seven cities (Figure 3). According to Table 1, as of the end of 2020, Guangdong-Hong Kong-Macao Greater Bay Area has put into operation Guangzhou-Shenzhen-Hong Kong, Beijing-Kowloon and Guangzhou-Kowloon railways running through Hong Kong, and the Zhuhai-Hong Kong-Macao Bridge will be put into use in 2018, further enhancing the connection between Hong Kong and Macao and Zhuhai, which is an important embodiment of Guangdong-Hong Kong-Macao Greater Bay Area's regional development and building an international Greater Bay Area. Guangzhou and Shenzhen are the core hub stations of Greater Bay Area Intercity Railway, connecting some surrounding cities, which has gradually formed a development pattern of "two cores and multiple centers".

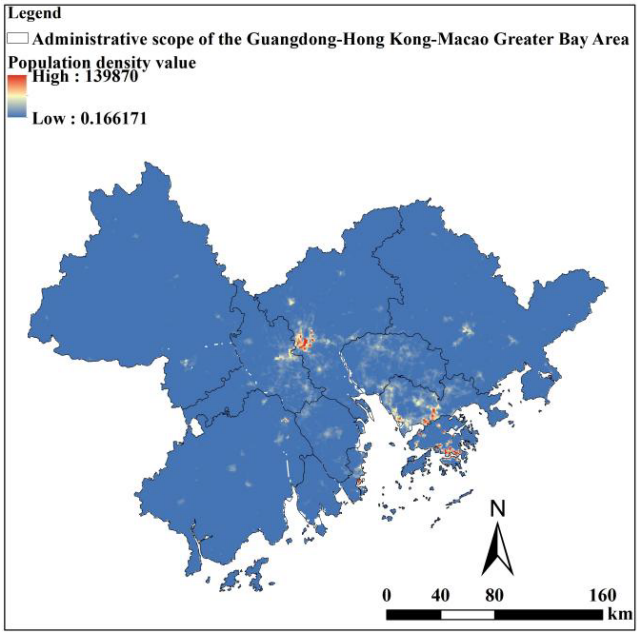

Figure 2. Population distribution spatial map

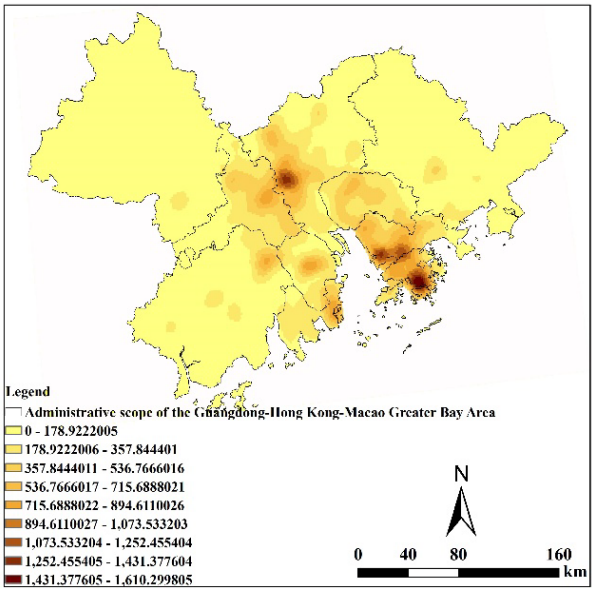

Figure 3. Distribution density map of traffic facilities

Table 1. Transportation facilities coverage table

Project	Guangzhou	Fo shan	Zhaoqing	Shenzhen	Dongguan	Hui zhou	Zhu hai	Zhongshan	Jiangmen	Hong Kong	Macao
Wuhan-Guangzhou high speed railway	●										
Guangzhou Shenzhen Hong Kong high speed railway	●			●	●						
Nanning Guangzhou Railway	●	●	●								
Guiyang Guangzhou Railway	●	●	●								
Xiamen Shenzhen railway				●		●					
Shenmao railway	●			●	●			●	●		
Liuzhaoguang Railway	●	●	●								
Canton-Kowloon Railway	●			●	●					●	
Beijing Kowloon Railway				●	●	●				●	
Guangzhou Zhuhai intercity	●	●					●	●	●		
Guangfozhao intercity	●	●	●								
Guangzhou Foshan Ring Intercity	●	●									
Foshan Dongguan intercity	●				●						
Xinbaiguang intercity	●			●							
Guangzhou Dongguan Shenzhen intercity	●			●	●						
Guangqing intercity	●										
Guanhui intercity					●	●					
Guangfojiangzhu intercity	●	●					●		●		
Zhongnanhu intercity	●				●			●			
Shenhui intercity				●		●					
Zhaoshunnan intercity	●	●	●								
Zhuhai Hong Kong Macao Bridge							●			●	●

3.2 Development characteristics of traffic space

In recent years, with the rapid development of urban and regional transportation, the flow of various development factors between cities is also accelerating, and the transportation facilities such as expressways, light rail and high-speed rail in Greater Bay Area are constantly improving. The time spent traveling between cities is decreasing, the overall connection of urban agglomerations is increasing obviously, and the connection between cities with high quality and surrounding cities is high. The core cities of Guangzhou and Shenzhen have strong ties with their neighboring cities, especially the geographically neighboring Guangzhou and Foshan, which rely on industrial cooperation and the development of integrated rail transit. Its association intensity is higher than that of other cities in the same period. According to the intensity of cross-city traffic links in Guangdong-hong kong-Macao greater bay are a9 city (Figure 4), the traffic links are as follows: Guangzhou and Foshan > Shenzhen and dongguan > Guangzhou and dongguan > Shenzhen and Huizhou > Shenzhen and Guangzhou. Foshan and Dongguan have a high degree of contact with Guangzhou, and Dongguan and Huizhou have a high degree of contact with Shenzhen. Due to the influence of location conditions and related development policies, the transportation integration in Foshan and Dongguan developed rapidly. The development of regional traffic in Greater Bay Area has formed a development pattern with "Guangzhou+Shenzhen" as the main core. The low degree of contact between Jiangmen, Zhongshan, Zhaoqing and Zhuhai and the other five cities reflects the unbalanced distribution of regional transportation facilities in Greater Bay Area and insufficient linkage of regional development.

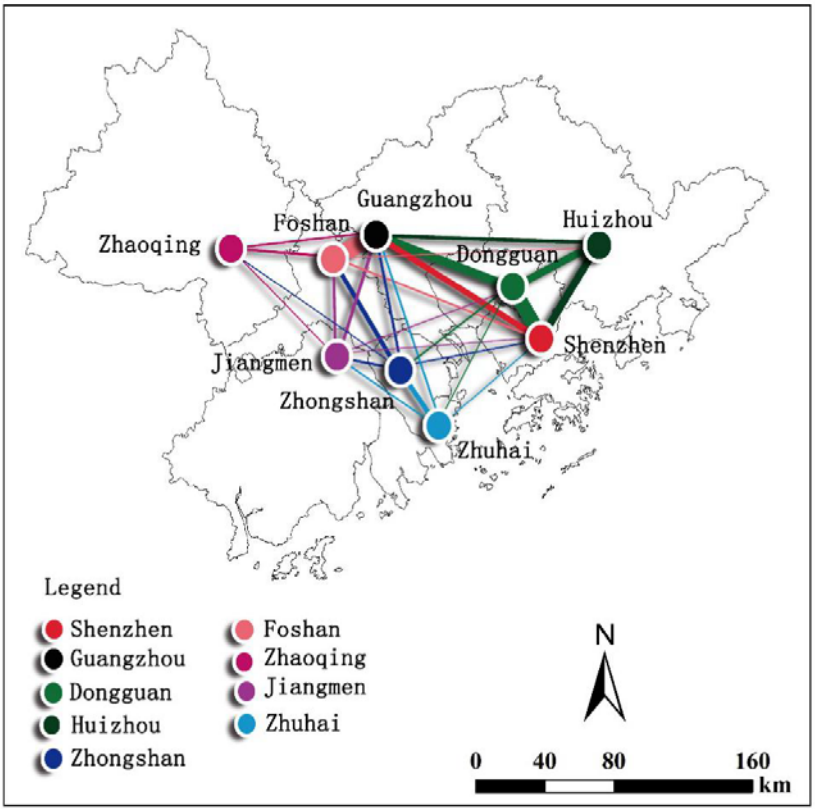

Figure 3. Traffic space connection diagram

4. Discussion

4.1 Functional development model of international transportation hub

The development mode of "multiple airports+rail transit+internal road network+underground transportation network" is the basis for the free circulation of talents and capital elements. There are five international airports in Guangdong-Hong Kong-Macau Greater Bay Area, which are the core of communication between the city and the outside world. The cities in Greater Bay Area are connected

by high-speed railway network and rail transit network. At the same time, the city operates with internal transportation network and underground transportation system, plans high-speed rail new town and airport new port, and sets up stations at the same point for high-speed rail, subway, bus system and taxi, to gradually build a world-class comprehensive international hub. In the future, the Greater Bay Area will mainly rely on the Shenzhen-China Passage, Humen Bridge and Hong Kong-Zhuhai-Macao Bridge to strengthen the connection between Hong Kong and Macao and the nine cities in the mainland, give full play to the radiation effect of the three bridges, and strengthen the interconnection between the nine cities in the mainland through intercity high-speed rail and high-speed transportation lines. Greater Bay Area's international exchanges and cooperation are realized through five airports. In essence, during the construction of Great Bay Area, it is necessary not only to promote the infrastructure construction of international hubs, but also to realize the organic coordination of the two institutional mechanisms in Great Bay Area.

4.2 Functional development road of international transportation hub

4.2.1 Construction of point axis transportation network system

Take the core city of Greater Bay Area as the pole of the regional transportation system, and play the role of radiation to form a point-axis transportation network system. Give full play to the leading role of Hong Kong, Shenzhen and Guangzhou, deepen the exchanges and cooperation between Hong Kong, Macao and Shenzhen and Zhuhai, further promote the construction of Guangzhou and Foshan as the same city, comprehensively enhance the comprehensive strength and international influence of the two places, form the core development axis of Guangdong-Hong Kong-Macao Greater Bay Area on the basis of Guangzhou, Foshan and Shenzhen, and lead Guangdong-Hong Kong-Macao Greater Bay Area to participate in cooperation at home and abroad in a deeper level. Relying on the core cities and important hub cities of Greater Bay Area, the axis of regional economic development and the axis of scientific and technological innovation are constructed, and the connection between the axes is strengthened by relying on the rapid transportation network and the high-speed railway. Taking intercity railways and high-grade highways as the main body, connecting port groups and airport groups, to form an efficient network space pattern between major cities. Thereby greatly enhancing the economic influence of the Greater Bay Area, promoting the transportation network of Guangdong-Hong Kong-Macao Greater Bay Area to extend to the periphery, promoting the formation of a networked spatial pattern of Guangdong-Hong Kong-Macao Greater Bay Area based on Guangdong Province, and promoting the construction of international hub functions.

4.2.2 Build a world-class international airport group and drive economic growth

Guangdong-Hong Kong-Macao Greater Bay Area International Transport Hub will focus on the construction of "5+4" backbone airports. That is, Guangzhou Baiyun International Airport, Shenzhen Baoan International Airport, Pearl River Delta Hub Airport, Zhuhai Jinwan International Airport and Huizhou Pingtan Airport in Greater Bay Area, as well as Chaoshan Airport, Zhanjiang Airport, Meixian Airport and Shaoguan Airport located in the eastern and western areas of Guangdong, to jointly build a world-class airport group. Build a multi-core driven international aviation hub model with Hong Kong, Guangzhou and Shenzhen international airports as the core, multi-point linkage with airports such as Macao and Zhuhai, networking with core airports, and build a new pattern of international transportation hub development. And further build a modern comprehensive transportation system, connect, consolidate, and enhance the influence of the three international hubs of Hong Kong, Guangzhou, and Shenzhen.

4.2.3 The development of transportation is networked, diversified and hierarchical

The future development of Guangdong-Hong Kong-Macao Greater Bay Area should focus on the interconnection of transportation and information infrastructure in core cities, and explore the organizational system of the connection system for external transportation across the hinterland, regional transportation radiating around, intra-city transportation and transportation between regions and cities. Weave an integrated transportation hub system in the mode of "airport+high-speed

rail+subway+public transport", so that its hub stations can set up air transportation, high-speed rail, subway and public transport at the same station, greatly improving its transportation efficiency, building a diversified, comprehensive, multi-scale, networked and hierarchical development and connection mode of multi-network integration, and forming a high-speed railway to drive the city to radiate its surroundings. The inter-city railway promotes the integrated development of urban agglomeration transportation, the urban express rail connects the peripheral city groups quickly, the multi-level urban rail supports the multi-center urban spatial structure, and the overall spatial operation mode in which the layout of hub stations is coordinated with urban development.

4.2.4 Intercity Railway promotes transportation integration in Greater Bay Area

Optimize the organization mode of "hub station+hub line+hub node", integrate inter-regional trunk railway, local regional railway, intercity rail transit, urban rail transit and other transportation networks, improve the overall operation efficiency of rail transit, and promote the construction of the Guangzhou-Hong Kong-Macau Greater Bay Area rail transit operation mode of "one network, one ticket, one string of cities". Build a multi-network integration development and convergence mode with multi-scale and networking in rail transit areas, hierarchical city areas and heavy nodes in cities. Form the overall spatial operation mode that high-speed railway drives the city to radiate its surroundings, intercity railway promotes the integrated development of urban agglomeration transportation, urban express rail connects peripheral city groups quickly, multi-level urban rail supports multi-center urban spatial structure, and hub site layout is coordinated with urban development. Strengthen the connection with Hong Kong and Macao ports, strengthen the combination of different modes of transportation, promote the unified dispatching and integrated development of inter-city rail transit in Greater Bay Area, and realize the transportation integration of Guangdong-Hong Kong-Macau Greater Bay Area.

5. Conclusions

With the development of the times, the functional construction of Guangdong-Hong Kong-Macao Greater Bay Area International Hub has been continuously improved, and the transportation system of airport+port+rail transit has basically taken shape. However, its management and coordination mechanism, functional structure planning, internal connection system and traffic carrying capacity are still lacking. Therefore, Guangdong-Hong Kong-Macao Greater Bay Area needs to further promote its development, build a world-class airport group, continue to improve the integrated construction of land transportation system, and enhance the transportation links of all parts of Greater Bay Area. In the future, Guangdong-Hong Kong-Macao Greater Bay Area will realize world-class Greater Bay Area and international urban agglomeration. The coordinated development of urban agglomeration in Greater Bay Area is the key, and the construction of international hub function is the basic premise. Only by continuously optimizing the infrastructure and configuration conditions in Guangdong-Hong Kong-Macao Greater Bay Area and strengthening the integration of transportation infrastructure to form a comprehensive international hub with complete system can the coordinated and efficient operation of Guangdong-Hong Kong-Macao Greater Bay Area be realized. Enhance the international competitiveness and influence of Great Bay Area, and build a world-class Great Bay Area and a world-class urban agglomeration.

Acknowledgments

We gratefully acknowledge the financial support of this work by the project supported by Guangdong Social Science Youth Innovative Talent Fund (No.2019WQNCX151); Humanities and Social Sciences Fund of Dongguan City University(156Q102710).

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