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Deciphering the spatial structure of China's megacity region: A new bay area— The Guangdong-Hong Kong-Macao Greater Bay Area in the making

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ABSTRACT

In 2015, the China State Council in its 13th Five-Year Plan for Economic and Social Development strategically initiated the Guangdong-Hong Kong-Macau Greater Bay Area, with emphasis on strengthening its role in economic development and its powerful synergy with the all-important The Belt and Road Initiative (BRI) in the country and globally. The Greater Bay Area is a unique mega city region situated at the Pearl River Delta, covering the 11 [9 mainland cities +2 special administrative regions (Hong Kong and Macau)] cities. However, few studies examined the bay area under a unique institutional and economic context. This study aims to examine regional integration and spatial connection that affect the growth and success of the megacity region using network analysis. Particularly, it analyzed the centrality of human movements, traffic flow and railway network through visualization of the results from Tencent (*QQ)* Location Big Data, railway service and census data. The study reveals that the vital contributor to the formation and success of the Greater Bay Area is its rapid growth of transport infrastructure and capacities, particularly high-speed railway, promoting free flowing of the key factors. Strong spatial and transport connection critically harness regional integration and boosting viable development of the Greater Bay Area. Guangzhou-Shenzhen-Hong Kong has shaped a triangle structure. The findings provide planning recommendation and policy implications for city planners and policy makers for regional governance and cooperation in mainland China, Hong Kong and worldwide.

Keywords:
Megacity region
Urban agglomeration
Regional integration
The Greater Bay Area
Regional planning and development

1. Introduction

Globalization has changed the spatial order of countries, regions, and cities (Knox & Taylor, 1995; Sassen, 2003), which facilitates urban and regional reorganization, and reshapes the global urban landscape. Massive urbanized regions are progressively functioning as the territorial foundation of the global economy. In order to reactivate the megacity region and strengthen the booming of the Pearl River Delta (PRD), the Guangdong-Hong Kong-Macau Greater Bay Area (Hereinafter the Greater Bay Area for short) was strategically initiated by China State Council (2015) in its *13th Five-Year Plan* and *Building the Silk Road Economic Belt and 21st Century Maritime Silk Road,* which is also known as the *One Belt and One Road Initiative* (*OBOR*), *The Belt and Road* (*B&R*) and *The Belt and Road Initiative* (*BRI*), including the land-based Silk Road Economic Belt and the oceangoing Maritime Silk Road. China adopts a five-year planning cycle for its socialist economy and *The 13th Five-Year Plan* from 2016 to 2020 is shortened for *The 13th Five-year Plan for Economic and Social Development of the People's Republic of China*. Meanwhile, as a key geographical node of air, land and sea transport, the Greater Bay Area links regions and countries in building *The Belt and Road*. The Greater Bay Area encompasses a world-class city cluster, driving this megacity region to a new growth and prosperity under the national development strategy. The strategic and comprehensive planning for the Greater Bay Area aims to further enhance economic cooperation and infrastructure connection within the PRD megacity region.

The construction of the Greater Bay Area has quickly moved from theoretical assumptions to the stage of planning and layout, based on four considerations: 1) China needs a completely new platform for openness in the second phase of globalization. After China's accession to the WTO, it has become the biggest beneficiary of globalization by participating in the global value chain. The effect of globalization and regional integration that the exchange of information, material, population, industry and capital, knowledge and culture between urban networks, closely connect cities in a dynamic-stable manner; 2) China's economic restructuring urgently needs an innovative development model. In recent years, the growth rate of China's total productivity has been declining as a result of technological innovation and industrial upgrading pressure. Forming megacity regions for economic development with the integration of Beijing-Tianjin-Hebei Region in the north, the Yangtze River Economic Belt in the middle, and the Greater Bay Area in the south, will produce strong momentum for China's economy; 3) the Greater Bay Area is leading the major growth poles and technological changes in the global economy; 4) there is an urgent need to re-boom Hong Kong's economic growth, integrate Hong Kong's free economy and promote the successful practice of "one country, two systems".

The Greater Bay Area plan proposed by China's central government is to build a world-class megacity region for cooperation mechanism innovation, cooperation platform construction, regional tourism cooperation, and cross-boundary infrastructure development, e.g. transport network, ports, airports, information technology infrastructure, etc. The keywords of the Greater Bay Area are 'Guangdong-Hong KongMacau', rather than 'bay area', the distinction of which is "one country, two systems, three tariff zones" (Lin, 2017).

Networks characterized by connection are measured in spatial terms, such as transport. Transport connection is the core of regional studies and also a key ingredient of spatial network analysis, which characterizes cities within the same region of all other cities with a geographic nature (Lang, Radke, Chen & Chan, 2016; Lang, Long, & Chen, 2018). A lot of researches investigated the interactions of a region between cities within a geographic space through transportation lines, transportation movements and flows (e.g. Burger, de Goei, Van der Laan, & Huisman, 2011; Cervero & Wu, 1997; Zhong, Arisona, Huang, Batty, & Schmitt, 2014). However, relatively little is known about how the spatial nature of China's megacity regions form and change over time. This study aims to enrich the knowledge of formation of the Greater Bay Area with specific concerns on transport connection and regional integration. By harvesting directly from the crowd, for a better understanding of the megacity regions as it is defined through flows, networks, and links (Batty 2013), we can achieve deep insights into the intricate interplay between inhabitants, functions, and connections of the regions. The questions are, therefore, what are the spatial configuration/characteristics of the emergence of the Greater Bay Area? How are the megacity regions in China shaped by the rapid growth of regional network of transport infrastructure? What are the success factors that affect the growth and sustainability across the cities in the region? What kind of implication would provide for regional cooperation?

The remainder of this paper is organized as follows. The next section introduces the literature related to megacity region and other economically advanced bay areas in the world. This is followed by a presentation of study area, data and research methods. The fourth section critically evaluates the Greater Bay Area's unique spatial layout and connections through network analysis and spatial analysis via ArcGIS, R Programming, and Tableau, using Tencent (*QQ)* Location Big Data, official railway service and census data, after which we have a discussion of factors affecting the growth of megacity regions. The paper concludes the main findings and provides a viewpoint for planners and policy makers concerning the China's recent call for the planning and development of the megacity region in the Greater Bay Area, for crossborder integration in an efficient, fair and sustainable manner.

2. Literature review

2.1. Megacity region

In recent years, many urban scholars have argued that as globalization proceeds, the worldwide megacity regions are coming into being (Hall, 2009; Wu & Zhang, 2007; Xu & Yeh, 2010). The term of megacity region comes from Eastern Asia, where it was originally applied to areas like the Pearl River Delta and Yangtze River Delta regions in China, the Tokaido (Tokyo–Osaka) corridor in Japan, and Greater Jakarta in Indonesia (Hall, 1999; Mcgee & Robinson, 1995). Scott (2001) coined the term 'global city regions' to point to the spatial unit of largescale urbanized regions that plays a vital role of the global economy. A wide range of related concepts has been presented in the literature with a popular term 'megacity region' (see Hall & Pain, 2006). As a new form of urban space, megacity region is a dense, urbanized region with multiple sizes of cities, proximately located and functional networked, clustered around one or two large cities, and drawing economic strength from a new functional division of labor (Hall, 2009). Network, as a key element of megacity region, is functioning through dense flows of people and information carried along motorways, high-speed rail lines and telecommunications cables (Hall & Pain, 2006), which affects the evolution of network structure of the megacity region.

Megacity regions are reshaping themselves around the world (Hall & Pain, 2006; Lang, Chen, Chan, Yueng, & Lee, 2018; Zhang, 2017). Megacity region, which has three crucial dimensions of shape, function and governance, has become an important form of regional spatial organization (Cowell, 2010; Hall & Pain, 2006). In respect of flow space and urban network, the regional rail traffic flow is one of the most important factors of functional region, including commercial behavior, personnel, and migrant workers (Dieleman & Faludi, 1998; Hull, 2010), which can be quantitatively measured by spatial network system (Taylor, Evans, & Pain, 2008). While some studies identified the concentration of 'Abstract Production' workers and firms' information flows in the agglomeration would prevent from forming an enlarged megacity region (Halbert, 2008). Hanssens, Derudder, Aelst, and Witlox (2014) assessed the functional poly-centricity of the megacity region of central Belgium based on advanced producer service transaction links. Taylor et al. (2008) measured poly-centricity and relations between cities within and beyond megacity regions applying the interlocking network model. The formation and development of megacity regions request planners and policy makers to response with multi-scalar and multi-temporal quality of city regions and their governance and planning (Neuman & Hull, 2009).

In recent decades, the megacity regions have drawn increasing research attention among Chinese scholars, for example, Zhao, Derudder, and Huang (2017) analyzed the spatial organization and unfolded functional polycentricism of the PRD region by measuring firms' networks, which is characterized with a functional polycentric and crossregional interaction. Yeh, Yang, and Wang (2015) examines the firm producer service linkages and city connectivity of the PRD megacity regions, which contributes to the regional network formation into a hierarchical and localized system. It can be noted that policymakers have already been interested in functional linkage and connectivity between cities. Zhang (2017) explored firms with headquarters in the PRD that network is shaped predominantly by major international firms from the developed world, and by local regulatory and market environment. Li and Wu (2017) studied territorial administrative divisions and configuration in the Yangtze River Delta, which shows that the formation of functionally integrated and networked megacity region as well as the creation of a sub-national space. Following the increasing interest for the 'spaces of flows' (Castells, 1996), Zhou, Luo, Shi, and Wang (2017) delineates the economic development of the cityregions in the Guangdong-Hong Kong-Macao Greater Bay Area. However, the analysis of city connection of megacity region in terms of different spatial pattern of flows of people, ideas, capital and goods that are the basic components of cities' linkages have not yet been researched intensively, particularly when striking improvement in technologies of transportation and communication over the last decade (Hall, 2009; Hui, Wong, Li, & Yu, 2011; Scott, 2011; Yang, 2006; Zhao et al., 2017).

The method of network analysis is increasingly important in the fields of regional science and economic geography in the last 10–15 years. Network analysis is the process of investigating urban and regional structures through the use of network and graph theories (Borgatti et al., 2009). It is also an approach to analyzing integrations between cities within the agglomerated region through nodes, links (dyad/pair of nodes), network (inter-regional link system) (Batten, 1995). Traditional regional analysis regard agglomeration as involvement in inter connections, and focuses on variance and change of relations between cities, but network analysis would look into cities and regions with actual interactions as well as consider network dependency (Zhong et al., 2014). Centrality that some places are more important (central) than others is the approach that turns cities into nodes and their connections into edges (Agryzcov, Tortosa, Vicent, & Wilson, 2017). Centrality indicates the relative importance of a node in an urban system (To, 2015). Thus, by investigating transportation connection through network analysis, it tries to answer what is the intensity of relations between cities in a region, and what is the impact of geographical interactions in terms of flows, movements, etc.

2.2. Great bay areas in the world

Bay areas, a new form of mega-city region, are the most important growth poles and stimulators in economic growth and technological innovation across the world. Over 60% of the global economy is concentrated in the bay area led megacity regions (Walker & Schafran, 2015), and the trend of people migrating from inland areas of a country to its coasts has been increasing. There are three worldwide famous and well-developed great bay areas, before critically evaluating the Greater Bay Area, we should learn some lessons from the international bay areas and the details are as follows.

2.2.1. San Francisco Bay Area

The San Francisco Bay Area is a populous region of 7.68 million people (United States Census Bureau, 2017) surrounding the San Francisco, San Pablo and Suisun estuaries in the U.S. state of California, which include nine counties: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma. Its population is the fifth-largest in the United States, and the 41st-largest urban area in the world. Stations, ports, airports are connected by a complex multimodal transportation network. It is a high commuting area in the United States — about 50,000 people commute from San Joaquin county into the San Francisco Bay Area daily. The Bay Area has developed huge economic growth in the financial and technology industries, creating a vibrant and diverse economy with a gross domestic product of over USD $700 billion, 6th among U.S. states and 16th among countries, and home to the second highest concentration of Fortune 500 companies in the United States, second only to the New York metropolitan area, with thirty such companies based throughout the region (Walker & Schafran, 2015), with world-class corporations headquartered, such as Google, Apple Inc., Intel, eBay, Cisco Systems, Yahoo!, Chevron, Calpine Corporation, PG&E, Visa Inc., Coca-Cola, and many others. The region is also known for institutions of higher education, ranging from primary schools to major research universities, e.g. NASA's Ames Research Center and the federal research facility Lawrence Livermore National Laboratory.

2.2.2. Greater Tokyo Bay Area

Tokyo Bay located in southern Japan, which covers the metropolitan zone of Tokyo, Kanagawa Prefecture, and Chiba Prefecture. The Tokyo Bay is both the most populous and largest industrialized area in Japan (see Table 1). Its area of 13,562 km^2 adds up to 8.5% of the total Japan land area, but takes over 40% of the population and GDP of the country (Statistics Bureau of Japan, 2016). The Tokyo Bay area upgraded its technology and restructured its economy in the 1950s and 1960s. The Tokyo Bay area advanced manufacturing industries allowing easier access to global markets, emphasizing the knowledgeintensive economy, in terms of information and communication technology and research and development, as well as high-end services. The Tokyo Bay area effectively manages transportation infrastructure in its large metropolitan areas, to allow the agglomeration economy fully developed in the coastal areas. The Trans-Tokyo Bay Highway opened in 1997 crosses the bay from Kawasaki on its western shore to Kisarazu on its eastern shore, which includes a 9.5 km undersea tunnel and a 4.4 km bridge. The Tokyo Bay has 6 ports in Tokyo, Yokohama, Yokosuka, Kawasaki, Chiba and Kisarazu. In order to avoid vicious competition, these ports were carefully planned with the aim of promoting coordinated division of labor and co-operation. Each port performs different functions according to its strengths and characteristics and there is synergy between the six ports to form a port cluster.

2.2.3. New York Metropolitan Area

The New York metropolitan area includes New York City, Long Island, the Mid- and Lower Hudson Valley, Newark, Jersey City, Paterson, Elizabeth, Edison, Bridgeport, New Haven, Stamford, Waterbury, Norwalk, and Danbury, and five counties in northeastern Pennsylvania. The New York metropolitan area is resided in the Metropolitan Statistical Area (20.2 million) and the Combined Statistical Area (23.7 million) (United States Census Bureau, 2016), which is one of the most populous urban agglomerations in the world, and the largest in North America. The MSA covers 17,405 km^2, while the CSA area is 34,493 km^2.The transportation network in the New York City region occupies around 1/3 users of the mass transit and 2/3 of rail riders in the United States. The metropolitan area is also fundamentally defined by the areas from which people commute into. The city is served by three primary commuter rail systems and Amtrak, i.e. the Long Island Rail Road, New Jersey Transit, and Metro-North Railroad, etc. It is a center for finance, international trade, new and traditional media, real estate, education, fashion, entertainment, tourism, biotechnology, law, and manufacturing. As one of the most important economic regions in the world, the MSA produced nearly US$1.60 trillion in 2015, that of the CSA over US$1.83 trillion, both ranking first nationally, and ranking 10th and 8th in the world respectively. The New York metropolitan region is also famous for higher education, such as Columbia University, Princeton University, Yale University, New York University, and Rockefeller University.

Overall, through open economic structure, efficient allocation of resources, and strong agglomeration and spillover capabilities, the world top three megacity regions of New York, San Francisco and Tokyo have developed international exchanges network and have demonstrated an unparalleled gathering advantage in terms of economy, population, science and technology, and industry (see Table 1).

3. Methodology

3.1. The study area

The Greater Bay Area consists of eleven (9 + 2) cities, nine mainland cities, namely Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, Zhaoqing, and the two special administrative regions, Hong Kong and Macao (see Fig. 1). It covers an area of 56,000 sq. m^2 with a total population of about 68 million. The total economic size and population of these nine cities in the PRD accounts for 85% and 52% that of Guangzhou Province, respectively (see Table 2 for each city's profile). The ranking of the eleven cities by total economic size in 2016 are as follows: The 9 + 2 cities in Greater Bay Area account for 13% of the country's overall economic size (CW CPA, 2017). According to estimates by the China Centre for International Economic Exchanges, one of the country's top think tank, by 2020, the total economic output of the Greater Bay Area will be comparable to that of the Tokyo Bay; by 2030 the Greater Bay Area's GDP is expected to amount to RMB 30.4 trillion (USD 4.62 trillion), surpassing the economic size of Tokyo Bay Area (RMB 21.3 trillion, USD 3.24 trillion) and the New York Bay Area (RMB14.4 trillion, USD 2.18 trillion), to become the world's largest bay in terms of economic scale.

Table 1

The Greater Bay Area compares to world bay areas and megacity regions.

Four bay areas	Area (sq. km)	GDP (trillion USD)	Population (million)	Units	GDP per capita (USD)	GDP of the country
San Francisco Bay Area	17,900	0.76	7.15	9 Counties	99,000	4.4%
Greater Tokyo Bay Area	36,800	1.8	43.47	1 City and 7 Counties	41,000	41%
New York Metropolitan Area	17,400	1.4	23.40	5 Counties	69,000	7.7%
Guangdong-Hong Kong-Macao Greater Bay Area	56,000	1.32	66.72	11 Cities	19,413	10.8%

Source: Guangdong Statistical Yearbook, 2016 Census and Statistics Department of Hong Kong, Marine department of Hong Kong, Statistics and Census Service of Macao, data of 2016; Statistics Bureau of Japan, 2016; United States Census Bureau., 2016. Exchange rate as of Sep, 2018: 1 USD ≈ 6.82 RMB ≈ 7.81 HKD.

Irrespective of there being at least 11 'major' cities, the Greater Bay Area as a whole is indeed a complex urbanized region with population dynamics, intensive economic activities and innovative clusters. As the most important bay area economy in China, the Greater Bay Area is becoming a powerful growth pole of radiation effect, which enlarges the economic benefit for the hinterland cities of Guangdong province. Geographically, the spatial structure forms a core circle of the Greater Bay Area, namely a total of 9 + 2 urban agglomeration, while by enlarging 200 km outside from the core circle of the Greater Bay Area to the periphery of Guangdong Province, other less developed cities in Guangdong Province form the outer circle of the Greater Bay Area, i.e. involving total 21 cities of Guangdong Province.

The Greater Bay Area can be illustrated by a series of concentric circles using Burgess' Concentric Zone Model (Burgess, 1925), which has been transformed into an important model and theory, and is widely used in the study of economic development and comprehensive planning of megacity region. Although these cities are currently underdeveloped, these areas provide a vast hinterland for the Greater Bay Area to rise and deep support for regional integration development. Meanwhile, the establishment and development of the Greater Bay Area, have deep roots in Guangdong Province's regional space, and provides impetus for the construction of Guangdong economic development. To obtain a comprehensive picture of city connection and

Table 2

Facts of the Guangdong-Hong Kong-Macao Greater Bay Area.

No.	Cities	Area (sq.km)	GDP (billion USD)	Population (million)	GDP per capita (USD/ person)	Density (person/ km^2)
1	Guangzhou[a]	7436	284.6	14.04	20,271	1888
2	Shenzhen	2007	283.0	11.90	23,782	5929
3	Foshan	3875	125.3	7.5	16,707	1935
4	Dongguan	2512	99.1	8.25	12,012	3284
5	Zhongshan	1770	46.4	3.23	14,365	1825
6	Zhuhai	1696	32.3	1.68	19,226	991
7	Jiangmen	9554	34.8	4.54	7665	475
8	Zhaoqing	15,006	30.2	4.06	7438	271
9	Huizhou	11,159	49.5	4.78	10,356	428
10	Hong Kong	1104	319.3	7.37	43,324	6676
11	Macao	29.2	44.7	0.64	69,844	21,918

Data source: Guangdong Statistical Yearbook, 2016 Census and Statistics Department of Hong Kong, Marine department of Hong Kong, Statistics and Census Service of Macao, data of 2016. http://www.gdstats.gov.cn/tjnj/2017/ directory.html.

Exchange rate as of Sep, 2018: 1 USD ≈ 6.82 RMB ≈ 7.81 HKD. [a] Provincial capital of Guangdong Province, China.

correlations within and beyond the boundaries of the Greater Bay Area, a spatial hierarchy/framework is arranged and shaped by the 21 cities in Guangdong province, in which of this framework will be used in our analyses.

3.2. Data

3.2.1. Human movement and traffic flow from Tencent (QQ) location big data

Human movement and traffic flow were periodically tracked using the Python 3.6.3 Programming Language IDLE module on Tencent (QQ) Heatmap API from https://heat.qq.com. Tencent (QQ) gathers geographical information data from smartphones and other apps using its Location-Based Service (LBS) with geo-tagged check-ins to produce the heatmap and human movement and traffic flow chart. This kind of map helps identify travel routes, points of origin and destinations where people are heading to and coming from, showing stats of cities through the search function, particularly the most popular cities. LBS data source contains travel route people travel to and leave from. The mobility will be recorded once the user's phone is on. It can be used to infer the majority and represent the event with high probability (Wang, Zhong, Xie, & Ye, 2015), which is not only about user coverage but also about the trend of regional situation. As long as people use Tencent application, his/her move could be counted into a line between locations in the map. In this study, with LBS, a weekday (18 September 2017) and a weekend (23 September 2017) was sampled for this study, which displays people's movements and traffic flows in Guangdong province, which is also called “Tencent Migration Map”, as Fig. 2 shows. Within the province, most people can reach their destinations by bus or railway. Thus, the Tencent Migration Map shows the human movement and traffic flow of train, bus, and composite respectively in Section 4.

3.2.2. Railway network

Daily schedule of number of trains within Guangdong province was crawled using Python Programming from http://www.12306.cn/ mormhweb/, which is a China's national online booking system for all running trains. The frequencies are on a daily base, consisting of 1070 inbound train runs and 959 outbound train runs, which include high-speed trains, bullet trains, inter-city rail, and ordinary trains. Daily rail transit data as an alternative characterization of inter-city passenger flow, and rail transit function, which basically reflects the intercity actual passenger transport data. Yet, due to the limitation of information sources, we cannot obtain the flow information of Hong Kong and Macao intercity rail transit data, which was supplemented by survey data as from Hong Kong Planning Department shown in Table 4. The traffic flow from/to Hong Kong and Macao is a lack of data which is difficult to collect, as well as the most links of the two cities to rest of the megacity region still stays on the 1–2 railways and motorways. Thus, there are 20 cities that will be used in the further analysis out 21 totals served with railway service. Table 3 shows the ranking of railway service among the cities connecting to Guangzhou within Guangdong province.

3.3. Network analysis and measures of centrality

Our approach for measuring the spatial configuration in the Greater Bay area is based on the quantitative approach for learning network analysis and centrality presented in Bavelas (1950); Everett, Sinclair, and Dankelmann (2004); Everett & Borgatti, 2005 Freeman (1979); Scott (1991), as well as the POLYNET successful

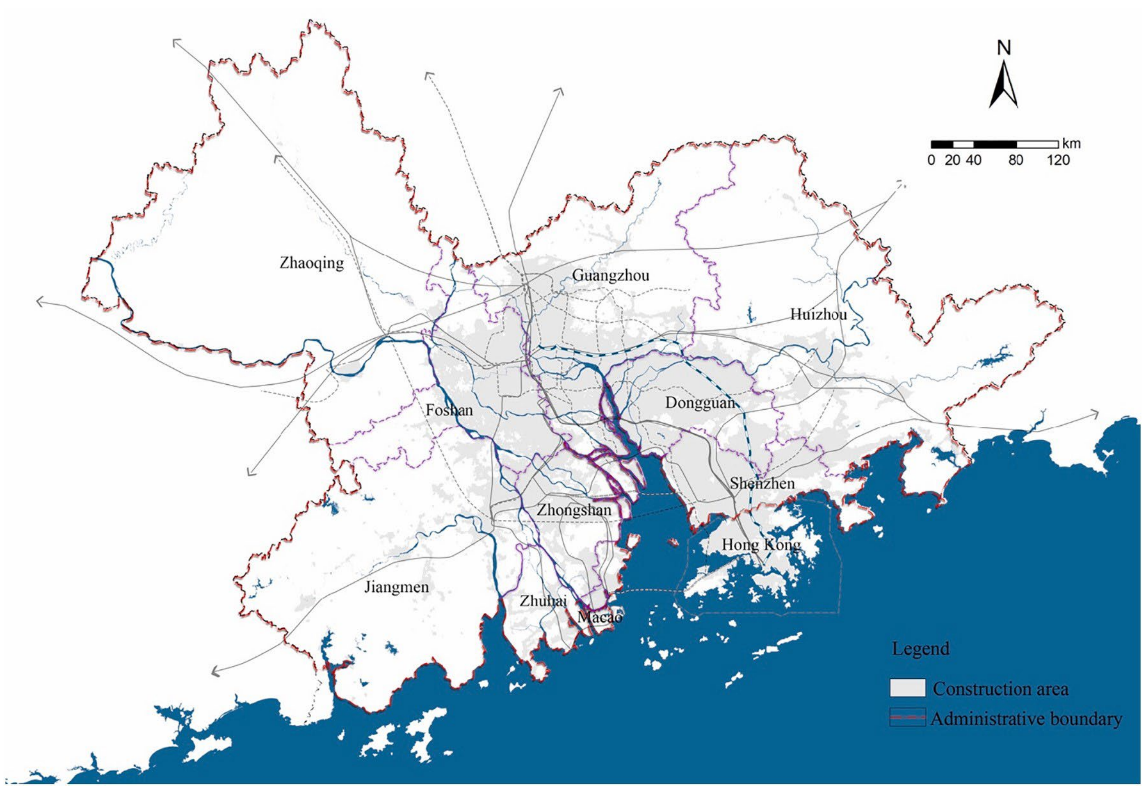


Fig. 1. The layout of the Guangdong-Hong Kong-Macao Greater Bay Area.

application of measurement methods from Hall and Pain (2006). This paper analyzed the characteristics of functional region and network of the Greater Bay Area, through Social Network Analysis in R and Spatial Network Analysis in ArcGIS with inter-city rail traffic flow data, to understand the networking relation between locations of cities in the megacity region.

Measures of centrality on the transportation network help determine the importance of a city node in the network of an area (De Montis, Barthélemy, Chessa, & Vespignani, 2007). Thus, this study used Degree Centrality, Closeness, and Betweenness to evaluate the performance of a node.

3.3.1. Degree centrality

The undirected network contains the node and link attributes. Degree centrality measures the number of links upon each node, which can be interpreted in terms of a number of links directed to the node and those the node directs to others. Eq. (1) shows the distribution of the degree centrality of the cities in Guangdong transportation network (Wasserman & Faust, 1994).

$$C_D(v) = \deg(v) \tag{1}$$

The degree centrality of node v_j to its adjacent nodes is given by Eq. (2):

$$C_D(v_j) = \sum_{i=1}^{n} a(v_i, v_j) \tag{2}$$

where i is the number of nodes in the network and $a(v_i,v_j)$ is a strength function. $a(v_i, v_j) = 1$, if and only if node v_i and node v_j are connected. $a(v_i,v_j) = 0$ otherwise. A normalized measure for comparing the degree centrality in different networks (Abbasi, Altmann, & Hossain, 2011; Freeman, 1979), i.e. the actual links compared to the maximum links, is given by Eq. (3):

$$C_D(v_j) = \frac{\sum_{i=1}^{n} a(v_i, v_j)}{n-1} \tag{3}$$

3.3.2. Closeness centrality

Closeness centrality measures each node's closeness to all other nodes within the network. A node at the shortest distance from other nodes is close to all other nodes in the network. Closeness is a surrogate measure for the independence and efficiency for connecting with other nodes in the network (Freeman, 1979). Closeness was defined as the reciprocal of the farness and a measure of distance among various nodes (Freeman, 1979, 2004), where the more central a node is, the closer it is to all other nodes (Bavelas, 1950). Defined as sum distance (Sabidussi, 1966), sum of reciprocal distance (Freeman, 1979, 2004), Closeness of node v_j is given by Eq. (4):

$$C_C(v_j) = \left[\sum_{i=1}^{n} d(v_i, v_j)\right]^{-1} \tag{4}$$

The normalized closeness is the connection extent of a node to other nodes using the maximum possible distance between any two nodes, shown as Eq. (5):

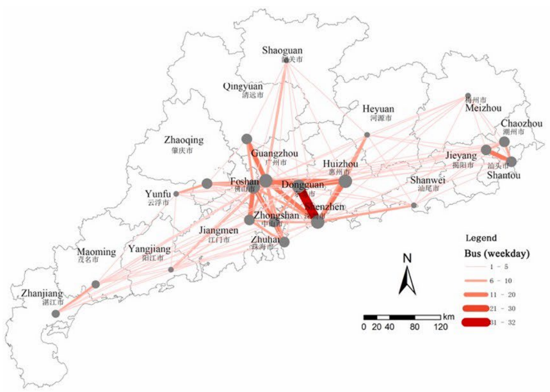
$$C_C(v_j) = \frac{\left[\sum_{i=1}^{n} d(v_i, v_j)\right]^{-1}}{n-1} \tag{5}$$

Betweenness centrality

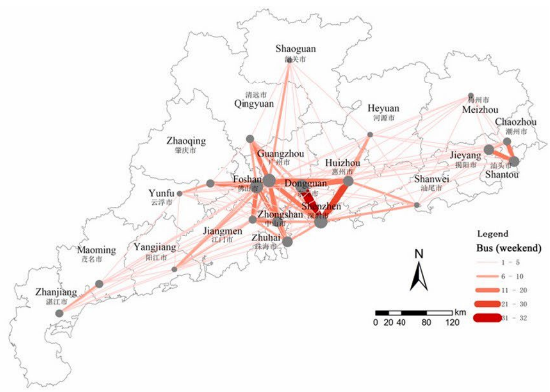
This centrality quantifies a city's spatial connection with other cities in a transportation network (Freeman, 1977, 1979). Nodes with a high probability lying on the path between other nodes exhibits a high Betweenness. Betweenness measures a number of times a node passthrough in shortest paths between all pairs of other nodes in the network, is given by Eq. (6):

$$C_B(v_j) = \sum_{i<j}^{n} \sum^{n} \frac{g_{ij}(v_k)}{g_{ij}}, \quad i \neq j \neq k \tag{6}$$

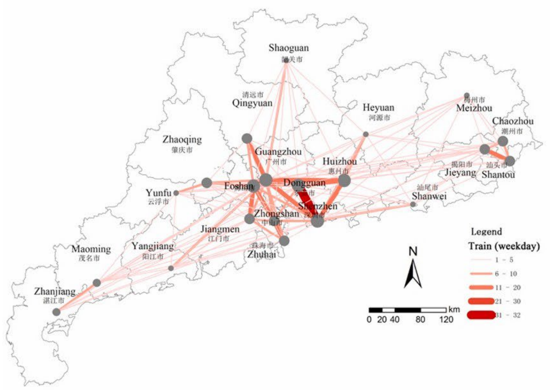
where g_{ij} is the number of shortest paths linking node v_i and node v_j and $g_{ij}(v_k)$ is the number of linking node v_i and node v_j that contains node v_k. The normalized measure by the maximum possible number of shortest paths in the undirected network, is given by Eq. (7):



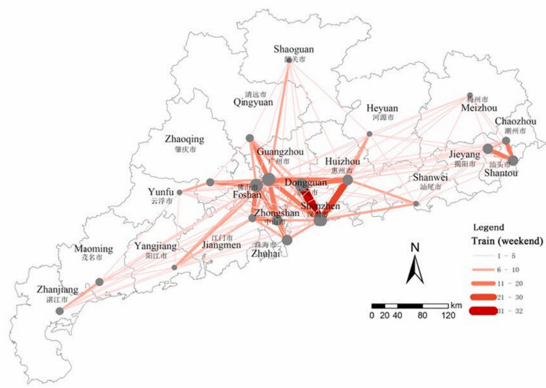
(a) Weekday Bus.



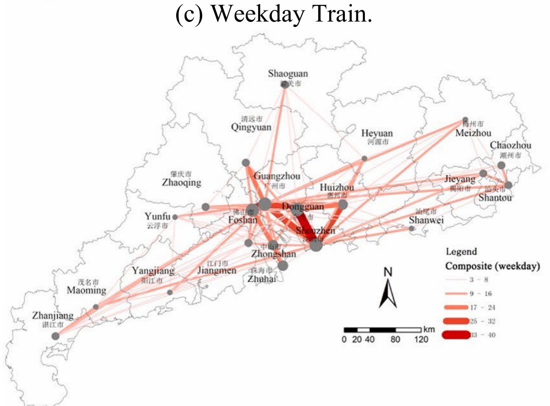
(b) Weekend Bus.



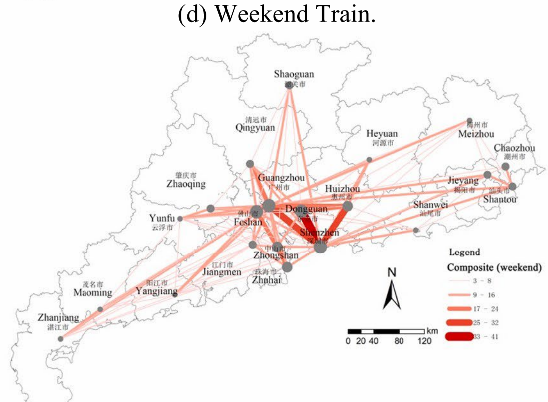
(c) Weekday Train.



(d) Weekend Train.



(e) Weekday Composite Transit.



(f) Weekend Composite Transit.

Fig. 2. Human movements and traffic flows among cities in Guangdong province.

$$C_B(v_k) = \frac{2*C_B(v_k)}{(n-1)(n-2)} \quad (7)$$

For human movement and traffic flow of Tencent Migration Map, the connections of the three categories (train, bus, and composite) were primarily weighted by their frequencies (total trips between two cities), number of people (population of each city), and distances (distance between each pair of two cities) in the generalized model for spatial network analysis, then were spatially mapped with ArcGIS and visualized with R Programming. For railway network, the train dataset was mapped with ArcGIS. The frequency of each city at different time frames was hourly interpreted. In addition to network analysis, the interacting connections from Tencent Migration Map between cities were analyzed with Tableau Desktop 10.4. A general form for weighting models of the above mentioned spatial network analysis can be briefly utilized in this study as:

$$C_{ij} = F_{ij} P_i P_j F(d_{ij})$$

where C_{ij} is the weighted measure of the spatial network between node *i* and node *j*;

F_{ij} is the total number of trips or link frequency generated for the pair between origin node *i* and the destination node *j*;

P_iP_j are population factors for the origin node *i* and the destination node *j* respectively; d_{ij} is a measure of distance between the origin node *i* and the destination node *j*; and,

F is the decay parameter or function of calculating distance between the origin node *i* and the destination node *j*.

4. Analyses and results

4.1. Human movement and traffic flow of the megacity region

We begin with a discussion of the distribution of human movement and traffic flows by bus and train in the Greater Bay Area (see Figs. 2 & 3). There are 235 days of bus connection network in a weekday. The Fig. 2a shows that the substantially strengthening linkages of traffic flow are visible in the cities of Shenzhen-Dongguan, GuangzhouFoshan, Shenzhen-Huizhou, Guangzhou-Shenzhen, GuangzhouHuizhou. In a weekend, there are 230 days of bus connection network at a weekend, Fig. 2b outlines that a large amount of traffic flows can be found in centrally located Shenzhen-Dongguan, Jiangmen-Zhongshan, Guangzhou-Jiangmen, Maoming-Zhanjiang, and Dongguan-Foshan transportation channels. In the 237 days of train connection network at weekday, the density of links has intensified the main passages in Shenzhen-Dongguan, Jiangmen-Zhongshan, Shantou-Chaozhou, Guangzhou-Zhongshan, Foshan-Zhaoqing, Jiangmen-Guangzhou transportation channels (Fig. 2c). The train connection network at weekends shows the similar trends to that of weekdays (Fig. 2d). In a composite transit connection of bus and train combined, Fig. 2e & f show that, for weekdays and weekends, Shenzhen-Dongguan, Guangzhou-Shenzhen, Huizhou-Guangzhou, Huizhou-Shenzhen, Guangzhou-Dongguan are the top five closely-connected city pairs.

Table 3
Ranking of railway service of all cities in Guangdong province.

All trains (out)		All trains (in)	
1	Guangzhou	1	Guangzhou
2	Shenzhen	2	Shenzhen
3	Shaoguan	3	Heyuan
4	Heyuan	4	Shaoguan
5	Dongguan	5	Dongguan
6	Zhaoqing	6	Zhaoqing
7	Zhongshan	7	Zhongshan
8	Zhuhai	8	Zhuhai
9	Huizhou	9	Huizhou
10	Maoming	10	Qingyuan
11	Chaozhou	11	Yunfu
12	Jiangmen	12	Chaozhou
13	Shanwei	13	Jiangmen
14	Foshan	14	Maoming
15	Yunfu	15	Shanwei
16	Jieyang	16	Foshan
17	Qingyuan	17	Jieyang
18	Zhanjiang	18	Zhanjiang
19	Meizhou	19	Meizhou
20	Shantou	20	Shantou

As a synthesis for the network of connection, in terms of both human movements and traffic flows by train and bus, the trips both to and from Guangzhou-Shenzhen, Dongguan-Shenzhen, ShenzhenHuizhou, Guangzhou-Dongguan, and Guangzhou-Huizhou are the 5 most popular network connections. As such, the most popular destination is Guangzhou, and dense connections mainly exist in Guangzhou, Shenzhen, Dongguan, Huizhou, and Foshan. This integrated traffic network, has not only increased people traveling inbetweens, but also has enhanced the density and frequency of inter-city connectivity, much higher and closer, in the Greater Bay Area. However, most cities in western, north western, and eastern part of Guangdong Province remained relatively less integrated and weakly connected.

According to the Hong Kong Planning Department, the total passenger traveling between Hong Kong and the Mainland in 2015 was 875,900. The major trip makers types were leisure trip makers (37.3%), Other frequent trip makers (20.4%) and business trip makers (19.1%) (see Table 4). Compared with the figures in 1999, we can see that the business trip makers and leisure trip makers occupied over 69%, while in recent years, the types are more diverse, indicating that Hong Kong is not an island city, but integrated into the megacity regions.

In order to further understand the degree of cities' network connections in this megacity region, a network analysis was conducted in R Programming Social Network Analysis (SNA) with data from "Tencent Migration Map". Fig. 4 gives the network graph samples by bus and by train. Table 5 presents the summary of centrality analysis results. For Degree Centrality, Guangzhou, Shenzhen, Dongguan, Foshan, and Huizhou position in the top five in bus, train, and composite transit network. Especially, Guangzhou, Shenzhen, and Dongguan show a very dominant central place in the network. Guangzhou is central place of the provincial transportation network. For Closeness, Guangzhou and Shenzhen rank the top two in bus, train and composite transit network. Dongguan, Foshan, and Huizhou follow the 3–5 rankings in both train and composite transit network, where Qinagyuan, Yangjiang, and Chaozhou exhibit 3–5 rankings in bus network. Guangzhou and Shenzhen are closely connected with the rest of this megacity region. For Betweenness, Guangzhou, Qingyuan, Shanwei, Yangjiang, and Shenzhen locate as the top five cities in bus and train network. In the composite transit network, Guangzhou, Yangjiang, Shenzhen, and Qingyuan rank as the big four, which have the advantage of better passing through position within this megacity region. Obviously, the first major finding is that Guangzhou-Foshan and Shenzhen-Dongguan are the best two clusters of transportation connection in the Greater Bay Area.

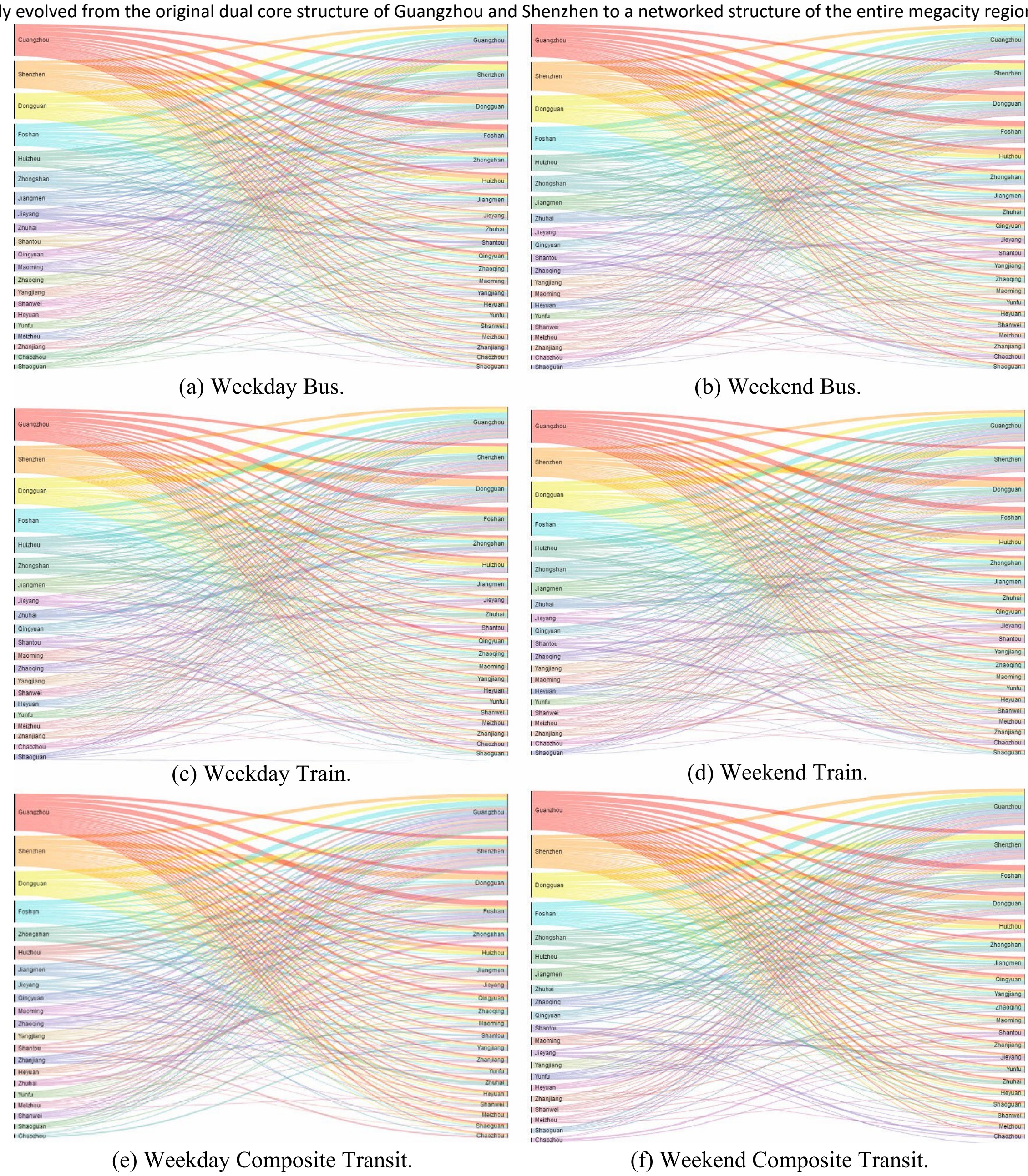
4.2. Railway service connection of the megacity region

Railway service development, especially high-speed train construction, has made significant strides in extending the boundaries of cities in the urbanization process, forming a networked megacity region. Based on the analysis of train schedules from China's 12,306 website within the province, Fig. 5(a) and (b) show both inbound and outbound railway services network on a daily basis. The second major finding is that Guangzhou and Shenzhen play an absolutely important role in connecting other cities in the Greater Bay Area and being two backbones of this megacity region. This finding is also in line with Section 4.1, and indicates that the Greater Bay Area are more multinuclei megacity region compared to San Francisco Bay Area, Greater Tokyo Bay Area, and New York Metropolitan Area.

Fig. 5(c) and (d) demonstrate both the inbound and outbound frequencies of train schedules in each city of Guangdong Province. The results indicate that the railway service exhibits a daily rhythmic pattern. Typically, more trips take place during the morning, late afternoon and late evening. In addition, according to data record, as Guangzhou's accumulated frequencies within provincial network are much higher than other cities, Guangzhou serve more as a provincial or regional hub, which linking more with cities within the Greater Bay area and Guangdong province. Comparatively, Shenzhen exceeds Guangzhou in total accumulated frequencies, and Shenzhen thus serves as more like a national or largely regional hub with more linkage to other cities cross China.

4.3. Shaping world-class megacity region of the Greater Bay Area

In order to visually understand the emergence pattern of spatial organization as it is taking shape in the megacity region, Fig. 6 presents the spatial structure of the Greater Bay Area based on the calculation of population density, economic activities (investment and GDP), density of railway lines and density of distribution of infrastructure facilities (ports, airports, stations). The higher index is, the more concentration of population and economic activities is occurring in the city-regions. Fig. 6 clearly shows that Guangzhou-Shenzhen-Hong Kong has shaped a triangle structure leading the megacity region to rise. In particular, Guangzhou and Foshan shape as a metropolitan cluster; Shenzhen, integrating with Huizhou and Dongguan, forms the second city-region cluster. Hong Kong, closely connects with Macao, Zhuhai and Jiangmen as an international-local cluster. This formulation indicates a shift in the structure of the Greater Bay Area, which gradually evolved from the original dual core structure of Guangzhou and Shenzhen to a networked structure of the entire megacity region.



(a) Weekday Bus. (b) Weekend Bus.

(c) Weekday Train. (d) Weekend Train.

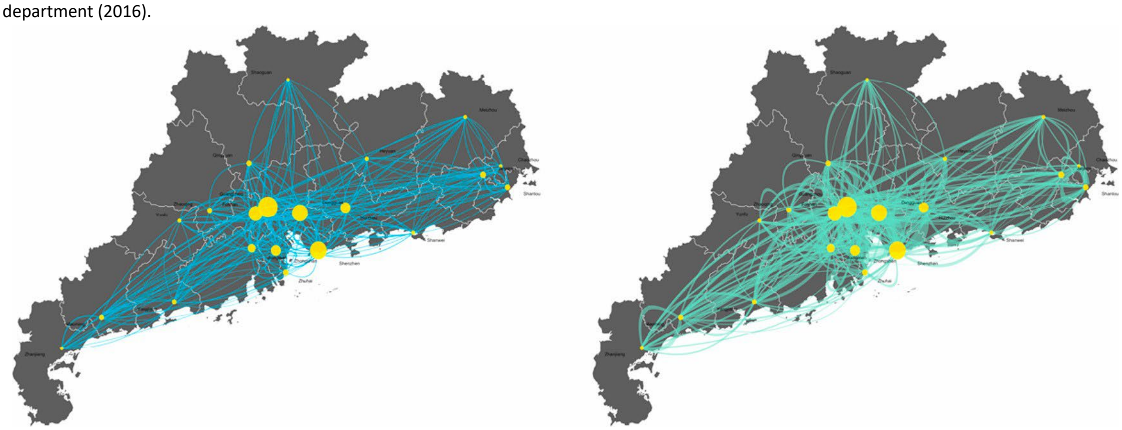
(e) Weekday Composite Transit. (f) Weekend Composite Transit.

Fig. 3. Transit network relations between cities in Guangdong Province.

Table 4
Number of frequent trip makers between Hong Kong and the Mainland by type.

Type of frequent trip makers	1999		2001		2006		2011		2015	
	No. of persons	%	No. of persons	%	No. of persons	%	No. of persons	%	No. of persons	%
Cross-boundary workers	7500	2.0	19,700	4.0	33,100	4.9	49,200	7.0	47,600	5.4
Cross-boundary students	910	0.2	2160	0.4	3690	0.6	12,790	1.8	27,790	3.2
Frequent business trip makers	164,800	44.7	220,300	44.4	208,200	31.1	137,600	19.6	167,400	19.1
Frequent leisure trip makers	89,700	24.3	152,600	30.8	255,100	37.4	308,500	43.9	326,500	37.3
Extended home-leavers	60,900	16.5	55,600	11.2	53,700	6.7	69,900	9.9	128,000	14.6
Other frequent trip makers	44,600	12.1	45,900	9.2	98,000	19.3	124,900	17.8	178,600	20.4
Total	368,500	100.0	496,300	100.0	669,500	100.0	702,800	100.0	875,900	100.0

Source: Planning department (2016).



(a) Analysis of Bus Network. (b) Analysis of Train Network.

Fig. 4. Network Analysis of human movements and traffic flows.

5. Discussion

In this section, we discuss the factors that affect the growth and success of the megacity region. We start with high-speed railway service basically covers the major functional areas of the megacity region. The discussion has reached the point that the networked transportation system of 'High Speed Rail – Urban Transit - City Express' is taking shape and transforming the spatial structure of the Greater Bay Area.

5.1. High-speed railway network

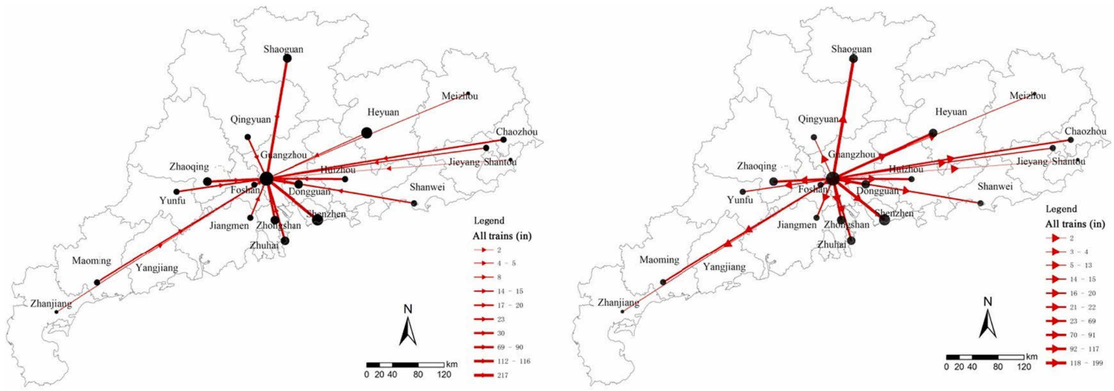
Megacity regions are being connected by major transport nodes and corridors that are underlying features of urban networks (Rimmer, 1999; Zhao, 2010). Given the forces of globalization and spatial transformation, the growth of vehicular transport and trunk highway systems in American metropolitan centres was allowing the daily fields of interaction of the core areas of the regions to extend well beyond traditional urban agglomeration into rural areas along the corridors extending upwards of 100 km from metropolitan centres (McGee and Robinson, 1995). Globalization of production, financial capital, and information require the physical content of megacity regions with well-connected networks and efficient infrastructure (especially transportation and communications linkages) to expand its territorial boundary (Castells, 2010; Fang & Yu, 2017).

The aforementioned spatial pattern heavily relies on the high-speed railway network in the Greater Bay Area. With one of the world's busiest and largest rapid transit system, the Greater Bay Area serves as the largest regional transportation hub in the world. The high frequencies of human movement and traffic flows discussed in the previous two sub-sections are not only enlarging the functional network and diminishing the impact of urban administrative boundaries (Li & Xu, 2006), but also forming the corridors between the three constituent parts for spatial connection and regional integration. By 2020, the total length of railway operation in the Greater Bay Area will reach 5500 km. The focus is to build a "five vertical and two horizontal" backbone network covering 2000 km of high-speed railway in operation, and to make high-speed railways available in all cities of the province and connect to neighbouring provinces (districts) on land and facilitate the development of 'one-hour commuting zone' (Urban Institute of Sun Yatsen University, 2017).

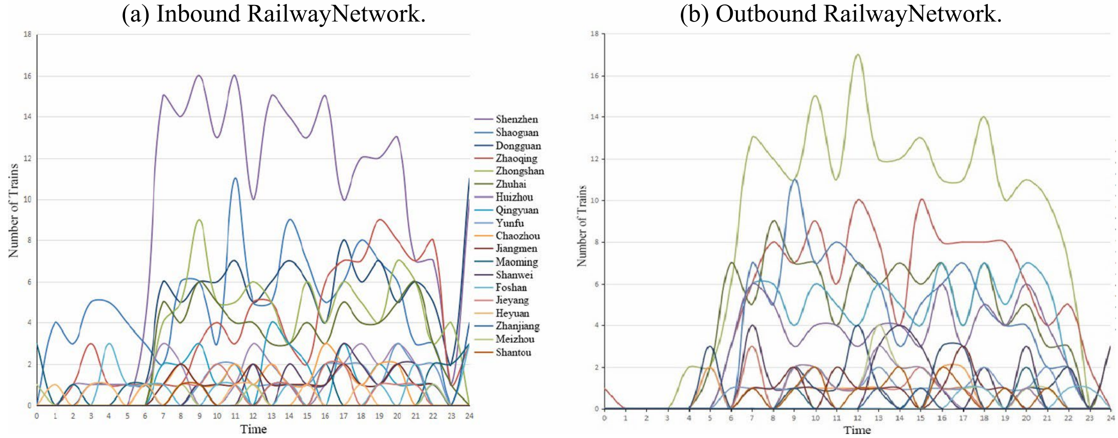
Moreover, the Guangzhou-Shenzhen-Hong Kong High-speed Railway is an important part of the Beijing-Guangzhou-Shenzhen-Hong

Table 5
Summary of results of centrality analysis in network analysis.

Cities				Closeness			Betweenness		Degree centrality
	Bus	Train	Composite	Bus	Train	Composite	Bus	Train	Composite
Guangzhou	1.000	1.000	1.000	5.669	5.668	11.667	1.000	1.000	1.000
Shenzhen	1.000	0.850	0.808	4.065	5.073	9.622	0.043	0.043	0.014
Dongguan	1.000	0.803	0.643	3.308	4.848	9.525	N.A.	N.A.	N.A.
Foshan	0.850	0.708	0.591	3.460	4.790	8.962	N.A.	N.A.	N.A.
Huizhou	0.650	0.497	0.369	2.674	4.284	7.746	N.A.	N.A.	N.A.
Zhongshan	0.625	0.496	0.348	2.697	4.065	7.284	N.A.	N.A.	N.A.



(a) Inbound RailwayNetwork. (b) Outbound RailwayNetwork.



Jiangmen	0.550	0.386	0.305	2.942	3.885	7.251	N.A.	N.A.	N.A.
Yangjiang	0.500	0.282	0.228	4.848	3.831	6.660	0.154	0.154	0.105
Maoming	0.500	0.279	0.212	2.780	3.459	6.380	N.A.	N.A.	N.A.
Jieyang	0.500	0.259	0.209	2.779	3.308	6.288	N.A.	N.A.	N.A.
Shanwei	0.475	0.251	0.205	2.831	3.138	6.188	0.154	0.154	N.A.
Heyuan	0.475	0.236	0.190	3.886	2.942	6.159	N.A.	N.A.	N.A.
Shantou	0.450	0.235	0.188	2.824	2.884	6.130	N.A.	N.A.	N.A.
Meizhou	0.450	0.220	0.184	2.884	2.830	6.124	N.A.	N.A.	N.A.
Zhuhai	0.400	0.187	0.170	3.138	2.823	6.022	0.026	0.026	N.A.
Zhaoqing	0.400	0.183	0.169	3.832	2.787	5.595	N.A.	N.A.	N.A.
Yunfu	0.400	0.182	0.166	4.285	2.780	5.521	0.009	0.009	N.A.
Shaoguan	0.400	0.175	0.152	2.788	2.780	5.507	N.A.	N.A.	N.A.
Qingyuan	0.400	0.165	0.152	5.074	2.698	5.268	0.179	0.179	0.014
Chaozhou	0.375	0.155	0.141	4.790	2.673	5.210	N.A.	N.A.	N.A.
Zhanjiang	0.350	0.139	0.117	2.233	2.232	4.632	N.A.	N.A.	N.A.

Note: N.A. = not available value. Calculations cannot assign the node's value in the network because some nodes have yet to constitute a viable figure in the network.

(c) Frequencies of Inbound Railway. (d) Frequencies of Outbound Railway.

Fig. 5. The analysis of railway service network in Guangdong Province. Train schedule data is of 2017 extracted from China's 12,306 web online booking systems. Guangzhou's accumulated frequencies within the provincial network are much higher than other cities' in Fig. 5(c) and (d).

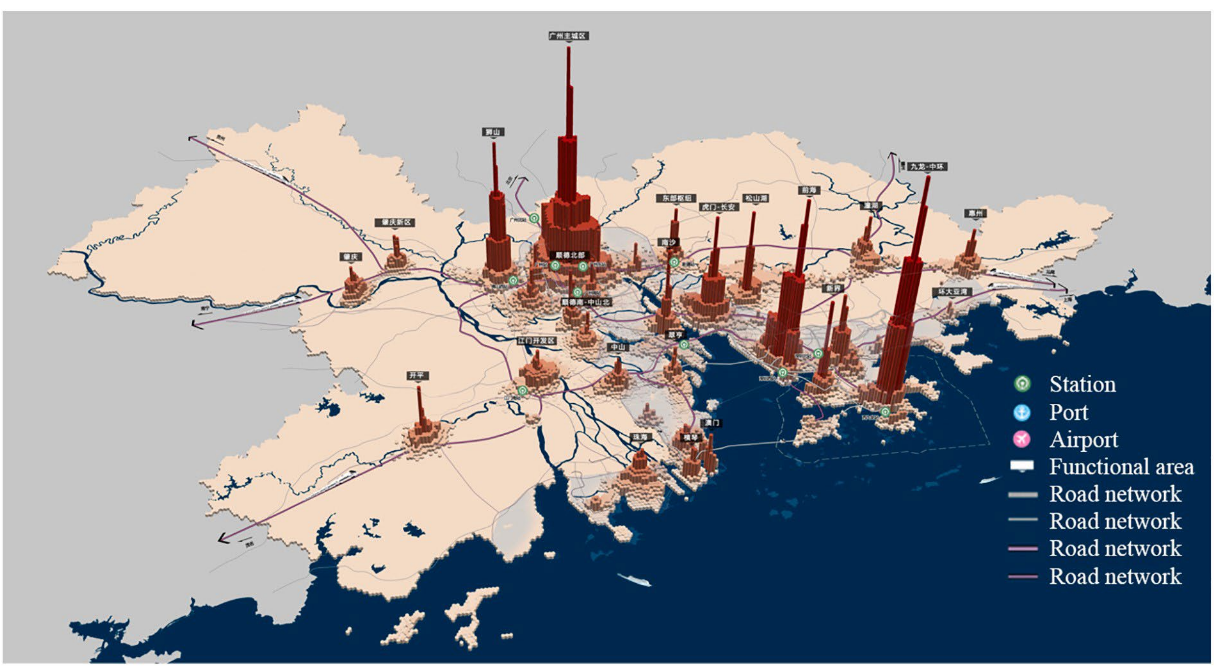


Fig. 6. The visualized spatial structure of the Greater Bay Area.

Note: Data is from Guangdong Statistical Yearbook, 2016 Census and Statistics Department of Hong Kong, Marine department of Hong Kong, Statistics and Census Service of Macao, http://www.gdstats.gov.cn/tjnj/2017/directory.html (for Guangdong).

Kong Express Rail Link to boost the economic development of Hong Kong, Shenzhen and Guangzhou and shorten the travel time from Hong Kong to Beijing (10h) and Shanghai (8 h). The formation of a hub city in a megacity region is linked together by the dramatic development of high-speed rail and railway lines (Dieleman & Faludi, 1998), since its location provide better access to the region. The existing pattern points that Guangzhou becomes an important transportation hub linking the whole country with Hong Kong. This high-speed railway not only functions as a means of cross-border commuting, but also a key step for Hong Kong connecting most large cities in China. It also facilitates the spillover of innovative elements and enhances the economic cooperation and personnel exchanges between mainland and Hong Kong.

Outstanding regional economies such as the San Francisco Bay Area, New York Bay Area and Tokyo Bay share a common feature, that is, their entire area is made up of a number of clusters with strong communication and interaction with one another. The fact that people's commute and travel distributed in different cities in the Greater Bay Area has raised the degree of regional integration of this megacity region. As such, the Greater Bay Area advances as a whole and naturally enlarges its economic agglomeration. In light of this, the *National Development and Reform Commission* mapped out the plan of the Guangdong-Hong Kong-

Macau Bay Area as a collective economy. However, the Greater Bay Area is different from other world bay areas which are the single core spatial structure rather than polynucleated structure, e.g., New York City as the regional core for New York Metropolitan Area, Tokyo City for Greater Tokyo Bay Area, and San Francisco for the San Francisco Bay Area. The Greater Bay Area has gradually evolved from the original dual core spatial structure of Guangzhou - Shenzhen to a networked structure of the entire megacity region which embodies Guangzhou, Shenzhen and Hong Kong as the three leading cores with different political, administrative, and economic systems.

5.2. Intercity urban rail transit

The growth of megacity region is closely associated with the surrounding smaller cities and a spatial trickling-down of development impulses (Douglass, 2000). The extent of the inter-city interaction, captured by network density and efficiency, is largely dependent on the length and coverage of rail transit. The cities in the Greater Bay Area are making efforts to achieve a full cover by the rail transit with a view to making full use of existing railways for a better local and regional accessibility, and facilitate the connection between metropolitan areas and their periphery areas. From Section 4.2, we can see that urban rail transit plays a key role in public transport in Guangdong Province, but relatively poorly connection in west part of Guangdong Province. Given the situation of the railway system with the total mileages of 4257 km, guiding by three core transport nodes, namely Guangzhou, Shenzhen, and Foshan, by 2020, urban rail transit will account for 55% of the total travel volume of public transport system for improving the urban rail transit network to a greater extent (Urban Institute of Sun Yat-sen University, 2017).

According to <*Framework Agreement on Deepening Guangdong-Hong Kong-Macao Cooperation in the Development of the Bay Area* > issued by the National Development and Reform Commission in July 2017, the local governments are making efforts on promoting infrastructure connectivity and building a convenient railway and urban rail transit network. For example, Guangzhou–Dongguan–Shenzhen Intercity Railway, Guangzhou-Foshan Rail Transit extensions, GuangzhouFoshan-Jiangmen-Zhuhai Intercity Railway, Dongguan- Huizhou Intercity Railway, Foshan–Dongguan Intercity Railway, ZhongshanHumen-Longgang Intercity Railway, Dongguan- Shenzhen Rapid Transit, Nansha port railway and Jiangmen-Maoming Railway, are the main passenger corridors connecting the core cities of the Greater Bay Area with east and west part of Guangdong Province. This is visible that the construction of intercity urban rail transit helps stimulate the rapid flow of population and capitals, greatly enhance the linkages between the west and the east bay area, thereby accelerating the integration of the Greater Bay Area.

5.3. Road and bridge

There has already been an enormous expansion of transport infrastructure for internal movement within the megacity region, basically in the form of urban expressways and their interchanges. Extensive spatial network transcends the nation-state in all form of economic interaction (Douglass, 2000). The Greater Bay Area as a potential world-class megacity region in the world has made these dynamics more obvious by initiating competitions among different governments within this region for reshaping spatial matrix and urban hierarchy. The local governments are internationally improving cross-border interchanges and linkages so as to accelerate the capitals and population to flow into the regional networks. These include Guangzhou-Macau New Channel, building seamless transfer between Macao LRT and Guangzhou–Zhuhai Intercity Mass Rapid Transit, which is the highest of the joint inspection buildings in Zhuhai and Macao reaches19 floors. The Shenzhen-Zhongshan Corridor that began to construct in 2016 and plan to serve in 2024 brakes spatial separation that the hinterland of Hong Kong and Shenzhen was restricted to the east coast of the Pearl River estuary, and expands the market hinterland of Hong Kong and Shenzhen to the west bay area. This also strengthens the linkages between the east and west of the Greater Bay Area. Furthermore, the construction of the Shenzhen-Zhongshan Corridor optimizes the traffic situation of *Nansha*, which relieves *Nansha*'s unfavorable situation of being away from the city centres. The rise of *Nansha* can be further propelled by the opening and completion of Metro Line 18 that is directly connected to Guangzhou CBD, and the ability of undertaking the transferred industry form Guangzhou, Hong Kong, and Shenzhen.

Another visible project of facilitating the growth of the Greater Bay Area is the Hong Kong-Zhuhai-Macao Bridge that directly links with Hong Kong and Macao and the west bank of the Pearl River Estuary, which provides convenient transportation tunnels for Hong Kong and Macao residents' movements to mainland, and for Hong Kong's industrial relocation. The bridge provides much needed accessibility for west bay area cities e.g. Zhongshan, Zhuhai, Jiangmen to connect to the east side of the Bay. That also enhances the flow of goods and services between the east and west of the bay area, directly or indirectly repositioning the roles and functions of Hong Kong, the city in between. Such change in the spatial network in the Greater Bay Area will bolster the international and regional connectivity and have profound influence over accessibility pattern and reshaping the spatial development patterns, for example, new towns.

Building a world-class megacity region is largely through: firstly, major infrastructure projects supported with subsidies and attractiveness of global investment and, secondly, drives to create the transport networks more integrated and competent (Neuman & Hull, 2009). In the Greater Bay Area, denser and more efficient integrated transportation system are not only part of a new approach to facilitating regional connection, integration and cooperation, but helping the Greater Bay Area participate in the global market competition. Inherently, such advancing reciprocal flows of capital, people, information, and technology are a matter of strategic significance, and so is taking advantage of regional planning by improving regional transport infrastructure for making the Greater Bay Area to be a new dynamic, regional hub for economic growth.

6. Conclusion and policy recommendation

In this paper, we explored the spatial configuration of the Greater Bay Area and investigated the factors that affect the growth and success of the megacity region using network analysis. Particularly, it analyzed the centrality of human movements, traffic flow and railway network through visualization of the results from Tencent (*QQ)* Location Big Data, railway service and census data. The study reveals that the vital contributor to the success of the Greater Bay Area is its rapid growth of transport infrastructure and capacities, particularly high-speed railway, promoting free flowing of the production factors, knowledge elements, resource ingredients, etc. Strong spatial and transport connection critically harness regional integration and boosting viable development of the Greater Bay Area.

The mathematical statistics analytical approaches to comprehending the megacity region, briefly outlined above, underscore one significant characteristic: the deep and compound interplay between urban space and the processes that produce the space within the Greater Bay Area. In particular we discussed in Section 4, several key areas that we envision to be central to this process as they pertain to analyzing and describing the centrality pattern of the Area. GuangzhouShenzhen-Hong Kong has shaped a triangle structure leading the megacity region to rise. Although it embraces different political and legal systems across the megacity region, the relational geographies capture multiple scales, spaces and speeds through an integrated infrastructure network, high speed rail - city express – metro. These three closely integrated, growth hubs in the Greater Bay Area enhance each other's spatial connections and with their hinterlands, bolster the human movements and traffic flows, and raise the Greater Bay Area to the world-class megacity region. Upon completion of construction of the 'one-hour urban rail transit zone', the flows between cities in the east and west bay area will become more convenient. Integrated infrastructure development provides the material basis to form and shape a first-class international bay area and world-class megacity region. These initiatives have contributed to improving the regional competitiveness against megacity regions under the megatrend of globalization, and in turn attract more domestic and foreign investors and commercial activities to establish a presence in the Greater Bay Area. As our world is changing and becoming increasingly interconnected, cities around the world are bound to experience increasing pressures on their networks.

Yet, it is worth noting that how to integrate the Greater Bay Area and enhance spatial connections with its hinterlands is an essential and long-lasting consideration for the success of this megacity region. In some fields, there are some homogenous competition and misallocation of resources in different hierarchy of cities, such as a long-standing battle for leadership and governance. We contend that the megacity regions will become the essential carrier for the socioeconomic development in the future. Thus, to fully benefit from the 'agglomeration' effect, the Greater Bay Area's focus is to motivate the unique nature of its partnership and synergies that are associated with the crucial role played by Hong Kong and Macao. In addition, a new perspective that the megacity region can borrow to govern, manage and plan regional development without administrative constraints, to develop sustainably and spatial equitably, should be addressed in the future.

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