Journal of Finance and Accounting, 2022, Vol. 10, No. 1, 15-22
Available online at http://pubs.sciepub.com/jfa/10/1/3
Published by Science and Education Publishing
DOI:10.12691/jfa-10-1-3

Herfindahl Index Methods and Special Analysis for Regional Competitiveness Inequality Evaluation

Han Wang[1,2,3,*], Weicheng Guo[4], Xueying Zou[5,*]

[1]Faculty of Data Science, City University of Macau, Macau, China
[2]Department of Big Data and Artificial Intelligence, Zhuhai Institute of Advanced Technology Chinese Academy of Sciences, China
[3]School of Computer, Beijing Institute of Technology, Zhuhai, China
[4]School of Finance, Golden Gate University, San Francisco, California, United States
[5]Faculty of Finance, City University of Macau, Macau, China
*Corresponding author: D20092100037@cityu.mo; xueyingzou@outlook.com

Received February 02, 2022; Revised March 04, 2022; Accepted March 11, 2022

Abstract In this study, based on Herfindahl Index and special analysis, a deep exploration on competitiveness regional inequality has been performed geographically and statistically. The tool of Geoda is utilized in this paper. Findings indicated that the comprehensive competitiveness of this area exhibits a growing trend with an eastward developing tendency over time. Cities of Hong Kong, Shenzhen, Guangzhou are defined as the first-tier cities of competitiveness, with great advantages in the aspects of science and technology, economic capacity and international competition. Considering its partial advantages and regional influence, this study regards Macau as the second-tier city, Dongguan and Huizhou as the third-tier cities, Zhaoqing as the fourth-tier cities, and Zhuhai, Foshan, Jiangmen and Zhongshan as the fifth-tier cities. First-tier and second-tier cities are in a line dividing the rest cities into two group, the right group of cities show a higher competitiveness level than the left ones. Besides, a low-low local autocorrelation of comprehensive competitiveness is discovered between Guangzhou, Foshan and their adjacent cities. Due to the unevenness of the cities' development at multiple determining factors, regional inequalities of this area will possibly exist for a long period of time.

Keywords: *competitiveness, regional inequality, Guangdong-Hong Kong-Macau Greater Bay Area, competitiveness evaluation, special analysis*

Cite This Article: Han Wang, Weicheng Guo, and Xueying Zou, "Herfindahl Index Methods and Special Analysis for Regional Competitiveness Inequality Evaluation." *Journal of Finance and Accounting*, vol. 10, no. 1 (2022): 15-22. doi: 10.12691/jfa-10-1-3.

1. Introduction

Regional competitiveness is one of the significant subjects of sociology and economics, which is defined as the labour resource attached to the enterprises, the attraction of regions to the enterprises and the share of regional economic indicators in the whole country [1,2,3]. The most representative competitiveness evaluation models are Porter diamond model and IMD regional competitiveness evaluation model [4]. The Porter diamond model was proposed for measuring the industry or nation's competitiveness in firstly, which was directly employed for regional competitiveness measurement in the recent years. There are four determinants involved in the Porter diamond model, which are firm strategy, structure and rivalry, demand conditions, supporting industries and factor conditions. Besides, potential capabilities to boost the competitiveness, like technology, regional policies, public infrastructures, social civilizations, knowledge and innovation are also included to evaluate the regional competitiveness. Practically, Organization for Economic Co-operation and Development ranked 78 mega-cities in OECD based on their cities' competitiveness, the evaluation indexes are economy performance (GDP), government policy, business companies, and public infrastructure. Furthermore, Yuemin and Lizhi (2001) regarded scientific and technological innovation, human resource, economic development, infrastructural accessibility, and integration into global economy as the major indicators of competitive evaluation system for China's urban areas [5]. Fan etc. (2019) also applied this model to calculate the competitiveness of 13 mega city-regions of China [6].

2. Methodology

Based on Fan's competitiveness evaluation index system, this study establishes a measuring model for cities of Guangdong-Hong Kong-Macau Greater Bay Area competitiveness evaluation. Five dimensions are involved, which are economic capacity, scientific and technology capacity, human resource capacity, public infrastructure capacity and international competition capacity.

2.1. Data Collection and Preparation

The indicators of 2016, 2017 and 2018 were calculated or collected from the government statistics and the internet searching. Data related to economic output, industrial structure, capital scale, urbanization level, labour level, human capital, export-oriented economy and globalization, the investment in R&D and transportation of highway and airline was collected from Guangdong statistical yearbook, statistic database of Macau and Hong Kong annual digest of statistics. Numbers of companies listed in world's top 500 were gathered from Fortune China Netword. The number of national laboratories and QS world's top 500 universities were from online searching. In parenthesis, QS university rankings is one of the most popular annual university rankings, which are provided by Quacquarelli Symonds (QS) company for Times Higher Education Supplement. Numbers of high-speed rail service average per day was obtained from the 12306-internet ticketing and reservation system, which is the official channel for railway booking behaviors in China. Numbers of mobile phone users were collected from Statistic Database of Guangdong-Hong Kong-Macau Greater Bay Area. Scores of world city were from internet online, which were calculated by Globalization and World Cities (GaWC). This organization (GaWC) was created by geography department at Loughborough university, who synthetically evaluates cities among the GaWC Research Network. Furthermore, the number of released patents is gathered from Guangdong statistical yearbook, database of Macau, Hong Kong annual digest of statistics and the reports of statistics bulletin of the national economic and social development for Huizhou, Zhaoqing, Jiangmen and Zhongshan in 2016, 2017 and 2018, which is issued by the local bureau of statistics and available in the Chinese Statistics Web Links. The urbanization level was measured by the indicator of urbanization rate, which is measured by such equation:

$$urbanization\ rate = \frac{urban\ \ population}{total\ \ population} \tag{1}$$

The dependence on foreign trade was calculated by such equation:

$$Dependence\ on\ \ foreign\ trade = \frac{total\ volume\ of\ \ imputand\ export\ trade}{gross\ domestic\ \ product} \tag{2}$$

2.2. Core Competitiveness and Regional Inequality Analysis

This study analyses the regional distribution of indicators for the Great Bay Area based on information entropy and Herfindahl index. Cities whose Herfindahl index value of specific indicator proports the total more than 5% are regarded as the core cities. The algorithm of the Herfindahl index is as the following:

$$H_j = \sum_{i=1}^{N}\left(\frac{X_{i,j}}{X_j}\right)^2 \tag{3}$$

The Herfindahl index is always employed to measure the concentration Ratio of regions or industries [6,7]. For instance, Kang and Park (2019) utilized the Herfindahl index and BASS competitive model to analyze the competitiveness of the explosive growth of mobile application service industry in Korea [7]. Fan, etc. (2019) also utilized Herfindahl index and the threshold of 5% to define core cities [6].

2.3. Spatial Analysis with Geoda Software

This study applied Geoda software [8] to make a spatial analysis on the competitiveness and regional inequality of Guangdong-Hong Kong-Macau Greater Bay Area. A process of hierarchical clustering and spatial autocorrelation analysis is performed on the result of comprehensive competitiveness of the Great Bay Area in 2016, 2017 and 2018. The method of hierarchical clustering aims at finding out how comprehensive competitiveness distributed geographically. While the goal of spatial autocorrelation analysis is exploring the spatial relevance and agglomeration between targeted cities, where a global Moran's index (GMI_t) and a local Moran's index (LMI_{ti}) are involved [9]. The algorithms of calculating GMI_t and LMI_{ti} are as following:

$$GMI_t = \frac{\sum_{i=1}^{n}\sum_{j\neq i}^{n} w_{ij}\left(x_{ti}-\overline{x}_t\right)\left(x_{tj}-\overline{x}_t\right)}{s^2\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \tag{4}$$

$$LMI_{ti} = \frac{\left(x_{ti}-\overline{x}_t\right)}{s^2}\sum_{j\neq i} w_{ij}\left(x_{tj}-\overline{x}_t\right) \tag{5}$$

In such algorithms, n is the number of target cities, which equals 11, w_{ij} is the spatial weight value of destination i and j, s^2 represents the attribute variance, X_{ti} and X_{tj} are the competitive values of i and j in year t.

3. Results and Discussion

3.1. Competitiveness Analysis

Competitiveness capability of indexes (x) are presented, where economic capacity (x1), scientific and technical capacity (x2), human resource capacity (x3), public infrastructure capacity (x4), and international competition capacity (x5) are involved. Results show that the cities of Shenzhen, Guangzhou, Macau, and Hong Kong are the top-4 cities in the three years. The competitiveness is in an increasing trend from 2016 to 2018. As shown in Table 1 and Figure 1.

Furthermore, the following table demonstrates that Hong Kong possesses the highest capacity for public infrastructure and international competition in the three years, and for economic capacity in 2016. Macau holds the highest capacity for economics in 2017 and 2018, and for science and technology in 2016. Throughout the three years, the highest record of human resource capacity is made by Guangzhou. And Shenzhen is proved to be the most competitive city in scientific and technology in 2017 and 2018.

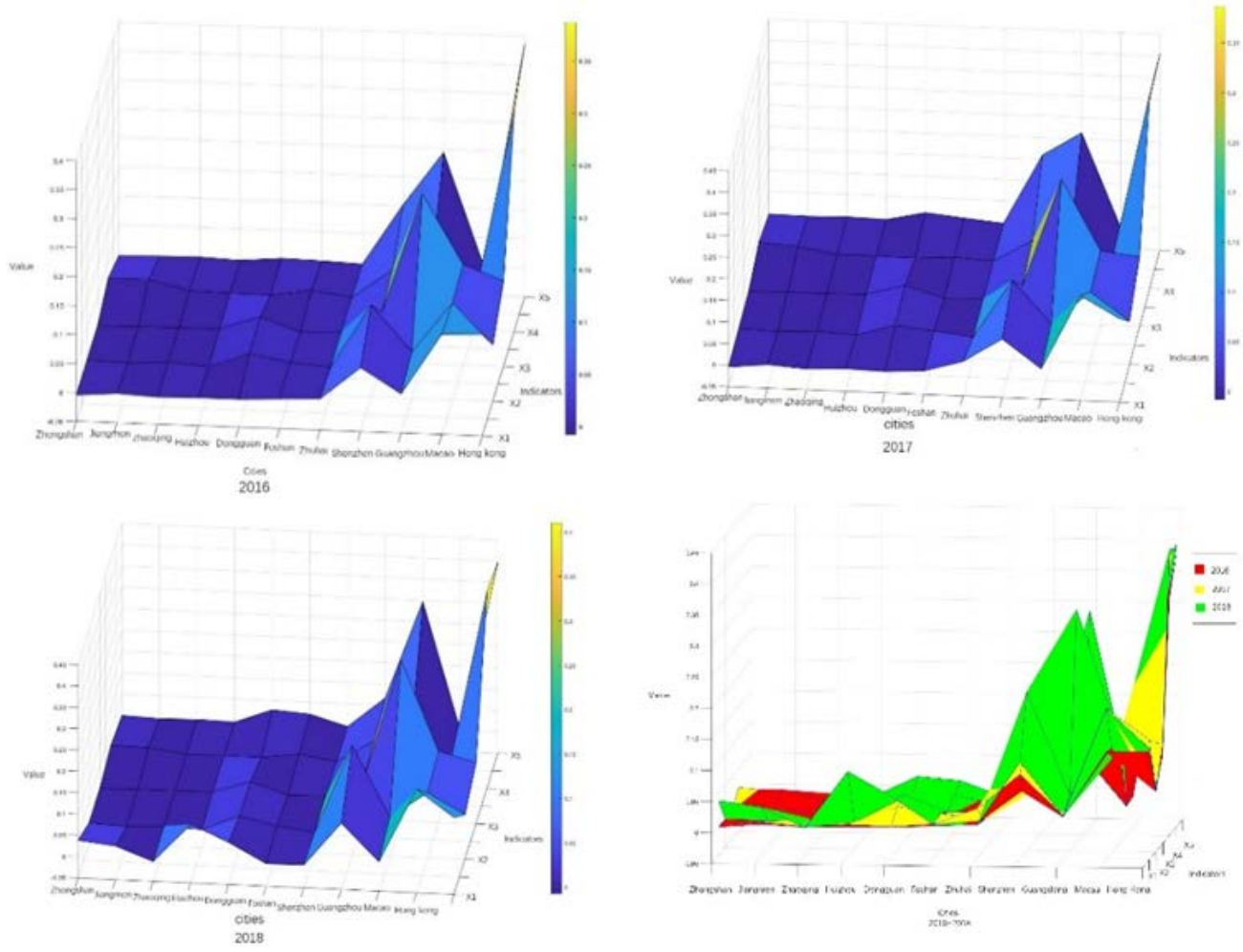

Figure 1. The analysis of competitiveness for Guangdong-Hong Kong-Macau Greater Bay Area from the second-level-index perspective

Table 1. The analysis of competitiveness for Guangdong-Hong Kong-Macau Greater Bay Area from the second-level-index perspective

	2016					2017					2018				
cities	$x1$	$x2$	$x3$	$x4$	$x5$	$x1$	$x2$	$x3$	$x4$	$x5$	$x1$	$x2$	$x3$	$x4$	$x5$
Hong Kong	0.125	0.047	0.098	0.332	0.388	0.144	0.05	0.111	0.4	0.405	0.13	0.054	0.093	0.411	0.398
Macau	0.123	0.117	0.124	-0.003	-0.001	0.193	0.113	0.121	-0.003	-0.001	0.192	0.101	0.116	-0.003	-0.001
Guangzhou	0.018	0.03	0.242	0.078	0.195	0.02	0.037	0.283	0.078	0.215	0.019	0.041	0.326	0.078	0.298
Shenzhen	0.061	0.109	0.036	0.049	0.102	0.086	0.134	0.033	0.05	0.16	0.105	0.205	0.04	0.05	0.067
Zhuhai	0.004	-0.001	0	-0.001	-0.003	0.03	-0.002	0	-0.001	-0.002	0.003	-0.002	-0.001	-0.002	-0.003
Foshan	0.001	0.005	-0.003	0.009	0	0.004	0.009	-0.003	0.004	0.007	0.003	0.008	-0.002	0.012	0.022
Dongguan	-0.002	0.017	0.02	-0.002	0.002	-0.001	0.019	0.023	-0.002	0.015	0.049	0.028	0.025	-0.001	0.028
Huizhou	-0.001	-0.008	-0.002	-0.001	-0.004	0.002	-0.008	-0.002	-0.001	-0.004	0.087	-0.008	-0.002	0	-0.004
Zhaoqing	-0.003	-0.002	-0.003	0.001	-0.001	-0.002	-0.002	-0.003	-0.001	-0.002	-0.004	-0.003	-0.003	-0.001	-0.002
Jiangmen	0.001	-0.007	-0.004	0.018	-0.002	0.004	-0.007	-0.004	0.014	-0.004	0.029	-0.008	-0.004	0.011	-0.004
Zhongshan	-0.004	-0.004	-0.005	0.018	-0.004	-0.005	-0.004	-0.005	0.02	-0.002	0.038	-0.004	-0.005	0.012	-0.001

Note: x1: economic capacity, x2: scientific and technology capacity, x3: human resource capacity, x4: public infrastructure capacity, x5: international competition capacity.

3.2. Spatial Analysis

This study performs a spatial analysis with Geoda software, geographically presents the results of the competitiveness for the Great Bay Area. Spatial distributions of the comprehensive competitiveness and economic competitiveness (shown as Figure 2 and Figure 3) exhibit that there is a reginal competitiveness developing tendency of moving eastward from 2016 to 2018 for such two indicators.

Figure 2. The comprehensive competitiveness differentiation change of Guangdong-Hong Kong-Macau Greater Bay Area from 2016 to 2018

Figure 3. The economic competitiveness differentiation change of Guangdong-Hong Kong-Macau Greater Bay Area from 2016 to 2018

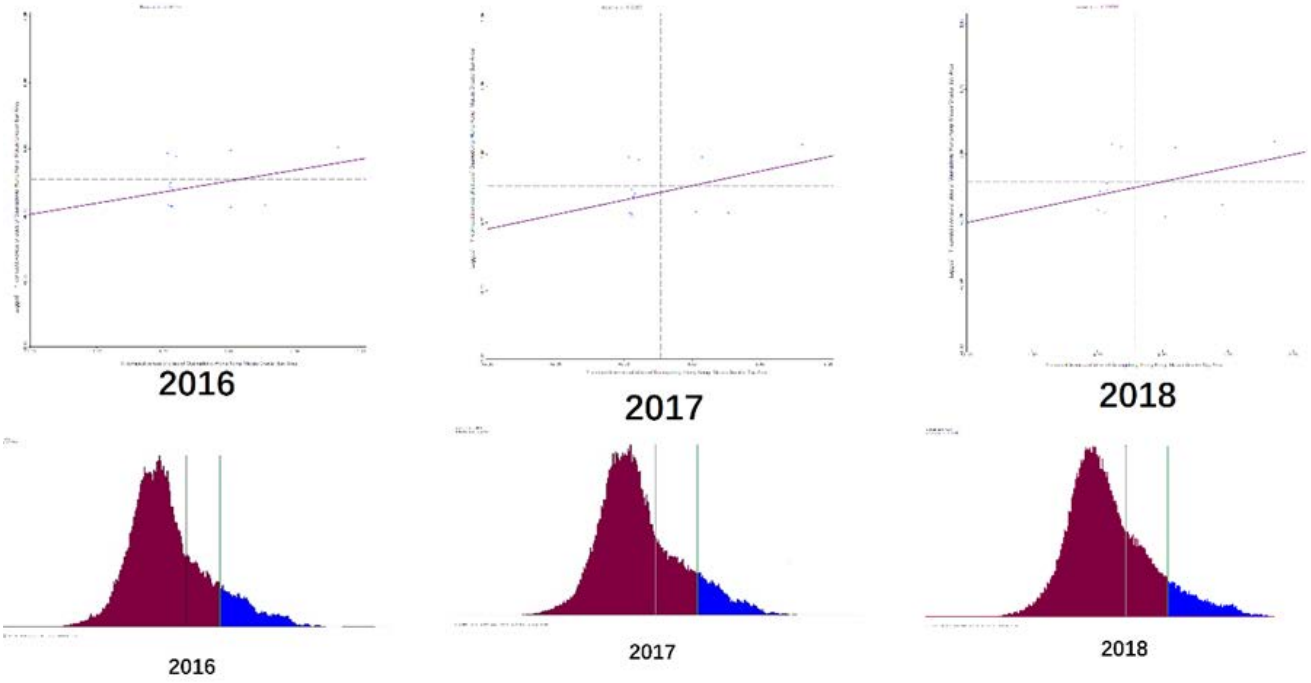

Figure 4. Spatial autocorrelation results based on Global Moran's I

Figure 5. Spatial autocorrelation results based on local Moran's I

As Figure 4 shown, when it comes to the spatial autocorrelation results based on local Moran's I, there is a low-low relationship between Guangzhou and its adjacent cities in 2016 and 2017. Foshan presents a low-low relationship with its adjacent cities in 2017 and 2018.

This study classifies such cities into 3 clusters and 5 clusters separately based on the comprehensive competitiveness of Guangdong-Hong Kong-Macau Greater Bay Area. Results presented as Figure 5 and Figure 6., when it is classified into 3 clusters, results of 2016, 2017 and 2018 come out as the same, Hong Kong and Macau are in the same cluster, Guangzhou and Shenzhen are in the same group, the rest cities are in one cluster. With regard to clustering into 5 groups, Macau is defined as one independent group, so is Hong Kong. Otherwise, this result demonstrates a fact that commonalities between Guangdong and Shenzhen, Zhuhai, and Dongguan are more and more obvious over time.

3.3. Regional Inequality Analysis

To explore the regional inequality of competitiveness for the Great Bay Area in-depth, this study calculated the Herfindahl index of each city in three years and extracted cities whose Herfindahl index value of specific indicator proports the total of more than 5%. The results (shown in Table 2) demonstrate that Herfindahl Index values of 24 indicators are in the range of [0.916523083, 6.980776853], which indicated that the indicators are clustered with different degrees of aggregation.

In this case, there are two major inferences statistically indicated by this result. Primarily, Hong Kong, Shenzhen Guangzhou and Macau possess great advantages for core competitiveness. As shown as the following illustration, Hong Kong is the core city of 15 indicators, which makes Hong Kong with the most core competitiveness, followed by Shenzhen, Guangzhou and Macau. Based on which, the other conclusion is that there is a strong relationship between the core competitiveness and comprehensive competitiveness. The top-5 cities of the core competitiveness and comprehensive competitiveness are as the same, which are Hong Kong, Shenzhen, Guangzhou, Macau and Dongguan, Zhongshan is the least competitive city in the Great Bay from ether aspect (as shown as Figure 7).

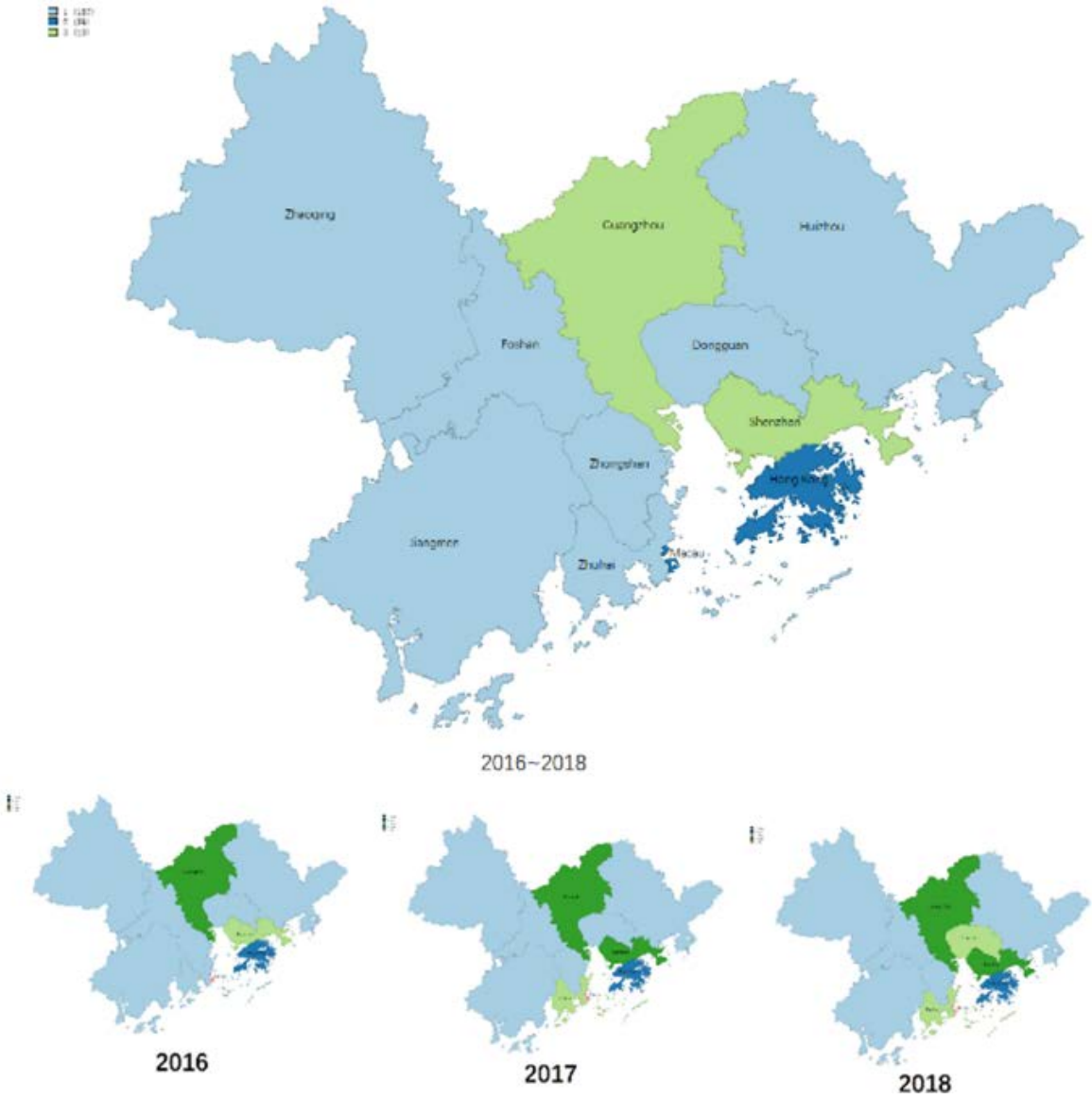

Figure 6. The results of hierarchical cluster analysis on comprehensive competitiveness of Guangdong-Hong Kong-Macau Greater Bay Area from 2016 to 2018

Table 2. The Herfindahl index and regional distribution of the third level indicators

Indicators	J1	J2	J3	J4	J5	J6	J7	J8
Herfindahl index	0.916523083	1.848500683	3.097998727	2.780691843	1.727975859	2.879556382	1.34260239	1.811914584
Cities (the proportion ≥ 5%)	Hong Kong, Macau, Guangzhou, Shenzhen, Zhuhai, Foshan, Zhaoqing, Zhongshan	Hong Kong, Macau	Macau	Shenzhen, Zhuhai	Hong Kong, Shenzhen	Hong Kong, Zhaoqing	Hong Kong, Shenzhen	Guangzhou, Shenzhen, Dongguan, Huizhou
Indicators	J9	J10	J11	J12	J13	J14	J15	J16
Herfindahl index	1.548560103	6.980776853	6.980776853	2.829454499	0.96986924	1.473965762	1.801753362	1.404626808
Cities (the proportion ≥ 5%)	Hong Kong, Guangzhou	Hong Kong	Hong Kong	Macau	Hong Kong, Macau, Foshan, Zhaoqing, Jiangmen Shenzhen	Guangzhou, Shenzhen, Dongguan, Huizhou	Hong Kong, Shenzhen	Hong Kong, Guangzhou, Shenzhen, Dongguan, Huizhou
Indicators	J17	J18	J19	J20	J21	J22	J23	J24
Herfindahl index	2.72180787	1.365485323	3.002582621	2.438782159	2.44517077	1.799645412	3.009935947	1.231518117
Cities (the proportion ≥ 5%)	Macau	Guangzhou, Shenzhen, Dongguan, Huizhou	Guangzhou	Hong Kong	Hong Kong	null	Hong Kong	Hong Kong, Shenzhen, Guangzhou

Note: J1: proportion of non-agricultural industries, J2:proportion of output value of tertiary industry and secondary industry, J3: per capita GDP, J4:GDP growth, J5:deposits of financial organs, J6:investment in fixed assets, J7: number of enterprises in top 500 list of China, J8:number of patents, J9:number of national laboratories, J10:number of universities listed in QS-World-university-ranking top-500, J11:investment in R&D, J12:Population density, J13:urbanization level, J14:number of employees in secondary and tertiary industries, J15:number of scientific research practitioners, J16:telecommunication business amount, J17:highway density, J18:average number of high-speed rail service per day, J19:annual airport passenger throughput, J20:port's cargo throughput, J21:total export-import volume, J22:ratio of dependence on foreign trade, J23:foreign direct investment(FDI), J24:Score of word city from GaWC, null: there is no item meeting the requirement.

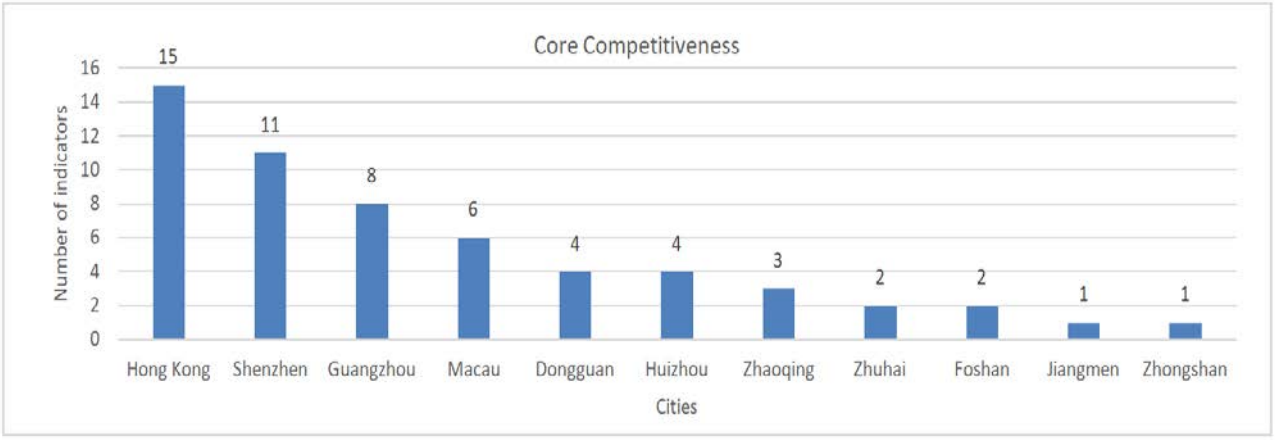

Figure 7. The core competitiveness illustration of Guangdong-Hong Kong-Macau Greater Bay Area

Besides, the capacity of science and technology is a dominated key for core competitiveness enhancement, which decides the highest spatial aggregation by contributing the highest average core competitiveness value in this research as 4.330507098. This indicator is evaluated by the sub-indexes of number of patents (J8), number of national laboratories (J9), number of universities listed in QS-World-university-ranking top-500(J10) and investment in R&D (J11). The cities whose Herfindahl index are over 0.05 for these inadicators are encompassed by such three cities exclusively. J9 and J10 are the major indicators to improve the sustainable development of scientific and technological innovation, where Hong Kong and Guangzhou hold great advantages. However, expect Hong Kong, the rest cities' Herfindahl index values of J8 are all higher than J11, the output is more than the input, which indicates the fact that these cities show a higher efficiency on the science and technology capability.

Additionally, international competition capacity is another reason for inequality of regional competitiveness, which is defined by the sub-indicators of total export-import volume (J21), ratio of dependence on foreign trade (J22), foreign direct investment (FDI, J23) and Score of word city from GaWC (J11). Hong Kong, Shenzhen and Guangzhou are unfolded a great advantage in these aspects.

Furthermore, economy capacity is the foundation to developing core competitiveness, the capital agglomeration degree defines the allocation capability of regional economy, which is illustrated by the indicators of number of enterprises in top 500 list of China (J7) and deposits of financial organs (J5). The core competitiveness of such indexes is cohered in Hong Kong and Shenzhen. In addition, Macau has great advantages at the aspects of the proportion of output value of tertiary industry and secondary industry, proportion of non-agricultural industries and per capita GDP. Zhaoqing exhibits a strength at the aspects of proportion of non-agricultural industries and investment in fixed assets.

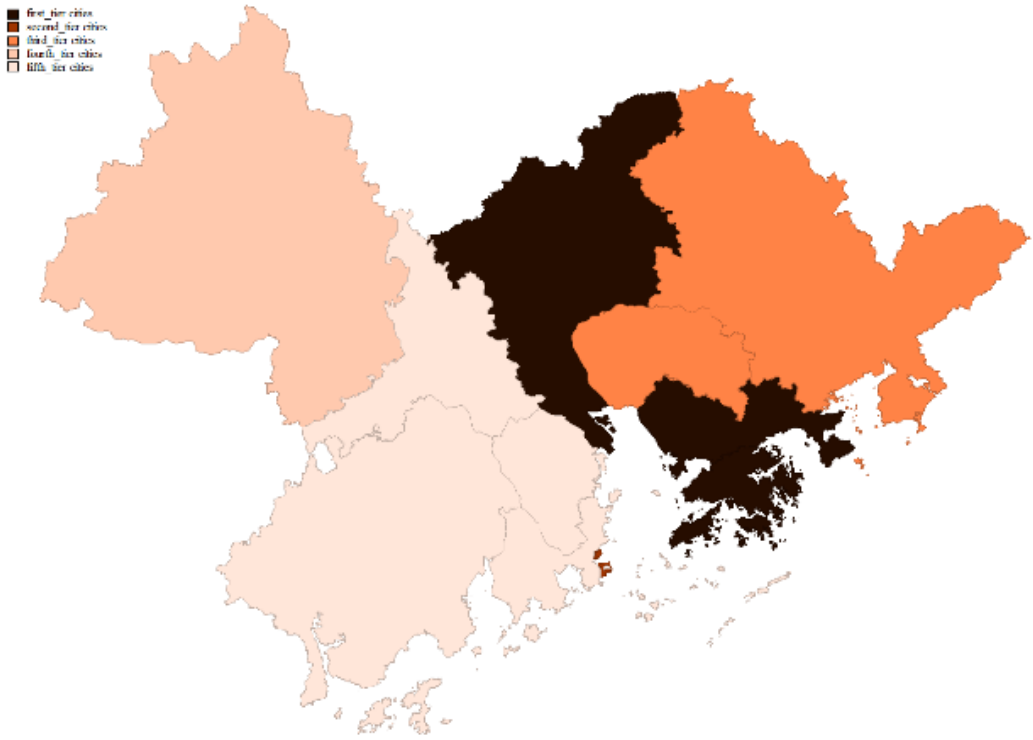

Figure 8. City classification results based on the core competitiveness

In conclusion, the average core competitiveness and the key indexes are all has a distinct inequality in the Great Bay Area. One the one hand, cities of Hong Kong, Shenzhen, Guangzhou and Macau are on the top-5 list of core competitiveness and comprehensive competitiveness, leaving Zhongshan the bottom. On the other hand, Hong Kong, Shenzhen and Guangzhou were respected as the first-tier city with a core competitiveness, which exhibit a huge strength in perspectives of average core competitiveness value, international competition capacity, science and technology capacity and economy capacity. However, Hong Kong and Shenzhen exhibit a higher capital agglomeration capability, Hong Kong and Guangzhou show a greater advantage on sustainable development of scientific and technological innovation, where Guangzhou displays a higher efficiency. With spectacular advantages in economy, Macau is defined as the secondary-tier city. Dongguan and Huizhou were regarded as the third-tier cities with their vital regional influence and partial advantages. Zhaoqing was considered as the fourth-tier with its specific strength in economic aspect. At last, this research thought Zhuhai, Foshan, Jiangmen and Zhongshan as the fifth-tier cities, who display a relatively weak competitiveness. As illustrated as the Figure 8. Hong Kong, Guangzhou, Shenzhen and Macau are the most competitive cities, taking these cities as a dividing line, cities on the left are with a relatively weak core competitiveness, cities on the right are oppositely stronger than the other side.

4. Contribution and Limitation

4.1. Conclusion and Contribution

In view of the concept of competitiveness, this study makes a deep exploration for competitiveness and regional inequality of Guangdong-Hong Kong-Macau Greater Bay Area, geographically and statistically, which delivers a comprehensive view of the development imbalance of such cities in the aspects of economic capacity, scientific and technology capacity, human resource capacity, public infrastructure capacity and international competition capacity.

There is a regional inequality development in the Great Bay Area. This study defined Hong Kong, Shenzhen and Guangzhou as the first-tier cities of competitiveness, Macau as the second-tier city, Dongguan and Huizhou as the third-tier cities, Zhaoqing as the fourth-tier cities, and Zhuhai, Foshan, Jiangmen and Zhongshan as the fifth-tier cities. Cities of Hong Kong, Guangzhou, Shenzhen and Macau are the most competitive cities, which generates a line through the Great Bay Area, separating this region into two areas with opposite polarities of competitiveness. Moreover, this research found that the first-tier cities exhibit a leading capacity of science and technology and international competition, the first-tier and the second-tier cities present great advantages in economy.

Additionally, a fragile global autocorrelation of comprehensive competitiveness emerges in the Great Bay Area, with a low-low local autocorrelation appearing between Guangzhou, Foshan and their adjacent cities. For somehow, results show that there is a gradually obvious commonality between Guangdong and Shenzhen, Zhuhai and Dongguan surfacing from 2016 to 2018.

Ultimately, to enhance the comprehensive competitiveness of the Great Bay Area, policies especially for weak competitive aspects for specific regions should be pay more attention to.

4.2. Limitation

This research also exists some inevitable errors, especially with the collected data. For instance, with no

statistic record of Macau's highway density, this research utilized the number of public road density as this indicator. And the numbers from the internet and government census also may not be 100% accurate. Besides, this study evaluated the comprehensive competitiveness from 5 major aspects, where 24 sub-indicators were involved, other factors without mentioned in this paper may also influence the comprehensive competitive measuring. In addition, the discussion made by this study may not cover all the explorations, future research may concentrate on competitiveness analysis applying more precise models with a bigger database.

Acknowledgments

This research was funded by the 2020 Key Technology R & D Program of GuangDong Province, grant number of 2020B1111540001, Zhuhai Technology and Research Foundation, grant number of ZH01110405180056PWC, Zhuhai Technology and Research Foundation, grant number of ZH22036201210034PWC, Zhuhai Basic and Application Research Project, grant number of ZH22017003200011PWC.

References

[1] Rahmat, s., & Sen, J. 2021. A multi-model approach to assess the relative weights and sensitivities of the factors of regional competitiveness. Journal of Urban & Regional Analysis, 13(1).

[2] Li, H., Wei, Y. D., & Swerts, E. 2020. Spatial inequality in the city-regions in the Yangtze River Valley, China. Urban Studies, 57(3), 672-689.

[3] Wei, Y. D., Wu, Y., Liao, F. H., & Zhang, L. 2020. Regional inequality, spatial polarization and place mobility in provincial China: A case study of Jiangsu province. Applied Geography, 124, 102296.

[4] Porter, M. E. 2000. Location, competition, and economic development: Local clusters in a global economy. Economic development quarterly, 14(1), 15-34.

[5] Yuemin, N. & Lizhi, T. 2001. The concept and indicator system of urban competitive capacity. Urban Research, (3), 19-22.

[6] Fan, Z., Yuemin, N. & Xiyang, L. 2019. Competitiveness and regional inequality of China's mega-city regions. Geographical Research, 38(7), 1664-1677.

[7] Kang, D., & Park, Y. 2019. Analysing diffusion pattern of mobile application services in Korea using the competitive Bass model and Herfindahl index. Applied Economics Letters, 26(3), 222-230.

[8] Anselin, L., Syabri, I., & Kho, Y. 2006. GeoDa: an introduction to spatial data analysis. Geographical analysis, 38(1), 5-22.

[9] Yan-guang, C. H. E. N. 2009. Reconstructing the mathematical process of spatial autocorrelation based on Moran's statistics. Geographic Study, 28(6), 1449-1463.