

Comprehensive Evaluation of High-quality Development of Higher Education in the Cities of the Guangdong-Hong Kong-Macao Greater Bay Area

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Abstract: Using cluster analysis to explore the differences and characteristics of higher education development in the Guangdong-Hong Kong-Macao Greater Bay Area, the study reveals that: the first category is Guangzhou, the second is Macao, and the third includes Hong Kong and Shenzhen, indicating significant disparities in the level of higher education development among various cities in the Greater Bay Area. The differences in higher education development within the Greater Bay Area stem from influencing factors such as the proportion of international students to total student population, average student enrollment, per-student educational funding, the ratio of educational funding to GDP, the number of countries (or regions) from which international students originate, and the proportion of senior titles among full-time faculty. Based on the analysis of the causes of these differences, combined with the internal characteristics of each city, the study ultimately proposes optimization strategies in three areas: enhancing international educational influence, increasing educational funding, and strengthening the construction of the teaching staff.

Keywords: Guangdong-Hong Kong-Macao, Greater Bay Area, Higher Education, Difference Analysis.

1. Introduction

A review of the formation and development history of the world's main bay areas reveals that higher education plays a unique role and significance in promoting interactive development within these regions. Currently, the combined number of top universities in the world rankings within the top ten for the four major bay areas is six, within the top fifty is seventeen, and within the top one hundred is twenty-five. Including the Guangdong-Hong Kong-Macao Greater Bay Area, each bay area has established a multi-level, multi-tiered, and highly compatible cluster of higher education that has effectively promoted the integration of industry and education, collaboration between schools and enterprises, and industry-academia-research cooperation, driving the high-quality economic development of the bay area [1]. The coordinated development of higher education in the Guangdong-Hong Kong-Macao Greater Bay Area, as an essential part of regional governance, not only facilitates the integration and development of higher education in the bay area but also adds value to the innovation of regional governance [2].

In November 2020, the "Plan for the Development of Cooperation in Higher Education in the Guangdong-Hong Kong-Macao Greater Bay Area," jointly issued by the Ministry of Education and the People's Government of Guangdong Province, clearly proposed that the Guangdong-Hong Kong-Macao Greater Bay Area actively builds a highland for talent cultivation and education, supports the construction of an international education demonstration zone in the bay area, and cultivates a large number of talents to promote the high-quality development of the Guangdong-Hong Kong-Macao Greater Bay Area. However, due to the unbalanced economic development levels among cities in the bay area, uneven urban governance structures, and the original layout of higher education institutions, the starting points for the development of higher education in urban areas

are not uniform, leading to differences in the development levels of general higher education in various cities, each with its own characteristics. Cluster analysis of the development status of each city in the Guangdong-Hong Kong-Macao Greater Bay Area, clarifying the differences and characteristics of the overall development status of general higher education in each city, is beneficial for relevant authorities or decision-making departments to grasp the overall development status of general higher education in the bay area from a macro perspective, formulate relevant policies, and better guide and plan the overall coordinated development of higher education in the bay area.

2. Indicator System and Analytical Methods

2.1. Selection of Higher Education Evaluation Indicators

Higher education is predicated on the development of general colleges and universities, and its development is necessarily reflected through various aspects of these institutions. The Guangdong-Hong Kong-Macao Greater Bay Area has a unique situation characterized by "one country, two systems, and three customs territories," which results in a complex composition of higher education institutions. To accurately measure the development level of higher education in various cities within the Greater Bay Area, the selection of evaluation indicators must adhere to: first, the principle of comparability; second, the principle of availability; and third, the principle of systematic comprehensiveness. Based on the intrinsic characteristics of higher education in China and considering the international education demonstration zone policy adopted by the Greater Bay Area for higher education, this study constructs and designs an indicator system by drawing on and referencing some relevant research findings [3-5].

The construction of the indicator system includes six dimensions, mainly covering the size of universities, the number of universities, the number of students, faculty strength, investment in educational funding, and international educational influence, etc. Each of these dimensions is further supported by one to three measurement indicators. In the process of extracting data characteristics, a cluster analysis model is used to comprehensively measure and evaluate the level of higher education in each city within the Greater Bay Area. Finally, the higher education level of each city is classified into different levels according to the calculation results.

2.2. Determination of Measurement Methods

Cluster analysis is a statistical method that defines numerical characteristics for samples and indicators, and solves the problem of grouping similar elements by measuring the distance between samples and the similarity coefficient of indicators [6]. Cluster analysis can be divided into two types in terms of objects: one is the aggregation and classification of variables or indicators, known as R-type, and the other is the classification of samples, referred to as Q-type. The results obtained from cluster analysis have significant importance for the rational analysis of problems.

The specific steps are as follows: First, set up a matrix with m-element observational data for n samples; secondly, standardize the observational values and calculate the correlation coefficient r; then standardize the matrix data and calculate the Euclidean distance; finally, use the average linkage method for clustering to select representative

indicators.

3. Data Materials and Results Analysis

3.1. Data Materials

The indicator data are derived from the 2023 Statistical Yearbook of the Guangdong-Hong Kong-Macao Greater Bay Area Cities [7-17] and the China Education Statistics Yearbook [18]. By dividing these data by the registered population of each city, twelve indicator values are obtained, as shown in Table 2. Specifically, X1 represents the number of institutions of higher education (per million population), X2 represents the number of graduates (per 100,000 population), X3 represents the number of enrollees (per 100,000 population), X4 represents the number of students currently enrolled (per 100,000 population), X5 represents the number of faculty and staff (per 100,000 population), X6 represents the number of full-time teachers (per 100,000 population), X7 represents the percentage of senior titles among full-time teachers, X8 represents the average number of students enrolled in each institution of higher education (per institution), X9 represents the proportion of national budgetary funding for running higher education institutions as a percentage of GDP, X10 represents the average funding per student (in yuan), X11 represents the number of countries (or regions including Hong Kong, Macao, and Taiwan) where international students originate from, and X12 represents the percentage of international students and foreign students among the total number of enrolled students.

Table 1. Data on the Development Status of General Colleges and Universities in Cities of the Guangdong-Hong Kong-Macao Greater Bay Area

Cities	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂
Guangzhou	8.6	301	374	1197	981	701	37.97	13914	1.36	35256	127	4.55
Shenzhen	2.4	52	62	192	354	279	52.21	14624	0.62	30599	60	2.36
Dongguan	3.6	126	143	496	312	228	24.45	13826	0.42	21937	15	0.22
Huizhou	1.3	30	44	126	90	60	24.26	9832	0.68	17698	13	0.28
Zhuhai	8.3	286	284	1047	975	469	28.51	12662	0.46	11461	18	1.58
Zhongshan	3.3	113	159	445	181	105	31.34	13496	0.59	20682	12	0.17
Foshan	2.8	76	78	282	118	82	27.12	10995	0.32	20707	15	0.26
Zhaoqin	1.1	42	106	230	112	64	25.28	20880	0.69	15049	8	0.19
Jiangmen	1.3	49	89	214	78	59	17.66	9595	0.59	21916	17	1.42
Hong Kong	2.6	51	28	319	229	203	44.86	9745	1.04	40049	68	22.2
Macao	5.9	120	125	442	521	381	42.55	6028	0.95	53815	66	40.5

3.2. R-type Cluster Analysis

To verify the strong correlation among the indicators of higher education development, data from Table 1 were first standardized, and then the correlation coefficients between the twelve indicators were calculated using relevant software. The results indicate that there exist strong correlations among some indicators, such as the number of higher education institutions per million population and the number of graduates from higher education institutions per 100,000 population, as well as the number of higher education institutions per 100,000 population and the number of enrollees in higher education institutions per 100,000 population. There is also a considerable correlation between the number of full-time faculty members in higher education institutions and the ratio of teachers with senior titles. Additionally, there is a certain correlation between the

number of countries (or regions) where international students originate and the proportion of international students among the total student population. Therefore, a cluster analysis was conducted on these twelve indicators to extract representative indicators based on their correlations, which provides significant guidance for analyzing the differences in the development of general higher education in the Guangdong-Hong Kong-Macao Greater Bay Area and their causes.

The study results show that the five indicators: the number of higher education institutions per million population, the number of graduates from higher education institutions per 100,000 population, the number of enrolled students in higher education institutions per 100,000 population, the number of enrollees in higher education institutions per 100,000 population, and the number of teachers in higher education institutions per 100,000 population, are significantly correlated and can be grouped into one category. If the

indicators are divided into seven categories, the twelve indicators are as follows:

- a: The proportion of international students and foreign students among the total student population
- b: The average number of enrolled students per higher education institution
- c: The average funding per student
- d: The proportion of funding for higher education institutions in GDP
- e: The number of countries (or regions) where international students originate
- f: The ratio of teachers with senior titles among full-time faculty members
- g: The number of full-time teachers in higher education institutions per 100,000 population.

3.3. Q-type Cluster Analysis

A Q-type cluster analysis can be conducted on the higher education of the 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area using the seven main indicators obtained.

Step 1: Delete the first to fifth columns of the data matrix in Table 1, i.e., use variables 6, 7, 8, 9, 10, 11, and 12.

Step 2: Standardize the data.

Step 3: Calculate the Euclidean distance between objects, with each row representing an object.

Step 4: Merge and cluster the objects using the average linkage method.

The computational results are presented in Table 2.

Table 2. Cluster Merging Distance and Ascending Order Arrangement Table

Clustering	Minimum Distance	Clustering	Minimum Distance
(Jiangmen, Huizhou)	0.00613	(Zhongshan, Zhuhai)	0.01172
(Huizhou, Foshan)	0.00769	(Shenzhen, Hong Kong)	0.0210
(Zhongshan, Dongguan)	0.00789	(Hong Kong, Macau)	0.02161
(Huizhou, Zhaoqing)	0.01165	(Guangzhou, Shenzhen)	0.02521

3.4. Result Analysis

As shown in the calculated data in Table 2, there exists a significant gap in the development level of higher education among various cities in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA), indicating an uneven distribution of higher education resources. Based on the level of higher education development, the 11 cities in the GBA can be divided into three categories, with the results as follows:

Category 1: Guangzhou; Category 2: Macao; Category 3: Other cities.

When the 11 cities are divided into four categories, the results are:

Category 1: Guangzhou; Category 2: Macao; Category 3: Hong Kong, Shenzhen; Category 4: Other cities.

Dividing the 11 cities into five categories yields the following results:

Category 1: Guangzhou; Category 2: Macao; Category 3: Hong Kong, Shenzhen; Category 4: Zhuhai; Category 5: Other cities.

From the above statistical data on merged distances, it can be observed that the development level of higher education in

Guangzhou is significantly stronger compared to the other 10 cities, reflected in its high numbers of universities per million population, graduates from higher education institutions per 100,000 population, enrollments in higher education institutions per 100,000 population, teachers in higher education institutions per 100,000 population, full-time teachers in higher education institutions per 100,000 population, and the proportion of national fiscal budget expenditure on higher education institutions in GDP, as well as the large number of countries (or regions) where international students originate. Guangzhou's higher education status is characterized by a large population, scale, and international exchange, along with sufficient funding for education. Shenzhen and Hong Kong, as renowned first-tier cities and special administrative regions (SARs) in China, have similar educational resource conditions to Guangzhou. Macao, as a SAR of China, has a unique educational situation compared to other cities and is classified separately. This is mainly reflected in its relatively high funding per student and the proportion of international students among the total student population, but the average number of enrolled students per higher education institution is the lowest. This represents the unique characteristics of Macao's higher education development: a small population, sufficient funding, and small school sizes. Zhuhai, as an emerging city in higher education in the GBA, has a different educational situation from other cities and is also classified separately. It excels in indicators such as the number of universities per million population, graduates from higher education institutions per 100,000 population, enrollments in higher education institutions per 100,000 population, and graduates from higher education institutions per 100,000 population, but suffers from insufficient funding for education and limited foreign exchange with international students. Zhuhai's higher education status is characterized by a small population, a large number of non-public universities, and insufficient teaching staff. The higher education status of other cities in the GBA is generally similar and can be grouped into one category.

4. Policies and Recommendations

In light of the aforementioned analysis, the relevant authorities can take corresponding measures, especially to tilt and support educational resources towards cities such as Zhuhai, Zhaoqing, Dongguan, Zhongshan, Foshan, Huizhou, and Jiangmen, to promote the balanced and healthy development of higher education in the Greater Bay Area.

4.1. Enhance International Exchange to Improve the Global Influence of Higher Education

One of the top-level designs of the "Greater Bay Area Higher Education Cooperation Development Plan" is to build the Greater Bay Area into an international education demonstration zone, enhancing the global influence of higher education. Cities lacking international influence in higher education should:

- Emphasize foreign language teaching to cultivate international talents, improve the pass rates of English proficiency tests, and expand the scale of exchange student programs;
- Promote outstanding faculty to study and exchange abroad, broaden their international research perspectives, and encourage and support faculty to

submit to top international journals;

- Actively hire renowned overseas scholars as visiting or honorary professors, organize or host international academic conferences, and promote international academic exchanges with renowned foreign scholars;
- Improve the enrollment and advancement policies for students from Hong Kong, Macao, and Taiwan, and actively promote the facilitation and flexibility of students from the mainland studying in Hong Kong and Macao, or vice versa;
- Actively carry out international student education, enrich the multiculturalism of universities, and ultimately enhance the level of international exchange and global influence in higher education.

4.2. Increase Funding for Higher Education Institutions in Cities to Promote Balanced Distribution of Higher Education Resources

For cities lacking higher education resources, per capita funding for running schools is one of the key factors inhibiting the healthy development of higher education. Increasing investment in running schools means continuously increasing the investment in educational facilities, both hardware and software, the number of full-time teachers, the scale of enrolled students, and research funding. It is not only about the total amount of educational funding but also the increase in per capita funding. The development of higher education in various cities in the Greater Bay Area is related to factors such as urban geographical space and economic development levels. For instance, Guangzhou, Macao, Shenzhen, and Hong Kong have a significantly higher number of central and provincial institutions, with funding sources including local and provincial financial funds, and even central financial budget transfers. In contrast, less developed areas like Jiangmen and Huizhou, where higher education is mainly composed of local institutions, rely primarily on local city financial budgets. Therefore, while underdeveloped cities in higher education should emphasize increasing local financial budgets, provincial financial budgets should also appropriately tilt towards supporting places like Zhuhai, Zhaoqing, and Jiangmen. At the same time, actively open up private capital and flexibly guide private capital into higher education to optimize the structure and components of funding for city universities. Only by reducing the differences in investment in running schools can we promote the balanced distribution of higher education resources among cities in the Greater Bay Area.

4.3. Enhance the Teaching Staff of Higher Education and Optimize the Structure of Professional Titles

The development of higher education ultimately depends on university teachers, whose actual quality is directly related to the level of higher education development. In recent years, there has been a significant change in the teaching staff in places like Zhuhai, Zhaoqing, Dongguan, Zhongshan, Foshan, Huizhou, and Jiangmen. However, compared to cities like Guangzhou, Macao, Hong Kong, and Shenzhen, there are gaps in the number, structure, and quality of teachers, especially the quality gap, which is increasingly expanding and severely restricting the balanced development of higher education in the Greater Bay Area. To enhance the teaching

staff of higher education, universities should retain talent through competitive compensation, career opportunities, and emotional connections. Specifically, universities should address substantive issues such as teachers' children's education, family employment, research environment, personal career planning, and medical insurance, especially with dignified compensation to attract high-quality teachers. In terms of professional titles, the university teaching staff is composed of four levels: teaching assistants, lecturers, associate professors, and professors. The higher the proportion of professor-level teachers, the higher the research level of the university, and consequently, the higher the level of educational development[19]. Therefore, cities lacking higher education resources should create conditions to focus on introducing high-quality talents such as senior technicians, senior engineers, doctors, outstanding young scholars, distinguished young scholars, Pearl River Scholars, Yangtze River Scholars, academicians, Nobel laureates, etc., to achieve leapfrog development in higher education.

In summary, the empirical research results of this paper, with the attention of the central party and local party and government at all levels (especially the special administrative region government), and with the concerted efforts of all cities in the Greater Bay Area, have made significant progress in the development level of higher education. However, from a horizontal comparison of the state of higher education, there is still a significant gap between the cities in the Greater Bay Area. Therefore, to continue promoting the balanced development of higher education in the Greater Bay Area, to narrow the differences between cities, it is necessary to focus on both institutional innovation and liberating thought, to promote the cities along the east and west banks of the Pearl River to develop in tandem, and to promote the coordinated development between the development of higher education and the regional governance of the Greater Bay Area.

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