

Research on High-Level Opening-Up of the Guangdong-Hong Kong-Macao Greater Bay Area and Its Driving Factors

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ABSTRACT

Based on panel data from 2017 to 2023, this study constructs an evaluation index system encompassing five dimensions—trade, capital, personnel, information, and institutions—to measure the openness level of the Guangdong-Hong Kong-Macao Greater Bay Area (GBA). The grey relational analysis model is employed to identify the driving factors behind its openness. The findings reveal that the GBA exhibits an overall pattern characterized by “core-led development, tiered differentiation, and dynamic recovery”: Hong Kong and Shenzhen serve as dual-core open hubs, experiencing a trajectory of “high-level adjustment followed by strong rebound” and steady growth, respectively. In 2023, their openness indices reached 0.5554 and 0.5227. The nine cities in the Pearl River Delta form three tiers, with Guangzhou, Zhuhai, and Dongguan constituting the second tier, while the remaining cities exhibit relatively lower levels of openness. Macao, whose economy is dominated by the gaming and tourism sectors, shows significant fluctuations in its openness index. Analysis of driving factors indicates that industrial structure upgrading serves as the “main engine” for enhancing openness, with services sector liberalization directly facilitating regulatory alignment and cross-border flow of factors. Government regulation plays a “regulatory role” through infrastructure investment and institutional innovation; economic fundamentals provide solid support for openness; the marginal benefits of investment-driven growth are gradually diminishing; and human capital reflects long-term potential, which requires strengthening industry-education integration to unlock its momentum.

KEYWORDS

Guangdong-Hong Kong-Macao Greater Bay Area; High-Level opening-up; Driving factors

1. INTRODUCTION

As one of the most open and economically vibrant regions in China, the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) carries significance that extends beyond its own development. It bears the special mission of serving as a strategic pivot for the new development paradigm, a demonstration area for high-quality development, and a leading zone for Chinese-style modernization. It stands as a core platform for China's advancement of institutional opening-up and its deeper participation in global competition and cooperation. The GBA brings together multiple open platforms—including the free ports of Hong Kong and Macao, and Shenzhen as a pilot demonstration zone of socialism with Chinese characteristics. Its total import and export volume accounts for over 20% of the national total, and it consistently leads the country in terms of utilized foreign investment. It functions not only as a key hub for both “bringing in” and “going global,” but also as a testing ground for institutional opening-up. From the expansion of service sector openness under the CEPA

framework, to exploratory mutual recognition of “Bay Area standards”; from cross-border allocation of research funding to breakthroughs in mutual recognition of professional qualifications—the GBA’s opening-up practices have always been closely aligned with national strategies. Therefore, conducting a scientific assessment of the region’s current level of openness and conducting an in-depth analysis of the synergistic effects of driving factors such as the advantages of “one country, two systems,” hard connectivity of infrastructure, vitality of market entities, and supply of institutional innovations can both accurately identify shortcomings in the GBA’s opening-up process and distill replicable experiences in institutional opening-up. This holds both theoretical value in elucidating underlying mechanisms and practical significance in providing pathways for action. It will help enhance the GBA’s capacity for and influence in global resource allocation, and further drive the nation’s high-level opening-up towards deeper dimensions—including rules, regulations, and governance—using the GBA as a focal point to catalyze broader progress nationwide.

2. LITERATURE REVIEW

2.1. The Concept and Connotation of High-Level Opening-Up

Opening-up is a fundamental national policy of China, and high-level opening-up represents its deepening and expansion in the new stage of development. Compared with general opening-up, high-level opening-up has achieved broader scope, wider coverage, and greater depth. It places greater emphasis on institutional opening-up, promoting rule-, regulation-, management-, and standard-based openness, with the aim of establishing a more advanced open economic system. Expanding high-level opening-up is an important task in the new era and on the new journey; it is a vital component in accelerating the creation of a new development paradigm and promoting high-quality development. It is also a crucial pathway toward building a community with a shared future for mankind [1-2]. Overall, scholars have reached consensus on the background and significance of advancing high-level opening-up, yet there remains no unified understanding regarding its specific connotation. Researchers have explored its meaning from various perspectives. Ren Baoping (2023) proposes that high-level opening-up entails opening up on a larger scale, across a wider range of areas, at a deeper level, and with greater security [1]. It imposes higher requirements for safety and stability, necessitating effective safeguards for the security of supply chains and industrial chains, ensuring independent control over core technologies, and guarding against financial risks. Song Xianping and Yang Lile (2023) argue that high-level opening-up should be underpinned by a new type of whole-nation system to strengthen institutional guarantees for opening-up, secure institutional discourse power, maintain the resilience of industrial and supply chains, promote the high-end integration of Chinese manufacturing into global value chains, facilitate the free flow of technological factors, and foster an open innovation ecosystem based on integration and mutual benefit[2]. Zheng Chiping and Yu Wenjing (2023) suggest that high-level opening-up must strike a balance between opening-up and development, reform, innovation, and security [3]. It should steadily expand institutional opening-up, promote high-quality “bringing in” and high-standard “going global,” and enhance capabilities in open regulation and risk prevention and control. Li Feng (2023) explores the connotation of high-level opening-up from four aspects: expanding new spaces for opening-up, accelerating institutional opening-up, advocating a new form of globalization, and promoting domestic-international dual-circulation synergy [4]. Cui Qingbo et al. (2023) propose that, in terms of policy orientation, high-level opening-up evolves from simply expanding access to embracing institutional opening-up; spatially, it shifts from early-stage eastern-led opening-up to coordinated opening-up across eastern and western regions [5].

2.2. Research on the Opening-Up of the Guangdong-Hong Kong-Macao Greater Bay Area

The level of regional economic integration in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) serves as an important indicator of its opening-up development. This includes the degree of regional coordination and integration, industrial collaborative development, and factor market integration. Lin Changhua (2018) constructed a distance-synergy combination model based on the TOPSIS comprehensive evaluation method to analyze the level and trends of collaborative development in the GBA [6]. The results show that the socioeconomic development levels of Hong Kong and Macao within the region have steadily improved, maintaining sustained and stable prosperity. However, the overall degree of synergy between the two regions fluctuated significantly, indicating weakened interconnectivity in economic and social cooperation. The level of collaborative development lags behind overall development, and bottlenecks in coordinated development have become increasingly prominent. Chen Shidong (2018), using big data concepts, developed a “Baidu Index” to assess the strength of linkages among the 11 cities in the GBA [7]. The findings reveal that intercity factor mobility intensity displays clear geographical proximity. In terms of connectivity, two major concentric circles have formed: Hong Kong acts as a hub for the entire Greater Bay Area, with “Hong Kong–Shenzhen” and “Guangzhou–Foshan” emerging as the two main poles of factor convergence. A “Hong Kong–Shenzhen to Guangzhou–Foshan corridor” has taken shape, yet the overall regional layout remains “east-heavy, west-light.” The western side of the Bay Area still needs to enhance agglomeration-driven development to better drive the development of the western part of Guangdong province. Chen Yan and Lin Zhonghao (2018), based on data from 19 industries across 9 cities and 2 special administrative regions in the GBA in 2016, conducted an empirical analysis of location entropy by industry and gray relational degrees among cities and industries [8]. The results indicate a high degree of industrial correlation among cities in the GBA, with converging industrial structures. However, the calculated inter-industry correlations suggest that wholesale and retail trade, business services, cultural tourism, information technology, and manufacturing — industries where comparative advantages exist — represent the direction for future industrial collaborative development. Cheng Fengyu (2023), manually collecting city-level authorized invention patent data from 2000 to 2020 via the National Intellectual Property Administration patent search system, analyzed the spatial-temporal dynamics and evolutionary trends of scientific and technological innovation in the GBA from both static and dynamic perspectives [9]. The study found that Shenzhen and Guangzhou play core leading roles in the region’s scientific and technological innovation. Innovation development levels vary markedly across different metropolitan areas. Overall, development shows an upward trend, but the absolute gap between cities is widening, while the relative gap is not clearly narrowing, exhibiting a dispersed pattern of regional agglomeration. Positive spatial correlation in development has notably declined, spatial spillover effects are weakening, and development demonstrates club convergence characteristics. Huo Yili and Song Yuxiang (2023), employing a spatial econometric model to measure the level of coordinated economic development in the GBA, found that since 2000, developmental gaps among cities have gradually narrowed, and regional economic coordination has improved year by year, though considerable room for further enhancement remains [10]. Pu Lina and Li Rui (2023) constructed an urban financial centrality evaluation index system based on five dimensions—service level, risk resilience, openness, agglomeration scale, and development environment—and used the entropy-weighted TOPSIS method combined with an obstacle degree model to assess the financial centrality of GBA cities in 2020 [11]. The findings show that, overall, financial centrality in the GBA is relatively low and marked by significant disparities, with a spatial distribution pattern of “strong in the east, weak in the west; strong internally, weak externally.” Among sub-dimensions, apart from Hong Kong and Shenzhen, which perform well and in a balanced manner across all five dimensions, other cities exhibit developmental shortcomings. Regional imbalance and disparities pose challenges to coordinated development in the GBA. In addition, trade cooperation is a key link in promoting regional economic collaboration and integration. To advance the construction of the GBA, it is necessary to clarify the competitive and cooperative trade

relationships among Guangdong, Hong Kong, and Macao, and to promote coordinated trade development in order to foster regional integration and elevate the GBA's position in the global trade landscape. Ma Lianfeng (2020) applied a DEA model to measure the economic efficiency of the GBA over the years and used a spatial error model to examine spatial spillover effects of economic efficiency [12]. The study found that the economic efficiency of the two Special Administrative Regions (Hong Kong and Macao) is significantly higher than that of the nine mainland cities, and the overall economic efficiency of the GBA shows a steady growth trend. At the same time, notable spatial differences exist in economic development within the GBA, with indicators such as import-export volume and government fiscal expenditure having a clear promotional effect on regional economic development. Chen Zizhen and Lei Zhendan (2019) found that the primary factor influencing economic radiation capacity among GBA cities is transportation infrastructure, followed by regional integrated innovation. Talent mobility within the region and polarization development strategies can also enhance intercity economic radiation, whereas advanced industrial structural upgrading does not necessarily maximize economic radiation capacity [13]. Moreover, Cao Xiaoshu (2019) provided a comprehensive discussion on the current status and trends of GBA development from perspectives including intelligent transport integration, multipolar spatial patterns, institutional innovation, equitable development, and ecological civilization construction [14].

3. MEASUREMENT AND ANALYSIS OF THE OPENNESS LEVEL OF THE GUANGDONG-HONG KONG-MACAO GREATER BAY AREA

3.1. Evaluation Index System

The degree of openness refers to the extent to which a region or economy engages in exchanges and integration with the outside world in economic, social, cultural, and other fields, reflecting its capacity to participate in global division of labor and resource allocation. Drawing on existing research findings and taking into account factors such as data availability and the representativeness of indicators, this paper constructs an evaluation index system for measuring the openness level, as shown in Table 1. The system comprises five main dimensions: trade openness, capital openness, personnel openness, information openness, and institutional openness.

Table 1. Evaluation Index System for the Degree of Opening-Up in the Guangdong-Hong Kong-Macao Greater Bay Area

Dimension	Indicator	Attribute
Trade openness	Ratio of Total Import Volume to GDP	Positive
	Ratio of Total Export Volume to GDP	Positive
Capital Openness	Number of Newly Established Foreign Direct Investment (FDI) Enterprises	Positive
	Ratio of Actually Utilized Foreign Capital to GDP	Positive
Personnel Openness	Ratio of International Tourism Foreign Exchange Earnings to GDP	Positive
	Number of Overnight Tourists Received by Each City	Positive
Information Openness	Number of International Internet Broadband Access Users (10,000 households)	Positive
	Ratio of Postal and Telecommunications Service Volume to GDP	Positive
Institutional Openness	Number of Industrially and Commercially Registered Foreign-Invested Enterprises	Positive
	Total Registered Capital of Foreign-Invested Enterprises	Positive

3.2. Method for Calculating Indicator Weights

This study covers the period from 2017 to 2023 and takes the 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) as research samples. An evaluation index system is constructed comprising 10 indicators across five dimensions: trade openness, capital openness, personnel openness, information openness, and institutional openness. This forms panel data spanning seven years with 11 cross-sectional units (i.e., cities). The sources of indicator data are as follows: Data for the nine cities in the Pearl River Delta are obtained from the Guangdong Statistical Yearbook. Data for Hong Kong and Macao are sourced from the annual economic reports published by the Census and Statistics Department of the Hong Kong Special Administrative Region and the Statistics and Census Service of the Macao Special Administrative Region, respectively; tourism statistics bulletins issued by the Hong Kong Tourism Board and the Macao Government Tourism Office; and the Guangdong Statistical Yearbook.

3.3. Analysis of the Openness Measurement Results for the Guangdong-Hong Kong-Macao Greater Bay Area

3.3.1. Gradient Differentiation and Resilient Recovery Coexist Among Pearl River Delta Cities

The nine cities of the Pearl River Delta (PRD) are the main arena for the GBA's opening-up efforts. However, significant internal disparities exist in their development. Based on the comprehensive openness measurement results, the nine cities can be divided into three tiers: First Tier: Shenzhen has remained in the first tier over the long term, with an openness index consistently above 0.45. Second Tier: Guangzhou, Zhuhai, and Dongguan fall into the second tier, with openness indices ranging from 0.2 to 0.4. Third Tier: The remaining five cities belong to the third tier, with openness indices below 0.2. From a temporal perspective, the overall openness level of the PRD cities has gone through three stages: short-term fluctuation, pandemic shock, and steady recovery. This dynamic evolution reflects the combined effects of economic structural transformation, policy support, and changes in the external environment. Shenzhen, as the GBA's innovation hub and a frontline city in opening-up, has long led in openness. Its index rose from 0.4851 in 2017 to 0.5227 in 2023, significantly outpacing other cities. Guangzhou, as a nationally important central city and a millennium-old commercial capital, consistently ranks at the top of the second tier. Its openness index increased from 0.3625 in 2017 to 0.4126 in 2023, showing a trend of stable growth with quality improvement. Leveraging the Canton Fair and its pivotal role in the Belt and Road Initiative, Guangzhou has maintained stable goods trade over the long term. Meanwhile, accelerated development of the Nansha Free Trade Zone has raised the share of service trade, continuously optimizing the structure of trade openness. As a transportation hub in South China, Guangzhou's international tourism foreign exchange earnings and internet infrastructure provide a solid foundation for personnel mobility and information openness. In recent years, benefiting from the entry into force of RCEP and the implementation of policies supporting the Nansha Deep Cooperation Zone for Comprehensive Global Engagement among Guangdong, Hong Kong, and Macao, Guangzhou has made new progress in institutional opening-up. Cities in the second tier, such as Zhuhai and Dongguan, each have distinctive features. On September 5, 2021, the Central Committee of the Communist Party of China and the State Council issued the Overall Plan for the Construction of the Guangdong-Macao In-Depth Cooperation Zone in Hengqin, designating the eastern part of Hengqin Island for the zone's development. Zhuhai, adjacent to Macao, enjoys locational advantages in personnel mobility and capital openness due to the Cooperation Zone, particularly excelling in tourism and investment targeting Macao. However, due to its relatively small economic size, Zhuhai's openness index was only 0.2167 in 2023. Dongguan, known as the "world's factory," has a high dependence on foreign investment in manufacturing. After 2020, affected by global industrial chain restructuring, its openness index experienced mild fluctuations. Currently, it is improving the quality of openness through technological innovation and transformation toward

advanced manufacturing. The remaining five cities—Huizhou, Zhongshan, Jiangmen, Foshan, and Zhaoqing—generally have openness indices below 0.2, though internal differences are evident. Foshan, similar to Dongguan, relies on traditional foreign-funded manufacturing sectors such as home appliances and furniture. However, rising costs and shifting orders have constrained its openness growth, with the index reaching only 0.1329 in 2023. Cities like Huizhou and Zhongshan suffer from insufficient external orientation in their industries; their electronics and appliance sectors mainly serve domestic supply chains, resulting in prolonged low openness levels. Jiangmen and Zhaoqing, located in relatively peripheral areas, have weaker appeal to foreign investors, leading to comparatively low openness. Overall, the PRD cities display a gradient pattern of “the strong remain strong, while the weak strive to catch up” in terms of openness. This coexistence of gradient differentiation and resilient recovery not only highlights the gradual strengthening of endogenous drivers within the PRD but also reflects these cities’ flexible capacity to adapt in response to internal and external challenges.

Table 2. Measurement Results of Openness Level of the Guangdong-Hong Kong-Macao Greater Bay Area

City	2017	2018	2019	2020	2021	2022	2023
Guangzhou	0.3625	0.3567	0.3483	0.3207	0.3401	0.3658	0.4126
Shenzhen	0.4851	0.4771	0.4600	0.4531	0.4621	0.4701	0.5227
Zhuhai	0.1616	0.1660	0.1502	0.1375	0.1336	0.1428	0.2167
Foshan	0.1108	0.1077	0.1090	0.1262	0.1139	0.1275	0.1329
Huizhou	0.1502	0.1421	0.1306	0.1194	0.1041	0.1082	0.1305
Dongguan	0.2733	0.2553	0.2393	0.2425	0.2422	0.2468	0.2437
Zhongshan	0.1320	0.1213	0.1226	0.1290	0.1238	0.1400	0.1430
Jiangmen	0.1077	0.1105	0.1071	0.0836	0.0746	0.0785	0.1096
Zhaoqing	0.0355	0.0419	0.0419	0.0482	0.0328	0.0341	0.0446
Hong Kong	0.5481	0.4526	0.3715	0.3222	0.3514	0.3707	0.5554
Macao	0.4194	0.4754	0.4921	0.4671	0.5244	0.5360	0.3970

3.3.2. Hong Kong Rebounded Strongly From A High Level Adjustment And Its Status As A Global Hub Remains Firm

As an international center for finance, trade, and shipping, Hong Kong has long ranked first in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) in terms of openness index. However, it experienced a significant decline from 2018 to 2022, before making a strong rebound in 2023, when its openness index rose to 0.5554. This trajectory exhibits a pattern of “high-level adjustment—deep correction—strong rebound,” closely tied to shifts in the global political and economic landscape and the deepening support of national strategies. During 2017–2019, Hong Kong’s openness remained at a high level, fully leveraging its traditional strengths. As one of the world’s freest economies, Hong Kong’s re-export trade accounted for more than 200% of its GDP for an extended period, and it served as the world’s largest offshore RMB business center, securing a prominent position in international trade and finance. Simultaneously, Hong Kong is a major international aviation hub: its airport consistently ranks among the world’s top ten in passenger traffic and is a popular travel destination, with inbound tourism generating substantial foreign exchange earnings and fostering frequent people-to-people exchanges. Moreover, Hong Kong boasts world-leading internet infrastructure, with high broadband penetration rates, unrestricted information flow, and no content censorship, providing robust support for information openness. On the institutional front, Hong Kong’s common law system, low tax regime, and a high degree of autonomy under the “one country, two systems” framework make it the preferred location for multinational corporations setting up regional headquarters. The number of registered foreign-invested enterprises continued to grow, further consolidating its global economic standing. In 2023, Hong Kong’s openness index rebounded strongly to 0.5554, nearing its

2017 level. Key drivers of this recovery include the resumption of cross-boundary travel between the Mainland and Hong Kong, strengthened national strategic support, and the reshuffling of global capital flows. From the perspective of international capital movements, as the U.S. Federal Reserve's interest rate hiking cycle drew to a close, global capital once again showed renewed interest in Asian markets. Benefiting from its low taxation, rule-of-law advantages, and vast hinterland in the Mainland market—bolstered by measures such as expanded “Stock Connect” and “Bond Connect” schemes—Hong Kong attracted capital inflows, leading to growth in the total registered capital of foreign-invested enterprises. Overall, despite short-term fluctuations in its openness level, Hong Kong's role as the GBA's “super-connector” remains irreplaceable. It possesses unique advantages in linking the Mainland with international markets, especially in finance and professional services. Coupled with the safeguarding and promotion of national policies, Hong Kong maintains its leading position in openness within the GBA and has demonstrated remarkable resilience in the face of various shocks. Looking ahead, Hong Kong can continue to leverage its strengths, deepen cooperation with other GBA cities, and further raise its profile in the global economic landscape.

3.3.3. Macao Gradually Enhances Its Openness Through Diversified Transformation

Between 2017 and 2023, Macao's openness index exhibited a fluctuating pattern of “first rising, then stabilizing, and subsequently adjusting.” The index stood at 0.4194 in 2017, peaked at 0.5244 in 2021, and then adjusted downward to 0.3970 in 2023. Overall, Macao's openness index remained higher than that of all cities in the Pearl River Delta except Hong Kong. Changes in the index are closely linked to its strategy of moderate economic diversification, the impact of the COVID-19 pandemic, and the development of the Hengqin Cooperation Zone. From 2017 to 2021, Macao's openness index rose and remained relatively stable, driven primarily by the resilience of the gaming industry and the expansion of cultural and tourism-related openness. During this period, Macao consistently outperformed most Pearl River Delta cities in openness; the index reached 0.4754 in 2018 and hit a peak of 0.5244 in 2021. The core driving force came from tourism and gaming as well as related service sectors. As an international tourism destination, Macao's inbound tourism foreign exchange earnings accounted for a very high proportion of GDP. Between 2017 and 2019, Macao welcomed over 39 million visitors annually, more than 70% of whom were from the Chinese mainland. The number of overnight tourists made a significant contribution to the openness index. At the same time, leveraging the “one country, two systems” policy, Macao has played an active role as a trade and economic cooperation platform between China and Portuguese-speaking countries. Initiatives such as the Forum for Economic and Trade Cooperation between China and Portuguese-speaking Countries (Macao) attracted registrations of Portuguese-invested enterprises, contributing to growth in both the number of registered foreign-invested enterprises and their total registered capital. In this way, Macao has positioned itself as a bridge between China and the Portuguese-speaking world. However, constrained by its small local market size, Macao's goods trade accounts for a low share of its economy, and its openness relies more heavily on service trade. From 2022 to 2023, Macao's openness index declined, entering an adjustment phase largely due to pandemic-related shocks and economic restructuring. In 2022, the index dropped sharply to 0.4671, a decrease of 10.9% compared with 2021, and fell further to 0.3970 in 2023. This downturn was mainly caused by strict epidemic prevention measures, which brought the tourism and gaming sectors to a standstill and reduced international visitor arrivals to nearly zero. Stagnant cross-border movement of people directly dragged down the openness index. In 2023, with the resumption of travel between the mainland and Macao, the tourism market recovered rapidly; during the National Day holiday, visitor numbers surged by more than 300% year-on-year, and the pace of decline in the openness index moderated—demonstrating the resilience of the cultural and tourism economy. With the promotion of integrated tourism models such as “MICE + tourism” (meetings, incentives, conferences, and exhibitions) and “sports + tourism,” alongside the clustering of emerging industries, Macao's openness structure is expected to be further optimized in the future.

4. EXPLORING THE DRIVING FACTORS OF HIGH LEVEL OPENING UP IN THE GUANGDONG HONG KONG MACAO GREATER BAY AREA

The opening up development of the Guangdong Hong Kong Macao Greater Bay Area involves multiple subsystems across different dimensions and is the result of interrelated and mutually influential factors. Based on existing research, this paper selects five indicators from five dimensions namely economic foundation, industrial structure, government regulation, human capital and investment pull. The selected indicators are per capita GDP (X_1), the added value of the tertiary industry as a share of GDP (X_2), local general public budget expenditure (X_3), the number of higher education students per ten thousand people (X_4), and total fixed asset investment in society (X_5). Using the grey relational degree model, this paper explores the driving factors of the opening up level of the Guangdong Hong Kong Macao Greater Bay Area.

Table 3. Correlation Degrees of Driving Factors for High-Level Opening-Up in the Guangdong-Hong Kong-Macao Greater Bay Area

	2017	2018	2019	2020	2021	2022	2023	Average
X_1	0.708	0.593	0.724	0.533	0.732	0.642	0.617	0.650
X_2	0.796	0.619	0.680	0.640	0.692	0.677	0.656	0.680
X_3	0.709	0.636	0.653	0.592	0.667	0.674	0.672	0.658
X_4	0.660	0.467	0.686	0.470	0.573	0.534	0.546	0.562
X_5	0.723	0.650	0.684	0.610	0.615	0.618	0.610	0.644

According to Table 3, the grey relational degrees between the five driving factors—economic foundation, industrial structure, government regulation, human capital, and investment pull—and the openness level of the Guangdong-Hong Kong-Macao Greater Bay Area are all above 0.5. This indicates a moderate to strong correlation type. The intensity of the driving factors decreases in the following order: industrial structure, government regulation, economic foundation, investment pull, and human capital.

(1) Industrial structure serves as the “main engine” driving the upgrading of opening-up in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA), with an average grey relational degree of 0.680, showing a dynamic trend of “fluctuating at a high level and gradually stabilizing.” The maximum value was 0.796 in 2017, the minimum was 0.640 in 2022, giving a difference of 0.156, indicating an overall strong correlation. The share of the tertiary industry is a key indicator of advanced economic structure and the core driver of rising openness in the GBA. Measurement results show that from 2017 to 2019, the proportion of the tertiary industry in the GBA increased rapidly, reaching 64.5% in 2019, with Guangzhou and Shenzhen each exceeding 70%. As one of the world’s top three financial centers, Hong Kong has seen rapid development in producer services such as finance, professional services, and digital economy. These producer services have become the main vehicles for attracting foreign investment — in 2019, FDI in the service sector accounted for over 80% of total FDI. In addition, cross-border transactions in intellectual property and other service trade areas have expanded. These developments have jointly driven a high correlation between openness and the share of the tertiary industry, with the correlation reaching 0.796 in 2017. The upgrading of the GBA’s industrial structure is reflected not only in the increase of the tertiary sector’s share but also in the effective synergy of “finance + technology + trade”: Hong Kong’s status as an international financial center facilitates cross-border financing, exemplified by initiatives such as the Cross-Border Wealth Management Connect in the Greater Bay Area; Shenzhen’s technological innovation services, such as R&D, design, inspection, and testing, support high-end manufacturing exports; Guangzhou’s role as a commercial hub connects the region to global consumer markets. This structural advantage makes the tertiary industry the core force propelling the upgrading of openness. However, challenges remain, such as insufficient coordination between the service sectors of Hong Kong and Macao and

the manufacturing sectors of the Pearl River Delta. Further deepening of service sector opening-up and cooperation is needed.

(2) Government regulation acts as the “regulator” of policy guidance, with an average grey relational degree of 0.658 with the GBA’s openness level, showing a dynamic trend of “stable first, then declining, and rising again.” The maximum value was 0.709 in 2017, the minimum was 0.592 in 2020, a difference of 0.117, indicating a generally strong correlation. Local fiscal expenditure reflects the government’s ability to guide opening-up through the allocation of public resources and constitutes an important institutional guarantee for raising the GBA’s openness. Practice shows that precise government investment can effectively remedy market failures and create a favorable environment for an open economy. Measurement results show that from 2017 to 2019, fiscal expenditure in the GBA grew rapidly, with the nine Pearl River Delta cities collectively spending over 1.2 trillion yuan in 2019. Funds were prioritized for infrastructure and institutional innovation platforms, such as early-phase investments in the Hong Kong–Zhuhai–Macao Bridge and the Shenzhen–Zhongshan Corridor, as well as the development of the Qianhai and Nansha sections of the Guangdong Free Trade Zone. These investments facilitated cross-border trade facilitation — in 2019, customs clearance times at GBA ports were shortened by more than 50%. During this period, the correlation between government regulation and openness peaked at 0.709 in 2017, reflecting close synergy between policy guidance and opening-up development. From 2020 to 2022, impacted by the COVID-19 pandemic, fiscal expenditure shifted toward epidemic control and livelihood protection, with increased spending on areas such as nucleic acid testing and vaccine procurement. However, support for opening-up was not weakened. Cities like Shenzhen and Guangzhou introduced fiscal subsidies to encourage firms to expand domestic sales and develop online exhibitions; Zhuhai’s Hengqin district used special funds to support the establishment of Macao-invested enterprises. Due to the short-term adjustment of overall expenditure structure, the correlation dropped to 0.592 in 2020, but quickly rebounded to 0.667 in 2021, demonstrating the supporting role of flexible policy adjustments in stabilizing openness. In 2023, fiscal expenditure further focused on “high-level opening-up,” with Guangdong allocating special funds to support key areas such as comprehensive cross-border e-commerce pilot zones and free trade account trials. The correlation remained stable at 0.672, continuing to inject momentum into the open economy. The core value of government regulation lies in providing policy guidance and risk buffering for the open economy through tax incentives, infrastructure investment, and institutional supply. As a key force for responding to changes in the internal and external environment and stabilizing expectations for opening-up, government regulation should further optimize the structure of fiscal expenditure in the future, increase support for institutional opening-up, and better fulfill its role as a policy “regulator”.

(3) Economic foundation serves as the “hard support” for open expansion, with an average grey relational degree of 0.650 with the GBA’s openness level, showing a dynamic trend of “rising with fluctuations before stabilizing.” The maximum value was 0.732 in 2021, the minimum was 0.533 in 2020, a difference of 0.199, indicating a generally strong correlation. Per capita GDP, as a core indicator of regional economic development, provides the material basis for raising the GBA’s openness. Practice shows that only when the economy reaches a certain level of strength can it effectively support enterprises in participating in international competition, attracting high-end factors, and resisting external risks. Measurement results show that from 2017 to 2019, per capita GDP in the GBA grew continuously, surpassing 150,000 yuan in 2019. Core cities such as Shenzhen and Guangzhou, with their high per capita incomes, attracted clusters of multinational corporate headquarters — for example, Shenzhen had eight Fortune Global 500 companies in 2019. Exports of high-value-added products, such as electronic information and biopharmaceuticals, increased their share, driving both openness and economic performance upward. The correlation reached 0.708 in 2017 and rose to 0.724 in 2019. In 2020, the COVID-19 pandemic triggered a global economic recession, shrinking external demand. The GBA faced pressure on exports, with the growth rate of total import and export volume slowing to 1.5%, and per capita GDP increasing by only 2.7% year-on-year. The correlation with openness fell to a trough of 0.533 in 2020. In 2021, aided by global

economic recovery and the domestic “dual circulation” strategy, per capita GDP in the GBA continued to rebound. Exports of high-tech products surged—for instance, Shenzhen’s new energy vehicle exports grew by 1.5 times—pushing the correlation back up to its peak of 0.732. Over the next two years, as economic growth stabilized, per capita GDP rose at an average annual rate of 4.2% in 2022–2023, and the correlation entered a relatively stable phase, at 0.642 in 2022 and 0.617 in 2023. The economic foundation is the cornerstone of the GBA’s opening-up, but there remains a significant gradient difference between the Pearl River Delta and Hong Kong–Macao. For example, Hong Kong’s per capita GDP exceeds 40,000 USD, while Zhaoqing’s is less than 10,000 USD, limiting the full realization of synergistic opening-up effects. In the future, it will be necessary to further strengthen the economic base, especially in the less developed cities on the periphery.

(4) Investment pull acts as the “foundation builder” of the open economy, with an average grey relational degree of 0.644 with the GBA’s openness level, showing a dynamic trend of “high at first, then declining, and finally stabilizing.” The maximum value was 0.723 in 2017, the minimum was 0.610 in 2023, a difference of 0.113, indicating a generally strong correlation. Total fixed asset investment in society is an important pillar for expanding the physical conditions of opening-up, laying the material foundation for raising the GBA’s openness. Practice shows that infrastructure and industrial investment directly determine a region’s capacity to sustain cross-border trade and investment. Measurement results show that from 2017 to 2019, fixed asset investment in the GBA remained at a high level, with the nine Pearl River Delta cities investing a total of over 3 trillion yuan in 2019. Funds were mainly directed toward transportation hubs, port facilities, and industrial parks. These investments directly enhanced cross-border logistics efficiency and industrial carrying capacity, driving the correlation to reach 0.723 in 2017. From 2020 to 2022, affected by the COVID-19 pandemic, the growth rate of fixed asset investment in the GBA slowed markedly, with a mere 3.2% year-on-year increase in 2020. However, the investment structure underwent significant optimization: more funds flowed into new infrastructure and emergency facility construction, while the marginal returns on traditional open-economy infrastructure projects gradually diminished. As a result, the correlation dropped to 0.610 in 2020. In 2023, with the advancement of major projects under the 14th Five-Year Plan — such as the completion of the main section of the Shenzhen–Zhongshan Corridor and the commissioning of the Hong Kong International Airport’s Three-Runway System — fixed asset investment’s supportive role for opening-up recovered, and the correlation reached 0.610. The core logic of investment pull lies in reducing transaction costs for cross-border trade and investment through the construction of physical space and industrial carriers. This is manifested in improved logistics efficiency and more complete industrial supporting facilities, thereby building a solid and reliable “hard foundation” for the open economy. Nevertheless, the GBA currently faces the practical challenge of diminishing marginal returns on investment. There is an urgent need to shift the development model from “quantitative expansion” to “qualitative improvement,” placing greater emphasis on the deep synergy between investment layout and technological innovation breakthroughs as well as upgrades in service capacity. This will continue to stimulate and unleash the endogenous dynamism of open economy growth.

(5) Human capital is the “source of potential” for innovative opening-up, with an average grey relational degree of 0.562 with the GBA’s openness level, showing a dynamic trend of “stabilizing amid fluctuations.” The maximum value was 0.660 in 2017, the minimum was 0.467 in 2018, a difference of 0.193, indicating a moderate correlation overall. Human capital reflects a region’s knowledge reserves and innovation potential, and serves as a long-term driving force for raising the GBA’s openness. Practice shows that high-caliber talent is a key support for the open economy’s shift toward higher-end and innovation-driven development. Measurement results show that from 2017 to 2019, higher education resources in the GBA accelerated their agglomeration. Universities in Hong Kong boasted globally leading research capabilities, while Shenzhen established new institutions such as Southern University of Science and Technology. The number of university students per ten thousand people rose steadily, reaching about 280 in 2019. This supplied the open economy with R&D talent in fields such as artificial intelligence and biomedicine, as well as managerial talent in

international business and financial services, driving the correlation to a peak of 0.660 in 2017. From 2020 to 2022, affected by structural adjustments in graduate employment and a temporary mismatch of skills, the direct contribution of human capital to opening-up weakened. The correlation remained low, extending from 0.467 in 2018 to 0.470 in 2020. However, in 2021, with the accelerated development of the GBA as an international science and technology innovation center and stronger alignment between higher education and industrial demand, the correlation recovered to 0.573. In 2023, reforms in vocational education and deeper cooperation among universities in Guangdong, Hong Kong, and Macao improved the quality of human capital. In the short term, however, its impact on openness remained largely potential-based, with a correlation of 0.546. Human capital is a long-term variable in the GBA's opening-up process. The region is currently transitioning from a "demographic dividend" to a "talent dividend," and the growing number of university students lays the foundation for a more high-end open economy in the future. Yet, converting this potential into real momentum depends on the deep integration of the education system with industrial needs. Going forward, efforts should be made to strengthen coordination between higher education and vocational skills training to improve talent–job matching.

5. CONCLUSIONS

This study constructed an evaluation index system covering five dimensions — trade openness, capital openness, personnel openness, information openness, and institutional openness — to measure the openness level of the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) from 2017 to 2023, and explored its driving factors. The main findings are as follows:

(1) The GBA as a whole exhibits the characteristics of "core-led development, tiered differentiation, and dynamic recovery." Shenzhen and Hong Kong serve as the two core cities with the highest openness, leading the region. Shenzhen's openness index rose from 0.4851 in 2017 to 0.5227 in 2023, benefiting from its innovative industries and institutional opening-up. Hong Kong, after being impacted by the pandemic, rebounded to 0.5554 in 2023, maintaining its firm position as a global hub. Among the nine Pearl River Delta cities, a clear gradient differentiation exists: Shenzhen ranks in the first tier; Guangzhou, Zhuhai, and Dongguan form the second tier; and the remaining cities belong to the third tier. Macao's openness level fluctuated significantly, reaching 0.3970 in 2023. Its economy remains reliant on tourism and gaming, but efforts are underway to promote diversified transformation. After the pandemic, all cities showed resilient recovery, although internal disparities remain pronounced.

(2) Grey relational analysis reveals that the five driving factors rank in decreasing order of influence as follows: industrial structure, government regulation, economic foundation, investment pull, and human capital. Industrial structure acts as the "main engine," with service sector opening-up directly enhancing the level of openness. Government regulation functions as the "regulator," optimizing the open environment through infrastructure investment and policy innovation. The economic foundation serves as the "hard support," where per capita GDP growth strengthens international competitiveness. Investment pull lays the hardware foundation for openness, but its marginal benefits are diminishing. Human capital is the "source of potential," and closer alignment between education and industry is needed to unleash its long-term momentum.

ACKNOWLEDGEMENTS

This paper is funded by the Guangdong Provincial Philosophy and Social Sciences Planning Jointly Built Project: "Mechanisms and Pathways for Promoting High-Quality Development of China's Foreign Trade under the Regional Comprehensive Economic Partnership (RCEP) in the New Development Paradigm" (GD24XYJ36).

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