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Research on the Temporal and Spatial Evolution of the Development Level of Strategic Emerging Industries in the Guangdong-Hong Kong-Macao Greater Bay Area

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Abstract: Strategic emerging industries serve as the core engine driving high-quality development of the Guangdong-Hong Kong-Macao Greater Bay Area (GBA). Based on panel data of the "9+2" urban agglomeration from 2018 to 2024, this paper constructs an evaluation index system covering four dimensions: industrial scale, innovation capacity, social benefits, and ecological environment. The entropy-weight TOPSIS model, the Theil index, and spatial autocorrelation analysis are adopted to analyze its temporal and spatial evolution characteristics. The study shows that temporally, strategic emerging industries in the GBA maintain a steady upward trend, with Guangzhou and Shenzhen taking the lead and node cities demonstrating strong catch-up momentum. Spatially, obvious differentiation of "strong east, weak west" and "core-periphery" can be observed, forming a stable dual-core driving pattern. In terms of dynamic evolution, spatial polarization effects gradually weaken, inter-regional imbalance narrows, and coordinated convergence becomes increasingly prominent. Finally, countermeasures such as deepening cross-regional industrial coordination and optimizing factor allocation are proposed.

Keywords: Guangdong-Hong Kong-Macao Greater Bay Area; Strategic emerging industries; Entropy-weight TOPSIS; Temporal and spatial evolution; Spatial differentiation

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1. Introduction

Strategic emerging industries are modern industries that play a leading and driving role in overall economic and social long-term development based on major technological breakthroughs and development demands [1]. Against the backdrop of a new global round of scientific and technological revolution and industrial transformation, core technologies such as big data and artificial intelligence are iterating at an accelerated pace, making strategic emerging industries a core arena for regions to seize the commanding heights of international competition. Therefore, measuring the development level of regional strategic emerging industries and exploring their spatial heterogeneity and coordinated evolution laws are of great practical urgency [2].

As one of China's most economically dynamic and innovation-rich regions, the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) undertakes the national mission of building a global science and technology innovation highland and a world-class advanced manufacturing center [3]. The *Outline Development Plan*

for the Guangdong-Hong Kong-Macao Greater Bay Area clearly proposes to foster and expand strategic emerging industries and build a modern industrial system with international competitiveness. Nevertheless, the GBA features special institutional boundaries of "one country, two systems, three customs territories and three currencies." Obvious dual structures exist among cities in factor endowments, development stages, and industrial foundations, leading to complex temporal-spatial unbalanced evolution of strategic emerging industries. Most previous studies focused on a single dimension or partial cities without comprehensive global analysis. Using refined panel data from 2018 to 2024, this paper quantitatively measures the development quality of strategic emerging industries in the GBA and reveals its temporal-spatial evolution rules, so as to provide references for integrated high-quality industrial development of the Greater Bay Area [4].

2. Index system and research methodology

2.1. Construction of evaluation index system

Following the principles of scientificity and systematicity, a multi-dimensional comprehensive evaluation index system is established with four target layers and 10 core specific indicators (see **Table 1**).

Table 1. Evaluation index system for the development level of strategic emerging industries in the Guangdong-Hong Kong-Macao Greater Bay Area

Target layer	Specific indicator	Attribute	Weight
Industrial scale	Added value of strategic emerging industries (100 million yuan)	Positive	0.26
Industrial scale	Proportion in GDP (%)	Positive	0.14
Innovation capacity	R&D expenditure as percentage of GDP (%)	Positive	0.18
Innovation capacity	Number of valid invention patents per 10,000 people (piece)	Positive	0.12
Innovation capacity	Number of high-tech enterprises (unit)	Positive	
Social & ecological benefits	Employees in strategic emerging industries (10,000 persons)	Positive	0.08
Social & ecological benefits	Reduction rate of energy consumption per unit GDP (%)	Positive	0.07
Social & ecological benefits	Comprehensive utilization rate of industrial solid waste (%)	Positive	0.05

2.2. Research models and formulas

The entropy-weight TOPSIS model is adopted to measure the comprehensive development index. The entropy weight method, an objective weighting approach, is used to calculate indicator weights and avoid subjective bias. The TOPSIS method then conducts dynamic evaluation according to the relative proximity of each evaluated object to the positive and negative ideal solutions.

First, standardization is performed on positive indicators to eliminate dimensional and magnitude differences among indicators:

$x_{ij}^{'} = \frac{x_{ij} - min(x_j)}{max(x_j) - min(x_j)}$ Where x_{ij} represents the raw value of indicator j of city i; $max(x_j)$ and $min(x_j)$ denote the maximum and minimum values of indicator j; $x_{ij}^{'}$ stands for the standardized value.

Second, calculate the characteristic proportion p_{ij} of city i under indicator j:

$$p_{ij} = \frac{x_{ij}^{'}}{\sum x_{ij}^{'}}$$

Based on information entropy theory, the information entropy e_j of indicator j is calculated:

$$\ln jP\text{-}\frac{1}{\ln n}\sum(p_{ij}\times \quad _{ij})$$

The difference coefficient and weight w_j of each indicator are derived from entropy values. A weighted target matrix is constructed, and Euclidean distances from each object to positive and negative ideal solutions are calculated to obtain the relative proximity C_i (comprehensive development index). The closer C_i is to 1, the higher the development level.

3. Temporal evolution of strategic emerging industry development level

From 2018 to 2024, the comprehensive index of strategic emerging industries in most cities of the GBA maintained a steady upward trend (**Table 2**), indicating effective regional industrial transformation and upgrading since the implementation of the GBA Development Outline.

Table 2. Comprehensive industrial development index of cities in the Guangdong-Hong Kong-Macao Greater Bay Area (2018–2024)

City	2018	2020	2022	2024
Shenzhen	0.88	0.91	0.94	0.96
Guangzhou	0.79	0.82	0.85	0.88
Hong Kong	0.72	0.74	0.75	0.77
Dongguan	0.53	0.58	0.62	0.65
Foshan	0.51	0.55	0.59	0.62
Zhuhai	0.42	0.46	0.49	0.53
Zhongshan	0.38	0.41	0.43	0.46
Huizhou	0.35	0.39	0.42	0.45
Jiangmen	0.26	0.29	0.31	0.34
Macao	0.25	0.27	0.28	0.30
Zhaoqing	0.22	0.24	0.27	0.29

As the dual-core engine, Shenzhen and Guangzhou show an obvious leading effect. Shenzhen's index rose from 0.88 in 2018 to 0.96 in 2024, supported by its unique "90% innovation ecosystem" and global competitiveness in next-generation information technology and new energy vehicles. Guangzhou's index increased steadily from 0.79 to 0.88, boasting a solid industrial foundation and risk resistance driven by pillar industries such as new displays, biomedicine and intelligent connected vehicles. See **Figure 1**.

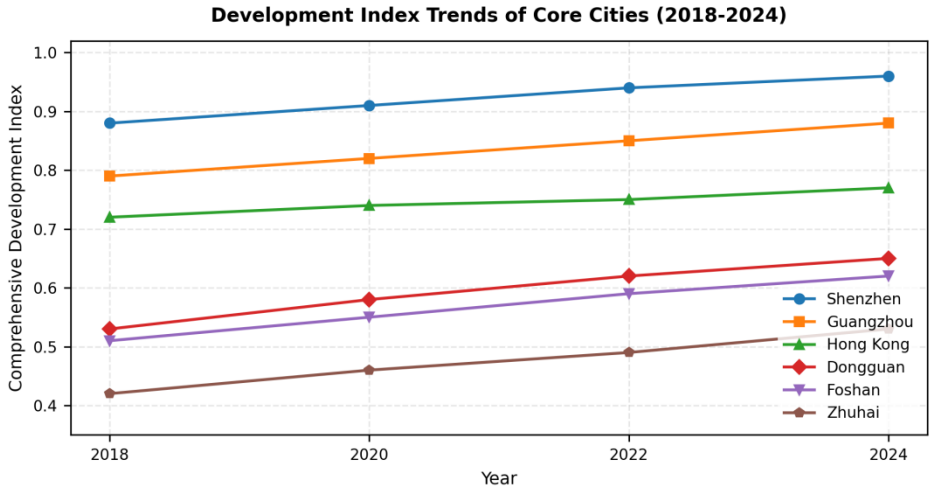

Figure 1. Trend chart of strategic emerging industry development index of core cities (2018–2024)

Meanwhile, Dongguan and Foshan show strong catch-up momentum. Dongguan's index climbed from 0.53 to 0.65 and Foshan from 0.51 to 0.62. As traditional manufacturing hubs, both cities achieved transformation into mid-to-high-end strategic emerging industrial clusters through digital and intelligent upgrading. Zhuhai, Huizhou, and Zhongshan realized differentiated steady growth in segmented industries relying on their respective geographical advantages.

4. Spatial evolution of strategic emerging industry development level

The spatial structure presents prominent "core-periphery" heterogeneity. Shenzhen and Guangzhou consistently outperform other cities, forming an unshakable first-tier group. The dual-core driving pattern of Guangzhou-Shenzhen lies on both sides of the Pearl River Estuary and generates a strong Matthew effect in factor absorption. Supported by private enterprises and capital markets, Shenzhen maintains absolute leadership in electronic information and high-tech sectors. As the provincial capital with abundant universities and research institutes, Guangzhou forms complementary development with Shenzhen in basic research and industrial transformation. See **Figure 2**.

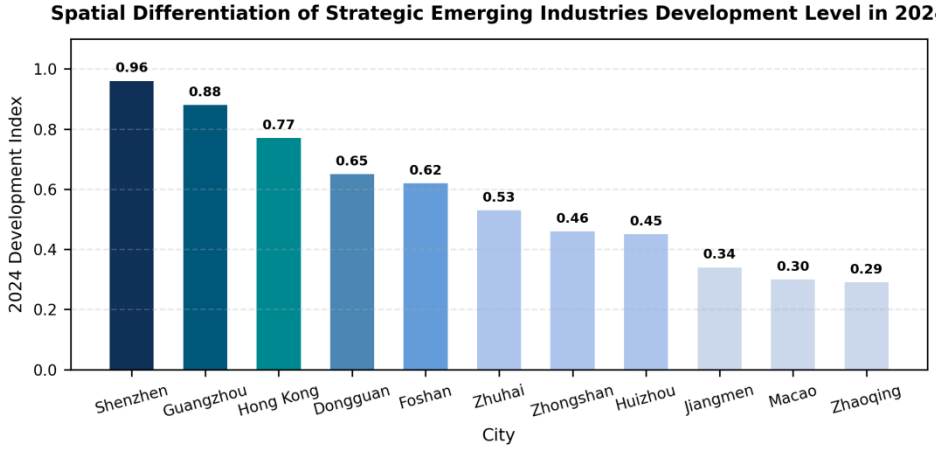

Figure 2. Spatial differentiation of strategic emerging industry development level in the Guangdong-Hong Kong-Macao Greater Bay Area (2024)

Dongguan and Foshan constitute the second tier, acting as the frontier of Shenzhen-Dongguan integration and Guangzhou-Foshan urban integration respectively. The two cities undertake innovation dividends and industrial spillovers from core cities: Dongguan deeply connects Shenzhen's innovation chain while Foshan absorbs intellectual resources from Guangzhou with its manufacturing hinterland. Nevertheless, the whole GBA still features an unbalanced pattern of "strong east, weak west" caused by investment inertia, infrastructure connectivity, and factor spillover attenuation. With the opening of major passages such as the Shenzhen-Zhongshan Link, spatial polarization of strategic emerging industries is weakening, and regional imbalance is gradually narrowing.

5. Conclusion and policy suggestions

5.1. Research conclusions

First, in terms of temporal evolution, the overall strength of strategic emerging industries in the Greater Bay Area has entered a period of comprehensive leapfrog development, with the development index of each city rising steadily. Second, in terms of spatial layout, there is a prominent differentiation pattern of "strong east and weak west" as well as "core-periphery," forming a gradient structure with Guangzhou and Shenzhen as the dual cores and Dongguan and Foshan as key supporting cities. Third, in terms of spatial dynamics, alongside the advancement of integrated market development, the marginal effect of spatial polarization is diminishing, the internal imbalance within the region is gradually narrowing, and the features of coordinated convergence are becoming increasingly obvious.

5.2. Policy suggestions

(1) Promote in-depth cross-regional industrial chain coordination: Strengthen the linkage effect of the Guangzhou-Shenzhen dual core, break administrative barriers, upgrade the Guangzhou-Shenzhen-Hong Kong Science and Technology Innovation Corridor, and facilitate free flow of R&D factors, high-end talents and capital.

(2) Encourage differentiated industrial undertaking by node cities: Take full advantage of supporting industries in Dongguan and Foshan to cultivate midstream and downstream sectors of advanced manufacturing and intelligent equipment, forming the manufacturing foundation of GBA strategic emerging industries.

(3) Improve institutional innovation and integration mechanisms: Tap unique strengths of Hong Kong and Macao in free port systems, international talents and top university basic research, and smooth the efficient closed loop of "research in Hong Kong & Macao + transformation in the Greater Bay Area."

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