Research on the Economic Development of the East, West and North of Guangdong Based on the Entropy Weight-TOPSIS Method

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Abstract: Our research selects 8 prefecture level cities in east and northwest Guangdong, uses entropy weight TOPSIS method, constructs an index system to evaluate economic development from the four dimensions of economic growth, human development, industrial development, scientific and technological innovation. We analyze the differences of economic development among cities, and then make policy recommendations according to their weaknesses. The data results show that Shantou has strong overall economic strength, and is the city with the strongest economic strength in east and northwest Guangdong; Zhanjiang has strong economic development and large geographical area, but its economic growth and industrial development factors are weak; The economic development of Meizhou, Qingyuan, Heyuan and Yunfu needs new ideas.

Keywords：TOPSIS method; Evaluation of economic development; Regional differences

1 Introduction

Guangdong Province is the largest province in China’s total economic output. It is located at the Pearl River Delta region of South China. The province has a land area of 179,800 square kilometers and has 21 prefecture-level cities under its jurisdiction. In 2020, Guangdong Province's GDP will reach 11.07 trillion yuan, a year-on-year increase of 2.3%.[1] Although Guangdong's overall economic aggregate ranks first in the country, it still has the problem of uneven regional development, and its per capita GDP ranks sixth. According to the GDP data of the cities in Guangdong Province in 2020 released by the Guangdong Provincial Bureau of Statistics, Shenzhen, which ranked first, had a total GDP of 2767.024 billion yuan in 2020, and Yunfu City, which is located on western Guangdong, had a total GDP of only 100.218 billion yuan in 2020.[2] The difference between the city is nearly 30 times. Overall, the development of prefecture-level cities in the east, west and north of Guangdong lags several cities in the Pearl River Delta. This article will establish a TOPSIS comprehensive evaluation model to scientifically evaluate and compare the comprehensive development level of several prefecture-level cities in the east, west, and north of Guangdong, to achieve a clear self-positioning, precise force, and promote the smooth implementation and stability of the rural revitalization strategy.

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2 Introduction to research area and construction of evaluation index system

2.1Introduction to the study area

In this paper, eight prefecture level cities, Zhanjiang, Maoming, Shantou, Meizhou, Shaoguan, Qingyuan, Heyuan and Yunfu, are selected for analysis. These eight prefecture level cities are distributed in the three directions of East, West and North of the Pearl River Delta. They are representative cities in east and northwest Guangdong, each with regional characteristic industries and economic development paths.

2.2Evaluation index system construction

According to the connotation of regional economic development, combined with the actual conditions of the eastern and western regions of Guangdong and the overall development requirements of Guangdong Province, this article builds an evaluation index system for urban economic development in the eastern and western regions of Guangdong based on the four dimensions of economic growth, human development, industrial development, and technological innovation (As shown in Tab 1), there are 4 first-level indicators and 15 second-level indicators. Among the two-level indicators, there are 13 positive indicators and 2 negative indicators. For positive indicators, the larger the indicator value, the better the economic development; for negative indicators, the larger the indicator value, the worse the economic development.[3] The data in this article comes from the 2019 and 2020 Guangdong Provincial Statistical Yearbook and the Guangdong Provincial Department of Industry and Information Technology.

Tab 1 Evaluation index table

First index	Secondary index	attributes
Economic Growth	GDP per capita	+
	GDP growth rate	+
	Economic growth volatility	-
Humanistic Development	Minimum wage standard	+
	Net population inflow	+
	Number of city parks	+
	Tourism income	+
Industrial Development	High-speed way density	+
	Electricity consumption	+
	Express business volume	+
Technological innovation	R&D expenditure	+
	Percentage of 2nd industry	+
	Percentage of 3rd industry	+
	unemployment rate	-
	Number of high-tech enterprises	+

2.3Determination of evaluation index weight

The data of each evaluation index involved in this paper are from the actual statistical data of Guangdong Province in 2019 and 2020. Therefore, we use the entropy weight method in the objective weighting method to determine the weight of each evaluation index. The entropy weight method determines the index weight according to the difference of the order degree of the information contained in each index, which only depends on the dispersion degree of the data itself, to have a certain grasp of the objective accuracy of the evaluation results and avoid the interference to the determination of the weight due to personal subjective speculation.

The specific operation of the entropy method to determine the weight of each indicator is as the largest prefecture follows:

2.3.1 Building a matrix

We construct the original data of 15-dimensional evaluation index information of 8 places in east and northwest Guangdong into the matrix form of $m \times n(15 \times 8)$, and the corresponding indexes are marked as $a_{ij}(i = 1, 2, \cdots, m; j = 1, 2, \cdots, n)$,then the original matrix is $A = (a_{ij})_{m \times n}$.

2.3.2 Standardize the matrix

All 15 evaluation indexes involved in local economic development cannot be directly compared with the original data because they involve different units and different scenarios. We use the range method to convert the data, to eliminate the problem that the data under different orders of magnitude cannot be compared due to different index dimensions. The processed data can be directly applied in the model.[4]

The range method is used to use the following formula for positive index and negative index data respectively:

$$\text{Positive index } \mathrm{x}_{ij} = \frac{a_{ij} - \min\left(a_j\right)}{\max\left(a_j\right) - \min\left(a_{ij}\right)} \tag{1}$$

$$\text{Negative index } \mathrm{x}_{ij} = \frac{\max\left(a_j\right) - a_{ij}}{\max\left(a_j\right) - \min\left(a_{ij}\right)} \tag{2}$$

In order to eliminate the influence of 0 on the data, we use 1×10^{-5} to replace 0 in the standardized matrix. After completing the standardization process, we will denote the resulting matrix as $A_{st} = (a_{ij})_{m \times n}$. This will ensure $\forall x_{ij} \in \left[0, 1\right]$ in the matrix without destroying the proportional relationship between the data.

2.3.3 Calculate the entropy value of each indicator

We remember the entropy value as e, then we have:

$$e_j = -k \sum_{i=1}^{m} \left(p_{ij} \ln p_{ij} \right) \tag{3}$$

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{4}$$

Where k is related to the number of samples, we take $k = \frac{1}{\ln m}$. In addition, we add the definition: if $p_{ij} = 0$, then let $p_{ij} \ln p_{ij} = 0$.

2.3.4 Determine the weight

According to the formula in 3), we use the following formula to obtain the weight between each indicator.

$$w_{ij} = \frac{1 - e_j}{\sum_{j=1}^{n} 1 - e_j} \tag{5}$$

3 Model establishment and analysis

3.1 Introduction to TOPSIS method

The TOPSIS method was first proposed by C. L. Hwang and K. Yoon in 1981. It is a multi-objective decision-making model widely used in regional economic development evaluation and comprehensive evaluation.

3.2 Standardize data

Before using the model, we use the range method to dimensionless process all data. See formulas (1) and (2) above for the formula of the range method.

In the above formula, X_{ij} is the standardized value of the indicator; x_{ij} is the original value of the indicator; $\max\left(x_{ij}\right)$ and $\min\left(x_{ij}\right)$ respectively represent the maximum and minimum values of the indicator in the original data. After index standardization, the decision matrix B is constructed.

3.3 Constructing a normative weighted decision matrix

According to the corresponding weight of each indicator, establish a standardized weighted decision matrix V:

$$V = B \times w = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1j} \\ v_{21} & v_{22} & \cdots & v_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ v_{i1} & v_{i1} & \cdots & v_{ij} \end{bmatrix} \tag{6}$$

3.4 Determine positive ideal solution and negative ideal solution

The positive ideal solution V^+ is composed of the maximum value of each column of elements in V:

$$\begin{aligned} V^+ &= (\max\left\{v_{11}, v_{21}, \cdots, v_{n1}\right\}, \\ &\max\left\{v_{12}, v_{22}, \cdots, v_{n2}\right\}, \cdots, \\ &\max\left\{v_{1m}, v_{2m}, \cdots, v_{nm}\right\}) \\ &= \left(Z_1^+, Z_2^+, \cdots, Z_m^+\right) \end{aligned} \tag{7}$$

The negative ideal solution V^- is composed of the minimum value of each column of elements in V:

$$\begin{aligned} V^- &= (\min\left\{v_{11}, v_{21}, \cdots, v_{n1}\right\}, \\ &\min\left\{v_{12}, v_{22}, \cdots, v_{n2}\right\}, \cdots, \\ &\min\left\{v_{1m}, v_{2m}, \cdots, v_{nm}\right\}) \\ &= (Z_1^-, Z_2^-, \cdots, Z_m^-) \end{aligned} \tag{8}$$

3.5 Calculate the closeness of each evaluation object to the positive ideal solution and the negative ideal solution

Calculate the distance D^+ from the evaluation vector of different evaluation samples to the positive ideal solution and the distance D^- to the negative ideal solution respectively.

$$D^+ = \sqrt{\sum_{j=1}^{m} \left(v_{ij} - v_j^+\right)^2} \tag{9}$$

$$D^- = \sqrt{\sum_{j=1}^{m} \left(v_{ij} - v_j^-\right)^2} \tag{10}$$

3.6 Calculate the closeness C_i between each evaluation object and the positive ideal solution

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{11}$$

3.7 result

Analyze and judge the sample the sample according to the size of C_i. The closer C_i is to 1, the closer the sample is to the positive ideal solution, the more representative the sample, and vice versa.

4 Result analysis

4.1 Economic development factor

Tab 2 Result of economic development factor

Region	D^+	D^-	C_i	Rank
Zhanjiang	0.06729	0.025205	0.272504	7
Maoming	0.076479	0.030385	0.284333	6
Shantou	0.061824	0.036453	0.370921	4
Meizhou	0.079125	0.019305	0.19613	8
Shaoguan	0.038599	0.052693	0.577196	3
Qingyuan	0.031049	0.073823	0.703933	1
Heyuan	0.082669	0.034849	0.296542	5
Yunfu	0.035972	0.081985	0.695038	2

It can be seen from Tab 2 that Qingyuan in northern Guangdong and Yunfu in western Guangdong rank high in this index, while Zhanjiang and Meizhou rank low. The analysis of specific data shows that the main reason for this situation is that the index of economic growth volatility has an impact on the data. In 2020, the growth rate of GDP in all parts of Meizhou increased despite the impact of COVID-19. However, it was significantly slower than that in 2019. This is evident in Zhanjiang and the two places, and the volatility in both places is above 50%. Although the overall economic level of Qingyuan and Yunfu is not as good as that of Zhanjiang, the two regions maintain good GDP growth, and the fluctuation of economic growth is not obvious.

4.2 Humanistic development factor

Tab 3 Result of Humanistic development factor

Region	D^+	D^-	C_i	Rank
Zhanjiang	0.041264	0.210682	0.836218	1
Maoming	0.094046	0.183484	0.661132	2
Shantou	0.183236	0.09507	0.341601	5
Meizhou	0.170063	0.122953	0.419613	3
Shaoguan	0.204505	0.034929	0.145881	7
Qingyuan	0.202988	0.0348	0.146349	6
Heyuan	0.153145	0.084968	0.356838	4
Yunfu	0.214084	0.035673	0.142832	8

From Tab 3, we can be announced that Zhanjiang scored far more than other regions in terms of Humanistic development, and became the top of the list with absolute advantages; while the overall human development capacity of Yunfu area is weak.

4.3 Industrial development factors

Tab 4 Result of Industrial Development Factors

Region	D^+	D^-	C_i	Rank
Zhanjiang	0.649560	0.07755	0.106656	2
Maoming	0.671390	0.037368	0.052724	5
Shantou	0.634895	0.702759	0.109534	1
Meizhou	0.660001	0.045307	0.064237	4
Shaoguan	0.690087	0.034377	0.047452	6
Qingyuan	0.673501	0.06659	0.089976	3
Heyuan	0.689750	0.017655	0.024957	8
Yunfu	0.701745	0.020524	0.028416	7

It can be seen from Tab 4 the in terms of industrial development factors, thanks to its superior geographical location, relatively perfect industrial system and national policies, Shantou ranks first in the list, and its overall industrial strength is far higher than that of other regions, especially in terms of express business volume.

4.4 Technological innovation factor

Tab 5 Result of Technological innovation factor

Region	D^+	D^-	C_i	Rank
Zhanjiang	0.10633	0.13115	0.552256	4
Maoming	0.103139	0.129358	0.556385	3
Shantou	0.075147	0.196725	0.723593	1
Meizhou	0.194091	0.065701	0.2529	6
Shaoguan	0.087419	0.133586	0.604447	2
Qingyuan	0.138705	0.079624	0.364697	5
Heyuan	0.196642	0.059564	0.232485	7
Yunfu	0.217928	0.025648	0.216872	8

As can be seen from Tab 5, in terms of technological innovation factors, Shantou, with a relatively perfect industrial system, ranks first again, with many high-tech enterprises. The proportion of secondary and tertiary industries far exceeds that of other regions in the list.

4.5 Results and recommendations

We analyze the content covered by the four first-level indicators separately by the entropy weight-TOPSIS method, which can reflect the performance of the eight prefecture-level cities in different aspects. Then we use the entropy weight-TOPSIS method to rank all the secondary indicators, and the results are shown in Tab 6 and Fig 1:

Tab 6 Results overview

Region	D^+	D^-	C_i	Rank
Zhanjiang	0.66314	0.261086	0.282491	2
Maoming	0.690763	0.228214	0.248335	3
Shantou	0.210244	0.736344	0.777893	1
Meizhou	0.713427	0.14709	0.170932	5
Shaoguan	0.726141	0.151895	0.172994	4
Qingyuan	0.717145	0.134655	0.158083	6
Heyuan	0.739064	0.105301	0.12471	7
Yunfu	0.765415	0.099591	0.115133	8

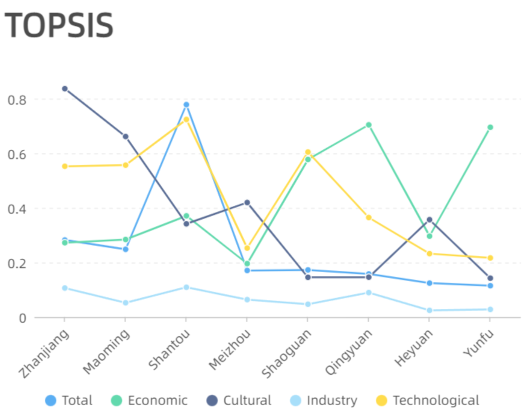

Fig 1 Results overview

5 Conclusion

Based on the economic development of 8 representative prefecture level cities in three directions of east and northwest Guangdong, this paper constructs the economic development evaluation system of east and northwest Guangdong from the regional economic growth level, humanistic development level, industrial development structure and scientific and technological innovation, and uses the entropy weight TOPSIS method to comprehensively evaluate it. Fig 2 shows the overall score and rankings of 8 cities.

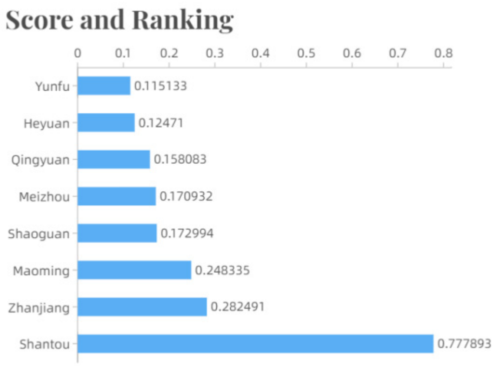

Fig 2 Score and Ranking

The evaluation shows that Shantou is among the best in the overall economic development of eastern and northwestern Guangdong, which is inseparable from the relatively perfect local industrial system and open national policy; as the largest prefecture level city in eastern and northwest Guangdong, Zhanjiang has good cultural heritages. However, its economic situation is greatly affected by the COVID-19 in 2020, its economic growth volatility is high, and its industrial structure is not as reasonable as Shantou, and its overall score is far lower than Shantou. From the overall research results, we make the following suggestions:

First, compared with the core areas of the Pearl River Delta, the eastern and northwestern regions of Guangdong have inherent deficiencies in talent introduction and industrial development, but these regions can still make up for this deficiency by developing characteristic industries. Zhanjiang has good agricultural resources and environment and a large farming area, using this series of conditions to develop characteristic industries can make up for its defects in industrial economy to a certain extent. Similarly, Shantou is rich in tourism resources, and vigorously developing characteristic tourism can also be an important way for its economic development.[5]

Secondly, infrastructure construction should be strengthened in eastern and northwestern Guangdong, especially in weak areas. The relatively backward infrastructure system in these areas makes the overall local economic development level relatively backward. Improving infrastructure is the basis for attracting talents.[6] Only when the construction of infrastructure reaches a certain level, can the region have the capital to attract high-level talents.

Finally, we can see from the data that in 2020, the net population outflow of Zhanjiang, Meizhou and Maoming exceeded one million, and the population outflow of the other five places was more than 200000. The local government should strengthen the support for talents and the introduction of talents in addition to retaining local people. The introduction of high-level talents is also an indispensable step in the process of economic development.

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References

[1] Guangdong Provincial Bureau of Statistics (2019). Guangdong Statistical Yearbook. http://stats.gd.gov.cn/tjsj186/index.html

[2] Guangdong Provincial Bureau of Statistics (2020). Guangdong Statistical Yearbook. http://stats.gd.gov.cn/tjsj186/index.html

[3] EEDMAN M. Targeted business incentives and local labor markets [J]. Journal of Human Resources, 2013, 48(2):311-344.

[4] Suranyi (2018) Introduction to TOPSIS method (distance method of superior and inferior solution) and implementation of python3.https://zhuanlan.zhihu.com/p/37738503

[5] ELVERY J A. The impact of enterprise zones on resident employment: An evaluation of the enterprise zone programs of California and Florida [J]. Economic Development Quarterly, 2008, 23(1):44-59.

[6] Pavlin S, Svetlicic M. Higher education, employability and competitiveness [J]. Hacettepe University Journal of Education, 2012, 43 (4): 386-397.