Study on Urban Fiscal Revenue and Industrial Upgrading Based on a Big Data Model

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Abstract. In order to reveal the high-quality level of fiscal revenue growth in the Chinese Pearl River Delta cities, this paper first constructs a Dynamic Equilibrium Index model. The model is based on the classical DEA model frame and includes two optimization indicators: maximum value and minimum value. It is compatible with stringent and loose evaluation standards, which can be weight adjusted according to the actual needs. This model belongs to the optimal dynamic planning algorithm and can be widely used to evaluate the production level. Then, the fiscal income, GDP, disposable income and employment population in the Pearl River Delta cities for nearly 10 years were taken as the variables of the above model, among which GDP, disposable income and employment population serve as the input variables, and fiscal income as the output variable. The results show that Shenzhen has been far ahead of the other six cities, followed by Guangzhou, Zhuhai, Foshan, Dongguan, Huizhou and Zhongshan. The results fully demonstrate the principle that the high-quality level of modern urban fiscal revenue growth depends on the proportion of advanced manufacturing, high-tech industry and modern services. Conclusion: Shenzhen is undoubtedly the city with the fastest growing fiscal revenue in the Pearl River Delta, because Shenzhen has high proportion of advanced manufacturing and high-tech industries.

Keywords: Local fiscal · Regional economic · Pearl River Delta · Dynamic Equilibrium Index model

1 Introduction

The 19th National Congress of the Communist Party of China (CPC) in 2017 pointed out that China's economy is shifting from a high-speed growth stage to a high-quality development stage and is in a period of transformation of development mode, optimization of economic structure and transformation of growth momentum. In this context, scholars carry out research work from different levels to reveal the form and level of the Chinese economy.

Representative research results include: First, the regional economic development mode perspective that the provincial fiscal and economic growth from high-speed to medium-high-speed, the degree of transformation depends on the industrial structure, industrial level [4, 9, 24]. Second, from the perspective of optimizing the regional economic, it is considered that scientific and reasonable functional zoning is conducive to

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balancing regional fiscal and promoting economic development [5, 16–18, 21]. Third, from the perspective of regional economic growth policy measures, moderate fiscal decentralization is conducive to promoting industrial development and gathering [20, 23, 25]; Appropriate government subsidies and preferential tax policies are favorable tools for industrial transformation and upgrading [7, 10].

It can be seen that most of the literature mainly focuses on the macro relationship above the provincial level between fiscal measures and industrial upgrading. They do not involve the micro mechanism below the provincial level between fiscal revenue and industrial upgrading.

Considering the index of "fiscal income" can reflect both the economic level and the reverse effect on the economy, this paper selects fiscal income as the research variable. The fiscal revenue data of seven cities in the Pearl River Delta has been used as an alternative data to reveal the heterogeneity of fiscal growth in the above cities.

The rest: Sect. 2 is the qualitative analysis of regional fiscal revenue; Sect. 3 is the construction of quantitative research methods of regional fiscal revenue; Sect. 4 is empirical research, and Sect. 5 is the conclusion of research and policy recommendations.

Key innovations: 1) The Dynamic Equilibrium Index Model (DEI) is built, which is economically significant and easy to operate, and can evaluate conversion efficiency between multiple parts from different dimensions. 2) It is revealed that advanced manufacturing, high-tech industry and modern service industry are the decisive factors to increase the growth of regional fiscal revenue.

2 Mechanism Analysis

2.1 Main Factors Determining the Scale of Local Fiscal Revenue

From the actual composition of China's fiscal revenue, the main source of local fiscal output is local tax, which is a stable and direct source of local fiscal output. From the perspective of tax sources, the current tax items can be roughly summarized as value-added tax, income tax, consumption tax and other taxes. The value-added tax and income tax are derived from the local GDP, and the consumption tax is derived from the number of employees and disposable income. It can be seen that local GDP, employment and disposable income are the main factors that determine local fiscal output.

2.2 Main Factors Determining the Growth Rate of Local Fiscal Revenue

The amount of local fiscal revenue depends on the local GDP, employment and disposable income; The intensity of action depends on the relevant indicators of GDP, employment and disposable income. The functions of relevant indicators are as follows: 1) The proportion indicators of local advanced manufacturing industry, high-tech industry, modern service industry, new products, research and development expenses increase the intensity; 2) increase the intensity of local employment rate; 3) weaken the ratio of income to the rich and the poor.

3 Methods and Data

3.1 Dynamic Equilibrium Index Model (DEI) Expression

Based on DDF (Dynamic Double Frontiers Model), DEI is expanded by the introduction of the equilibrium coefficients ξ and ε. DDF was created by Yufeng Shi in 2021 under the DEA framework [1–3, 6, 8, 11–15, 19, 22] and is widely used in dynamic multi-objective evaluation. DEI has the following expression (Table 1):

$$\lambda = \xi \cdot Min \sum\nolimits_{t=1}^{T} \left(\sum\nolimits_{\alpha=1}^{n} \left(\varphi_{\alpha,s,t} \sum_{\beta=1}^{m} \phi_{\beta,s,t} \right) \right)$$
$$+\varepsilon \cdot Max \sum\nolimits_{t=1}^{T} \left(\sum\nolimits_{\alpha=1}^{n} \left(\varphi_{\alpha,s,t} \sum\nolimits_{\beta=1}^{m} \phi_{\beta,s,t} \right) \right) \quad (1)$$

Notes:
$\varphi_{\alpha,s,t} = v_{\beta,s,t} / \sum_{k=1}^{K-1} v_{\beta,k,t} w_{k,t}^{s}$; $\phi_{\beta,s,t} = \sum_{k=1}^{K-1} u_{a,k,t} w_{k,t}^{s} / u_{\alpha,s,t}$.

3.2 The Economic Significations of DEI

$$\lambda = \xi \cdot \left(v_{\beta,s,t} / u_{\alpha,s,t} \right) / Max \eta_{s,t}(\alpha, \beta)$$
$$+\varepsilon \cdot \left(v_{\beta,s,t} / u_{\alpha,s,t} \right) / Min \eta_{s,t}(\alpha, \beta) \quad (2)$$

Notes: $\eta_{s,t}(\alpha, \beta) = \sum_{k=1}^{K-1} v_{\beta,k,t} w_{k,t}^{s} / \sum_{k=1}^{K-1} u_{a,k,t} w_{k,t}^{s}$.

Formula (2) is the simplest form of formula (1), and the economic significance of formula (2) is as follows:

According to Eq. (2), when $\eta_{s,t}(\alpha, \beta)$ gets the maximum value, $\left(v_{\beta,s,t} / u_{\alpha,s,t} \right) / Max \eta_{s,t}(\alpha, \beta)$ may be understood as "the substitution coefficient for the

Table 1. The interpretation of the parameter

Variable	Paraphrase	Variable	Paraphrase
α	Input variable	β	Output variable
s	Evaluated department	t	Evaluated period
N	The number of input variables	M	The number of output variables
k	Any department	K	The total number of departments
ξ	The equilibrium factor under strict criteria	ε	The equilibrium factor under loose criteria
$u_{\alpha,k,t}$	The value of the input variable α of department k in period t	$v_{\beta,k,t}$	The value of the output variable β of department k in period t
$w_{k,t}^{s}$	The variable weights, and $\sum_{k=1}^{K-1} w_{k,t}^{s} = 1$	λ	Evaluation index value

highest output-input combination efficiency". Correspondingly, when $\eta_{s,t}(\alpha, \beta)$ reaches a minimum value, $\left(v_{\beta,s,t}/u_{\alpha,s,t}\right)/Min\eta_{s,t}(\alpha, \beta)$ may also be understood as "the substitution coefficient for the lowest input-output combination efficiency". In summary, Eq. (2) represents a balanced evaluation index.

3.3 Experimental Big Data of DEI

In this paper, GDP, employment population, disposable income and fiscal revenue from 2009 to 2018 in Shenzhen, Guangzhou, Zhuhai, Foshan, Huizhou, Zhongshan and Dongguan are selected as input variables and output variables of DEI model respectively.

4 Results and Discussion

Through Eq. (1) and programming language, the DEI is solved, and the dynamic equilibrium index value ($\varphi_{1,s,t} \sum_{\beta=1}^{3} \phi_{\beta,s,t},\ \xi = \varepsilon = 0.5$) is obtained. The results are shown in Figs. 1, 2, and 3. Then, according to the fiscal revenue mechanism in Sect. 2, it is analyzed as follows:

4.1 Analysis of Fiscal Growth in Shenzhen, Guangzhou and Zhuhai

4.1.1 Fiscal Revenue Growth Trend

As shown in Fig. 1a, in the past 10 years, Shenzhen's fiscal output efficiency has been on the leading level, showing a "√"shape. Especially in the past five years, Shenzhen's leading advantage has further expanded. Guangzhou's performance is not good, showing an "L" shape, which is at the lowest level in the past five years and basically equal to Zhuhai's. Zhuhai is in the shape of "-"which is lower than Shenzhen and Guangzhou, but significantly higher than Dongguan, Foshan, Huizhou and Zhongshan.

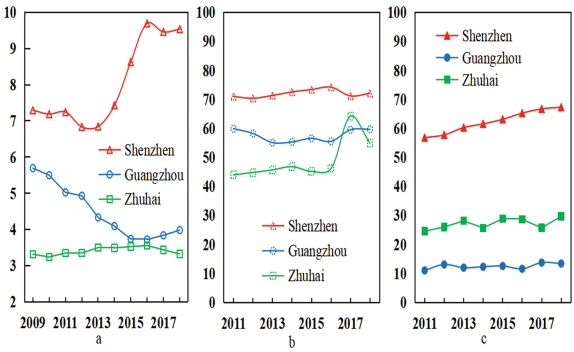

Fig. 1. Fiscal λ (a), advanced manufacturing industry proportion (b) and high-tech industry proportion (c). *Notes: we own the copyright of the image and of course we are free to use it.*

4.1.2 Industry-Driven Analysis

As can be seen from Figs. 1b and 1c) 1) in recent 10 years, Shenzhen's advanced manufacturing industry has maintained at more than 70%, and its high-tech industry has also reached 67%, which together become the supporting factors for Shenzhen's fiscal output efficiency to maintain a high level. It is worth mentioning that Shenzhen has continued to implement the "Dual Transfer" industrial policy of Guangdong province, achieved good expected results in industrial upgrading, and initially formed industrial clusters with strong competitiveness (finance, new generation information technology, new energy, Internet, artificial intelligence). 2) Although Guangzhou's advanced manufacturing industry is still above 50%, it's high-tech industry is only about 12%, far lower than that of Shenzhen's 67%. However, it cannot be ignored that Guangzhou has many governments, universities, medical and other institutions, which has become the consumption engine of local fiscal revenue. 3) The advantages of advanced manufacturing and high-tech industries in Zhuhai are not obvious, accounting for only 40% and 20%, but the modern service industries such as tourism, exhibition and hotel services are relatively developed.

Notes: the "Double Transfer" industrial policy was proposed by the Guangdong provincial government as early as 2008, meaning to "transfer labor-intensive industries in the Pearl River Delta to remote areas of Guangdong province and introduce high-quality talents from remote areas to the Pearl River Delta".

4.2 Analysis of Fiscal Growth in Foshan and Dongguan

4.2.1 Fiscal Revenue Growth Trend

Figure 2A shows that the fiscal output efficiency of Foshan and Dongguan has shown a "W" trend in recent 10 years, but Foshan continues to be higher than Dongguan by more than 15% year by year.

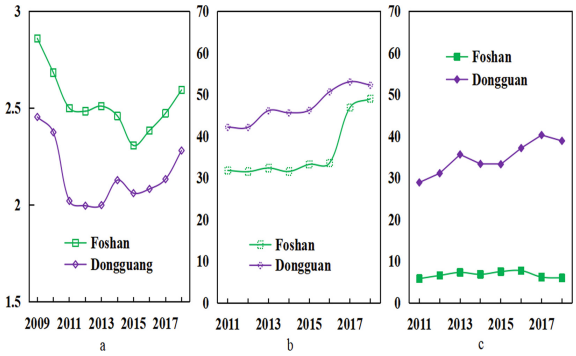

Fig. 2. Fiscal λ (a), advanced manufacturing industry proportion (b) and high-tech industry proportion (c). *Notes: we own the copyright of the image and of course we are free to use it.*

4.2.2 Industry-Driven Analysis

Figure 2B and Fig. 2c show that: 1) the high-tech industry in Dongguan is more than 20% higher than that in Foshan. In recent years, the development level of Dongguan's manufacturing industry is significantly higher than that of Foshan, the industrial transformation and upgrading has been completed, the "depression" has been reversed, and the industrial prospect is for the better. At present, Songshanhu and other famous high-tech parks, Huawei terminal company, OPPO, VIVO and other famous high-tech industrial clusters have been formed. 2) Foshan is better than Dongguan in employment rate, income to wealth ratio and other indicators.

4.3 Analysis of Fiscal Growth of Huizhou and Zhongshan

4.3.1 Fiscal Revenue Growth Trend

As shown in Fig. 3a, in recent 10 years, the financial output indexes of Huizhou and Zhongshan have been in the shape of "inverted V". From the trend, the decline in Huizhou is slow, and that in Zhongshan is obvious.

4.3.2 Industry-Driven Analysis

Figure 3B and Fig. 3c show that: 1) Huizhou's advanced manufacturing industry and high-tech industry are obviously ahead of Zhongshan, more than 20%. In addition, Huizhou is adjacent to Shenzhen and has more opportunities to undertake manufacturing. It is worth mentioning that Huizhou has been listed as one of the "Seven Major Petrochemical Industrial Bases" during the 13th Five Year Plan period. In recent years, Huizhou has introduced large petrochemical projects such as CNOOC (US $ 5.6 billion) and ExxonMobil (US $ 10 billion). 2) Zhongshan has no advantage in seven indicators, such as advanced manufacturing industry, high-tech industry and innovative products (widely distributed in small household appliances, lighting, agriculture and fishery, furniture and other small industries).

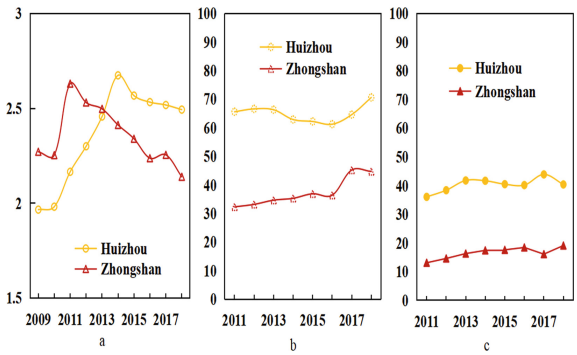

Fig. 3. Fiscal λ (a), advanced manufacturing industry proportion (b) and high-tech industry proportion (c). *Notes: we own the copyright of the image and of course we are free to use it.*

5 Conclusion

Based on theoretical analysis and empirical research, combined with the new tasks of China's high-quality economic development, the following policy suggestions are put forward:

First, Chinese cities should deeply adjust their own industries to ensure the stability and reliability of fiscal sources. The Shenzhen model means to take the road of "high-tech", "green" and "environmental protection", while the Guangzhou model means to take the road of "quality service", "livable city" and "headquarters economy". The former requires strong capital, talent and technology, while the latter requires a quality living environment, convenient transportation and an efficient business environment.

Second, Chinese cities should follow the model of coordinated development. Different cities should cooperate with each other, seek common ground while preserving differences. They also jointly cultivate characteristic industrial clusters, form a highly complete industrial chain and internal cycle path, and highlight the innovation advantages of rapid innovation and large-scale iteration.

Third, Chinese cities should upgrade industry from modern manufacturing, high-tech industries, to the future industry. The upgrading target of large and medium-sized enterprises should be "high technology manufacturing" mode, small and micro-enterprises should be "professional", "refined", "special", "novel" mode.

Notes: "professional", "refined", "special", "novel" mode was proposed by the Chinese government in 2012, which refers to the characteristics of a product or service in terms of performance, processing, technology, market, social benefits and economic value.

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