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Performance Evaluation of Maoming Science and Technology Finance based on Malmquist-DEA model

Ganzhou Wu

School of science, Guangdong University of Petrochemical Technology, Maoming 525000, China

ABSTRACT

Since the Malmquist index can analyze the change of decision-making units at different times and eliminate the factors of technological progress, it can get more accurate results than cross-sectional data. Therefore, by introducing Malmquist index and combining with BCC-DEA model, this paper analyzes the efficiency of the combination of science, technology and finance in different periods in Guangdong province, this provides a strong theoretical support for Maoming's co-ordination of science and Technology Innovation and Technology Finance. The study found that Maoming's innovation output was at the average level of Guangdong, but compared with Zhuhai and Shenzhen, Science and technology innovation was less dynamic and was at an unbalanced stage of development.

KEYWORDS

Science and Technology Finance; Science and Technology Innovation; Malmquist-DEA model

1. INTRODUCTION

At present, there is no specific research concept of science and technology finance in the whole society. With the continuous attention to the development of science and Technology and finance in our country, the pace of the combination of science and technology and finance is advancing continuously, the research on science and technology finance is not enough. Generally speaking, from the research results, the domestic and foreign research on the combination of science and Technology and Finance has reached a basic agreement, but the research level in the field of science and technology finance needs to be further improved. The related theory of “Science and Technology Finance” was put forward by Zhao Changwen [1] and accepted by many scholars, which provides effective reference and research value for the research development of science and Technology Finance. Xiao Zelei believes that technology finance is the product of many aspects of integration [2]. In the theory of economic development, Schumpeter is the first scholar to put forward the theory of innovation, and systematically expound it [3].

Wang proposed the “Two-step theory” of innovation formation [4]. Xu affirmed the supporting role of the regional innovation system [5]. Bart Leten's view of the early stages of innovation measures scientific and technological innovation in terms of capital investment and personnel [6]. Riddle and Schwer discuss technological innovation capacity in the United States from the perspective of knowledge stock and high-tech human capital [7]. In China, Ba Wuer River, Dong Yanbin and so on take the domestic 30 provinces and cities as the sample, carries on the research to each place science and technology innovation ability [8]. Zhu Xinling and Gan Lihua take our country 11 provinces and cities as research sample, take innovation input and innovation output as the index, comprehensively evaluated each place science and technology innovation ability [9].

In this paper, based on the principles of selecting indicators, the selected indicators can meet the input-output criteria of DEA model. Since the Malmquist index can analyze the change of decision-making units at different times and eliminate the factors of technological progress, it can get more accurate results than cross-sectional data.

2. MALMQUIST-DEA MODEL

At present, DEA method has become an effective analysis tool in economics, management and other important fields. Since the traditional DEA model can not reflect the efficiency change of DMU in different periods, this paper introduces Malmquist index and BCC model to analyze the difference of the efficiency of technology-finance integration between the two adjacent periods in Maoming, the results obtained by eliminating the factors of technical progress are more accurate than those obtained by cross-sectional data analysis.

(1) variable return on scale model (BCC model)

In fact, the appearance of imperfect competition and the change of state policy will make it difficult for enterprises to operate at the optimal scale, therefore, it is very necessary to establish a DEA model with variable returns of scale, which is the origin of BCC model. For any decision-making unit, it is possible to generate sets based on axiomatic assumptions of invalidity, convexity, taper, and minimization:

$$T = \left\{(X, Y) \middle| \sum_{j=1}^{n} X_j \lambda_j \le X_i, \sum_{j=1}^{n} Y_j \lambda_j \ge Y, j = 1,2, \dots, n\right\} \tag{1}$$

On this set, the BBC model in DEA model is obtained. Because the BBC model eliminates the effect of scale efficiency in calculating technical efficiency, the final result is pure technical efficiency:

$$\begin{cases} \min\left[\theta - \varepsilon\left(\sum_{i=1}^{n} s_i^- + \sum_{r=1}^{s} s_r^+\right)\right] \\ s.t. \quad \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{ij_0}, i \in (1,2, \dots, m) \\ \sum_{j=1}^{n} x_{rj}\lambda_j - s_i^+ = \theta y_{rj_0}, \ r \in (1,2, \dots, s) \\ \sum_{j=1}^{n} \lambda_j = 1, \ \theta, \ \lambda_j, \ s_i^- s_i^+ > 0, \ j = 1,2, \dots, n. \end{cases} \tag{2}$$

s_i^-, s_i^+ represents the relaxation variable, m, s are the number of input and output indicators, x_{ij_0}, y_{rj_0} are corresponds to the input i and output r of the $j_0$decision-making unit. $\varepsilon = 10^{-6}$.

If $\theta = 1$, $s_i^- = 0$, $s_i^+ = 0$, then the DMU-j is DEA efficient, scale efficiency and technical efficiency are both efficient.

If $\theta < 1$, $s_i^- \neq 0$, $s_i^+ \neq 0$, then the DMU is invalid for DEA, and it has the defects of redundant input and insufficient output, so it needs to be adjusted accordingly.

(2) Malmquist Index

The Malmquist index is defined by the distance function, and is based on the t-period technique T^t, which can be expressed as:

Based on the output angle can be expressed as:

$$M_0^t(x_{t+1}, y_{t+1}, x_t, y_t) = d_0^t(x_{t+1}, y_{t+1}) / d_0^t(x_t, y_t) \tag{3}$$

$$M_0^{t+1}(x_{t+1}, y_{t+1}, x_t, y_t) = d_0^{t+1}(x_{t+1}, y_{t+1}) / d_0^{t+1}(x_t, y_t) \tag{4}$$

Modelled on Fisher's structural ideal index method, Caves et al calculated (3) and (4) geometric mean (5) to measure the MALMQUIST index of cycle productivity change from t to t+1, to avoid possible differences due to the randomness of periodic selection. If the index is above 1, the Total factor productivity from t to t+1 is in a state of growth.

$$M_0(x_{t+1}, y_{t+1}, x_t, y_t) = \left(\frac{d_0^t(x_{t+1},y_{t+1})}{d_0^t(x_t,y_t)} \times \frac{d_0^{t+1}(x_{t+1},y_{t+1})}{d_0^{t+1}(x_t,y_t)}\right)^{1/2} \quad (5)$$

$(x_{t+1},\ y_{t+1})$represents the inputs and outputs of the t+1 period, similarly (x, y) represents the inputs and outputs of the t period; d_0^t and d_0^{t+1} represent the technical T^t of the t period, respectively, as a reference, the distance function of period t and period t+1, the Malmquist index obtained by the above steps, can be decomposed into the technical efficiency change index and the Technical Progress Index:

$$M_0(x_{t+1}, y_{t+1}, x_t, y_t) = \frac{d_0^t(x_{t+1},y_{t+1})}{d_0^t(x_t,y_t)} \times \left(\frac{d_0^t(x_{t+1},y_{t+1})}{d_0^t(x_{t+1},y_{t+1})} \times \frac{d_0^{t+1}(x_t,y_t)}{d_0^{t+1}(x_t,y_t)}\right)^{1/2} \quad (6)$$

The technical efficiency change index is the product of the Pure Technical Efficiency Index and the scale efficiency index, as follows:

$$Ech = \frac{d_0^{t+1}(x_{t+1},y_{t+1})}{d_0^t(x_t,y_t)} = \frac{SE_0^{t+1}(x_{t+1},y_{t+1})}{SE_0^t(x_t,y_t)} \times \frac{d_0^{t+1}(x_{t+1},y_{t+1}|V)}{d_0^t(x_t,y_t|V)} \quad (7)$$

Namely:

Technical Efficiency = pure technical efficiency × scale efficiency

Total factor productivity = Technical Efficiency X technical progress

3. EMPIRICAL ANALYSIS

As for Maoming's own statistical data, mainly based on the 2001-2023 Guangdong Science and Technology Statistical Yearbook and other 2023, to construct panel data of 21 prefecture-level cities, this paper analyzes and compares the efficiency of science and technology finance in Guangdong Province.

According to the above conditions, because the data of input and output variables in DEA model must not be negative, and the same four operations on the same index in DEA model do not affect the validity of decision making unit, this article uses the following form for regularization:

New data value = old data value + rounding the absolute value of the minimum data value + 1

In this paper, the original data are pre-processed into the corresponding formula, using the software DEAP2.1 to solve. The results are shown in Table 1.

Table 1. comparison of the results of machine decomposition of the comprehensive efficiency of science, technology and finance in Guangdong Province

City	Technical Efficiency Index	Technical Progress Index	Pure Technical Efficiency Index	Scale efficiency index	Total Factor Productivity Index
Guangzhou	1.000	1.043	1.000	1.000	1.043
Shaoguan	0.585	1.260	0.572	1.023	0.738
Shenzhen	1.000	0.847	1.000	1.000	0.847
Zhuhai	1.000	1.319	1.000	1.000	1.319
Shantou	1.000	1.125	1.000	1.000	1.125
Foshan	1.000	1.021	1.000	1.000	1.021
Jiangmen	0.978	1.047	0.967	1.012	1.024
Zhanjiang	1.497	0.975	1.000	1.497	1.459
Maoming	0.934	0.797	1.000	0.934	0.744
Zhaoqing	1.261	1.056	1.153	1.093	1.332
Huizhou	0.927	1.271	1.000	0.927	1.179
Meizhou	0.889	0.776	1.000	0.889	0.690
Shanwei	1.000	0.877	1.000	1.000	0.877
Heyuan	1.000	1.684	1.000	1.000	1.684
Yangjiang	1.000	0.835	1.000	1.000	0.835
Qingyuan	1.408	1.246	1.116	1.262	1.755
Dongguan	1.000	0.940	1.000	1.000	0.940
Zhongshan	1.027	0.933	1.000	1.027	0.958
Chaozhou	1.000	0.680	1.000	1.000	0.680
Jieyang	0.905	0.696	1.000	0.905	0.630
Yunfu	1.230	1.016	1.000	1.230	1.250
Average	1.014	0.996	0.984	1.031	1.010

As shown in Table 1, the technical efficiency and scale efficiency of Maoming City in Guangdong Province in 2021 were 0.934 and 0.934 respectively, but they were within the acceptable range.

TFP was 0.744, indicating that Maoming's 2021 science and technology shows that Maoming's science and technology output is relatively inadequate, we should improve the efficiency of science and technology output on the basis of keeping the scale of input to realize the optimization of scale benefit. In terms of the efficiency of technological progress, the drop in 2021was larger than that in 2020, at (0.797), indicating that Maoming's scientific and technological strength is weak and the development of new and high-tech industries needs to be strengthened. NET technical efficiency remained unchanged at 1.000 in 2021.

In terms of technical progress, all the cities except Maoming, Meizhou, Chaozhou and Jieyang had a technical progress index of less than 0.8, as shown in Table 1. This shows that Maoming is not very active in innovation activities and needs to be more active in innovation activities.

4. CONCLUSION

The model covers Maoming's science and technology innovation capability and the practical application of science and Technology Finance. Finally, based on the empirical results and analysis, the main advantages of the work done are as follows:

(1) To objectively and effectively evaluate Maoming's sci-tech innovation capability and sci-tech financial development, DEA PCA and DEA models were used respectively.

(2) The financial performance evaluation model of Malmquist-dea model is adopted, and the indexes which have high correlation with financial performance are selected scientifically and reasonably. In addition, the model structure is simple, convenient for mutual verification, more detailed analysis of the various cities in Guangdong province at different stages of technology and financial integration efficiency, this will provide strong theoretical support for Maoming's co-ordination of science and Technology Innovation and Technology Finance.

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