

Maoming's Technological Innovation and Technological Finance based on DEA

Ganzhou Wu

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

Abstract

We constructed a DEA model based on the data of the basic situation of research and development institutions in Maoming from 2012 to 2021. Under the condition of variable returns to scale, we chose the BCC method and applied matlab to obtain the relative evaluation results of Maoming's sustainable development.

Keywords

Technological Innovation; Technological Finance; DEA.

1. Introduction

The combination of science and technology and finance is to support the transformation of economic development and the cultivation strategy. The driving force of the emerging sex industry will also guide social capital to actively participate in innovation. We will greatly improve the transformation effect of scientific and technological achievements, and vigorously promote the spirit of science and craftsmanship. The development of technology finance will promote the improvement of the innovation system and strengthen the power of science and technology. Promote technology Organically combine innovation with modern finance, innovate and optimize financial tools to support the technology industry, guide financial institutions to increase support for innovation, and promote high-tech industries with high quality Quantitative development [1]. Therefore, to further promote the development of science and technology finance is a new era based on the self-development of science and technology. It is an important support for self-improvement and building a powerful country in science and technology. Improve financial support for technological innovation Institutions and mechanisms can boost the development and growth of small, medium and micro science and technology enterprises, and unblock innovative enterprises It can better support the research and development of key technologies of enterprises and promote the upgrading of emerging industries [2].

Technological finance as an independent concept was introduced in 1993 by the China Science and Technology Finance Promotion Association Proposed in the first enlarged meeting of directors. At present, science and technology finance has become a theoretical hotspot in the business world. Ang sees finance as an important influence on knowledge productivity [3]. King & Levine incorporates the financial system into the analysis framework of the endogenous growth model, prove that a good financial system can improve the success rate of innovation and accelerate economic growth [4]. Distortions in the financial system can make innovation less successful, which in turn slows economic growth. Zhao For the first time, Changwen et al. gave a clear definition of technological finance, which is to promote Systematic and innovative arrangements of a series of financial instruments and policies for the development of science and technology [5]. The essence of technological finance is to support and promote the development of technological innovation through various financial resources. It is a relationship in which nonlinear coupling promotes and complements each other [6]. On the one

hand, the Section Technological finance provides diversified financing channels and services for technological innovation, effectively reducing innovation financing Difficulty and cost, improve the success rate of scientific and technological innovation [7]. On the other hand, technological innovation is Finance provides new technologies, promotes the upgrading of financial services, and improves the efficiency of financial services. Effectively promote the high-quality development of finance [8]. After the hard work of some scholars, the collaborative development model related to technological innovation and technological finance has also come out, but the situation of each city is different, so the model may have certain errors for different cities, which also shows that we need to establish different models for different cities to analyze and solve to minimize the error. How to establish a scientific and technological innovation and scientific and technological financial evaluation model for a place or city that conforms to its development law has also become a problem to be solved. We intend to construct a mathematical model for the evaluation of technological innovation and technological finance in Maoming.

2. The DEA Model

2.1. Introduction of DEA

Data Envelopment Analysis (DEA) is based on the concept of "relative efficiency" by well-known operations research scientists A. Charnes and W. W. Copper and other scholars. A systematic approach to assessing relative effectiveness or benefit. The main steps of the DEA method are shown in Figure 1: Among them, DMU is the decision-making unit of DEA. In the field of DEA research, the consumption (or input) of a production process is called "Inputs", and the products (or outputs) based on consumption are called "Outputs". For example, for an educational institution, the input can be teachers, projectors, staff wages, etc.; the output can be the number of students, the improvement of students' performance, and the total income. Usually, input indicators and output indicators have the following properties:

(1) Generally, input indicators are negative and negative indicators, while output indicators are positive indicators, that is to say, our input indicators are a consumption of resources, and the smaller the better; while the output indicators are a kind of consumption of resources. The indicators represent the results achieved on consumption, so the bigger the better, the more beneficial to the decision-making unit. Similarly, in the study of science and technology innovation and science and technology finance in Maoming City, but in our actual life, sometimes there are situations that contradict the generality, that is, the output indicators are not motivated, and the input indicators are not motivated. For example, in the operation of an educational institution, there will be students whose grades improve and students whose grades decline or who do not move forward. Students whose grades improve are what the educational institution expects, while students whose grades decline or fail to move forward are not. As expected by educational institutions, the processing of undesired output indicators often linearly transforms raw data into expected inputs or outputs.

(2) Dimensionless, that is, the efficiency value of DEA has nothing to do with the dimension selection of the index, but it must be ensured that the dimensions of all the evaluated units of the unified index are the same.

(3) Handleability, the output index value will not appear the phenomenon that the input increases and the output decrease accordingly.

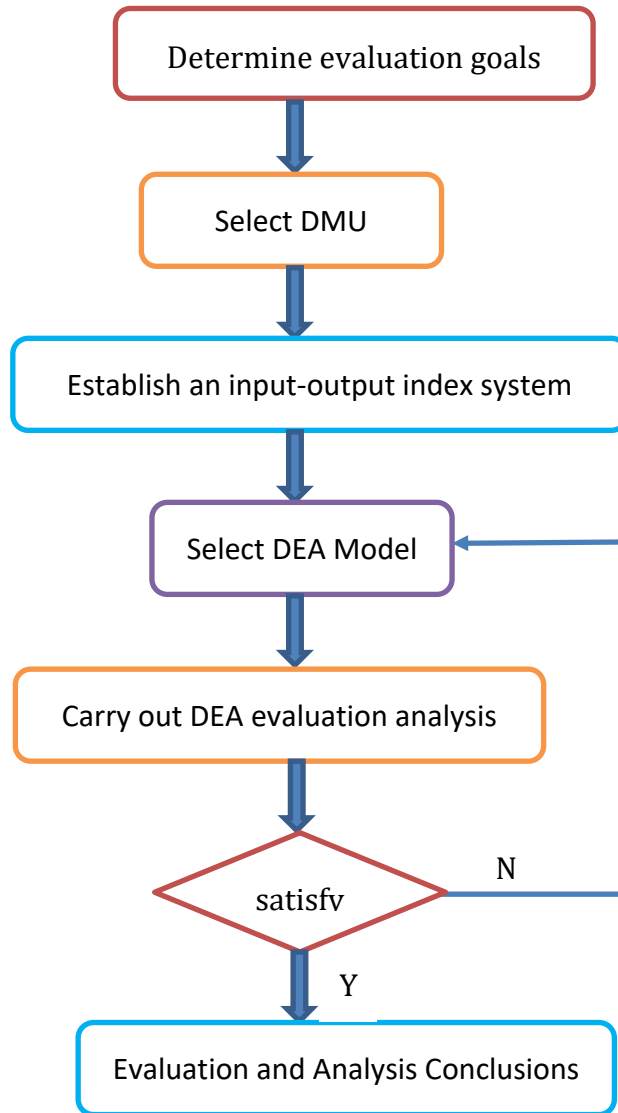


Figure 1. Steps of DEA

2.2. BBC Model

There are many basic models of DEA, such as CCR, DEA-Malmquist model and so on. Based on the impact of returns to scale on production systems, Banker, Charnes and Cooper proposed the BCC model.

Input-Oriented BBC Model:

$$\begin{aligned}
 & \max \sum_{r=1}^s u_r y_{rd} + u \\
 & \text{s. t.} \\
 & \sum_{r=1}^s u_r y_{rj} - \sum_{i=1}^m w_i x_{ij} + u \leq 0, j = 1, \dots, n. \\
 & \sum_{i=1}^m w_i x_{id} = 1 \\
 & w_i > 0, i = 1, \dots, m \\
 & u_r > 0, r = 1, \dots, s
 \end{aligned} \tag{1}$$

Its dual problem is:

$$\begin{aligned}
 & \min \theta_d \\
 & \text{s. t.} \\
 & \sum_j^n \lambda_j x_{ij} \leq \theta_d x_{id}, i = 1, \dots, m \\
 & \sum_j^n \lambda_j y_{rj} \geq y_{rd}, r = 1, \dots, s \\
 & \sum_j^n \lambda_j = 1 \\
 & \lambda_j \geq 0, j = 1, \dots, n
 \end{aligned} \tag{2}$$

Output-oriented BCC model:

$$\begin{aligned}
 & \min \sum_{i=1}^m w_i x_{id} - w \\
 & \text{s. t.} \\
 & \sum_{i=1}^m w_i x_{ij} - \sum_{r=1}^s u_r y_{rj} - w \geq 0, j = 1, \dots, n. \\
 & \sum_{r=1}^s u_r y_{rd} = 1 \\
 & w_i > 0, i = 1, \dots, m \\
 & u_r > 0, r = 1, \dots, s
 \end{aligned} \tag{3}$$

Its dual problem is:

$$\begin{aligned}
 & \max \varphi_d \\
 & \text{s. t.} \\
 & \sum_j^n \lambda_j x_{ij} \leq x_{id}, i = 1, \dots, m \\
 & \sum_j^n \lambda_j y_{rj} \geq \varphi_d y_{rd}, r = 1, \dots, s \\
 & \sum_j^n \lambda_j = 1 \\
 & \lambda_j \geq 0, j = 1, \dots, n
 \end{aligned} \tag{4}$$

The value of u in the input-oriented BCC model is not limited and can be greater or less than 0. When $u \geq 0$, it indicates that the model evaluates decision-making units in a production system with non-decreasing planning rewards; when $u \leq 0$, it indicates that the model evaluates decision-making units in a production system with non-increasing planning rewards; in output-oriented In the type BCC model, when w is not constrained, it means that the model does not consider the increase in returns to scale or the impact on the production system; when $w \geq 0$, it means that the model evaluates decisions in a production system with non-increasing

planning returns unit, when $w \leq 0$, it indicates that the model evaluates decision-making units in a production system with a non-decreasing planning system reward.

3. Result Analysis

3.1. Selection of Evaluation Indicators

We use the DEA model in the data envelope to analyze this, which is a systematic analysis method to evaluate the relative effectiveness or benefit of the same type of department according to the multi-indicator input and multi-indicator output. Taking the input and output weights of the decision-making unit as variables, evaluating from the most favorable aspect effectively avoids excessive analysis due to the selection of which index is the most suitable, removes many unnecessary subjective factors, and makes objectivity enhanced. It is found that most people use this method to evaluate the relative benefits of technological finance and technological innovation. They are shown in [Table 1](#):

Table 1. Input-output original variable indicators of technological finance and technological innovation

item	index	Attributes
Technology and Finance Investment Indicators	Internal expenditure of R&D funds	Ten thousand
	Government funding	Ten thousand
	business expenses	Ten thousand
	Total Venture Capital Management	Ten thousand
Technological Finance Output Indicators	Full-time equivalent of R&D personnel	people/year
	number of patent applications	piece
	Number of patents granted	piece
	new product output	Ten thousand
	New product sales revenue	Ten thousand

To make the relative benefit evaluation results of the DEA model credible, the relationship between the input and output of its technology must be positively correlated. Therefore, we use SPSS software to test the correlation between the input indicators of science and technology finance and the output indicators of scientific and technological innovation. The results show that the correlation coefficients between the indicators of Maoming are all positive numbers, that is, the input and output indicators are positive.

3.2. Results of DEA

Table 2. DEA Results of Technological Finance and Technological Innovation in Maoming

Year	θ	results
2012	1.000	efficient
2013	1.000	efficient
2014	0.810	not efficient
2015	0.791	not efficient
2016	0.776	not efficient
2017	0.832	not efficient
2018	0.689	not efficient
2019	0.997	efficient
2020	1.000	efficient
2021	1.000	efficient

According to the principle of the BBC model, using MATLAB to program and run, the final results of technology finance and technological innovation in Maoming is shown in [Table 2](#). DEA composite scores θ are explained below in [Table 3](#).

Table 3. The effective relationship between efficiency score and DEA

DEA Efficiency Score	Decision-Making Unit (DMU) Overall Efficiency
1	It is in an effective state, indicating that the input and output are very balanced, and the amount of input is very small, but the output is large, forming a good level of development.
[0.9,1)	In a relatively effective state, it shows that the investment and production of technological finance and technological innovation are relatively effective, and only need to make certain adjustments to achieve overall effectiveness.
[0.1,0.9)	In an ineffective state, various departments need to adjust the economic aspects and relevant policies to meet the current situation in order to achieve an effective state.
[0,0.1)	It is in an invalid state, which is different from the normal operation law of the social economy.

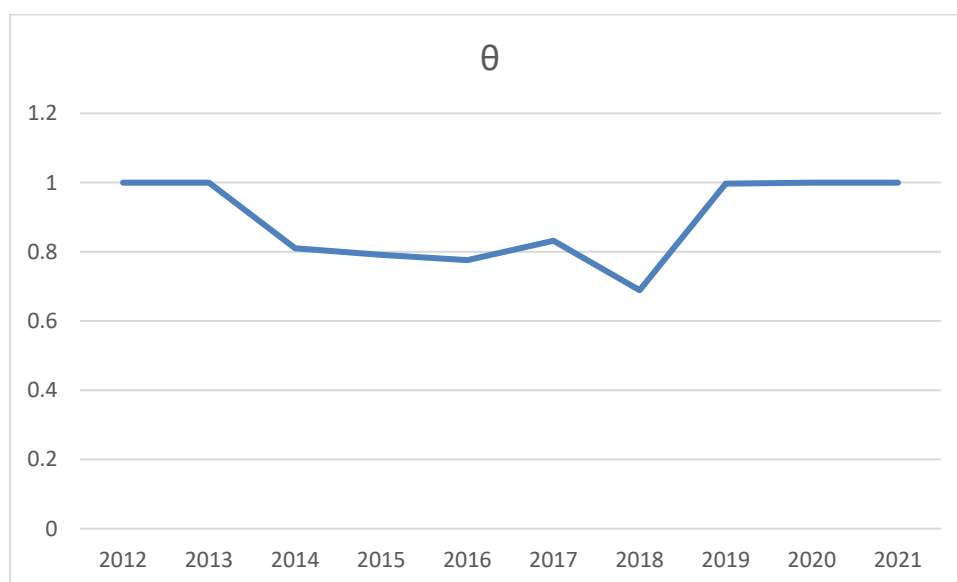


Figure 2. DEA evaluation results of science and technology finance in Maoming

According to the results in Table 2 and Figure1, we can see that from 2012 to 2021, the city's average comprehensive benefit of science and technology finance was 0.890, which was in the ineffective state of DEA and was still far from the overall effective value. During this period, the development of technology and finance in the city was not very satisfactory, and the efficiency was not high. Since the average value of pure technical efficiency is 0.929, and the average value of scale efficiency is 0.957, we can know that the main reason for the low overall efficiency of the city is the low pure technical benefit, and the pure technical input and output of technology finance should be adjusted, so as to make the resource structure reasonable and effective, and achieve the overall effective state of DEA. In 2012, 2013, 2020 and 2021, the average score of development efficiency was 1, reaching DEA's effectiveness, but the comprehensive benefits in the remaining years failed to achieve overall efficiency and effectiveness.

In order to better explore the development relationship of each indicator in the past 10 years, we combined the deap2.1 software on the original basis to further analyze the evaluation results of relative benefits.

Table 4. Overall efficiency of science and technology finance in Maoming

Year	Overall efficiency	pure technical efficiency	scale efficiency	returns to scale
2012	1.000	1.000	1.000	-
2013	1.000	1.000	1.000	-
2014	0.810	0.860	0.942	decrease
2015	0.791	0.828	0.956	increment
2016	0.776	1.000	0.776	decrease
2017	0.833	0.877	0.949	decrease
2018	0.689	0.722	0.954	increment
2019	0.997	1.000	0.997	decrease
2020	1.000	1.000	1.000	-
2021	1.000	1.000	1.000	-
average	0.890	0.929	0.957	

Judging from the scale efficiency in the past 10 years, the average scale efficiency of the city is 0.957, and the DEA is not effective, but it is not far from 1, indicating that the overall level is at a very high level. Although only the DEA in 2012, 2013, 2020 and 2021 was in effect during this decade, in addition to these 4 years, there are 5 years in the remaining 6 years. The efficiency value is between 0.9 and 1, and the distance from 1 is not much different, that is, the input and output are relatively efficient; in general, the development of scale efficiency is at a high level from 2012 to 2021.

4. Conclusion

From 2012 to 2021, the average score of pure technical efficiency in Maoming was 0.929, which did not reach an effective state, but it was also at a relatively high level of development. The pure technical efficiency score of the remaining 6 years is 1, achieving the effective state of DEA, indicating that the investment and output of science and technology finance in recent years have developed very well, and the overall policies and adjustments are in line with the current situation; The pure technical efficiency value of the years in the effective state is between 0.7 and 0.9, and only one year has a score of 0.7 to 0.8, which means that it has been in a stable and relatively good state in these 10 years.

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