

Evaluation of China's Provincial and Municipal Financial Science and Technology Input-Output Efficiency in the "Belt and Road" Initiative

—Based on super-efficient DEA model and Malmquist index analysis method

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Keywords: "One Belt and One Road"; financial technology input-output efficiency; super-efficiency DEA model; Malmquist index

Abstract: The article uses the super-efficient DEA model and the Malmquist index analysis method to evaluate the efficiency of fiscal science and technology input and output in 18 provinces and cities in China from 2013 to 2016 in the "Belt and Road" initiative area, and uses the Tobit regression model to analyze the impact of fiscal technology input and output Factors affecting the external environment. The research results show that: in terms of static analysis, the overall efficiency of fiscal science and technology input and output in 18 provinces and cities along the "Belt and Road" initiative area is relatively high but the regional differences are obvious; in terms of dynamic analysis, the Malmquist index showed a slight downward trend from 2013 to 2016.

1. Introduction

The "Belt and Road" initiative is the abbreviation of the cooperative initiative of "New Silk Road Economic Belt" and "21st Century Maritime Silk Road" proposed by China. Technological innovation is the cornerstone of the "Belt and Road" initiative. The degree of technological innovation determines the height of the sustainable development of the "Belt and Road". The government should pay more attention to the "Belt and Road" technological innovation. The development of science and technology requires the investment of national financial funds. Since the proposal of the "Belt and Road Initiative", the total amount of financial investment in science and technology in 18 provinces and cities along the route delineated by China (including municipalities and autonomous regions, the same below) has been increasing, from 1351.9 in 2013 100 million yuan has increased to 194.05 billion yuan in 2016, an increase of 43.6% in four years. It has actively and effectively promoted the technological innovation and progress of the "Belt and Road" initiative, and provided sustained power for the economic development of countries and regions along the "Belt and Road Initiative". Considering the basic national conditions of China's vast territory and uneven development among different regions, the Chinese government should not only focus on the increase in the total amount of financial science and technology input from various provinces and cities, but also further improve the efficiency of the use of financial technology investment funds. The Chinese government has identified 18 provinces and cities in the "Belt and Road" initiative, and there are large differences in financial science and technology investment between different regions. Therefore, it is necessary to discuss the efficiency of the use of financial science and technology funds in different regions.

Since the "Belt and Road" initiative was put forward, relevant research has been mostly placed on the trade and policy interpretation of countries along the "Belt and Road" initiative. For example, Kong et al. [1] calculated and analyzed the trade facilitation level of more than 60 countries along the "Belt and Road" initiative by constructing a complete trade indicator system. The results show that the "Belt and Road" initiative can improve the trade facilitation level of various countries. To tap the trade potential between different countries and regions. Fang et al. [2] used the stochastic frontier model to measure the export potential of cultural products between China and the countries along the initiative, and reached the conclusion that the regional export potential of cultural

products is unevenly distributed. Wei et al. [3] used the QAP model to examine the structural characteristics of the “Belt and Road” national agricultural trade network. Song et al. [4] analyzed the topological relationship between the “Belt and Road” trade network and the global trade network using methods such as community discovery and topological network visualization, and clarified the important position of the “Belt and Road” trade zone in global trade.

1.1. Related Work

Many scholars at home and abroad have adopted different evaluation methods to measure and analyze the efficiency of science and technology. Li Zheng [6] studied the effect of fiscal decentralization on the efficiency of regional scientific and technological innovation by using panel simultaneous equations and stepwise regression analysis. Gao et al. [7] uses the DEA-BCC model to analyze the innovation efficiency of Qingdao Marine Science and Technology. Li et al. [8] Wang et al. [9] uses the three-stage DEA model to measure the input-output efficiency of China’s provincial science and technology finance in 2015. The results show that China’s science and technology finance efficiency is generally low, and corresponding improvement suggestions are given based on the measurement results. While paying attention to the efficiency of the use of scientific and technological investment funds, many scholars have also conducted relevant research on the efficiency of scientific and technological achievements. Cherchye et al. [10] used data envelopment analysis to measure the impact of various factors on the output of scientific and technological achievements. De et al. [11] used data envelopment analysis and decision tree models to measure the impact of technological innovation on corporate performance. Sueyoshi et al. [12] used data envelopment analysis to measure the impact of ecological technology input-output efficiency on environmental improvement. SchmidtEhmcke et al. [13] combines the traditional stochastic frontier method and the super-efficiency model to measure the research and development efficiency of different countries. The results show that the increase in investment in the technology industry is conducive to the improvement of research and development efficiency. Nasierowski et al. [14] used the DEA model to measure the efficiency of innovation investment.

It can be seen that Data Envelopment Analysis (DEA) is widely used in performance evaluation and analysis, and is the mainstream method for evaluating the effectiveness of decision-making units. Existing literature studies on the “Belt and Road” initiative are mostly focused on policy analysis and international trade issues, and there are few studies on the efficiency of fiscal science and technology input and output in the provinces and cities in the “Belt and Road” initiative. This paper uses the super-efficiency DEA model and Malmquist index analysis method to evaluate and analyze the efficiency of the 18 provinces and cities in the use of financial science and technology investment funds delineated in the "Belt and Road" initiative area from 2013 to 2016, and finds out the low efficiency values in some provinces.

2. Research methods, variables and data description

2.1 Research methods

2.1.1 Super efficiency DEA model

The traditional DEA model was first proposed by American operations researchers A. Charnes and W.W. Cooper. Andersen and Petersen proposed the super-efficient DEA model based on the traditional CCR model. The main purpose is to overcome the problem that the traditional DEA model cannot further sort the fully effective decision-making units. The super-efficiency can compare and sort all the decision-making units. Assuming that each decision-making unit has K input unit and M output unit, the vectors X_j and Y_j represent the j decision unit, the input relaxation variable S^+ and the output relaxation variable S^- are introduced to evaluate the decision unit TTT, and its super efficiency The DEA model is:

$$\min \left[\theta - \varepsilon \left(\sum_{i=1}^m s_i^- + \sum_{r=1}^s s_r^+ \right) \right] \quad (1)$$

$$s.t. \begin{cases} \sum_{\substack{j=1 \\ j \neq j_0}}^n X_j Y_j + s^- = \theta X_{j_0} \\ \sum_{\substack{j=1 \\ j \neq j_0}}^n Y_j \lambda_j - s^+ = Y \\ \lambda_j \geq 0 (j = 1, 2, 3, \dots, n) \\ s^+ \geq 0, s^- \geq 0 \end{cases} \quad (2)$$

2.1.2 Malmquist index analysis method

In the early 1850s, Swedish economist Sten. Malmquist proposed the evaluation model of total factor productivity index. In 1982, Caves first used this model to measure production efficiency. Then Fare et al. Built a dynamic Malmquist index model based on the static DEA model, that is, Total Factor Productivity Change. The Malmquist index analysis method can analyze the efficiency value of different decision-making units by measuring the Malmquist index $M(x^{t+1}, y^{t+1}, x^t, y^t)$ of the decision-making unit in period t and period $t + 1$. The formula of Malmquist index is expressed as:

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

2.2 Selection of evaluation indicators and data sources

The key to the DEA model's measurement of input-output efficiency lies in the selection of indicators of decision-making units. The input index mainly considers the two major production factors of labor and capital, and selects financial technology input, R&D funding input, R&D practitioners and regional high-tech industry investment as input indicators. With regard to the selection of output indicators, taking into account the important role of international trade in promoting the economy of the provinces and cities in the “Belt and Road” initiative, this paper adds the existing financial science and technology input-output efficiency research and has never used high-tech product import and export trade as The output index, together with the number of high-tech enterprises and the import and export trade volume of high-tech products, constitutes a financial science and technology input-output efficiency index system for provinces and cities along the Belt and Road Initiative.

3. Evaluation of the input and output efficiency of financial science and technology

3.1 Super efficiency DEA analysis

Substitute the input-output indicator data from 2013 to 2016 into DEA-Solver5.0 software, and select the super-efficiency model with constant scale returns to measure and analyze the “Belt and Road” 18 provinces and municipalities' financial science and technology input-output efficiency, and its evaluation results as shown in table 1.

It can be seen from the evaluation results in Table 1 that from 2013 to 2016, the efficiency values of financial science and technology input and output of 18 provinces and cities along the “Belt and Road” route ranged from 1.2 to 1.3, and showed an upward trend year by year. 1.20 rose to 1.24 in 2016, and increased by four percentage points in 4 years, and the annual super efficiency value is greater than 1, which means that the decision-making unit is generally effective, indicating that 18 provinces and cities along the “Belt and Road” route invested in financial technology The output is generally effective. The highest average value of super-efficiency from 2013 to 2016 is Guangdong Province, which is 2.26, which is an effective unit of DEA. The lowest efficiency value is Gansu Province, which is only 0.76, which is an invalid DEA unit. Further analysis shows that the efficiency of fiscal science and technology input and output varies greatly in different regions. The

coastal area has the highest efficiency value, with an average super efficiency of 1.632, followed by the southwest and northeast regions, with average super efficiency of 1.15 and 1.10, respectively. The average value is 1.03, and there is still a certain distance compared with other regions.

Table 1 2013-2016 “Belt and Road” Chinese provinces and cities fiscal science and technology input and output super efficiency value

Regional	DMU	2013	2014	2015	2016	Mean	Rank
Northwest	Xinjiang	1.25	1.12	1.05	0.93	1.09	11
	Shaanxi	1.06	0.93	0.81	0.88	0.92	16
	Gansu	0.83	0.83	0.71	0.77	0.76	18
	Ningxia	0.84	1.14	0.65	0.61	0.81	17
	Qinghai	0.96	0.97	1.16	1.07	1.04	13
	Inner Mongolia	1.73	1.67	1.42	1.38	1.55	4
Southwest	Guangxi	0.96	0.94	1.08	1.24	1.06	12
	Yunnan	1.18	1.16	1.22	1.04	1.15	8
	Tibet	1.12	0.97	0.96	1.06	1.03	14
	Chongqing	1.11	1.10	1.54	1.63	1.35	5
Northeast	Heilongjiang	1.16	1.19	1.16	1.11	1.16	7
	Jilin	1.16	1.12	1.09	1.20	1.14	9
	Liaoning	0.81	0.77	1.10	1.28	0.99	15
Coastal area	Shanghai	1.07	1.63	2.30	2.66	1.91	2
	Fujian	1.11	1.04	1.12	1.13	1.10	10
	Guangdong	2.43	2.77	1.89	1.94	2.26	1
	Zhejiang	1.69	1.58	1.80	1.83	1.73	3
	Hainan	1.12	1.06	1.39	1.06	1.16	6
Mean		1.20	1.22	1.25	1.27	1.24	

From the analysis of various provinces and cities within the region, the overall efficiency value of the coastal area is the highest, with an average value of 1.63, and it has increased year by year, from 1.484 in 2013 to 1.724 in 2016, an increase of 24 percentage points in 4 years. Among the coastal regions, Guangdong, Shanghai, and Zhejiang have developed economically and have complete supporting equipment for related science and technology. Therefore, these provinces have a relatively high level of financial technology input and output efficiency. The economic development levels of Fujian and Hainan are average, and the efficiency of financial science and technology input and output is basically at a medium level. As the core area of the 21st century Maritime Silk Road construction, Fujian Province is an important link connecting China and Southeast Asian countries. Since the proposal of the “Belt and Road” initiative, Fujian Province has actively adhered to the policy of going abroad and bringing in, and has made significant progress in the construction of “Haisi” interconnected channels, the construction of economic and trade platforms, and the innovation of systems and mechanisms. Fujian Province should increase the total investment in fiscal science and technology and increase the efficiency level of fiscal science and technology input and output to promote scientific and technological progress and economic development.

4. Research conclusions and countermeasures

This paper uses the super-efficiency DEA model and Malmquist index analysis method to evaluate the efficiency of financial science and technology input and output of 18 provinces and cities along the “Belt and Road” initiative area from 2013 to 2016, and uses Tobit regression to analyze the external environmental factors of financial technology input and output. And the degree of impact, relevant conclusions and countermeasures are as follows:

Static super-efficiency DEA results show that the average value of the input and output

efficiency of financial science and technology of the provinces and cities along the “Belt and Road” initiative area from 2013 to 2016 is relatively high, and the overall reached the effective production frontier. Further analysis shows that the financial science and technology input and output efficiency values of various provinces and cities vary greatly, mainly manifested as the highest in coastal areas, followed by southwest and northeast, and the lowest in northwest. From the perspective of the provinces and cities along the initiative area, Guangdong, Shanghai and Zhejiang have higher average value of financial science and technology input and output efficiency, while Shaanxi, Gansu, Liaoning and Ningxia have lower average efficiency. Provinces and cities should choose science and technology development strategies according to local conditions and improve the efficiency of financial science and technology input and output. The provinces and cities along the proposed area should also play a role in the radiating role of the provinces and cities with higher efficiency in financial science and technology input and output. The improvement of the efficiency of financial technology input and output. At the same time, technology transfer and financial support from coastal areas to the northeast, southwest, and northwestern regions should also be increased to realize exchanges and cooperation in areas with high efficiency of financial science and technology input and output and areas with low efficiency, and to promote the rational and effective allocation of resources.

Overall, the provincial science and technology input and output of the “Belt and Road” initiative areas are generally effective but the regional differences are obvious. The government should give full play to the radiation and driving effect of regions with high efficiency of financial science and technology input and output. Output efficiency. Provinces and cities with low efficiency values should also seize the important opportunity of the “Belt and Road” initiative, strengthen regional cooperation and exchanges, and implement the go-out strategy, not only to reasonably adjust the input-output structure from internal factors, but also from external environmental factors such as Strength, industrial structure, regional openness, and government support provide a good environment for scientific and technological development, improve the efficiency of financial input and output of science and technology, and achieve economic and efficient development.

References

- [1] Kong Qingfeng, Dong Hongwei. "Belt and Road" countries' trade facilitation calculation and trade potential research [J]. *International Trade Issues*, 2015 (12): 158-168.
- [2] Fang Ying, Ma Rui. China and the countries along the “Belt and Road” cultural trade potential and influencing factors: an empirical study based on the stochastic frontier gravity model [J]. *World Economic Research*, 2018 (1): 112-121.
- [3] Tan Jingrong, Wang Sisi, Chen Shengjie. Research on the trade potential of major agricultural products between China and five Central Asian countries under the background of “One Belt and One Road” [J]. *Business Economics and Management*, 2016 (1): 90-96.
- [4] Song Zhouying, Che Shuyun, Zhang Wei. Research on the trade characteristics of China and the countries along the “Belt and Road” [J]. *Bulletin of the Chinese Academy of Sciences*, 2017, 32 (04): 41-47.
- [5] Zhang Huiqing. A study on the trade potential between China and the regions along the “Belt and Road” [J]. *International Trade Issues*, 2017 (07): 87-97.
- [6] Li Zheng, Yang Siying. Fiscal decentralization, government innovation preference and regional innovation efficiency [J]. *Management World*, 2018 (12): 34 (12), 29-42 + 110 + 193-194
- [7] Gao Tianyi, Chang Fei, Gao Siqi. Research on the Transformation and Upgrading of Qingdao Marine Economic Industrial Structure——Analysis and Evaluation Based on Technological Innovation Efficiency [J]. *Management Review*, 2018, 30 (12): 42-48.
- [8] Li Linhan, Wang Hongyan, Tian Weimin. Research on inter-provincial technology financial efficiency and its influencing factors based on the three-stage DEA-Tobit model [J]. *Science and*

Technology Management Research, 2018, 38 (02): 231-238.

[9] Wang Ning, Xu Youzhen, Yang Wencai. Based on factor analysis and DEA model of Henan province 's scientific and technological talent policy implementation effectiveness evaluation [J]. Scientific Management Research, 2018, 36 (04): 69-72.

[10] Cherchye L, Moesen W, Rogge N, et al. Creating composite indicators with DEA and robustness analysis: the case of the technology achievement index [J]. Journal of the Operational Research Society, 2008, 59 (2): 239- 251.

[11] Wu D. Detecting information technology impact on firm performance using DEA and decision tree [J]. International Journal of Information Technology and Management, 2006, 5 (2): 162-174.

[12] Sueyoshi T. Damages to return with a possible occurrence of eco-technology innovation measured by DEA environmental assessment [J]. Journal of Economic Structures, 2017, 6 (1): 52-76.

[13] Schmidtehmcke J, Zloczynski P. Industries at the World Technology Frontier: Measuring R & D Efficiency in a Non-Parametric DEA Framework [J]. Cepr Discussion Papers, 2011, 9 (3): 112-146

[14] Nasierowski W. Assessment of technical efficiency of NIS with the use of DEA [C] IEEE International Conference on Management of Innovation & Technology. IEEE, 2008.