Research on the Integration Efficiency of Science and Technology Finance in Jiangsu Province based on DEA Model

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Abstract— *Using data envelopment analysis (DEA) to measure the integration efficiency of science and technology finance in Jiangsu Province from 2009 to 2019, the results show that the overall efficiency of science and technology finance integration in Jiangsu Province during this period was not good, and it was only in a comprehensive and effective state for 5 years. There are 2 years in a state of pure technical inefficiency, and 5 years in a relatively effective state of scale efficiency. According to the actual situation of Jiangsu Province, the following suggestions are put forward for relevant departments: improve the financial credit system of technology enterprises, improve the intermediary service market system, and optimize the investment structure of science and technology finance.*

Keywords— *Data envelopment analysis; science and technology; finance; efficiency.*

I. INTRODUCTION

Science and technology are the primary productive forces and an important source of promoting social and economic development. Finance is the blood of the real economy, providing financial support for the operation and development of enterprises. For the birth of any scientific and technological achievement, financial capital runs through every process from research and development, application and transformation to industrialization. Looking back at the world's economic development over the centuries, it is clear that the close connection between technology and finance is unstoppable. The report of the 19th National Congress of the Communist Party of China clearly pointed out that my country's economic development has entered a stage of high-quality development, and is currently facing problems such as economic structural reform and growth momentum adjustment. In recent years, my country's R&D expenditure has reached a new high year by year, and the R&D expenditure intensity has also continued to increase. The R&D expenditure intensity has risen from 1.66 in 2009 to 2.24 in 2019.

In recent years, in order to improve the integration efficiency of science and technology and finance, Jiangsu Province insists on innovation-driven development and financial services to the real economy, the financial investment in the technology industry has been increasing year by year, and at the same time, it has strengthened the financial services to the real economy and improved the technological innovation capabilities of enterprises. , providing a great help for the integrated development of science and technology and finance in my country. In addition, the government has given preferential conditions in related policies to vigorously support scientific and technological innovation projects. It can be seen that Jiangsu Province has invested a lot in the integration of science and technology and finance. Therefore, it is particularly important to measure and study the integration efficiency of science and technology finance in Jiangsu Province, identify problems and put forward suggestions for improvement.

II. OVERVIEW OF DATA ENVELOPE ANALYSIS (DEA)

The data envelopment analysis method is a method used to evaluate the relative effectiveness of similar departments. Its essential idea is relative efficiency and linear programming. By selecting the input and output indicators of each decision-making unit, various indicators are determined. The optimal weight coefficient of, constructs a multi-input index and multi-output index evaluation system composed of multiple DMUs. According to the input index data and output index data, the relative efficiency of decision-making units can be evaluated, that is, the relative effectiveness between departments, enterprises or periods can be evaluated.

The data envelopment analysis method is divided into two models. One is the CCR model, which assumes the constant return to scale and measures the overall efficiency, including scale efficiency and technical efficiency. The overall efficiency is the numerical product of scale efficiency and technical efficiency. The second is the BCC model, which is to analyze the contribution of pure technical efficiency when all DUMs (decision-making units) are not operating at the optimal scale. The specific evaluation rules of the CCR model are as follows: when the score is 1, it indicates that the DUM has reached an effective level as a whole, and the input and output are balanced; when the score is in the range of 0.9 to 1, it indicates that the DUM is relatively effective as a whole. Improve efficiency; when the score is lower than 0.9, it indicates that the DUM is ineffective as a whole, and it is necessary to improve and adjust the input and output.

III. RESEARCH ON THE EFFICIENCY OF SCIENCE, TECHNOLOGY AND FINANCE INTEGRATION IN JIANGSU PROVINCE

A. Indicator selection and data processing

Using the DEA model to analyze the efficiency of the integration of science and technology finance, this paper first divides the evaluation indicators of science and technology into two parts: input index and output index, combined with the

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cases to be studied, referring to Qiao Hong, Guo Yajing, Meng Liyang (2016), Zeng Sheng, Zhang Minglong (2016), Jiang Yong, Yan Xiaoxu et al. 2017), Jiang Junxian (2017) and other scholars' methods, and with reference to the actual situation in Jiangsu Province, the final selected indicators are as follows:

TABLE 1. Input and output indicators of science and technology finance

Category	Indicator
Financial input	R&D personnel full-time equivalent
	Internal expenditure of R&D funds
	New product development expenses
Science and technology output	Number of domestic patent applications granted
	New product sales revenue

First, in terms of financial investment, it mainly includes financial investment in science and technology finance and investment in scientific research personnel. The core activity of scientific and technological activities is scientific research and experimental development (R&D) activities. The amount of R&D expenditure, the total number of scientific researchers and the strength of scientific and technological innovation in the region are closely related. The full-time equivalent of R&D personnel can better measure the investment in human resources; the internal expenditure of R&D funds refers to the actual expenditures used by the research and development institution in the institution in that year. Therefore, this paper will select the internal expenditure of R&D funds and the full-time equivalent of R&D personnel as the An important indicator reflecting investment in technology finance. At the same time, the expenditure of new product development funds is selected as an indicator to measure the investment in science and technology finance of various enterprises.

Secondly, in terms of scientific and technological output, the number of domestic patent applications granted is typically used to evaluate the output of scientific and technological activities, and they can directly reflect the scientific and technological innovation achievements of a country or region. Moreover, this paper also selects the new product sales revenue as an indicator to directly reflect the commercial output of scientific and technological achievements.

Obviously, there is a time lag effect in the relationship between technological output and financial input. Usually, the current financial investment will affect the scientific and

technological achievements of the following year or even several years after. Referring to the processing methods of relevant scholars, this paper will set a time difference of 1 year, that is, the technological output lags behind the financial input by 1 year. In the processing of the DEA model data, it is reflected that the output data is delayed by 1 year compared with the input data. Relevant data come from China Science and Technology Statistics Network.

B. Empirical analysis on the efficiency of science and technology finance integration in Jiangsu Province

Based on the index data of science and technology finance in Jiangsu Province for 11 years from 2009 to 2019, Deap2.1 is used for calculation, and the results are shown in Table 2 & Table 3 below:

TABLE 2. Calculation results of the integration efficiency of science, technology and finance in Jiangsu Province from 2009 to 2019

Year	Comprehensive Efficiency	Pure Technical Efficiency	Scale Efficiency	Returns to Scale Stage
2009	1.000	1.000	1.000	-
2010	1.000	1.000	1.000	-
2011	0.833	0.834	0.999	irs
2012	0.857	0.916	0.936	drs
2013	0.928	1.000	0.928	irs
2014	0.967	1.000	0.996	drs
2015	0.954	1.000	1.000	drs
2016	1.000	1.000	1.000	-
2017	1.000	1.000	1.000	-
2018	1.000	1.000	1.000	-
2019	0.949	1.000	0.949	drs

Data source: Deap2.1 calculation results

From the data in Table 2, it can be seen that during the 11 years from 2009 to 2019 in Jiangsu Province, under the assumption that the scale returns are fixed, the comprehensive efficiency score of Jiangsu Province's science and technology finance in 2009, 2010 and 2016 to 2018 was 1. It shows that the combination of technology and finance is better, the capital allocation during the period is reasonable, and the input and output are in a relatively balanced state. In 2011-2015 and 2019, the overall efficiency score was less than 1, indicating that the integration of science and technology and finance in Jiangsu Province was not ideal in these years.

TABLE 3. Redundancy value table of input and output of science and technology finance in Jiangsu Province from 2009 to 2019

Year	Full-time equivalent of R&D personnel/person-year	R&D expenditure internal expenditure/10,000 yuan	New product development expenditure/10,000 yuan	Number of domestic patent applications authorized/item	New product sales revenue/10,000 yuan
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	30001.709	0.000	2824.131	0.000
2012	220139.107	5392.228	0.000	0.000	1131697.827
2013	0.000	0.000	0.000	0.000	0.000
2014	0.000	0.000	0.000	0.000	0.000
2015	0.000	0.000	0.000	0.000	0.000
2016	0.000	0.000	0.000	0.000	0.000
2017	0.000	0.000	0.000	0.000	0.000
2018	0.000	0.000	0.000	0.000	0.000
2019	0.000	0.000	0.000	0.000	0.000

Data source: Deap2.1 calculation results

From the perspective of pure technical efficiency, except for 2011 and 2012, the pure technical efficiency is 1 in other years, indicating that the pure technical efficiency of science and technology finance in Jiangsu Province was in an effective state during the period, and the optimal output or output when the input was fixed was obtained. The best investment for a certain time. In 2011 and 2012, the pure technical efficiency was 0,834 and 0.916, respectively, indicating that the pure technical efficiency was ineffective and relatively effective, usually due to improper capital allocation and insufficient resource utilization. The financial capital investment structure should be adjusted and the capital investment system should be optimized.

In addition, in 2013, 2014 and 2019, the scale efficiency is less than 1 and the pure technical efficiency is 1, resulting in its overall efficiency being less than 1, which is due to the relatively efficient scale efficiency, which leads to its relatively effective overall efficiency. Especially in 2013, the return to scale was in the increasing stage, indicating that there were serious problems of insufficient scientific and technological output and redundant financial input. Therefore, Jiangsu Province should expand the scale of production and make full use of resources to improve the efficiency of scale and thus improve the overall efficiency.

IV. CONCLUSIONS AND COUNTERMEASURES

A. Conclusions

The DEA model is used to calculate the efficiency of science and technology finance in Jiangsu Province from 2009 to 2019. The results show that the overall performance of the input-output efficiency of science and technology finance in Jiangsu Province is average, the overall efficiency is only valid for 5 years, and the pure technical efficiency is 2 years. Invalid state. The main reasons for this phenomenon are the ineffectiveness of scale efficiency, and the second is that the resource input structure is not perfect, which will lead to low efficiency in the use of financial resources by enterprises. In order to keep financial input and technological output in a relatively balanced state, combined with the actual situation of Jiangsu Province, the following suggestions are put forward.

B. Countermeasures

First, promote the transformation of scientific and technological achievements. The research and development of scientific and technological achievements is time-consuming and labor-intensive, and the investment is huge. Therefore, it is necessary to promote the capital transformation of scientific and technological achievements, and transform the scientific and technological innovation fruits in campuses or scientific research institutions into a continuous and powerful driving force for social and economic development, and at the same time, it can promote the structural reform of the local economy. In addition, the government should take the responsibility of management in this transformation process, and coordinate the relationship between entities, scientific research institutions, universities, intermediary service agencies and other participants, so as to give full play to the advantages of all parties and achieve industry-university-research cooperation. Through close contact, guide the efficient combination of scientific and technological achievements with the market economy, and realize the industrialization of scientific and technological achievements.

Second, optimize the investment structure of science and technology finance. It can be seen from the model analysis that there is redundant financial investment in Jiangsu Province, which leads to the ineffectiveness of the overall efficiency of the integration of science and technology finance. Therefore, it is very important to optimize the investment structure of science and technology finance. At the moment when financial resources are very limited, Jiangsu Province should rationally arrange the flow of financial resources. It is necessary to improve the management system of science and technology finance and improve the efficiency of the use of financial investment capital.

Third, improve the environment for scientific and technological innovation. At present, the scale efficiency of Jiangsu Province has reached a relative equilibrium, achieving the largest scale benefit, so there is no need to expand the scale of scientific research institutions. Local governments should encourage technological innovation, attach importance to the coordinated development of technological innovation and technological finance, implement technological finance-driven development strategies, and realize a good model of mutual promotion and coordinated development of technological innovation and technological finance output. While vigorously introducing scientific and technological talents, we will increase financial support for science and technology, and provide some preferential policies such as tax incentives to guide market capital into the field of scientific and technological research. Optimize the market-led evaluation mechanism for scientific and technological achievements, establish and improve intellectual property protection laws and regulations, and enhance the motivation of scientific and technological enterprises to carry out scientific research activities.

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