Advances in Economics, Business and Management Research, volume 159
Fifth International Conference on Economic and Business Management (FEBM 2020)

Research on Relative Efficiency of Input and Output of Sci-Tech Finance Based on DEA Model: A Case Study in Shanghai

Mengying Yu[1,*]

[1]*School of International Education, Wuhan University of Technology, Wuhan 430000, China*
[*]*Corresponding author. Email: yumengying@whut.edu.cn*

ABSTRACT
By using the DEA model, this paper establishes the evaluation index system of sci-tech financial efficiency and calculates the relative efficiency of sci-tech finance in 30 province-level regions in China including Shanghai from 2014 to 2018. The results indicate that although the efficiency of sci-tech finance in Shanghai is relatively above the average level in China, there are still some deficiencies in the management of technology. Aimed at further improving the allocation efficiency of sci-tech financial resources in Shanghai, it is crucial to increase government investment and policy support, strengthen the training and introduction of talents, and improve the sci-tech financial system.
Keywords: *Data envelopment analysis, Shanghai, sci-tech finance, relative efficiency*

1. INTRODUCTION

The scientific and technological innovation is inseparable from the support of capital, and it begins with technology and succeeds with capital. The capital markets can optimize the allocation of innovative resources, and finance has the function of diversifying innovation risks [1], which makes the integrated development of sci-tech and finance extremely urgent. Moreover, finance has an increasing contribution to the technology improvement and economic growth, but the financial resources are scarce. So it is in line with the demand of the times and the national strategic guidelines to research the efficiency of Chinese sci-tech finance, which can promote the rational allocation of factor markets and a better integration of the financial and sci-tech industry [2].
Initially, research on sci-tech finance was concentrated at the national level, and then expanded to the provincial and municipal levels. The theory of research gradually matured and the research methods have been increasingly extensive. As early as 2003, Wang Hai et al. [3] discovered this problem and used the analytic hierarchy process to evaluate the efficiency of Chinese technology and finance integration in the past 10 years, laying the foundation for follow-up research. Lu Jianglin et al. [4]established a scientific input-output evaluation system, using input index data in 2009 and output index data in 2010 to study the integration of technology and finance in central and eastern regions of China, and put forward some reasonable suggestions. Hua Yuyan et al.[5] used DEA method to analyze the efficiency of technology and finance integration in Anhui Province from 1997 to 2010. Based on the DEA-Tobit model, Han Wei[6] collected relevant data on technology and finance in 18 cities in Henan Province from 2005 to 2014, and conducted an empirical study on the efficiency of its technology and finance integration.
Based on previous studies, this paper takes Shanghai as the research object, and establishes a scientific and reasonable evaluation system of scientific and technological financial input and output indicators. Firstly, the DEA model is used to evaluate the efficiency of scientific and technological financial integration in 30 provinces, autonomous regions, and municipalities across the country (excluding Tibet, Hong Kong, Macao and Taiwan), then comparing Shanghai's efficiency with other regions across the country, and conducting preliminary evaluation. After that, collecting the input and output data of Shanghai’s sci-tech finance from 2014 to 2018, deeply exploring the rationality of the input and output relationship of Shanghai sci-tech finance and the problems that exist in the process of combining technology and finance. Finally, in response to the problems that found in the research, puting forward some policy recommendations for the development of Shanghai's future sci-tech finance.

2. RESEARCH DESIGN

2.1. Research Method

The DEA-BCC method is an improved model of the DEA-CCR method proposed by Banker et al.[7]
Suppose $X_j = (X_{1j}, X_{2j}, ..., X_{mj})^T$ is the input vector, $Y_j = (Y_{1j}, Y_{2j}, ..., Y_{sj})$ is the output vector, j=1,2,..,n. Adding a constraint $\sum \lambda_j = 1$ to the CCR model to construct BCC model, and the optimal value of this model is:

$$\begin{cases} \min[\theta-\varepsilon(\sum_{j=1}^{m}s^{-}+\sum_{j=1}^{r}s^{+})]=v_{d}(\varepsilon) \\ s.t.\sum_{j=1}^{n}x_{j}\lambda_{j}+s^{-}=\theta x_{0} \\ \sum_{j=1}^{n}y_{j}\lambda_{j}-s^{+}=y_{0} \\ \lambda_{j}\geq 0, s^{+}\geq 0, s^{-}\geq 0 \end{cases} \quad (1)$$

The economic meaning of formula(1) is: If the pure technical efficiency and scale efficiency are both 1, it means that DEA is efficient; if only one of them has achieve 1, it means that only weak DEA is efficient; if both are low, it means that DEA is inefficient.

The Malmquist index method was proposed by Swedish economists in 1953. Later, Fare et al.[8] turned the malmquist productivity index into an empirical index, combined it with the DEA method, and formed the DEA-Malmquist index method, the formula is as follows:

$$\text{Tfpch}=\text{Sech}\times\text{Pech}\times\text{Techch} \quad (2)$$

2.2. Index Selection

The construction of the evaluation index system needs to follow the principles of systematic, typical, dynamic, comparable, operable, and quantifiable to make the index system scientific and standardized. The process of technological innovation is the result of the joint action of manpower and capital. Therefore, measurement indicators can be selected from two aspects: human and finance. Based on the above principles, and referring to the predecessor's researches, the indicator system are constructed as shown in the Table 1.

Table 1 Input and Output Indicators

	Evaluation Content	**Specific Indicators**
Input Indicators	Financial Resources	R&D internal expenditure
	Human Resources	Number of R&D personnel
	Policy Resources	Government financial technology appropriation
Output Indicators	Direct Innovation Ability	Number of patent applications granted
	Economic Benefit	Technical contract turnover
	Academic Achievement	Number of scientific papers

3. EMPIRICAL ANALYSIS

3.1. DEA Model Results and Analysis

This paper uses DEAP 2.1 software to calculate the input and output efficiency of science and technology finance in 30 regions in Mainland China, then obtains the relative efficiency value, and takes the average value of the five-year data. The overall efficiency can reflect the overall allocation of technology and financial resources in various provinces and cities. The results are shown in Table 2.

It can be seen from Table 2 that the overall efficiency of Beijing and Zhejiang from 2014 to 2018 is both 1, and both are at the forefront of efficiency. In terms of pure technical efficiency, the pure technical efficiency of Beijing, Zhejiang, Shaanxi, Guangdong, and Qinghai all reached 1, which means that there is no misallocation of resources, and the management level is relatively good. The reason why the overall efficiency of Shaanxi, Guangdong, and Qinghai has not reached the optimal level is that the scale efficiency has not reached the optimum. The remaining inefficient provinces and cities should increase the output of sci-tech finance to increase the pure technical efficiency. In terms of scale efficiency, with the exception of Beijing and Zhejiang have achieved scale efficiency, that is, the return to scale remains unchanged; Jiangsu and Guangdong have shown diminishing returns to scale; other provinces and cities across the country have shown increasing returns to scale, which means that they are supposed to increase science and technology finance investment to improve scale efficiency. Jiangsu and Guangdong have redundant investment in science and technology finance, and output is relatively insufficient. To sum up, the overall efficiency of the eastern region is higher than that of the central and western regions. Shanghai’s overall efficiency ranks 10th in the country, at the upper-middle level, but its pure technical efficiency is at the lower-middle level nationwide. From 2014 to 2018, Shanghai’s pure technical efficiency and scale efficiency have not reached the frontier of efficiency. Therefore, Shanghai should increase investment in sci-tech finance on the one hand, and increase its emphasis on sci-tech finance output on the other hand, so that the overall efficiency can reach effective.

3.2. DEA-Malmquist Index Model Results and Analysis

Table 3 shows the dynamic trend of Shanghai science and technology financial efficiency from 2014 to 2018. It can be seen that Shanghai's sci-tech financial efficiency is showing an upward trend. The technical efficiency change index from 2014 to 2015 and 2015 to 2016 were 1.004 and 1.039 respectively, that is, the technical efficiency increased by 0.4% and 3.9%, then dropped by 2.1% from 2016 to 2017, and rebounded afterwards. The technology change index has been on the rise from 2014 to 2018, and the trend is relatively significant, with growth rates of 9.7%, 27.4%, 14.6% and 11.7% respectively. This may be related to Shanghai's increasing emphasis on innovation and entrepreneurship and related favorable policies.

Table 2 Allocation efficiency of Sci-Tech Finance in various regions from 2014 to 2018

City	2018			2017			2016			2015			2014			Average					
	crste	vrste	scale	crste	vrste	scale	crste	vrste	scale	crste	vrste	scale	crste	vrste	scale	crste	rank	vrste	rank	scale	rank
Beijing	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1	1.000	1	1.000	1
Tianjin	0.638	0.877	0.727	0.524	0.610	0.860	0.497	0.659	0.754	0.501	0.697	0.719	0.466	0.683	0.682	0.525	18	0.705	25	0.748	15
Hebei	0.507	0.818	0.620	0.461	0.573	0.804	0.444	0.717	0.619	0.461	0.687	0.671	0.379	0.697	0.544	0.450	21	0.698	27	0.652	17
Shanxi	0.305	0.812	0.376	0.296	0.802	0.369	0.281	0.793	0.355	0.250	0.667	0.374	0.360	0.735	0.490	0.298	23	0.762	22	0.393	22
Inner Mongolia	0.169	0.822	0.205	0.140	0.716	0.195	0.136	0.719	0.189	0.141	0.699	0.201	0.121	0.696	0.173	0.141	27	0.730	23	0.193	27
Liaoning	0.672	0.897	0.749	0.604	0.865	0.698	0.610	0.839	0.727	0.533	0.657	0.810	0.489	0.640	0.763	0.582	13	0.780	19	0.749	14
Jilin	0.538	0.986	0.546	0.503	0.968	0.520	0.539	0.978	0.551	0.650	1.000	0.650	0.589	0.976	0.604	0.564	15	0.982	8	0.574	20
Heilongjiang	0.651	1.000	0.651	0.597	1.000	0.597	0.621	1.000	0.621	0.680	0.969	0.701	0.664	0.985	0.674	0.643	9	0.991	6	0.649	18
Shanghai	0.665	0.706	0.941	0.639	0.668	0.957	0.653	0.665	0.981	0.628	0.655	0.958	0.626	0.672	0.931	0.642	10	0.673	29	0.954	3
Jiangsu	0.887	0.936	0.948	0.846	0.923	0.916	0.833	1.000	0.833	0.825	1.000	0.825	0.814	1.000	0.814	0.841	4	0.972	9	0.867	8
Zhejiang	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1	1.000	1	1.000	1
Anhui	0.558	0.707	0.789	0.519	0.581	0.894	0.606	0.731	0.829	0.581	0.710	0.818	0.592	0.771	0.768	0.571	14	0.700	26	0.820	10
Fujian	0.789	1.000	0.789	0.725	0.814	0.891	0.716	0.919	0.779	0.629	0.824	0.763	0.514	0.765	0.672	0.675	8	0.864	14	0.779	12
Jiangxi	0.543	0.910	0.597	0.517	0.684	0.756	0.506	0.880	0.575	0.440	0.811	0.542	0.338	0.800	0.423	0.469	20	0.817	18	0.579	19
Shandong	0.605	0.653	0.926	0.583	0.609	0.957	0.550	0.580	0.949	0.523	0.564	0.928	0.487	0.545	0.893	0.550	16	0.590	30	0.931	4
Henan	0.612	0.794	0.772	0.573	0.650	0.882	0.535	0.688	0.776	0.495	0.640	0.773	0.433	0.644	0.673	0.530	17	0.683	28	0.775	13
Hubei	0.652	0.767	0.851	0.607	0.699	0.868	0.592	0.682	0.867	0.602	0.704	0.855	0.633	0.770	0.822	0.617	11	0.724	24	0.853	9
Hunan	0.591	0.773	0.765	0.599	0.735	0.815	0.588	0.739	0.796	0.646	0.786	0.822	0.635	0.842	0.754	0.612	12	0.775	20	0.790	11
Guangdong	0.981	1.000	0.981	0.924	1.000	0.924	0.756	1.000	0.756	0.790	1.000	0.790	0.637	0.665	0.957	0.818	5	0.933	12	0.882	7
Guangxi	0.329	0.871	0.377	0.320	0.761	0.421	0.308	0.820	0.375	0.264	0.699	0.378	0.239	0.721	0.332	0.292	24	0.774	21	0.377	24
Hainan	0.093	0.999	0.093	0.079	0.972	0.082	0.078	0.990	0.079	0.084	0.980	0.085	0.075	0.974	0.077	0.082	29	0.983	7	0.083	29
Chongqing	0.626	0.924	0.678	0.629	0.796	0.791	0.755	1.000	0.755	0.760	1.000	0.760	0.617	0.995	0.621	0.677	7	0.943	11	0.721	16
Sichuan	0.837	1.000	0.837	0.802	0.871	0.921	0.795	0.870	0.914	0.839	0.924	0.907	0.786	0.940	0.837	0.812	6	0.921	13	0.883	6
Guizhou	0.312	0.860	0.363	0.257	0.725	0.355	0.204	0.808	0.252	0.278	0.865	0.322	0.248	0.887	0.280	0.260	25	0.829	16	0.314	25
Yunnan	0.336	0.851	0.395	0.318	0.767	0.415	0.293	0.799	0.367	0.341	0.834	0.409	0.299	0.837	0.357	0.317	22	0.818	17	0.389	23
Shaanxi	0.879	1.000	0.879	0.845	1.000	0.845	0.966	1.000	0.966	0.910	1.000	0.910	0.838	1.000	0.838	0.888	3	1.000	1	0.888	5
Gansu	0.398	1.000	0.398	0.796	1.000	0.796	0.348	0.974	0.357	0.433	1.000	0.433	0.401	1.000	0.401	0.475	19	0.995	5	0.477	21
Qinghai	0.103	1.000	0.103	0.294	1.000	0.294	0.089	1.000	0.089	0.099	1.000	0.099	0.063	1.000	0.063	0.130	28	1.000	1	0.130	28
Ningxia	0.104	0.951	0.109	0.050	0.927	0.054	0.073	0.945	0.078	0.059	0.959	0.062	0.057	0.969	0.059	0.069	30	0.950	10	0.072	30
Xinjiang	0.208	0.920	0.226	0.139	0.836	0.166	0.192	0.857	0.224	0.219	0.840	0.261	0.165	0.818	0.201	0.185	26	0.854	15	0.216	26

Table 3 Malmquist index in Shanghai

	Effch	Techch	Pech	Sech	Tfpch
2014-2015	1.004	1.097	0.975	1.029	1.102
2015-2016	1.039	1.274	1.015	1.024	1.324
2016-2017	0.979	1.146	1.004	0.975	1.123
2017-2018	1.04	1.117	1.057	0.983	1.161

4. CONCLUSION AND SUGGESTION

Based on the DEA-Malmquist index model, this paper uses the input-output indicator data of science and technology finance in 30 regions of the country from 2014 to 2018 to evaluate the efficiency of the allocation of science and technology finance resources in various regions, and finds that the overall efficiency of Shanghai science and technology finance is not effective. The return to scale is not effective and increasing, indicating that Shanghai still needs to expand the scale of technology finance to increase the corresponding output results. Inefficient technology means that financial resources have not been fully used to maximize scientific and technological output under the condition of fixed financial resource input. Based on the results of the model analysis and the future development of science and technology finance in Shanghai and the whole country, this paper puts forward the following suggestions:

(1) Increase government investment and policy support

The Shanghai government are supposed to increase its allocation of funds, give full play to its advantages in scale, strictly supervise the invested funds, and urge financial institutions to rationally use the R&D funds invested in each enterprises. At the same time, the government should increase the guidance for social capital to participate in technological and financial innovation.

(2) Strengthen the training and introduction of talents

While improving technical efficiency, Shanghai also needs to stabilize its technological progress. Technological progress is one of the important conditions for the development of science and technology finance, and it requires talents in the corresponding fields to advance. It is necessary to take advantage of the resources of Shanghai universities and encourage them to cultivate a group of compound people who have a good command of both finance and technology.

(3) Improve the science and technology financial system

A well-established science and technology financial system is the cornerstone of improving the efficiency of sci-tech finance, which helps companies improve their management and decision-making capabilities. Shanghai should make its technology financial system more diversified, gradually improve the multi-tier financial market, and actively support the development of various new technology financial intermediaries to improve their financial services.

The combination of finance and technological innovation is the main reason for promoting economic growth. Under the background of the current era, only by continuously improving the technology and financial management system, accelerating the output of technology and financial results, and truly improving the efficiency of technology and financial resource allocation, can Shanghai achieve the optimal integration of technology and finance.

REFERENCES

[1] Li Ye, Yali Wang, Xiangsheng Meng, Research on the innovation supporting efficiency of china’s sci-tech finance: theoretical analysis and empirical test based on firm level, Nankai Economic Studies (2015) 37-53.

[2] Changfa Zhou, Protection mechanism for sci-tech finance development, China Soft Science (2011) 72-81.

[3] Hai Wang, Yuanxu Y, Study on efficiency evaluation of science technology and finance integration, Chinese Journal of Management Sciences (2003) 67-72.

[4] Jianglin Lu, Xinlong Wang, Gaotang Song, A comparative study on the combination efficiency of technology and finance in central china and developed eastern provinces and cities—analysis based on dea model, Journal of Finance and Economics (2012) 7-11.

[5] Yuyan Hua, Na Zhao, Study of T&F efficiency based on dea model—a case of Anhui province, Research of Finance and Education (2013) 46-49.

[6] Wei Han, Empirical analysis of combination efficiency of S&T and finance based on DEA-Tobit model：taking henan province as an example, Journal of Financial Development Research (2015) 36-40.

[7] R.D. Banker, A. Charnes, W.W. Cooper, Some models for estimating technical and scale inefficiencies in data envelopment analysis, Management Science 30 (1984).

[8] R. Färe, S. Grosskopf, B. Lindgren, P. Roos, Productivity changes in Swedish pharamacies 1980－1989: a non-parametric malmquist approach, Journal of Productivity Analysis 3 (1992).