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# Statistical Measure and Spatiotemporal Evolution Analysis of Inter-provincial Finance Efficiency of Science and Technology Based on Non-expected SBM Model

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**Abstract:** The report of the 20th Party Congress pointed out that the real economy must be the core of economic development, and the financial sector, as the "backbone" of the real economy, is a key factor in realizing high-quality economic development. Science and technology finance, as a new type of bridge connecting finance and science and technology, on the one hand, accelerates the flow of capital to new technologies, and on the other hand, helps scientific and technological innovations to constantly reach a new level. Although the strength of China's science and technology financial investment has been increasing, the problems of emphasizing investment over performance and unbalanced development of science and technology finance among regions still exist. Therefore, taking the inter-provincial data of the decade 2010-2019 as the research object, based on the input-oriented three-stage SBM-DEA model containing non-expected outputs, we constructed China's S&T financial efficiency evaluation index system to measure the S&T financial efficiency of China's provinces. In order to further empirically test the geographical differentiation of China's S&T financial efficiency, based on the results of the three-stage SBM-DEA, the Dagum Gini coefficient decomposition method is used in combination with Kernel kernel and other statistical methods to reveal the characteristics of the geographical differentiation of China's S&T financial efficiency in China and the trend of its spatial and temporal evolution.

**Keywords:** Science and technology finance; Efficiency measurement; SBM model; Non-expected output; Spatio-temporal evolutionI. Introduction.

## 1. Introduction

The report to the 20th National Congress of the CPC pointed out that the real economy should be the focus of economic development. The real economy is China's development capital, and the financial sector, as the "blood" of real enterprises, is the "fuel" for high-quality development of the real economy, and the key to creating strategic advantages for China's future development. As an important resource allocation factor, finance can optimize the allocation of social resources in the critical period of China's economic development transformation and modernization, match the different needs of science and technology industry and technology enterprises, provide services such as capital intermediary, transaction channels and value creation, realize the target system of promoting science and technology innovation, and contribute to the realization of the goal of promoting science and technology innovation. However, due to China's traditional indirect financing model, the cost of capital is high, the cycle preference is short, the risk appetite is low, and the industry awareness is low. Therefore, the existing financial system has been unable to fully adapt to the needs of technological innovation and development, and the existing financial system must be reformed in order to better cultivate the elements of innovation, support the main body of innovation, and expand the benefits of innovation. In this context, technological finance came into being.

As a new bridge connecting finance and science and technology, sci-tech finance will promote capital flow to new technology, so that the financing conditions of sci-tech smes can be better improved, and sci-tech smes can get more funds and technology by using sci-tech finance. With the great attention of the state, the output of scientific and technological innovation achievements in China has steadily increased. However, in the development of the combination of science and technology and finance, China is faced with the problem of unbalanced development of science and technology and finance among regions. Efficiency is an important index to comprehensively evaluate the development of science and technology funds, and also an important benchmark to promote the regional coordination of science and technology funds.

### 1.1. Research ideas and methods

First, based on the inter-provincial data from 2010 to 2019, this paper constructs an evaluation index system for the efficiency of science and technology finance in China and measures the efficiency of science and technology finance in China's provinces based on the input-oriented three-stage SBM-DEA model with non-expected output. In terms of index construction, input indexes are selected from two aspects: labor input and capital investment. The output variables are selected from the two aspects of achievement transformation output and enterprise performance output. At the same time, the non-expected output and environment variables are introduced, so that the value of inter-provincial science and technology financial efficiency is more accurate.

Secondly, by referring to the existing research[1] and starting from the Dagum Gini coefficient decomposition method, this paper analyzes the regional differences and their sources of the efficiency of science and technology finance in China. Through this method, it reflects the internal level gap of each region, the level gap between each region, and the cross-overlapping phenomenon of each region, so as to reflect the relative gap[2]. At the same time, the Kernel density estimation method[3] is used to investigate the spatial distribution characteristics and changing trends of China's inter-provincial science and technology financial efficiency, and the evolution analysis is carried out in time and space.

# 2. Related Literature Research

In recent years, the research on the effectiveness of science and technology finance has gradually attracted the attention of the theoretical circle. However, according to the review of relevant literature, there are great differences on the definition and measurement of the effectiveness of sci-tech finance. The concept of "Sci-tech finance" was first put forward at the first China Sci-Tech Finance Promotion Conference in 1994, but so far, the academic community still has different understandings of the concept of sci-tech finance. Zhao Changwen and Chen Chunfa [4]first defined "science and[4] technology finance" in 2009. In their view, science and technology finance refers to a series of financial instruments, financial systems, financial policies and financial services of systematic and innovative arrangements, which can promote the development of science and technology finance. In the empirical aspect, there are many research methods for the statistical measurement of the efficiency of sci-tech finance. Even if the same method is used and samples from the same time and region are selected for analysis, the results may be different. Based[5] on the DEA-BCC model, He Baocheng and Li Shanshan analyzed the sample data of 29 provinces in China from 2008 to 2018, and pointed out that the overall level of scientific and technological financial efficiency in China is not high, and there is still a large room for improvement. For example, from 2008 to 2018, the efficiency index of science and technology funds fell first and then rose, while the efficiency index of science and technology finance of all provinces was very low, and only five provinces such as Beijing took the lead in comprehensive efficiency. This is consistent with the research conclusion[6] by Jiang Zhaojun , Xu Bo et al. Yi Ming, Zhang Lian, Zhang Liao,Huang Lei[7]qiong et al., using[8] the DEA-BCC model, argue that there are obvious regional differences in the efficiency of sci-tech finance in China, which are as follows: in the eastern region, DEA is effective in Beijing and Shanghai, in the central and western regions, DEA is weak, and in the northwest region, DEA is not effective.

It is not difficult to find that scholars mainly adopt empirical analysis in the research on the level measurement of sci-tech financial efficiency, including traditional three-stage DEA, DEA-Malmquist method, improved EBM-DEA model containing non-expected output and other methods. [9]Hou Xuhui selected[9] 14 typical resource-based provinces for analysis. Based on the three-stage DEA model, he conducted an analysis of the efficiency level of science and technology finance. The results show that environmental factors have a great impact on the efficiency of science and technology finance in resource-based regions, especially the degree of government support. [10]Song Yufei and Zhang Baojian adopted the BCC-[10]Malmquist research method, took the effect of science and technology finance in Anhui province as the research object, and drew the conclusion that the efficiency level of science and technology finance in Anhui province was on the rise as a whole, but there was a big difference between different regions and it was greatly affected by scale efficiency. Wang Jian also adopted the DEA-Mal[11]mquist method; Yao Fengtong and Jia Haonan adopted superefficiency [12] [13] Liu Xin et al. adopted the TSC-DEA model[13] and took the overall effect of science and technology finance in China as the research object to evaluate and conduct empirical research on the efficiency of science and technology finance. Wang Ren and Li Zhiwei used the panel stochastic frontier model to systematically sort out and evaluate the historical evolution, spatial distribution and structural heterogeneity of science and technology financial efficiency in China[13]'s provinces from 2013 to 2017.

# 3. Principle and Advantages of The Research Method

The traditional three-step DEA modeling involves first calculating the relaxation variables of each DDU using the BBC or CCR model. Then the stochastic frontier analysis method is used to regression the lag variables, remove the influence of environmental factors, and get the new correction value of each input, so as to separate the three influences of environmental factors, random interference and management inefficiency. Finally, the adjusted data is fed back into the traditional DEA model to calculate the efficiency.

This model effectively eliminates the influence of environment and random factors, but the existing model still has shortcomings such as only static analysis, not effective measurement of expected output, and ignoring regional economic differences.

Therefore, this paper makes an improvement on the basis of the traditional three-stage model. The model of the first stage is changed from BBC or CCR to SBM model. The traditional DEA model is a linear technique to determine the efficiency, but not all cases can meet the linearity, sometimes there will be a lot of non-expected output, which is not the expected output after input. In addition to avoiding the deviation of radial and angular measurement, the SBM model also takes into account the influence of the factor of non-expected output in production efficiency. Therefore, the SBM model can more scientifically and objectively reflect the level of science and technology and finance in 30 provinces and cities in China.

# 4. Model Construction and Indicator Description

(I) The first stage: the construction of SBM model

This paper uses Toney's 2001 and 2007 papers for modeling calculations (the SBM form with undesired outputs defined in 2007). SBM model Tone(1997,2001), refer to Fan Ziying and Zhang Jun[13]The SBM model has two advantages: (1) the input and output units have no effect on the efficiency value, that is, they are dimensionless;

(2) As the input and output decay, the efficiency value is monotonically decreased. Each province is a production decision unit, each decision unit has n inputs and s outputs, for a production with n inputs and s outputs, we can get the production possibilities :p=$\{(x,y)|x \geq X\lambda, y \leq Y\lambda, \lambda \geq 0\}$To measure the efficiency of a DMU with n inputs and s outputs using the SBM model, the basic form is$\rho^*$min=$\frac{1-\frac{1}{n}\sum_{k=1}^{n} s_k^- / x_{io}}{1+\frac{1}{s}(\sum_{r=1}^{s} s_r^+ / y_{ro})}$

Where, represents the redundancy of input and undesired output, while Representing the deficiency of expected output; Referring to the model construction of Pan Dan and Ying

Ruiyao[16], ρ is the value of technological financial efficiency to be calculated, and its value range is between 0 and 1. The closer ρ is to 1, the higher the efficiency of the decision unit; If ρ=1, the decision unit is completely efficient and on the production front; If ρ<1, the decision unit loses efficiency. The efficiency level of input and output will affect the efficiency value of SBM, so the purpose of improving the financial efficiency of science and technology can be achieved by optimizing the input or output.

### 4.1. The second stage: panel SFA estimation

SBM model selects input-oriented analysis. In the calculation results, slack is positive. Input slacks represent the amount of input that needs to be reduced, output slacks represent the amount of output that needs to be increased, and non-expected output slacks represent the amount of non-expected output that needs to be reduced. However, the efficiency calculated by the traditional DEA model is not accurate enough due to the conicity and radiality of the calculation results, or the DEA model cannot be adopted when the non-expected output is considered. Therefore, we use the stochastic frontier SFA model to optimize the relaxation of the input and output indicators of science and technology finance, so as to obtain the revised input and output data.

### 4.2. The third stage: the improved SBM-DEA third-order model

The original data will be replaced with the improved data, and the SBM model in the first stage will be used to measure the scientific and technological financial efficiency again. At this time, the efficiency value can reflect the current situation of our country's scientific and technological financial efficiency more accurately, and lay a more scientific foundation for the subsequent analysis of space-time evolution.

### 4.3. Variable selection and sample explanation

1. Index construction

Input in science and technology finance: Input is analyzed from two aspects: labor input and capital input. Science and technology finance mainly involves the input level of enterprises, governments and high-tech companies, etc. Therefore, the full-time equivalent of R&D personnel and the employment of urban units in the financial industry are selected as labor input variables. Government financial expenditure on science and technology, R&D expenditure and financial institution loan on science and technology are selected as capital input variables. The output of science and technology finance is divided into two parts: expected output and non-expected output. In terms of expected output: Whether the output of science and technology finance can be transformed into high-quality results is very important, and the output can be reflected in the development of patent, trademark and technology market. Therefore, the number of authorized domestic patent applications, trademark approval and registration, and technology market turnover are selected as the output of results transformation, and enterprise performance is also a measure of output. The production and operation situation of high-tech industry is selected as the performance output of enterprises; In terms of non-expected outputs, the number of inventions accepted but not authorized, the number of utility models accepted but not authorized, and the number of designs accepted but not authorized are all in the invention patents of science and technology finance. In terms of environmental variables: In order to exclude the impact of environmental variables, the stochastic frontier analysis is used to select the level of economic development, the degree of government support and population density as environmental variables.

Generally speaking, there is a close relationship between the level of economic development and the benefits of science and technology finance. With the change of a region's economic development, the contribution of finance to science and technology will also change, and with the improvement of economic development, the efficiency of science and technology funds will also increase. In this paper, the total GDP of each region is used to reflect the economic development level of each region. In addition, the degree of support of local governments to the development of science and technology finance also affects the efficiency of science and technology finance, and the increase of government financial support helps to improve the efficiency of financial institutions. In this paper, the proportion of government financial expenditure on science and technology in the budget expenditure of each region is used to characterize the degree of support for science and technology finance. Population density is the embodiment of population size, and will also affect the economic development of a region and the overall level of science and technology finance. Therefore, urban population density is also included in the evaluation index system of this paper.

In view of the authenticity, reliability and accessibility of the data, this paper takes 30 provinces and cities nationwide from 2010 to 2019 (excluding Hong Kong, Macao, Taiwan and Tibet) as the research object, draws on existing[1][17] studies, and selects relevant data of science and technology finance in each province to establish an indicator system and measure the efficiency of science and technology finance in China. Specific sample data include: National Bureau of Statistics website, China High-tech Industry Statistical Yearbook and China Science and Technology Statistical Yearbook. Since the National Bureau of Statistics will no longer publish the data of science and technology loans of financial institutions after 2009, we choose to use the total R & D funds from regional funding sources to subtract government, enterprise and foreign funds to roughly represent the science and technology loans of financial institutions.

## 5. Results of Empirical Analysis

### 5.1. Analysis of the measurement results of China's inter-provincial science and technology finance efficiency

### 5.2. The first stage: initial efficiency measurement of science and technology finance

In this stage, Dearun3.0 software is used to substitute the collected original data into the SBM-DEA model containing non-expected output for measurement, and the initial efficiency values of science and technology finance in each province can be obtained, and the measured results are drawn in Figure 1. On the whole, the efficiency of science and technology finance in most provinces shows an upward trend, while the efficiency of a few provinces decreases or remains unchanged during the investigation period. This shows that the output effect of science and technology finance brought by investment in science and technology finance during 2010-

2019 is on the whole rising, that is, investment in science and technology finance has a significant promoting effect on the transformation of scientific and technological achievements and enterprise performance output.

Figure 1. Trend chart of the efficiency of sci-tech finance in provinces in the first stage In addition to Tibet, there is a significant difference in the efficiency of science and technology finance among the 30 provinces in China. With an average efficiency of 0.9 as the boundary, five provinces, namely Guangdong, Jiangsu, Qinghai, Shaanxi and Zhejiang, ranked the first echelon in terms of average efficiency. Among them, Jiangsu ranks the first with an average efficiency of 0.9962, which is at the effective frontier. The average efficiency of Guangdong and Qinghai is around 0.95, and the average efficiency of Shaanxi and Zhejiang is around 0.92. There are 10 provinces with efficiency lower than 0.9 but higher than 0.8, ranking in the second tier of technological and financial efficiency, accounting for one third of the provinces in China. Combined with the five provinces in the first stage, it can be seen that half of the regions in the country have a high average efficiency of science and technology finance. There are 7 provinces with average efficiency lower than 0.8 but higher than 0.6. The efficiency of science and technology finance of these provinces has certain room for improvement, and there is still a certain gap between them and the effective frontier and even the top 15 provinces with high average efficiency. We should actively learn from other provinces. There are also 7 provinces with average efficiency lower than 0.6, and there is great room for improvement in the effect of science and technology finance in these provinces. Among them, the average efficiency of Shaanxi and Inner Mongolia was only 0.4452 and 0.4495, respectively, which were the lowest among the 30 provinces in China. The average efficiency of Hebei, Hunan, Shanghai and Yunnan in the past ten years is about 0.5; Liaoning was slightly higher, at 0.5944. According to the spatiotemporal differentiation of the efficiency of science and technology finance in different provinces, the standard deviation of science and technology finance efficiency in Anhui, Fujian, Gansu, Inner Mongolia, Shanghai and Chongqing is larger. The main reason for this phenomenon is that there are significant differences in the intensity of S&T financial input, market incentive mechanism and innovation policy coordination among different regions, which results in a significant step-type difference in S&T financial efficiency among regions. In addition, although the standard deviation of Hunan, Liaoning, Shanxi and Yunnan provinces is relatively small on the whole, the fact that the efficiency of science and technology finance has been at a low level for a long time cannot hide the lack of achievements in the process of realizing financial support and promoting scientific and technological innovation in these regions.

## 5.3. The second stage: SFA regression analysis

In this stage, Frontier2.1 is used to decompose the inefficiency in the first stage into three effects: environmental factors, random interference and management inefficiency. The above three effects are separated through regression of relaxation variables, and the real efficiency of science and technology and finance in each region only restricted by management inefficiency is obtained. The results are drawn as Table 1. As can be seen from Table 1, the four environmental variables selected in this paper all pass the significance test at the 5% level. Among them, there is a positive correlation between the two environmental variables, the level of economic development and the degree of government support, and the five input relaxation values, indicating that the increase of these environmental variables will correspondingly lead to the redundancy of scientific and technological financial input, and further lead to the low efficiency of scientific and technological financial. Population density has a positive correlation with the slack value of full-time equivalent of R&D personnel, the slack value of total salary of urban units employed in the financial industry, the slack value of scientific and technological expenditure of government finance and the slack value of scientific and technological loans of financial institutions, but has a negative correlation with the slack value of R&D expenditure. On the other hand, there is a negative correlation between the added value of the financial industry and the five input relaxation values, that is, the greater the added value of the financial industry, the more conducive to the improvement of the efficiency of science and technology finance.

As can be seen, economic development level has a certain positive effect on the relaxation value of R&D expenditure, and the relationship between it and the other four input relaxation values is not obvious. The possible reason is that with the improvement of economic development level, each region will use the increased income to improve the development of other fields, so the attention to the field of science and technology finance is relatively low, that is, the improvement of economic development level has no significant effect on the improvement of the efficiency of science and technology finance. The degree of government support has the most obvious promoting effect on the five input relaxation variables, among which the full-time equivalent relaxation value of R&D personnel, the relaxation value of R&D expenditure and the relaxation value of scientific and technological loans of financial institutions have the greatest influence. It shows that the greater the government's support for science and technology finance, the more detrimental to the flow of capital to new technologies, and the improvement of the financing conditions of small and medium-sized science and technology enterprises, thus restricting the efficiency of science and technology finance. Compared with the other four input relaxation values, population density has a negative correlation with the relaxation value of R&D expenditure, that is, the greater the population density, the lower the input redundancy of R&D expenditure, the higher the use efficiency of R&D expenditure, and the further increase the efficiency of science and technology finance. This means that while improving the level of economic growth, we should not only pay attention to the use efficiency of R&D expenditure, but also pay attention to the unreasonable allocation of labor force related to science and technology finance, science and technology finance expenditure and loans. The added value of the financial industry has a negative correlation with the five input slack values, in which the full-time equivalent of R&D personnel, the full-time equivalent of R&D personnel and the redundancy of investment in scientific and technological loans of financial institutions have a relatively obvious weakening effect, indicating that the continuous improvement of the added value of the financial industry will gradually reduce the above three input slack values, and alleviate the low efficiency of science and technology finance to a certain extent.

## 5.4. The third stage: real efficiency measurement of sci-tech finance

In this stage, adjusted input variables were used to replace the initial input data, and then substituted into the SBM-DEA model. Dearun3.0 was used to calculate the true efficiency of science and technology finance in each region after eliminating environmental interference, and the results were drawn as FIG. 2.

By comparing FIG. 2 and FIG. 1, it can be found that after environmental adjustment, the efficiency of science and technology finance in each province changes significantly. On the whole, the efficiency of science and technology finance in each province deserves to be improved and the fluctuation range is reduced, which also proves the conclusion of the second stage, that is, the environmental variable is indeed the cause of the low efficiency of science and technology finance in most provinces. Apart from Xizang, only Hubei and Hunan among the 30 provinces showed a downward trend in their efficiency values during the study period. In Hubei Province, the efficiency of science and technology finance was U-shaped from 2010 to 2013, and then gradually increased. It returned to the effective frontier in 2018, and finally decreased slightly in 2019, with the final efficiency of science and technology finance being 0.7842. Hunan Province was also at the effective frontier in 2010, and its efficiency of science and technology finance also decreased to 0.8959 in 2019. In other provinces, the efficiency of S&T finance either increased or remained unchanged. During the study period, the efficiency of science and technology finance in 10 regions, namely Beijing, Guangdong, Jiangsu, Shanxi, Inner Mongolia, Ningxia, Qinghai, Shandong, Sichuan and Zhejiang, always fluctuated slightly around 1, and their average efficiency was above 0.95, and these regions were usually not on the effective frontier in only a few years. From the perspective of regions, once again using the average efficiency of 0.9 as the boundary, the number of provinces in the first echelon increased from 5 in the first stage to 28. It can be seen that except Guangdong, Jiangsu, Qinghai, Shaanxi and Zhejiang, the 5 regions with high efficiency in science and technology finance in the first stage, The reason for the low efficiency of science and technology finance in the 23 regions newly promoted to the first tier is not entirely due to the low efficiency of science and technology finance investment or capital allocation, but to a large extent affected by external environmental variables. Only Anhui and Hubei provinces have an average efficiency of less than 0.9, but also above 0.8 in ten years. Among them, Anhui province has a low average efficiency value and a large fluctuation range, with an average value of 0.8052; In Hubei province, the average efficiency in the past ten years was slightly higher and the fluctuation was greater, with an average value of 0.8529. It shows that the efficiency of science and technology finance in Anhui and Hubei still has some room for improvement compared with other regions. From the regional analysis, it can be seen that the efficiency of science and technology finance in 30 provinces has spatial convergence characteristics, and the gap between the provinces with higher efficiency and the provinces with lower efficiency is narrowing. In the first stage, Jiangsu Province, which has the highest average efficiency (0.9962), is 0.551 higher than Shaanxi Province, which has the lowest average efficiency (0.4452), that is, more than 123.76%. In the third stage, Beijing with the highest average efficiency (0.9977) was only 0.1925 higher than Anhui with the lowest average efficiency (0.8025), and the percentage of excess dropped to 23.99%.

## 5.5. Spatio-temporal evolution

## 5.6. Spatial dimension evolution analysis based on Dagum Gini coefficient and its subgroup decomposition method

In this paper, Stata16.0 is used to study the overall spatial differences of China's S&T financial performance across the country. Based on the three-stage SBM-DEA model, Dagum's Gini coefficient and its subgroup decomposition method were used to analyze the value of the S&T financial efficiency of Chinese provinces during 2010-2019. Figure 3 shows that the overall spatial difference of S&T financial efficiency in China during the study period presents an overall downward trend. It can be concluded that the Gini coefficient of S&T financial efficiency has declined by an average of 0.4 percent per year in the past decade.

Specifically, the regional gap in the efficiency of science and technology funding widened significantly from 2010 to 2013, which can be attributed to the good economic development and high efficiency of science and technology funding in the eastern region, leading to the widening of the regional gap. From 2013 to 2015, as the economy shifted to high-tech development, resulting in capital flowing into new technology industries and forming new basic technology industries, the gap in the efficiency of science and technology funds narrowed as the industry helped transform scientific and technological achievements. The spatial difference in the efficiency of science and technology finance remained almost unchanged from 2015 to 2016, decreased rapidly from 2017 to 2018, and rebounded slightly after 2018.

At the same time, further decompose the sources of regional differences in sci-tech financial efficiency and draw the following table 2. From the spatial sources of regional differences in Table 2, it can be seen that intra-regional differences, inter-regional differences and super-variable density all have a proportion in the decomposition of sources of regional differences, and the main cause of differences is inter-regional differences. In terms of the contribution to regional development differences, the average contribution of regional development differences is 45.2651%; The average contribution of super-variable density is 26.9622%; And the average contribution of intra-regional differences is 27.7722%. Therefore, improving the efficiency of science and technology finance in the central and western regions of China and narrowing the gap between regions are the key to overcome the current regional imbalance in the development of R&D fund efficiency.

**Table 3.** Sources of regional differences in science and technology financial efficiency

| Year | Overall Gini coefficient | Contribution rate (%) | | |
|---|---|---|---|---|
| | | Within the district | Inter-district | Supervariable density |
| 2010 | 0.021 | 29.5 | 36.23 | 34.269 |
| 2011 | 0.038 | 31.432 | 30.511 | 38.056 |
| 2012 | 0.041 | 28.614 | 44.789 | 26.597 |
| 2013 | 0.052 | 28.756 | 51.298 | 19.946 |
| 2014 | 0.043 | 27.477 | 23.031 | 49.492 |
| 2015 | 0.024 | 24.826 | 64.444 | 10.73 |
| 2016 | 0.024 | 28.687 | 44.114 | 27.198 |
| 2017 | 0.036 | 27.955 | 40.661 | 31.383 |
| 2018 | 0.016 | 28.756 | 42.784 | 28.459 |
| 2019 | 0.017 | 21.719 | 74.789 | 3.492 |
| Mean | 0.0312 | 27.7722 | 45.2651 | 26.9622 |

By converting Table 2 into Figure 4, it can be seen that the contribution rate of intra-regional differences is relatively stable, and the contribution rate of super-variable density and inter-regional gap fluctuate greatly. The inter-regional difference curve showed "a slight decline from 2010 to 2011, a slow rise from 2011 to 2013, a sharp decline from 2013 to 2014, a sharp rise from 2014 to 2015, a slow decline from 2015 to 2016 and then a steady rise. Finally, it increased significantly from 2018 to 2019 "

During the study period, the super-variable density changed irregularly and the trend was opposite to the inter-regional gap curve, while the intra-regional difference showed a stable state. When the three contributions are transformed, in 2012-2013 and 2015-2019, the intra-regional gap and the supernormal density are lower than the inter-regional gap, while the contribution of the super-normal density and the intra-regional gap shows a decreasing trend.

In order to more intuitively show the evolution trend of Gini coefficient within the region, Figure 5 is drawn. From 2011 to 2014, the western region has the largest difference in the efficiency of science and technology finance, which is always higher than the eastern and central regions. From 2015 to 2019, the central region had the biggest difference in the efficiency of science and technology finance, which was always higher than the eastern and western regions.

During this period, Gini coefficients between regions were also compared with each other, as shown in Figure 6 below. The trend shows that although the Gini coefficient in the western region was significantly higher than that in the country as a whole between 2011 and 2014, there was still an overall downward trend. The Gini coefficients in the East varied more than those in the central and western regions, indicating that intra-regional differences in the east were more volatile. The pattern of distribution change in the eastern and western regions is similar, showing a clear and repeated decline and a clear rise. In the central region of China, the spatial differentiation of the benefit of science and technology expenditure is small, and has a trend of gradual increase.

According to the trend of inter-regional Gini coefficient, the differences between regions are generally decreasing. In terms of the size of the Gini coefficient, the regional differences between the eastern and central, central and western regions are narrowing, mainly due to the differences in many aspects between the eastern and western regions. The eastern region has a good geographical location, but also has greater advantages in economic investment and high-tech development, which has laid a good foundation for improving the efficiency of science and technology in the eastern region. However, due to the limitations of natural geographical conditions and other factors, the level of economic development in the western region is relatively low, so it lags behind in financial development and scientific and technological innovation. Therefore, in the short term, there is still a huge gap between the efficiency of science and technology funds in the eastern and western regions. From the perspective of development trend, the Gini coefficient between regions shows a fluctuating state. However, in general, the inter-regional differences gradually decrease, and the development pattern of science and technology finance is similar.

## 5.7. Time dimension evolution analysis based on Kernel density

In order to better explain the spatio-temporal evolution of the coordination degree of S&T financial efficiency in 30 provinces and cities in China, this study uses the kernel density estimation method to analyze the development characteristics and the differences in the degree of polarization of the coordination degree. stata17.0 was used to obtain the kernel density estimation results, as shown in Figure 7 below.

It can be concluded that the dynamic evolution of the linkage and coordination degree of scientific and technological financial efficiency has the following characteristics: First, the overall level of the linkage and coordination degree of the two has increased significantly. As can be seen from the location characteristics of the kernel distribution curve, it is on the left side in 2016 and the highest point in 2018. The peaks from 2014 to 2019 are similar. It can be seen that the efficiency of the use of science and technology funds has increased year by year in the past decade, but the annual growth degree is different; Second, the absolute difference tends to decrease. According to the distribution law of the curve, the crest of the bidirectional coordination curve fluctuates up and down in each year, but the overall trend is upward. This shows that during the test period, the linkage and coordination degree of scientific and technological financial efficiency has a general trend of decreasing dispersion. In general, in the sprint stage of China's modernization construction, the efficiency of science and technology finance and the coordination between the two have been greatly improved, but because of different degrees of regional economic development, there are some differences in the efficiency of science and technology finance across the country, which plays an important role in accelerating the improvement of the efficiency of science and technology finance between regions.

# 6. Research Conclusions

In this paper, 30 provinces in China are selected as research objects, the super-efficiency EBM model is used to measure the efficiency of science and technology finance in 30 provinces in China, and the Dagum Gini coefficient is used to deconstruct their spatial differentiation characteristics, and kernel density estimation is used to conduct empirical research on the efficiency of science and technology finance in 30 provinces in China. The following conclusions are drawn:

From 2010 to 2019, the overall efficiency of sci-tech finance showed an increasing trend year by year. At the regional level, the central region has the highest efficiency while the eastern region has the lowest.

The overall spatial change of the efficiency of science and technology finance shows an upward and downward trend, and the overall efficiency of science and technology finance shows a continuous downward trend, indicating that the main reason for the overall regional change is regional differences. From a recent perspective, the difference in the efficiency of science and technology finance in western and eastern regions shows a downward trend, while the difference in the efficiency of science and technology finance in central regions shows an upward trend.

From the perspective of distribution, the main peak of kernel density function becomes steeper and shifts to the right, indicating that the development level of science and technology finance is constantly improving.

# References


[1] Ma Yulin, Ma Yunpeng, Peng Wenbo. Regional differences and dynamic evolution of sci-tech finance efficiency in China [J]. Macroeconomic Research, 2020(7):14.

[2] Lv Chengchao, Cui Yue, Yang Shanshan.] Modern economic system: Index evaluation system, regional Gap and spatiotemporal evolution [J]. Academic Digest of Liberal Arts, 2022, 39(1):2.]

[3] Hu Huanhuan, Liu Chuanming. Regional differences and dynamic evolution of S&T financial efficiency in China [J]. Statistics and Decision,2022,38(24):117-122.]

[4] Zhao Changwen, Chen Chunfa, Tang Yingkai. Science and Technology Finance [M]. Beijing: Science Press, 2009.

[5] He Baocheng, Li Shanshan. Analysis on spatiotemporal evolution of provincial sci-tech financial efficiency [J]. Cooperative Economy and Science and Technology, 2022 (01): 54-56.

[6] Jiang Zhaojun, Xu Bo.] Evaluation of Sci-tech finance efficiency in Yangtze River Delta: An empirical study based on three-stage DEA model and Malmquist model [J]. Northern Economy and Trade, 2022(11):4.

[7] Yi Ming, Zhang Lian, Yang Lisha, Fu Lina. Spatiotemporal differentiation and regional equilibrium of sci-tech financial efficiency in China [J]. Science and Technology Progress and Countermeasures,2019,36(10):34-40.

[8] Zhang Liao, Huang Leiqiong. Measurement and spatiotemporal differentiation of green technology innovation efficiency of Chinese industrial enterprises: Based on improved three-stage SBM-DEA model [J]. Statistics and Information Forum, 2020, 35(12):12.]

[9] Hou Xuhui. Research on Sci-tech financial efficiency of resource-based region based on three-stage DEA model [J]. Business Exhibition Economics,2021(02):134-136.]

[10] Song Yufei, Zhang Horizontal Level. Research on efficiency of sci-tech finance in Anhui Province based on BCC-Malmquist method [J]. Journal of hunan institute of science and technology, 2020, 9 (3) : 68-71. The DOI: 10.16336 / j.carol carroll nki cn43-1459 / z. 2020.03.018.

[11] Wang Jian. Research on Efficiency Evaluation of Technology and Finance Combination in China based on DEA-Malmquist Index [J]. Shanghai Finance, 2018(8):4.]

[12] Yao Fengtong, Jia Haonan. A study on the measurement and spatial correlation of technological finance efficiency in China [J/OL]. Price theory and practice.

[13] Wang Ren, Li Zhiwei. Structural heterogeneity and spatial distribution of sci-tech financial efficiency in China: based on two-dimensional output perspective.] Management review, 2022 (9) : 35-46. DOI: 10.14120 / j.carol carroll nki cn11-5057 / f 2022.09.002.

[14] Liu Xin, Li Yunjing, Guo Kai. Two-stage Efficiency of Financial Support Technology Innovation in China: A Test based on TSC-DEA model [J]. Research on Financial Issues, 2018(11):8.

[15] Fan Z Y, Zhang J. Fiscal decentralization and efficiency of China's economic growth: An analysis based on the non-expected output model.] Management world, 2009 (7) : 15-25 + 187. DOI: 10.19744 / j.carol carroll nki. 11-1235 / f 2009.07.003.

[16] Pan D, Ying R Y. Evaluation methods and empirical evidence of agricultural eco-efficiency in China: an analysis of SBM model based on non-expected output [J]. Acta Ecologica Sinica, 2013, 33 (12):3837-3845.

[17] Jiang R B. Research on regional financial innovation in China: Efficiency differences, environmental impacts and spatial effects.] Zhejiang University.

[18] Cao Junyong, Zhang Lezhu. Coupling regional differences and spatiotemporal evolution of digital inclusive finance and rural industry.integration: An empirical study based on Dagum Gini coefficient decomposition and Kernel kernel density estimation [J]. Rural financial.