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Evaluation of the Efficiency of Financial Investment in Science and Technology in Xi'an Metropolitan Area Research with Enhancement Strategies

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Abstract

This paper uses the super-efficient SBM-Malmquist-Tobit integrated model to measure the efficiency of financial science and technology inputs in the Xi'an metropolitan area from 2016 to 2020, explore the sources of inefficiency in each city in the circle, decompose the total factor productivity of financial science and technology inputs, and further explore the influencing factors of financial science and technology input efficiency. It is found that: 1) the efficiency of financial science and technology inputs in the Xi'an metropolitan area between 2016 and 2020 did not reach DEA, and there are evident and increasing gaps in efficiency among cities; 2) Xi'an has the highest efficiency level in the Xi'an metropolitan area and can play the leading role as a core city to be classified as a high-efficiency city. Xianyang, Tongchuan, and Yangling are mainly due to insufficient or redundant inputs, which can be classified as input inefficiency. In contrast, the inefficiency of Weinan is mainly influenced by insufficient outputs, which can be classified as output inefficiency; 3) The change in technical efficiency is the main reason for the change in total factor productivity in Xi'an Metropolitan Area. The direction of change between the two is the same, showing the characteristics of the mirror "N"-type change, first subtracting and then increasing; The Technological Progress Change Index maintained steady growth; 4) The ratio of personnel in scientific research institutions and the number of scientific research institutions, the proportion of total exports of high-tech products in GDP, and the proportion of patents granted all positively affect the efficiency of financial investment in science and technology. The summary is that as each indicator increases, efficiency grows. The R&D investment intensity and the fiscal share of science and technology will, to a certain extent, constrain the development of the efficiency of budgetary science and technology investment. The more

the acquisition, the higher the efficiency. Based on the above research findings, recommendations are made.

Keywords

Xi'an Metropolitan Area, Fiscal Science and Technology Input Efficiency, Super-Efficient SBM-Malmquist-Tobit Model

1. Introduction

Modern regional development theory believes that a metropolitan area or economic zone with a central city as the core is a powerful source of radiation to drive regional development (Tang, 2021), which is confirmed by the economic development practices of various countries. In March 2022, the National Development and Reform Commission approved the Xi'an Metropolitan Area Development Plan, making Xi'an the fifth metropolitan area approved by the state after Nanjing, Fuzhou, Chengdu, and Changzhutan Metropolitan Area. The Xi'an metropolitan area covers the whole area of Xi'an (including Xi'an New Area) and some districts and counties in Xianyang, Tongchuan, and Weinan, as well as Yangling Agricultural High-tech Industry Demonstration Zone, with an area of about 20,600 square kilometers and a resident population of more than 18 million. The Xi'an metropolitan area is rich in science and innovation resources. The number of national central science and technology infrastructures, national key laboratories, and other high-powered innovation platforms is among the highest in central and western China. The Development Plan of Xi'an Metropolitan Area clearly states that it should adhere to the core position of innovation-driven development, make efforts to build a nationally important source of scientific and technological innovation, and construct a collaborative innovation system.

Financial science and technology input is one of the primary funding sources for science and technology innovation activities, and the input's efficiency directly affects the innovation-driven strategy's implementation effect. Financial science and technology input efficiency is a measure of the effectiveness of the use of government monetary funds in science and technology, which is a close relationship between financial science and technology output and input. Many studies have found that the efficiency of regional fiscal science and technology inputs in China is not high (Wang et al., 2020; Wang, 2017), which directly impacts the implementation of the innovation-driven strategy. Further studies have found specific differences in the efficiency of financial science and technology inputs among provinces in China, with an overall trend of higher in the east and lower in the west (Han & Zhao, 2015; Wu, 2014; Wang et al., 2013). As an important scientific and technological innovation center in the western region, the financial and scientific and technological investment of Xi'an Metropolitan Area in 2020 will be 2.649 billion yuan, accounting for 47% of the investment scale of Shaanxi Province. Is the efficiency of its financial investment in science and

technology high or low? What sources of inefficiency exist? What are the factors that affect it? How to further improve the efficiency of financial investment in science and technology? The study of these questions is of great significance for deepening the reform of the fiscal budget system, realizing the target tasks of the development plan for the Xi'an metropolitan area, and promoting the coordinated development of the east-west region in the new development stage.

2. Literature Review

In terms of the spatial scope of the research on the efficiency of financial science and technology investment, the existing literature primarily focuses on 31 provinces and urban areas across China (Zhao & Chen, 2018; Tan et al., 2013; Li, 2011) or a specific province and urban area (Tian et al., 2016; Huang et al., 2014; Xu & Chen, 2017). As an emerging economic growth pole, the metropolitan area has an important position and role in the construction and development of China's innovation system (Sui & Xie, 2008). However, the research on the efficiency of financial science and technology investment in the metropolitan area has not been carried out yet. Regarding the evaluation method of financial science and technology input efficiency, researchers at home and abroad have mostly adopted the data envelopment approach (DEA). Shen Yuan, Jin Rongxue, Yang Jianfei, et al. all measured the region's financial science and technology efficiency based on the traditional DEA model by constructing an efficiency evaluation system with universality. However, the traditional DEA model cannot avoid the influence of environmental effects and random errors and cannot objectively reflect the efficiency level of the decision unit, so many researchers started to use the three-stage DEA model (Zeng et al., 2020; Meng et al., 2019). Some researchers apply non-radial and non-angular super-efficient DEA models (Lv & He, 2011).

Compared with the existing literature, the contribution and structure of this article are as follows: firstly, this paper breaks through the original administrative division limitation and carries out research from the spatial scope of the metropolitan area, which expands the scope of financial science and technology efficiency research; secondly, this paper adopts the super-efficient SBM model and Malmquist index model to measure the efficiency of financial science and technology input in the Xi'an metropolitan area from 2016 to 2020 in a static and dynamic all-round way, and the super The super-efficient SBM model combines the advantages of super-efficient DEA and SBM models, which makes the efficiency measurement more accurate; finally, this paper further decomposes the inefficiency, explores its leading causes, and constructs a Tobit model to analyze the possible influencing factors of financial science and technology input efficiency.

3. The Current Situation of Financial Science and Technology Investment

The financial investment in science and technology mainly includes human and

financial investment. This paper analyzes the current situation of financial investment in science and technology in Shaanxi Province and Xi'an metropolitan area from two perspectives: financial expenditure in science and technology and R&D personnel investment. Restricted by the lack of statistics on districts and counties, this paper takes municipal-level data as the research unit.

The fiscal expenditure in Shaanxi Province rose from 438.937 billion yuan in 2016 to 592.428 billion yuan in 2020, with an average annual growth rate of 8.74%. Science and technology expenditures in fiscal expenditures show a change of increasing and decreasing between 2016 and 2020. As shown in Figure 1, the total fiscal science and technology expenditure in the province was 6.201 billion yuan in 2016, reached a peak of 8.722 billion yuan during the study period in 2018, and the total fiscal science and technology expenditure in the province was 5.645 billion yuan in 2020. The fiscal S&T expenditure in Xi'an metropolitan area was RMB 2.922 billion in 2016, RMB 5.295 billion in 2018, and RMB 2.436 billion in 2020. The proportion of S&T expenditures to total fiscal expenditures also shows changes in the same direction.

As seen in Figure 2, the differences in fiscal science and technology expenditures within the Xi'an metropolitan area are apparent. Among them, Xi'an's fiscal science and technology expenditure is relatively high, and Tongchuan's expenditure is low. Among these five districts and cities, Xi'an's fiscal S&T expenditure always maintains a high level, reaching 4.823 billion yuan in 2018, accounting for 91% of the total fiscal S&T expenditure in the Xi'an metropolitan area. Except for Yangling, the financial S&T expenditures of all regions showed a decreasing trend after 2018.

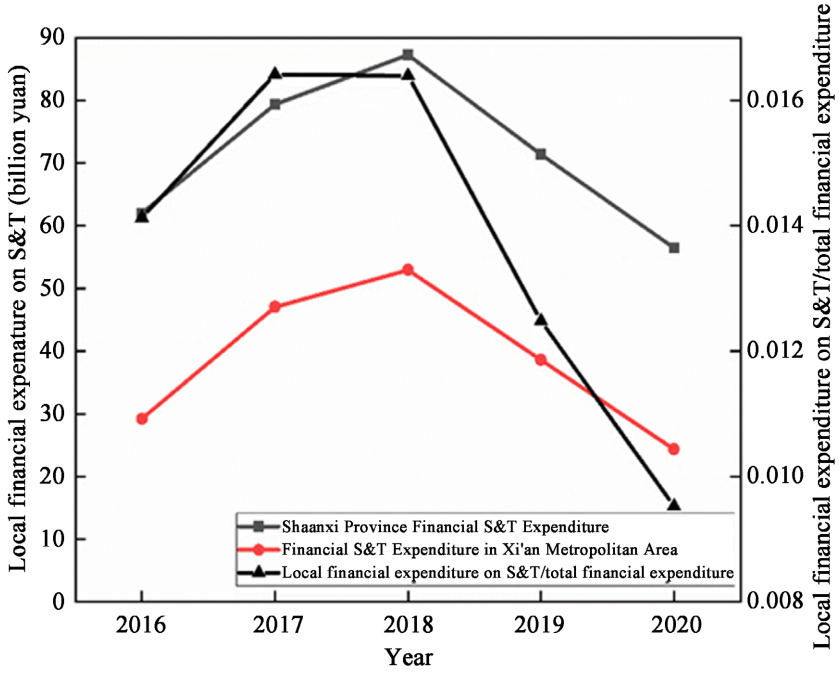

Figure 1. Fiscal expenditure on S&T and its proportion of total fiscal expenditure in Shaanxi Province, 2016-2020.

R&D personnel is engaged in 3 activities within the unit: basic research, applied research, and experimental development. As an important indicator to measure the investment in the science and technology workforce, the full-time equivalent of R&D personnel is the sum of the workload of personnel engaged in R&D activities for more than 90% of the working time throughout the year and the workload of part-time personnel converted by actual working time. From Figure 3, the number of personnel engaged in R&D activities in industrial enterprises above the scale in Shaanxi Province during the "13th Five-Year Plan" period decreased and then increased. In 2018, 56,928 people engaged in R&D activities in industrial enterprises above the designated size in the province, a decrease of 13,883 people compared with 2016, a decrease of 19.6%. In terms of equivalent full-time personnel, it was 39,315 person-years, a decrease of 13.33%

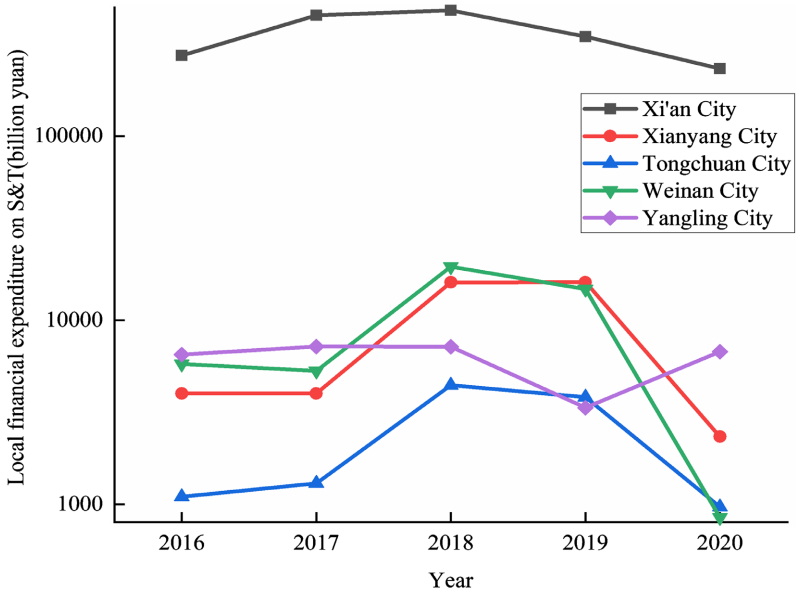

Figure 2. Financial S&T Expenditure by Region, 2016-2020.

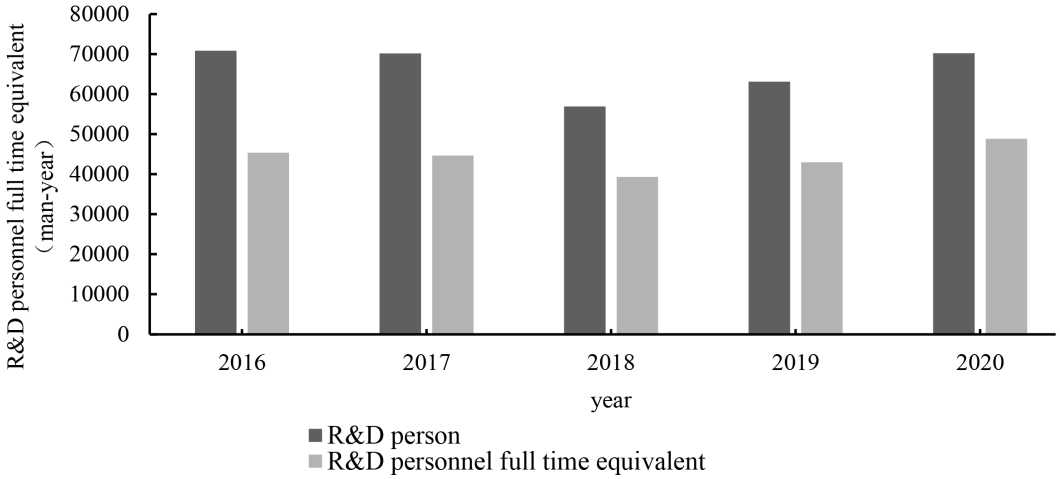

Figure 3. R&D personnel and equivalent full-time personnel of industrial enterprises above the scale in Shaanxi Province, 2016-2020.

compared with 2016. By 2020, there will be 70,206 people engaged in R&D activities in industrial enterprises above the scale in Shaanxi Province, and the full-time equivalent of R&D personnel will be 48,809 person-years, reaching the maximum value during the 13th Five-Year Plan period, with an increase of 7.6% and 24.15% compared with 2016 and 2018, respectively.

As shown in Figure 4, the equivalent full-time personnel in the Xi'an metropolitan area first decreased and then increased during 2016-2020, from 36,066 person-years in 2016 to 31,421 person-years in 2018, a decrease of 5.38% compared with the previous year and then rebounded significantly, reaching 35,661 person-years by 2020. The full-time person-equivalent of each city within the Xi'an metropolitan area varies widely. The increase or decrease trend of Xi'an City is the same as that of the metropolitan area, but the difference is that Xi'an City's full-time staff equivalent will grow to a maximum of 29,052 person-years in 2020. The full-time person-equivalent data of Xianyang and Weinan fluctuate between 1400 - 4000 person-years, while the value range of Tongchuan and Yangling Demonstration Zone is below 500 person-years.

All data in this article are from Shaanxi Statistical Yearbook, Shaanxi Science and Technology Yearbook and the National Economic and Social Development Statistical Bulletin. All figures contained in this article are original.

4. Method Selection and Index System Construction

4.1. Super-Efficient SBM-Malmquist-Tobit Integrated Model

The super-efficient SBM-Malmquist-Tobit model consists of a combination of the super-efficient SBM model in the data envelopment method, the Malmquist index model, and the Tobit model for analyzing the influencing factors. At this

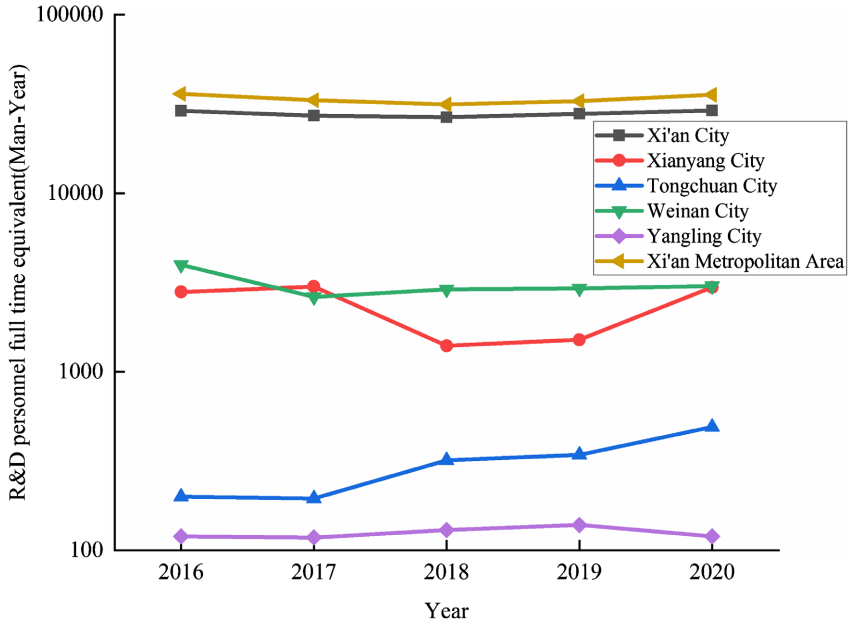

Figure 4. Converted full-time personnel equivalents of R&D personnel in industrial enterprises above scale in Xi'an metropolitan area, 2016-2020.

stage, the data envelopment method is commonly used; the measurement of the degree of inefficiency is only based on the reduction (increase) of the input (output) proportion. However, it ignores the measurement error caused by the variable relaxation and the radial problems, resulting in inaccurate measurement results. Therefore, this paper draws on the ultra-efficient SBM model proposed by Tone in 2001, based on the measurement method of relaxation variables, further explores the problems of input redundancy and insufficient output, and at the same time ranks the relative efficiency of the decision-making unit with the same efficiency value of 1 at the production frontier. Suppose there are n decision making units (DMUs) to be evaluated, denoted as DMU_j ($j=1,2,\cdots,n$); each DMU has m inputs, denoted as $x_i\left(i=1,2,\cdots,m\right)$, and r outputs, denoted as $y_r\left(r=1,2,\cdots,s\right)$. the SBM model expressions are:

$$\min_{\lambda,s^-,s^+}\rho=\frac{1+\frac{1}{m}\sum_{i=1}^{m}s_i^-/x_{ik}}{1-\frac{1}{s}\sum_{r=1}^{s}s_r^+/y_{rk}},\quad\begin{cases}x_{ik}\geq\sum_{j=1,i\neq k}^{n}x_{ij}\lambda_j-s_i^-\\ y_{rk}\leq\sum_{j=1,i\neq k}^{n}y_{rj}\lambda_j+s_r^+\\ \sum\lambda=1,\lambda_j\geq 0,\ j=1,2,\cdots,n;\\ s_i^-\geq 0,i=1,2,\cdots,m;\ s_r^+\geq 0,r=1,2,\cdots,s\end{cases}. \quad (1)$$

In Equation (2), ρ^* denotes the efficiency value of DMU, s^- denotes the slackness of the input variables, s^+ denotes the slackness of the output variables, and λ is the weight vector. The input inefficiency value α_i and the output inefficiency value β_r can be stripped from the equation on ρ^*.

$$\rho^*=\frac{1-\sum_{i=1}^{m}\alpha_i}{1+\sum_{r=1}^{s}\beta_r},\quad\begin{cases}\alpha_i=\frac{1}{m}\frac{s_i^{-*}}{x_{i0}},i=1,2,\cdots,m\\ \beta_r=\frac{1}{s}\frac{s_r^{+*}}{y_{r0}},r=1,2,\cdots,s\end{cases}. \quad (2)$$

If $0<\rho^*<1$, it means that the DMU efficiency does not reach the effective level, and the closer ρ^* is to 0, the lower its efficiency level is; if $\rho^*\geq 1$, it means that DEA is effective. By comparing the magnitude of the absolute values of α_i and β_r, it is determined whether the input is redundant or the output is insufficient.

Given that the DEA method can only statically analyze the relative efficiency of DMUs in the same period, this paper adopts the Malmquist index model to dynamically evaluate the total factor productivity (M) of local finance in science and technology. The main cities (districts) in Xi'an metropolitan area are used as the decision unit to construct the technology-efficient frontier and observe the Malmquist index of total factor productivity growth under the time series. At the same time, the change of technical efficiency (EC) and the change of technical progress rate (TC) are obtained. The change in total factor productivity from t to $t+1$ is:

$$M_i\left(x^{t+1},y^{t+1},x^t,y^t\right)=\sqrt{\frac{E_i^t\left(x^{t+1},y^{t+1}\right)}{E_i^t\left(x^t,y^t\right)}\frac{E_i^{t+1}\left(x^{t+1},y^{t+1}\right)}{E_i^{t+1}\left(x^t,y^t\right)}}=\mathrm{EC}\times\mathrm{TC}. \quad (3)$$

The changes in technical efficiency over the two periods are:

$$\mathrm{EC} = \frac{E_i^{t+1}\left(x^{t+1}, y^{t+1}\right)}{E_i^{t}\left(x^{t}, y^{t}\right)}. \tag{4}$$

The movement of the two periods of the frontier can represent changes in the rate of technological progress:

$$\mathrm{TC} = \sqrt{\frac{E_i^{t}\left(x^{t}, y^{t}\right)}{E_i^{t+1}\left(x^{t}, y^{t}\right)} \frac{E_i^{t}\left(x^{t+1}, y^{t+1}\right)}{E_i^{t+1}\left(x^{t+1}, y^{t+1}\right)}}. \tag{5}$$

Where E represents the distance function between decision units; EC represents the change in the efficiency of financial science and technology input-output technology from t to $t+1$; TC indicates the change in technological progress from the t period to the $t+1$ financial science and technology input and output. The total factor growth rate increases if the Malmquist index is greater than 1. If EC > 1, the technical efficiency increases, and if TC > 1, it indicates technological progress.

The minimum SBM efficiency value is 0, which is consistent with the range of values of Tobit model (restricted dependent variable model), so Tobit model can be chosen for analysis. the expression of Tobit model is:
$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon_i$, where Y denotes the dependent variable, X_n denotes the explanatory variable, α denotes the intercept term, β_n denotes the regression coefficient of the explanatory variables, and ε_i denotes the random disturbance term. in the Tobit regression model, the efficiency values measured in the text are used as the dependent variables, the influencing factors are used as independent variables, and the parameters are estimated using the maximum likelihood estimation method, and whether they pass the significance test is judged according to the ρ^* value in the regression results.

Firstly, this paper measures the efficiency of financial science and technology inputs and outputs of five major cities (districts) in the Xi'an metropolitan area using the super-efficient SBM model and analyzes the sources of inefficiency in each city (district). In the second step, the Malmquist index model is used to study the influencing factors of total factor productivity changes in terms of technological progress and technical efficiency. Finally, the Tobit model is used to analyze the influencing factors of financial science and technology input-output efficiency by regression with the efficiency value measured by the SBM model as the dependent variable.

4.2. Indicator Selection and Data Sources

Financial and human inputs are crucial to the progress of science and technology. The index system of evaluating the efficiency of financial science and technology inputs and outputs in the metropolitan area constructed in this paper contains input indicators in two dimensions of human and financial resources and output indicators in three dimensions: direct output, indirect output, and

transformation of scientific and technological achievements. Referring to the input indicator design process of Liang-Yu Peng and Xiugaku Tan, the full-time equivalent of R&D personnel is used to measure human input. Local fiscal S&T expenditure and the proportion of local fiscal S&T expenditure to total fiscal expenditure are used as financial input indicators, with the former measuring the absolute scale of fiscal S&T funds and the latter reflecting the intensity of financial support for S&T. Table 1 demonstrates the system of financial science and technology input efficiency indicators. The premise of the DEA model is the isotropy of input and output indicators. In this paper, the correlation between input and output indicators is tested with the help of SPSS Statistics 28.0 software, and the results are shown in Table 2. The results in Table 2 show that the correlation coefficients between the indicators are all positive, which is consistent with the homogeneity assumption of DEA. The correlation coefficients of most of the input and output indicators are close to 1. The correlation is strong, among which the correlation coefficient between R&D personnel full-time equivalent

Table 1. Index system of efficiency of local financial investment in S&T in Xi'an metropolitan area.

	Index	Unit	Remarks
Input	Local financial expenditure on S&T x_1	Billion	Reflect the total amount of local financial investment in science and technology
	Local financial expenditure on S&T/total financial expenditure x_2	%	Reflect the intensity of local financial investment in science and technology
	R&D personnel full time equivalent x_3	Man-Year	Reflects the total amount of R&D manpower investment
Output	Business income of industrial enterprises above the scale y_1	Billion	Reflects the innovation benefits of the company
	Invention patent authorization y_2	Pieces	Reflect the direct output of scientific and technological activities
	Technology market contract turnover y_3	Billion	Reflect the transformation and promotion of the results of scientific and technological activities

Source: taking into account the lag of financial science and technology inputs and outputs, the outputs are set with a lag of one period on the basis of reference to other literature, and the years selected for inputs are 2016-2020 and outputs are 2017-2021.

Table 2. Correlation coefficients of input-output terms.

Index	y_1	y_2	y_3
x_1	0.895	0.892	0.863
x_2	0.906	0.852	0.813
x_3	0.986	0.991	0.984

and the number of patents granted is the largest at 0.991. The correlation coefficient between the proportion of local fiscal expenditure on science and technology to total fiscal expenditure and technology market contract turnover is the lowest at 0.813, which is a reasonable indicator setting in general.

5. Process of Empirical Analysis

5.1. Efficiency Value Measurement Results Based on the Super-Efficient SBM Model

The super-efficient SBM model has the advantage of further ranking the decision units with effective DEA and decomposing the essential causes of inefficient sources. The measurement result of its efficiency value of less than 1 indicates that the DEA is invalid in the corresponding year and that the financial science and technology input is inefficient. In contrast, the measurement result is greater than 1 and the larger the difference, the higher the efficiency of its input. This paper, MaxDEA8.0 is used to calculate the super-efficiency values of major cities (districts) in Xi'an metropolitan area for each year as shown in Table 3.

Figure 5 shows that the efficiency of financial science and technology investment in the Xi'an Metropolitan Area from 2016 to 2020 is invalid, and the average value is 0.767. Among them, the efficiency gap between cities is large, and Xi'an has the highest efficiency, with 1.129; Yangling has the lowest efficiency, at 0.445. The efficiency values are sorted as Xi'an>Weinan > Xianyang > Tongchuan > Yangling. As shown in Table 4, the efficiency difference between Xi'an and Yangling in 2020 is 0.98, and the gap between 2016 and 2020 has an increasing trend. From each city's perspective, Xi'an's efficiency values in the 13th Five-Year Plan period are DEA invalid. Combined with the state of financial science and technology inputs, Xi'an is a high input and high output type. Weinan's fiscal efficiency in science and technology is higher than 1 in 2017, 2019, and 2020, which means that the efficiency level is higher in these years but fluctuates wildly; while Xianyang, Tongchuan, and Yangling have efficiency values greater than 1 in individual years, but the overall fluctuation decreases.

To further explore the sources of inefficiency, the inefficiency values in Table 3 are decomposed from two perspectives of inputs and outputs. The larger the corresponding inefficiency value means the farther away from the production frontier surface, the lower the efficiency level. The inefficiency value of zero

Table 3. Efficiency of financial investment in S&T in Xi'an metropolitan area, 2016-2020.

	Region	2016	2017	2018	2019	2020	Average
Xi'an metropolitan area	Xi'an	1.046	1.188	1.105	1.111	1.193	1.129
	Xianyang	1.137	0.427	0.687	0.668	0.579	0.700
	Tongchuan	0.932	0.791	0.330	0.825	0.458	0.667
	Weinan	0.513	1.010	0.741	1.125	1.073	0.892
	Yang ling	1.043	0.413	0.296	0.261	0.213	0.445

means no adjustment is needed. the decomposition results of non-DEA effective sources of major cities (districts) in Xi'an metropolitan area from 2016 to 2020 are shown in Table 5.

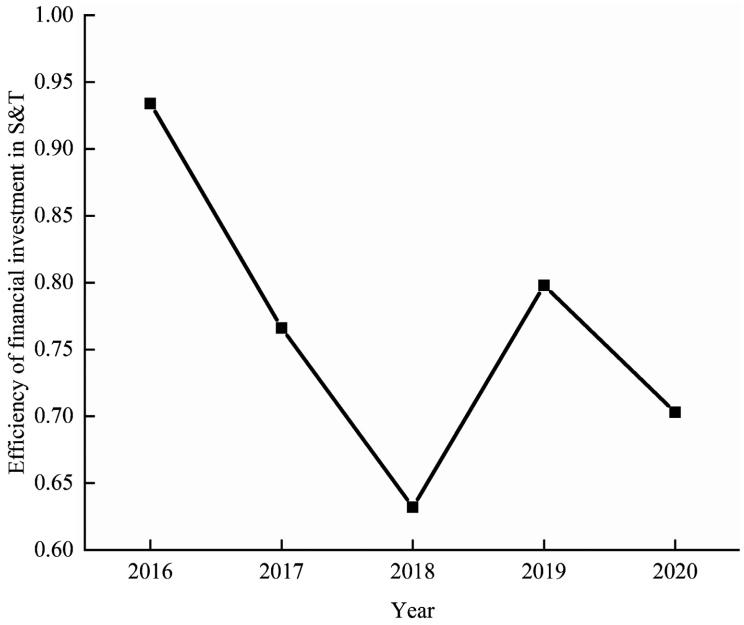

Figure 5. Trends in the efficiency of financial investment in S&T in Xi'an metropolitan area.

Table 4. City efficiency differences in the Xi'an metropolitan area, 2016-2020.

Year	2016	2017	2018	2019	2020
Extreme areas	Xianyang-weinan	Xi'an-yangling	Xi'an-yangling	Weinan-yangling	Xi'an-yangling
Efficiency difference	0.624	0.775	0.809	0.864	0.98

Table 5. Decomposition of non-DEA effective sources in Xi'an metropolitan area, 2016-2020.

Region	2016			2017			2018		
	ρ^1	α_1	β_1	ρ^2	α_2	β_2	ρ^3	α_3	β_3
Xianyang				0.427	0.002	0.261	0.687	0.016 (−)	0.016 (−)
Tongchuan	0.932	0.062 (−)	0.110 (−)	0.791	0.070 (−)	0	0.330	0	3.492
Weinan	0.513	0.255	5.582				0.741	0	8.551
Yang Ling				0.413	0.010 (−)	0	0.296	0.180	0.106

Region	2019			2020		
	ρ^4	α_4	β_4	ρ^5	α_5	β_5
Xianyang	0.668	0.009 (−)	0	0.579	0.377 (−)	0.055 (−)
Tongchuan	0.825	0.121 (−)	0	0.458	0.537 (−)	0
Weinan						
Yang Ling	0.261	0.111 (−)	0.162 (−)	0.213	0.073 (−)	0

α is used to determine that the inefficiency comes from input redundancy or insufficient input (−), and β can be judged that the source of inefficiency is insufficient output or excess output (−). Xianyang shows four consecutive years of inefficient financial science and technology inputs, mainly from the input side, with a negative alpha meaning insufficient inputs and outputs in 2017. Tongchuan exceeded the output in 2016 yet still could not offset the impact of insufficient inputs on the efficiency results, and the common problem in 2017, 2019, and 2020 manifested itself in the number of inputs not meeting the corresponding outputs, which corroborates with the low amount of inputs in Tongchuan as mentioned earlier. The positive value of β in the inefficiency year for Weinan indicates that the lack of output is the main reason for the inefficiency of financial science and technology inputs in Weinan. For Yangling, the problem of insufficient input and input redundancy coexists, with input redundancy in 2018 being the mainstay, and in 2016, 2019, and 2020, it was mainly manifested as insufficient output.

5.2. Efficiency Decomposition Based on Malmquist Index Model

Total factor productivity reflects the level of change in the efficiency value of the $t+1$ period compared to the efficiency value of the t-period. As shown in Figure 6, the total factor productivity and technical efficiency change direction of Xi'an Metropolitan Area from 2016 to 2020 are the same, showing the characteristics of mirror "N" changes. The law manifests itself as first decreasing and then increasing, which shows that changes in technological efficiency are the main reasons for changes in total factor productivity. During the study period, the two showed an overall upward trend, decreasing in 2017-2018, and total factor

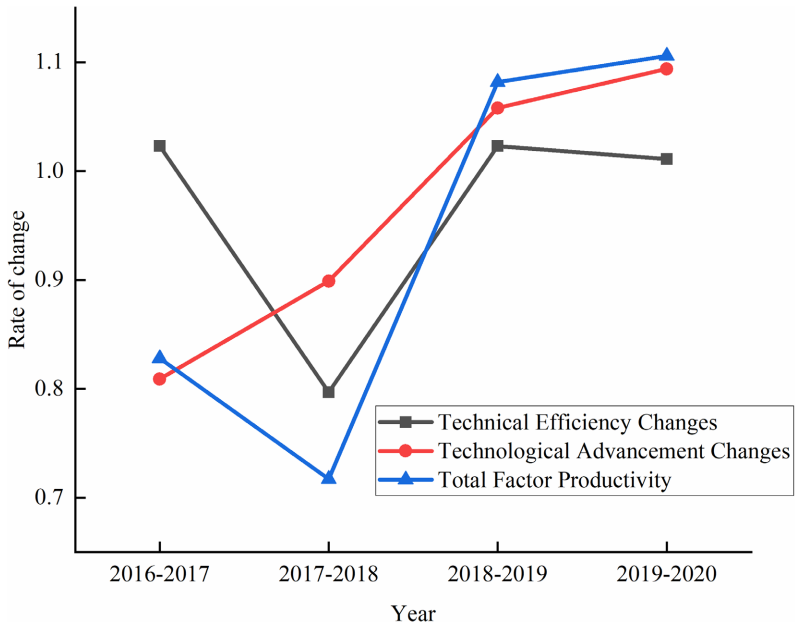

Figure 6. Trend of total factor productivity of financial science and technology investment in Xi'an metropolitan area, 2016-2020.

productivity and technical efficiency decreased from 0.828 and 1.023 to 0.717 and 0.797, respectively, which may be affected by the reform of budget performance management on budget allocation and innovation support—stable volatility around "1" after 2018. The Technology Progress Change Index shows an upward trend, with results more significant than one reaching DEA effectiveness in 2018-2019.

5.3. Results of Tobit Regression Model Analysis

In this paper, starting from the three dimensions of government, enterprises, and regional innovation level, five explanatory variables are selected to analyze the influencing factors of regional financial science and technology efficiency. The results of specific Tobit regression analysis are shown in Table 6.

From the regression coefficients, the order of the degree of influence on the efficiency of regional financial investment in science and technology is the intensity of R&D investment, the ratio of personnel in research institutions and the number of research institutions, the proportion of total exports of high-tech products in GDP, the proportion of patents granted, and the proportion of local financial expenditure on science and technology in local finance. Among the five selected influencing factors, R&D investment intensity has a significant negative correlation with the efficiency of local fiscal science and technology investment ($\alpha = -0.042$; $p < 0.01$), followed by a negative correlation with the proportion of local fiscal science and technology expenditure in local finance ($\alpha = -0.003$; $p < 0.01$). The efficiency of local financial science and technology investment decreases by 0.003 units for every 1 unit increase in the proportion of financial science and technology expenditure in local finance, not the more the investment, the higher the efficiency. The ratio of personnel of scientific research institutions and the number of scientific research institutions is positively correlated with the efficiency of financial science and technology investment ($\alpha = 0.041$; $p < 0.01$). High-tech talents are essential to a region's competitiveness in science and technology. For every 1 unit increase, the efficiency of financial

Table 6. Trend of total factor productivity of financial science and technology investment in Xi'an metropolitan area, 2016-2020.

Explanatory variables	Regression coefficient	robust standard errors
The proportion of local financial expenditure on science and technology in local finance	−0.00285***	0.080
R&D investment intensity	−0.04162***	0.048
Total exports of high-technology products as a percentage of GDP	0.01183***	0.066
Proportion of patents granted	0.00306***	0.057
Ratio of research institution personnel to number of research	0.04074***	0.022

Note: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

science and technology investment increases by 0.041 units, so the importance of talents is self-evident. Next is the ratio of total exports of high-tech products to GDP and the ratio of patents granted; for every 1 unit increase in the export value of high-tech products and the number of patents granted, the efficiency of science and technology increases by 0.012 and 0.003 units, respectively.

6. Empirical Results and Recommendations

This paper uses the super-efficient SBM-Malmquist-Tobit integrated model to measure the efficiency values of financial science and technology inputs in the Xi'an metropolitan area from 2016 to 2020, explore the sources of the inefficiency of each city, decompose the total factor productivity of financial science and technology inputs during the study period and explore the influencing factors of financial science and technology input efficiency, and draw the following conclusions: 1) the efficiency of financial science and technology inputs in the Xi'an metropolitan area between 2016 and 2020 did not reach DEA, and there are evident and increasing gaps in efficiency among cities; 2) Xi'an has the highest efficiency level in the Xi'an metropolitan area and can play the leading role as a core city to be classified as a high-efficiency city. Xianyang, Tongchuan, and Yangling are mainly due to insufficient or redundant inputs, which can be classified as input inefficiency. In contrast, the inefficiency of Weinan is mainly influenced by insufficient outputs, which can be classified as output inefficiency; 3) The change in technical efficiency is the main reason for the change in total factor productivity in Xi'an Metropolitan Area. The direction of change between the two is the same, showing the characteristics of the mirror "N"-type change, first subtracting and then increasing; The Technological Progress Change Index maintained steady growth; 4) The ratio of personnel in scientific research institutions and the number of scientific research institutions, the proportion of total exports of high-tech products in GDP, and the proportion of patents granted all positively affect the efficiency of financial investment in science and technology. The summary is that as each indicator increases, efficiency grows. The R&D investment intensity and the fiscal share of science and technology will, to a certain extent, constrain the development of the efficiency of budgetary science and technology investment. The more the acquisition, the higher the efficiency. Because of the above conclusions, the following countermeasures are proposed:

First, optimize the structure of monetary fund allocation. According to the SBM empirical results, Xi'an belongs to the high-efficiency type. At the same time, Xianyang, Tongchuan, and Yangling are inefficient in financial science and technology investment due to insufficient input for some years. Provincial financial departments should fully consider the efficiency of using monetary funds in previous years when making budget allocations and increase and reduce financial allocations in a targeted manner to avoid the coexistence of input redundancy and under-input within regions.

Second, strengthen the transformation of scientific and technological achieve-

ments. Strengthening the transformation of scientific and technological achievements is one of the essential measures to improve the scientific and technological output of cities with insufficient output, such as Weinan. Scientific and technological achievements can only become real productivity if they enter the market, so it is necessary to strengthen the construction of a team of scientific and technological brokers and build a bridge of communication between universities, research institutes, and enterprises. The primary position of enterprise innovation should be consolidated, and a two-way interaction mechanism should be established. The government should also give policy preferences, increase policy support, and reward technology transfer institutions and technology brokers for facilitating the transformation of scientific and technological achievements. At the same time, it should enrich the marketization of scientific and technological achievements and promote the transformation of primary research results into the market.

Third, crack the efficiency gap within the metropolitan area, enhance the radiation-driving ability of Xi'an national central city and improve the scientific and technological innovation ability of small and medium-sized cities. The fundamental advantage and development impetus of the metropolitan area comes from the agglomeration and radiation function of the central city. The precondition for the central city to play its agglomeration and radiation function is that there must be several economic hinterlands around it, i.e., it must be supported by small and medium-sized cities and other metropolitan areas. The relative advantageous resources of Xianyang, Tongchuan, Weinan, Yangling and other cities are fully utilized to enhance Xi'an's ability to radiate and drive as a national central city. A good division of labor and collaboration in planning objectives, planning strategies, planning tasks, and action plans are complemented to achieve resource integration and redistribution to maximize benefits. It will improve the mechanism of integrated regional development, stimulate the role of intra-regional coordination, promote the deep integration of the metropolitan area, and escort high-quality development.

Fourth, we attach importance to the cultivation and introduction of scientific research talents. Scientific institutions and researchers have a significant role in promoting financial investment in science and technology efficiency. It is necessary to cultivate scientific research reserves and, improve the basic scientific research facilities; set up special subsidies to provide reciprocal treatment levels for scientific research talents. Secondly, we should pay attention to the university student group and broaden the channels of school-enterprise cooperation. Finally, we should introduce high-end talents in a targeted manner and improve the talent introduction policy through systematic and comprehensive talent performance assessment. In particular, we should focus on the flexible introduction of talents to Weinan. With the new model of "government + university + research institute + enterprise", the advantages of universities and research institutes are integrated. To create a demonstration platform integrating industrial science and technology innovation, industry-academia-research cooperation,

and achievement transformation, to provide development momentum for government development planning, talent training, and other fields, and to promote high-quality regional economic development.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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