ISSN:2790-1661 Volume-5-(2023)

Research on the Efficiency of Cross-Region Scientific and Technological Innovation Resources Allocation in Chengdu-Chongqing Economic Circle

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Abstract. Analyzing the efficiency of cross-region scientific and technological innovation resources allocation in Chengdu-Chongqing economic circle is helpful to understand the achievements in the construction of economic circle and development trend, and it is great significance to important growth pole for promoting the high-quality development of Chengdu-Chongqing economic circle. Applying the method of three-stage DEA, combined with the input-output data of scientific and technological innovation resources in 44 regions of Chengdu-Chongqing economic circle from 2014 to 2019, this paper studies the allocation efficiency and influencing factors of scientific and technological innovation resources in this region during this period. Results indicate that: Firstly, after excluding the influence of external environmental factors, the average allocation efficiency of scientific and technological innovation resources in Chengdu-Chongqing economic circle changes little from year to year and is at a low level. The allocation efficiency composition of each region is generally characterized by high pure technical efficiency and low scale efficiency. Secondly, the improvement of the degree of opening to the outside world and the level of education investment is conducive to the improvement of the allocation efficiency of scientific and technological innovation resources, while the improvement of the level of economic development and the adjustment of industrial structure have not effectively driven the improvement of the allocation efficiency of scientific and technological innovation resources to a certain extent.

Keywords: Chengdu-Chongqing economic circle; three-stage DEA model; scientific and technological innovation resources; allocative efficiency.

1. Introduction

Currently, China is committed to building the Chengdu-Chongqing Economic Circle into a national influential technological innovation center. In recent years, the overall level of scientific and technological innovation investment in Chengdu-Chongqing area has increased significantly, but some regional scientific and technological innovation investment levels have grown slowly, and even the relative investment proportion has declined. For example, in 2019, the internal expenditure of R&D funds in Chengdu-Chongqing area was about 128.1 billion yuan, an increase of 96.7%over 2014. Among them, the internal expenditures of Chongqing and Chengdu R&D accounted for 32%and 35%of the total expenditure of Chengdu-Chongqing area, respectively. In 2019, the sum of the internal expenditures of R&D, Guangan City, Meishan City, Yaan City, and Ziyang City, only 1.5%of the total expenditure of Chengdu-Chongqing area, a decrease of 0.6%from 2014. The sum of the internal expenditures of R&D in Fengdu County, Shizhu County, Yunyang County, and Tongliang District accounted for only 0.2%of the total expenditure of Chengdu-Chongqing, which is almost the same as in 2014. It can be seen that at present, there are uneven distribution between scientific and technological innovation resources in Chengdu-Chongqing area, which may cause waste and mismatch loss of scientific and technological innovation resources [1], which leads to low efficiency of scientific and technological innovation resources, inconsistency between regional innovation, etc. Therefore, in-depth exploration of the efficiency of cross-regional scientific and technological innovation resource allocation efficiency of the Chengdu-Chongqing Economic Circle, and promote the technological achievements of the Chengdu-Chongqing Economic Circle, the non-obstacle flow of innovative talents and innovative capital elements, and the co-construction

sharing of innovative subjects. It is of great significance to realize the strategic deployment of the Science and Technology Innovation Center in the area.

It can be seen through the literature that domestic scholars have launched many active explorations on the allocation of scientific and technological innovation resources and achieved a series of research results. (1) Research area. Some scholars have selected relevant indicators from the perspective of my country's overall perspective to analyze the efficiency of technological resource allocation, and propose to improve the efficiency countermeasures on the basis of finding the unreasonable reasons of the resource allocation [2-4]; Another part of the scholars used a certain province, city, or region as the research object to calculate the efficiency of its resource allocation, and found problems such as uneven distribution and improper allocation of scientific and technological innovation resources [5-6]. (2) Construction of the indicator system. The indicator system of the efficiency of scientific and technological innovation resource allocation is mostly constructed from two aspects: scientific and technological innovation input and output [7-13]. (3) Research methods. Most of the classic DEA models [11, 14] and its improved models calculate and evaluate the efficiency of technological innovation resource allocation. Super efficiency SBM model [15], three-stage SBM model [16]; some scholars use random cutting-edge production function analysis (SFA), MALMQUIST index model, multi-dimensional entropy right-TOPSIS method or above models, etc. Empirical analysis of the efficiency of scientific and technological resource allocation [10, 17-18].

It is found that most of the existing research is studied nationwide or a certain area perspective, and the lack of research on the allocation of scientific and technological innovation resource elements between cross -region lacks. Therefore, this article builds a scientific and technological innovation resource input production index system based on the objective environment of the Chengdu-Chongqing economic circle, using the three-stage Data Envelopment Analysis method (Three stage DEA) that can eliminate the external environment and statistical noise, to measure and analyze the efficiency of the allocation of scientific and technological innovation resources and its influencing factors.

2. Research method and data source

2.1 Research method

The Data Envelopment Analysis (DEA) is a nonparametric model evaluation method that currently commonly used in the calculation efficiency of domestic scholars. This method fully considers the input -output solution for the decision-making units, so it can ideally reflect the information and characteristics of the evaluation object. At the same time, the DEA method is unique to evaluating the multiple input and multiple output analysis of the complex system. However, scholars such as Fried [19] pointed out in the relevant papers that the traditional DEA model did not consider the impact of environmental factors and random noise on the efficiency evaluation of decision-making units. In response to the above deficiencies, Fried introduced the three-stage DEA model, and the random cutting-edge model (SFA) of non -parameter data packaging models and parameter methods is to use the SFA regression model in the second stage to eliminate the inefficient management, environmental factors and random noise in the second stage. The impact on the original decision-making units, so as to get more realistic efficiency values. Therefore, combined with the characteristics of the efficiency evaluation of scientific and technological innovation resource allocation in the Chengdu-Chongqing economic circle, this article uses the three-stage DEA model as the evaluation method.

(1) The first stage. The DEA model in the first stage of this article adopts a BCC model with input -oriented and large-scale remuneration. The 16 cities are regarded as evaluation units (DMU), and the BCC model of input-oriented is used to obtain a preliminary evaluation of comprehensive efficiency, pure technical efficiency, and scale efficiency. The BCC model of the puppet form under the input orientation can be represented as follows.

$$\min \theta - \varepsilon \left(\hat{e}^T S^- + e^T S^+ \right)$$

$$s.t. \begin{cases} \sum_{j=1}^{n} X_j \lambda_j + S^- = \theta X_0 \\ \sum_{j=1}^{n} Y_j \lambda_j - S^+ = Y_0 \\ \lambda_j \geq 0, S^-, S^+ \geq 0 \end{cases} \tag{1}$$

Among them, j means decision-making unit; x, y represents input and output vector, respectively. If $\theta = 1, S^+ = S^- = 0$, the decision-making units DEA is valid; if $\theta = 1, S^+ \neq 0$、$S^- \neq 0$, the decision-making units is weak; if $\theta < 1$, the decision-making units is not valid. The efficiency value calculated by the BCC model is comprehensive technical efficiency (TE), TE = SE*PTE.

(2) The second stage. Establish the SFA regression model to analyze the relaxation variables input. Guided by input, the relaxation of the first stage is decomposed into environmental factors, inefficient management, random interference items, and the relaxation variables calculated in the first stage are used as the dependent variable, and the external environmental factors are adjusted as an independent variable to adjust the relaxation variables, Eliminate the impact of environmental factors and random factors on efficiency measurement, so that all decision -making units can be adjusted in the same external environment and the same luck, and use this data as the basis of calculation foundation in the third stage. Input-oriented SFA regression function is as follows.

$$S_{ni} = f(Z_i; \beta_n) + v_{ni} + \mu_{ni}$$
$$i = 1, 2, \cdots, I; n = 1, 2, \cdots, N \tag{2}$$

Among them, Sni is the relaxation value invested in the n item of the i decision unit; Zi is an environmental variable, β nis the coefficient of the environment variable; Vni+Uni is a mixed error term and the two are independent of each other, Vni indicating that random interference, Uni indicating that the management is inefficient.

(3) Third stage. Use the model of the first stage to calculate the adjustment variable and original output to obtain the relative efficiency value of each decision-making unit. The adjusted data has excluded the impact of the external environment such as environmental variables and random interference, so the efficiency value obtained is more objective and realistic.

2.2 Index System and Data Source

Science and technology innovation resources are the sum of scientific and technological elements such as human, material resources, financial resources, information, technology, and organizations. In order to reflect the overall situation of the efficiency of science and technology innovation resources in the Chengdu-Chongqing economic circle, this article borrows the existing research results, Combined with the characteristics of the allocation of science and technology innovation resources in Chengdu-Chongqing economic circle, and considering the rationality and acquisition of data, Three types of indicators for the allocation of science and technology resources were established (Table 2.1).

The data of this article comes from 15 cities such as "China Statistics Yearbook", "Chongqing Statistics Yearbook", "Sichuan Statistics Yearbook", "Sichuan Science and Technology Yearbook", and "Chengdu Statistics Yearbook", including statistical yearbooks, government work in various districts and counties in Chongqing The report and the statistics of the national economic and social development statistics of each district and county, including the use of interpolations of individual

missing data. At the same time, considering the objective existence of input and output activities, the indirect output of output variables will be lagged behind.

Table 2.1 Scientific and technological innovation resource efficiency index system

First-level indicator	Secondary indicator	Three-level indicator	Unit
Input	Human Resources	R&D personnel full-time equivalent	(Year of people)
	Material Resources	Technology business incubator	(indivual)
	Financial Resources	R&D Internal expenditure	(10,000 yuan)
	Technical Resources	Number of high -tech enterprises	(indivual)
Output	Direct output	Number of applications for invention patents	(Part)
	Indirect output	High -tech industry new product sales revenue	(100 million yuan)
External environment	The level of economic development	Per capita GDP	(yuan)
	Industrial structure adjustment	The output value of the tertiary industry accounts for GDP ratio	(%)
	Degree of openness	The total import and export value accounts for GDP ratio	(%)
	Education level	Educational expenditure accounts for GDP ratio	(%)

3. Analysis of the efficiency of scientific and technological innovation resource allocation and its influencing factors

3.1 The first stage DEA test results

Using Deap2.1 Software to measure the input and output indicators of the Chengdu-Chongqing region (15 cities in Sichuan, 29 areas in Chongqing) 2014-2019, the comprehensive technical efficiency (TE), pure technical efficiency (PTE), and scale efficiency (SE) that included environmental factors and statistical noise were obtained. Without considering the inconsistency, environmental factors and random errors, the average value of comprehensive technical efficiency (TE) of each evaluation unit scientific and technological innovation resource allocation is 0.55, the average value of pure technical efficiency (PE) is 0.67, and the average value of scale (SE) is 0.80, the overall allocation efficiency of scientific and technological innovation resources is low, and the scale efficiency of the allocation of scientific and technological innovation resources is higher than that of pure technology. In terms of comprehensive technical efficiency, Ziyang City, Shapingba District, Banan District, Tongliang District and Fengdu County are 1.00. It is located on the forefront of technology. The remaining 39 areas are invalid.

From the perspective of time series, the average efficiency of the comprehensive technical efficiency is 0.66-0.66-0.52-0.42-0.50-0.53, which is manifested as a "decline-rise" trend. The average efficiency of pure technical efficiency is 0.76-0.77-0.64-0.61-0.61-0.64, which is manifested as a "rise-decrease-rising" trend. The average scale efficiency is

0.87-0.85-0.79-0.68-0.80-0.81, which is manifested as a "decline-rise" trend. The three efficiency values have a small change, but the efficiency trend is a decline.

The efficiency value of the first stage does not exclude the effects of environmental factors and random errors, it cannot truly reflect the real situation of the efficiency of scientific and technological innovation resource allocation in various regions. Therefore, it is necessary to eliminate the effects of external environmental factors and random interference, and re -measure and evaluate the efficiency of comprehensive technical efficiency.

3.2 The return result of the second stage

Adopt FRONTIER4.1 software, with the per capita GDP, the output value of the third industry, the proportion of GDP, the total import and export ratio of GDP, and the proportion of education inputs in the GDP as an independent variable's investment in the second stage of SFA return. To decompose the relaxation variable in the first stage. The amount of relaxation is the difference between the actual production process and the highest efficiency of the municipal districts, it reflects the Initial management inefficient, environmental variables and random errors of the Chengdu-Chongqing Economic Circle。

It can be seen from the results, R & D personnel full-time equivalent, technology corporate incubators, R & D internal expenditure, and total number of high-tech enterprises than inspection statistics are significant at a level of 1%, verifying the rationality of the model. From the above table, it can be seen that the per capita GDP will restrict the excessive investment in the above three variables. High configuration efficiency; The regression coefficient of the total number of high-tech enterprises is positive and passed 1%inspection, indicating that as the per capita GDP increases, it will lead to redundant investment in the total number of high-tech enterprises and reduce the efficiency of the allocation of scientific and technological innovation resources. The output value of the tertiary industry accounts for GDP ratio is positive and significant for R&D personnel full-time equivalent, the number of technology companies incubators, and the internal expenditure of R&D funds. The total number of high-tech enterprises is significantly negative. It shows that the increase in the output value of the tertiary industry will lead to the redundancy of the above three items, but it can reasonably suppress the total investment in high-tech enterprises. The total import and export value accounts for GDP ratio has a negative impact on R&D personnel full-time equivalent, R&D funding internal expenditure, and the total number of high-tech enterprises. However, the impact on technology company incubators is not significant. The higher the degree of opening to the outside world, the lower the redundant value of the above four items. Education expenditure accounts for GDP ratio has a negative significant effect on the coefficients of the four factors. The higher the level of education input, the lower the redundant value of the four investment variables, and the higher the utilization rate of investment, The increase in education input can effectively reduce the redundancy of the four types of scientific and technological innovation resources, and play a positive role in the allocation of scientific and technological innovation resources in Chengdu-Chongqing.

3.3 Third stage DEA model calculation

The four variables of the second stage of the second stage are re-repeated the calculation of the first phase of the model. The results of the adjustment after adjustment show that the average value of the comprehensive technical efficiency (TE) of each evaluation unit scientific and technological innovation resource allocation is 0.45, and average value of pure technical efficiency (PE) is 0.92, and the average value of scale (SE) is 0.49. The efficiency of most decision-making units has changed significantly. The effective decision unit of DEA has fallen to three, of which Ziyang City, Tongliang District, and Fengdu County have been changed from DEA effective to DEA invalid. Chengdu has risen from DEA invalid to DEA effective. The impact of the decision-making units are differentiated. Compare the results of the first stage efficiency value and the third stage efficiency value can be discovered:

(1) The average value of comprehensive technology in Chengdu-Chongqing area has decreased by 0.1, the average value of pure technical efficiency has increased by 0.25, and the average value of scale efficiency has decreased by 0.31, It shows that the decline in the efficiency of comprehensive technical efficiency mainly originated from the sharp decline in scale efficiency, and the pure technical efficiency and scale efficiency of scientific and technological innovation resource allocation are greatly affected by environmental factors, indicating that traditional DEA cannot reflect the real situation in the evaluation of efficiency values. After the adjustment, the pure technical efficiency values in most areas have improved. Among them, the highest improvement is that Zigong City has increased by 0.53, indicating that the impact of external environmental factors on the efficiency of scientific and technological innovation resource allocation is obvious.

(2) From the perspective of time sequence, after the impact of factors such as the external environment is eliminated in the third stage, the average value of comprehensive technical efficiency changes to 0.51-0.54-0.37-0.46-0.51. Compared with the first stage efficiency value, there is a significant decline. The average value of pure technical efficiency changes to 0.96-0.94-0.89-0.92-0.91, which has increased significantly compared with the first stage efficiency value. The average value of scale efficiency changes to 0.53-0.57-0.43-0.35-0.50.56, a significant decrease in the efficiency value of the first stage.

Conclusions

The overall allocation efficiency of the scientific and technological innovation resources of the Chengdu -Chongqing Economic Circle is at a lower level. From 2014-2019, without considering the impact of incomplete efficiency, environmental factors and random errors, the average value of comprehensive technical efficiency was 0.55, the average value of pure technical efficiency was 0.67, and the average value of scale efficiency was 0.80. It can be seen that it was mainly due to pure technology. Efficiency. After eliminating the impact of incomplete management, environmental factors and random errors, the average value of the comprehensive technical efficiency is 0.45, the average value of pure technical efficiency is 0.92, and the average value of scale efficiency is 0.49. It can be seen that the decline in comprehensive technology efficiency is mainly caused by the sharp decline in scale efficiency, and the efficiency of pure technology has increased significantly. Among them, the efficiency value of Chengdu is effective from non-DEA to DEA, and Ziyang, Tongliang District, and Fengdu County are valid from DEA to non-DEA. Most of the other regions have varying degrees of fluctuations, indicating that environmental factors and random errors have a great impact on the efficiency of scientific and technological innovation resource allocation in the Chengdu-Chongqing Economic Circle.

Acknowledgments

This work is supported by the Humanity and Social Science Youth Foundation of Ministry of Education of China (Grant No. 19YJCZH054), the National Social Science Fund of China (Grant No. 21XMZ002).

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