Research on the Allocation Efficiency of Science and Technology Resources in the Guangdong Hong Kong Macao Greater Bay Area

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ABSTRACT
This paper explores three dimensions of science and technology resources to analyze allocation efficiency in Guangdong Hong Kong Macao Greater Bay Area, including technology sources, inputs and outputs. Based on the Data Envelopment Analysis, the research designs empirical test for 11 core cities in Greater Bay Area during 2014-2019.Theresearch reveals: the average level of science and technology resources allocation of Greater Bay Area has been a leading position, but the extreme distribution is obvious. This essay provides some feasible avenues: accelerate the construction of scientific innovation circle, improve technological talent guarantee mechanism, strengthen the industry technology innovation platform construction, coordinate the risk investment mechanismand broaden the financing channels for high-tech enterprises.
Keywords: *The Guangdong Hong Kong Macao Greater Bay Area, science and technology resources, allocation efficiency, data envelopment analysis*

1. INTRODUCTION

As a national economic and global industrial center of science and technology industry, Guangdong, Hong Kong and Macao Greater Bay Area has a very outstanding innovative driving ability, has formed a modern industrial system with advanced layout, and has strong industrial agglomeration radiation ability. Scientific and technology innovation will become the main direction for the future development of Guangdong, Hong Kong and Macao Greater Bay Area, which will be built into aninternational scientific and technological innovation base. [1]
Science and technology resource is the general terms of human, finance, organization, management, information and other supporting elements in innovation activities. Its remarkable feature is the diversification of input forms and the difficulty in quantifying supporting elements, which makes the science and technology output lack of a unified measurement standard. In recent years, Data Envelopment Analysis (DEA) is mainly used to calculate and analyze the management efficiency. Based on this method, this paper makes further optimization, combined with the allocation of science and technology resources in Guangdong, Hong Kong and Macao Bay Area in 2014-2019, 11 core cities are taken as decision-making units. C2GS2 model of Data Envelopment Analysis is used for empirical analysis to explore the internal causes and main factors of inefficient allocation, so as to provide reference for relevant departments and researchers to formulate science and technology management.

2. RESEARCH DESIGN

According to the distribution of science and technology in Guangdong, Hong Kong and Macao Bay area, the C2GS2 model of Data Envelopment Analysis is used to analyze the allocation efficiency of science and technology resources of 11 core cities during the years of 2014-2019.From the horizontal and longitudinal perspectives, 32 indicators are established as the analysis basis of the allocation efficiency of science and technology resources. Mainly focus on three dimensions of source, input and output. Data sources: The Wind Database and the statistical reports of the science and technology departments, “China Regional Iinnovation Capability Report”, “Index Report of Guangdong Hong Kong Macao Bay Area and New York Bay Area, San Francisco Bay Area and Tokyo Bay Area”, etc.

2.1. Index System

In this research, the online and offline questionnaire surveies were carried out for 2582 science and technology enterprises in 11 cities. 2027 valid questionnaires were collected, with a recovery rate of 78.51%. Three types of indicators for the allocation of science and technology resources were established: source indicators, input indicators and output indicators of science and technology resources(Table 1).

Table 1 Efficiency Allocation Evaluation Index System

Category of Resources	Input			Output	
	Human Resources	**Scientific Research Institution**	**Financial Support**	**Scientific Achievements**	**Economic Performance**
High Tech Enterprises	R&D Personnel	ProportionofScientificInstitutions	R&D/GDP Ratio	Number of National Science	Output Value of High-tech Industry
Local Finance	Proportion of Professionals	Proportion of High-tech Industry Parks	R &DRatio	Number of patent applications	Total exports of high-tech products
Financial Institution	Proportion of Technology Leaders	Proportion of NationalLaboratories and Engineering	Total R & D Expenditure	Patent RuthorizationRatio	Total Amount of Contracts Concluded in High-
Risk Investment	Proportion of Scientific Researchers	Distribution Ratio of High-tech Enterprises	R & D Ratio of High-tech Enterprises	Number of Awards for Scientific Achievements	New Quantity of High-tech Enterprises
Other	Proportion of ResearchersinSubsidiaries	Proportion of National Experimental Bases	Proportion of Local Financial	Transformation Ratio in Patent Market	Export Ratio of High-tech Products

2.2. Application Model -C^2GS^2

Data Envelopment Analysis(DEA) is a nonparametric model evaluation method. According to the effective production frontier, whether the decision-making unit is effective or ineffective. [2]The corresponding improvement direction and degree are determined by DMU_j. DMU_j is used to represent the decision-making unit, the input and output of each DMU_j are X_{ij} and Y_{ij}; X_{ij} is used to represent the input of DMU_j;Y_{ij} is used to represent the output of DMU_j to the input; $V_i$and U_r are used to represent the i^{th} input and r^{th}out put respectively. With DM_{Uj} efficiency value as the constraintto establish C^2GS^2 model.

$$\begin{cases} \max \dfrac{\sum_{r=1}^{s} u_r y_{rj0}}{\sum_{i=1}^{m} v_i x_{ij0}} & (1) \\ s.t.\ \dfrac{\sum_{r=1}^{s} u_r y_{rj0}}{\sum_{i=1}^{m} v_i x_{ij0}} \le 1 \quad (j=1, 2\ldots n) & (2) \\ u_r \ge 0 \ (r=1,2\ldots s) \\ v_i \ge 0 \ (i=1,2\ldots m) \end{cases}$$

The above model is transformed into equivalent linear programming.
If θ = 1 and S + = S -= 0, then DMU_{j0} is DEA efficient, which means that the input and output of science and technology resources constituted by each $DMU_j$is in the optimal state; if θ = 1 and S + ≠ 0 or S - ≠ 0, then DMU_{j0} is weakly efficient, which can be recombined to form a new decision-making unit group to increase the output of DMU_{j0} when the input is set.

$$\begin{cases} \min \theta & (3) \\ s.t.\sum_{j=1} \lambda_j X_j + \theta X_0 \le 0 & (4) \\ \sum_{j=1}^{n} \lambda_j Y_j \ge Y_0 & (5) \\ \lambda \ge 0 \ (j=1,2\ldots n) \end{cases}$$

3. EMPIRICALANALYSIS

3.1. Horizontal Analysis

According to the selection of decision-making units and relevant indicators, the horizontal analysis of technical efficiency and scale efficiency is carried out on the two aspects: resource vs. input and inputvs.outputinsample cities, as shown in Table 2.
DEA is toevaluate whether the technological efficiency of the decision-making unit is 1.000 to determine whether the source of the city's scientific and technological resources is technically effective for input and output. It can be seen from Table 2 that only Guangzhou and Shenzhen have the technical efficiency value of resource allocation of 1.000, and the resource allocation has realized the basic transformation of input demand; 9 cities such as Zhongshan, Dongguan, Huizhou and Foshan have the technical efficiency higher than the average value of 0.732, accounting for only 42.9%, indicating that less than half of the cities with relatively effective resource allocation.
The scale efficiency analysis of C^2GS^2 model can reflect the impact of the change of input on the output of, and evaluate whether the technology resource input is effective on the output by the scale efficiency value of 1.000.

From Table 2, Foshan, Dongguan and Huizhou have achieved scale efficiency in terms of resource source input. Zhaoqing and Zhongshan have achieved scale efficiency lower than the average of 0.756, accounting for 57.2%, which indicates that science and technology resource source lacks scale efficiency in input transformation. Only Zhuhai and Zhongshan have achieved scale efficiency of 1.000 in the calculation of scale efficiency of input output It is pointed out that the input of science and technology resources in these cities are non-scale effective for the output, and the quantity and structure of resource input need to be adjusted. The data shows that the technical efficiency and scale efficiency are 1.000, but there is no continuous DEA effective resource allocation of technical efficiency and scale efficiency, 9 cities such as Guangzhou and Shenzhen have the technical efficiency value of resource allocation for output.The technical efficiency of resource input to output is lower than the average value of 0.785, which indicates that the input of scientific and technological resources is lack of technical efficiency to output.

Table 2 2014-2019 Horizontal Analysis of Technical Resources Allocation

NO.	DMU	Source vs. Input		Input vs.Output	
		Technical Efficiency	Scale Efficiency	Technical Efficiency	Scale Efficiency
1	Guangzhou	1.000	0.997	1.000	0.945
2	Shenzhen	1.000	0.983	1.000	0.983
3	Zhuhai	0.897	0.986	0.975	1.000
4	Foshan	0.890	1.000	1.000	0.975
5	Dongguan	0.976	1.000	0.852	0.863
6	Huizhou	0.897	1.000	1.000	0.835
7	Zhongshan	0.882	0.887	0.859	1.000
8	Jiangmen	0.672	0.652	0.782	0.512
9	Zhaoqing	0.763	0.525	0.744	0.553
10	Hongkong	0.730	0.943	0.833	0.453
11	Macau	0.624	0.604	0.675	0.433
	AVE	0.732	0.756	0.785	0.663

Table 3 2014-2019Longitudinal Analysis of Technical Resources Allocation

No.	DMU	Technical Efficiency			Scale Efficiency		
		2014-2015	2016-2017	2018-2019	2014-2015	2016-2017	2018-2019
1	Guangzhou	0.975	0.964	0.985	1.000	0.972	1.000
2	Shenzhen	0.974	1.000	0.989	0.987	0.943	0.932
3	Zhuhai	1.000	0.918	0.954	0.834	0.836	0.893
4	Foshan	0.937	0.954	1.000	0.938	1.000	0.974
5	Dongguan	0.998	1.000	0.927	1.000	0.968	0.987
6	Huizhou	0.965	0.937	0.939	1.000	0.947	0.974
7	Zhongshan	0.933	0.832	0.912	0.932	0.932	0.943
8	Jiangmen	0.845	0.698	0.734	0.683	0.765	0.727
9	Zhaoqing	0.632	0.684	0.673	0.682	0.633	0.628
10	Hongkong	0.783	0.852	0.827	0.827	0.764	0.778
11	Macau	0.643	0.575	0.610	0.614	0.626	0.554

3.2. LongitudinalAnalysis

As shown in Table 3, during the years of 2014 -2019, the allocation of scientific and technological resources of 7 cities in Guangdong Hong Kong and Macao Bay area can achieve efficient transformation from source to output. The results show that the technical efficiency and scale efficiency are 1.000, but there is no continuous DEA effective resource allocation of technical efficiency and scale efficiency, mainly divided into four situations. Firstly, the increasing trend. The technical efficiency of DMU has been in an increasing trend, but the scale efficiency of technical efficiency is not always rising, showing that increasing scale efficiency and then decreasing technical efficiency; Secondly, the decreasing trend. The technical efficiency has been keeping at a low level and has been declining year by year, but the scale efficiency shows a trend of increasing first and then decreasing, mainly in the northern and western regions of Greater Bay Area.Thirdly, the trend of decreasing first and then increasing. The Pearl River Delta citiesare the main regions with high efficiency in the early stage. Although the technical efficiency is not completely effective, the technical efficiency of resource transformation is high, and the technical efficiency in the later stage declines, and then improves. This adjustment process has been accompanied by high scale efficiency; fourth, the trend of increase first and then decrease.

4. CONCLUSIONS

The technical efficiency and scale efficiency of technology resource allocation in 11 core cities of Guangdong, Hong Kong and Macao Greater Bay Area are difficult to achieve full efficiency at the same time. There aresynergistic obstacles to reach the core demand of enterprises for resources. High tech zones can provide a new space carrier and innovative network. Their technical efficiency and scale efficiency are nearly DEA efficiency. In terms of function construction and service system improvement, it focuses on the construction of soft environment and the support of intangible resources. Therefore, the following countermeasures and suggestions may put forward.First of all, accelerate the construction of scientific innovation circle to promote the talent guarantee mechanism of technological innovation and actively introduce leading scientific and technological teams;[3]Secondly, satisfy adequate and reasonable financial support to the advantages of high tech zones, improve resource allocation and strengthen the construction of industrial technology innovation platform; Thirdly, make efforts to increasenationall science and technology innovation centers and R&Dauxiliaries, especially to provide service platforms in the eastern and northwestern regions oftheGreater Bay Area, form characteristic industry basesandtransformationparks of scientific and technological achievements to improve the support ability of science and technology for emerging technology industries in the regions around the core cities. [4]Improve the mechanism of venture capital and broaden the financing channels of science and high technology enterprises.

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