R&D Resource Allocation and Innovation Performance Evaluation

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Abstract. The paper used DEA method to evaluate the efficiency of regional R&D resources allocation in hebei province, on the basis of this, it applied index method to further analyze the economic characteristics of R&D resources allocation.

Introduction

R&D resource allocation is the configuration of R&D resources in time and space, R&D resources allocation efficiency refers to the total input-output rate of R&D resources in one area. The investigation to the R&D resources allocation efficiency is generally based on the relative efficiency or comprehensive efficiency, the main purpose is to evaluate R&D activities which to use of limited resources rationally, thus R&D resource allocation evaluation is a kind of comprehensive evaluation, the analysis of characteristics of R&D resource allocation in different regional especially has more reference significance to decision makers.

The Analysis of R&D Resources Allocation Efficiency Based on DEA

The Data Envelopment Analysis (DEA) method of measuring efficiency is elaborated by Charnes et al. in 1978[1].This approach has been widely used in computing relative performance(efficiency or productivity) of so-called ‘decision-making units’ (DMUs)which use multiple inputs to produce multiple outputs. As DEA does not require input or output prices in determining efficiency frontiers based on best practice technology and related measures of inefficiency, it has become especially popular in the study of public sector, such as efficiency evaluation[2], resource allocation[3], as well as policy analysis[4].

This paper taken the 11 cities in hebei province as decision making units to examine their R&D resource allocation performance, and selected four input indicators and four output indicators, as shown in table 1.

Table 1 System of R&D resources allocation evaluation

Input	Output
R&D/GDP	Invention patent applications
Intramural expenditure for R&D	Number of S&T papers
Total R&D personnel	Added value of high-tech industry/ industrial added value
R&D personnel /S&T personnel	Sales Revenue of New Products/sales revenue /

Using LINDO tools (Linear, Interactive, and Discrete Optimizer), the calculation results are shown in table 2.

As table 2 shown, except DMU2 (Tangshan), DMU5 (Xingtai) and DMU8 (Chende) the three cities, the other DUMs had all achieved scale efficient. Using traditional DEA method, it is difficult to further distinguish those DMUs which all achieved efficient at the same time. Although Per Andersen & Niels Christian Petersen put forward MDEA model in 1993[5], to a certain extent, which

solved the rank problems of DMUs, we had no good method to analyze the characteristics of resource allocation in each decision-making unit, so we need to bring in other ways.

Table 2 Results of R&D resources allocation evaluation base on DEA

DMUs	Shijiazhuang	Tangshan	Qinhuangdao	Handan	Xingtai	Baoding
	DMU1	DMU2	DMU3	DMU4	DMU5	DMU6
Efficiency	1.00	0.87	1.00	1.00	0.67	1.00
DMUs	Zhangjiakou	Chengde	Cangzhou	Langfang	Hengshui	--
	DMU7	DMU8	DMU9	DMU10	DMU11	--
Efficiency	1.00	0.97	1.00	1.00	1.00	--

The Analysis of the Economy Characteristics of R&D Resources Allocation

For further analysis of the economic characteristics of R&D resource allocation in each DMU, this paper draws lessons from the "Global Competitiveness Report" and "The National Science and Technology Progress Monitoring Report", using the index method, makes the Input and output indicators dimensionless. The results are shown in table 3.

Table 3 Total input-output of R&D resource and innovation performance

	DMU1	DMU2	DMU3	DMU4	DMU5	DMU6
Total input	100	74	45	37	37	82
performance	84	43	54	22	25	100
	DMU7	DMU8	DMU9	DMU10	DMU11	--
Total input	32	26	30	37	13	--
performance	29	14	22	48	19	--

Sit reference line at 60 point, we get the scatter diagram of the total input and total output of each DUM, see figure 1.

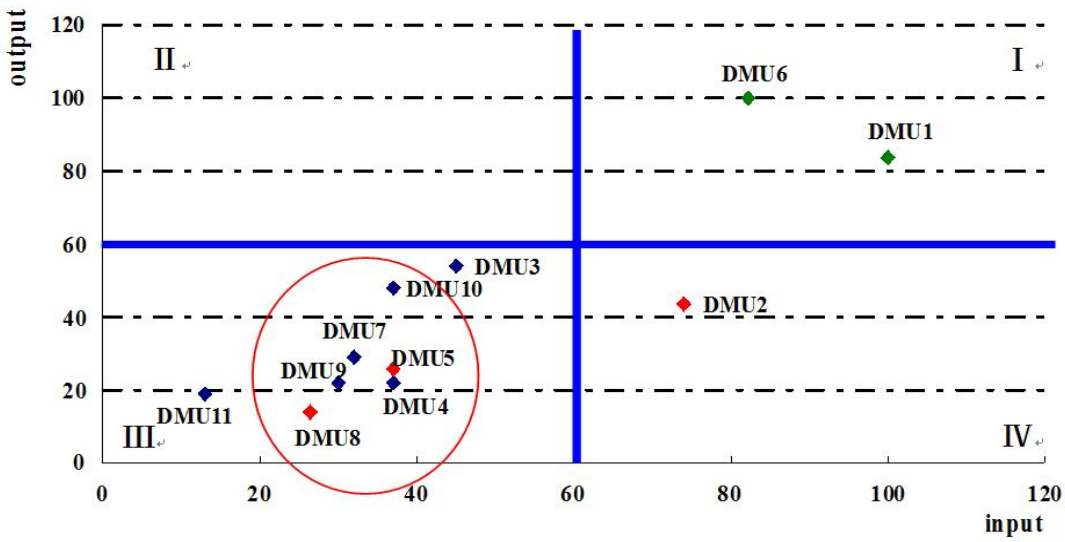

Fig.1 The scatter diagram of the total in-put of R&D resource and innovation performance

Using index method, figure 1 shows the evaluation performance of R&D resources allocation. Combined with table 2 and table 3 and figure 1, we made a comprehensive analysis, and had the following enlightenment:

First. Contrast table 2 and table 3, we found that although we used two different methods --DEA and index method , the principle of two the methods are not the same, the results have higher alignment. The difference is according to the index method, the efficiency of DUM4's R&D input-output is inferior to DMU5's, but according to the results of DEA, DUN4 is efficient but DUM5 is inefficient, this is the result of the two algorithm principle is different. Index method is simple and intuitive, this is also the basis of this method is widely used. Seeing from calculation result of this paper, these conclusions are in accord with our intuitive impression about cities' R&D resources condition and innovation performance in hebei province.

Second. Scatter plot is divided into four quadrants. The first quadrant said high input, high output; The second quadrant said low input, high output; The third quadrant said low input, low output; The fourth quadrant said high input, low output; Ideally, we are always pursuit the input-output bonding point fallen in the second quadrant, but this is rarely in the real economic life. More often, we make more efforts to pursue the bonding point falls on the first quadrant, namely the high investment and high yield, this is also the pursuit of scale economies, avoiding the bonding point falls on the fourth quadrant, namely, high input, low output.

Third. This paper uses DEA method to evaluate the effectiveness of the 11 cities R&D resources allocation, the results show that eight DMUs are all reached the DEA effective except DMU2, DMU8, DMU5, but we can't give more judgment to the economic characteristics of the R&D resource allocation in each DMU. But in combination with figure 1, we can do further distinguish the economic characteristics of decision making units.

Figure 1 shows, although with DEA effective, only DMU1 and DMU6's input-output bonding point fall in the first quadrant, indicates that the two cities R&D resources allocation belong to the high investment, high output, and this is the pursuit of scale economy; Although the rest of the 6 DMUs achieved DEA effective, but belong to the low-input, low-output state, further more, DMU6 input-output performance is better than DMU1; DMU2, DMU8 with DMU5 for DEA is ineffective, but the figure 1 shows that their invalid also has difference, DMU2 belongs to the high input, low output state, the DMU5 and DMU8 are low input, low output state.

Fourth. Further investigation the six DMUs in the third quadrant: DMU4, DMU5, DMU7, DMU9, DMU10 and DMU8 (DMUs within the circle), their R&D input are roughly equal, respectively between26-37 (points), but their output is larger difference, especially the effectiveness of DEA, DMU8 and DMU5 for DEA is invalid. For input with 37 (points) for the three DMUs--DMU4, DMU5 and DMU10, DMU5 for DEA is invalid, DMU4 andDMU10 achieve DEA effective, but DMU10 output performance is much better than that of DMU4, suggesting that although R&D resources input being the same, because of the difference of R&D resource allocation, the same R&D input may lead to different output performance. It also conforms to Joseph Alois Schumpeter's innovation theory who think the purpose of the technology innovation (R&D activities) is to change the combination way of the production factors (namely R&D resource allocation mode), that cause the change of the production function, in a direction conducive to economic growth.

Fifth. For the DMUs in the third quadrant, if it want to transfer to the first quadrant, the most direct way is along the baseline and moving up to the right, i.e. increasing the input and output of R&D capability, in other words, increasing the ability of R&D investment and output can improve the performance of R&D resources configuration.

Summary

Using DEA method, this paper obtained the efficiency of R&D resource allocation, except Tangshan, Xingtai, and Chengde, other cities are all reached DEA effective. Using index method, this paper evaluated the relationship between R&D resource allocation and innovation performance in hebei province, and distinguished the economic characteristics of R&D resource allocation.

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