Big Data Analysis of Innovation Efficiency in the National Innovation Reform Pilot Zone

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Abstract. Based on the background of Hebei province, this paper calculates the innovation input-output efficiency of national typical region with DEA method，combine with the input and output base of innovation and the average annual growth rate, this paper analyzes the comprehensive innovation situation in the three cities of Shibaolang, and puts forward suggestions on the development of innovation efficiency in Shibaolang comprehensive innovation reform pilot area.

At present, all regions and departments should deeply learn from general secretary xi Jinping's major strategic thoughts on innovation-driven development，We will fully implement the decisions and plans of the CPC central committee, the state council, provincial party committees and provincial governments, seize major opportunities, make good use of policy dividends, and promote a new round of major development driven by innovation. Conduct in-depth and systematic research on comprehensive innovation and reform experiment work. It is an important measure to deepen the reform of science and technology system and strengthen regional innovation, and it is a great opportunity for regional development，It plays a crucial role in implementing the innovation-driven development strategy, promoting the supply-side structural reform through innovation and further optimizing and adjusting the structure. This paper will evaluate and analyze the innovation efficiency of comprehensive innovation reform from the perspective of innovation efficiency, hoping to play a certain reference role in the construction of comprehensive innovation reform experimental area.

1. Establishment and Selection of Regional Innovation Efficiency Evaluation Index System

The selection of the output index of innovation efficiency refers to the previous literature, and this paper chooses to consider the two aspects of knowledge output and economic output. Correlation analysis was conducted on the number of patent application acceptance and the number of patent authorization of the patent index. The correlation coefficient was 0.979, which was higher than 0.95，they are highly correlated . The number of patent authorization was selected as the measure index of knowledge output. Economic output is measured index chooses gross regional product.

In the selection of the index of innovation efficiency input, it can be found that scholars generally consider two aspects personnel input and funds input，considering the availability of data, this paper will focus on the input of funds when selecting the index of innovation efficiency. Select data from Shanghai, Guangdong, Anhui, Sichuan, Wuhan, Xi 'An, Shenyang and Beijing-Tianjin-Hebei regions from 2013 to 2016 as measurement samples (Beijing-Tianjin-Hebei region is 3 regions). Since there is a time lag from input to output, the time lag from input to output is set as 2 years. That is, input index data were selected from 2013 to 2014, and corresponding output index data were selected from 2015 to 2016.

Table 1 shows that，the correlation coefficient between the internal expenditure of R&D expenditure and the science and technology expenditure of local finance is 0.754，lower than 0.95，this indicates that there is no high correlation between these two indicators. Therefore, the internal expenditure of R&D fund and the science and technology expenditure of local finance are selected as the index of expenditure input.

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Table 1 Correlation analysis results of expenditure input index in typical areas

Correlation			
		Internal expenditure of R&D fund（100 million Yuan）	Financial expenditure on science and technology（100 million Yuan）
Internal expenditure of R&D fund（100 million Yuan）	Pearson correlation	1	.754**
	Significance (double-tailed)		.000
Financial expenditure on science and technology（100 million Yuan）	Pearson correlation	.754**	1
	Significance (double-tailed)	.000	

**. At level 0.01 (double-tailed), the correlation was significant.

The output index of innovation efficiency is still considered from the two aspects of knowledge output and economic output. The patent index is selected for knowledge output and the number of patent applications and the number of patent authorization is recalculated according to the value of invention patent, utility model patent and appearance design patent 0.5:0.25:0.25 assignment. Economic output selection index GDP. SPSS24.0 was used to conduct correlation analysis on these four patent indicators. Select data of 2015 and 2016, and the results were shown in table 2.

Table 2 correlation analysis results of four patents in typical regions

correlation			
		Number of patent applications accepted(pcs）	Number of patent applications granted (pcs）
Number of patent applications accepted(pcs）	Pearson correlation	1	.972**
	Significance (double-tailed)		.000
Number of patent applications granted (pcs）	Pearson correlation	.972**	1
	Significance (double-tailed)	.000	

**. At level 0.01 (double-tailed), the correlation was significant.

As can be seen from table 2, the correlation coefficient between the number of patent application acceptance and the number of patent application authorization is 0.972 respectively, which is greater than 0.95, indicating that there is a strong correlation between them. Here, select the index of the amount of authorization applied for invention patent as the index of knowledge output.

To sum up, in terms of the index selection for evaluating the innovation efficiency of the experimental zone of comprehensive innovation reform in typical regions, select two indexes of internal expenditure of R&D fund and science and technology expenditure of local finance as the index of innovation efficiency evaluation； Select the number of patent applications granted and the gross regional product as the output indicators of innovation efficiency evaluation. Before using the data envelopment analysis method, the correlation test of input and output indicators was carried out, and the correlation analysis of input and output indicators was conducted by using SPSS24.0. The results are shown in table 3.

Table 3 Correlation between input and output indicators in typical areas

Correlation					
		Internal expenditure of R&D fund（100 million Yuan）	Financial expenditure on science and technology（100 million Yuan）	Number of patent applications granted (pcs）	GDP（100 million Yuan）
Internal expenditure of R&D fund（100 million Yuan）	Pearson correlation	1	.754**	.940**	.951**
	Significance (double-tailed)		.000	.000	.000
Financial expenditure on science and technology（100 million Yuan）	Pearson correlation	.754**	1	.780**	.697**
	Significance (double-tailed)	.000		.000	.001
Number of patent applications granted (pcs）	Pearson correlation	.940**	.780**	1	.931**
	Significance (double-tailed)	.000	.000		.000
GDP（100 million Yuan）	Pearson correlation	.951**	.697**	.931**	1
	Significance (double-tailed)	.000	.001	.000	
**. At level 0.01 (double-tailed), the correlation was significant.					

As can be seen from table 3, the positive correlation between input and output indexes is consistent with the premise of data envelopment analysis method. Therefore, the index system of innovation efficiency evaluation in typical regions is finally determined as shown in table 4.

Table 4 Evaluation index system of innovation efficiency in typical regions

Level 1 indicators	Level 2 indicators
Input indicators	Internal expenditure of R&D fund（100 million Yuan）
	Financial expenditure on science and technology（100 million Yuan）
Output indicators	Number of patent applications granted (pcs）
	GDP（100 million Yuan）

2. Analysis of Innovation Efficiency

(1)Input-output Efficiency Analysis

From the perspective of comprehensive technical efficiency in 2015, Wuhan, Xi 'an and Shenyang are the most effective ones. In 2016, Wuhan, Xi 'an and Hebei achieved effective comprehensive technical efficiency.

From the changes of returns to scale，in 2015, Wuhan, xi 'an and Shenyang were in a state of constant returns to scale, indicating that the proportion between innovation input and output in the three regions was reasonable and innovation resources were fully utilized；Beijing, Tianjin, Hebei, Shanghai, Anhui, Guangdong and Sichuan are in a state of diminishing returns to scale, indicating that the proportion of innovation output is less than that of innovation input, and there is redundancy in innovation input. In 2016, the return on scale in Hebei province changed from diminishing return on scale in 2015 to unchanged return on scale, indicating that the input and output ratio of innovative resources in Hebei province is reasonable；The return on scale in Shenyang changed from unchanged in 2015 to increasing in 2015, indicating that the proportion of innovation output in Shenyang is larger than that of innovation input, and the innovation efficiency

is in the growth stage.

On the whole，in 2015-2016, the regions with relatively balanced innovation input and output are Hebei province, Wuhan, xi 'an and Shenyang, with the innovation efficiency above 0.9；The regions with unbalanced input and output of innovation are Beijing, Tianjin, Shanghai, Anhui, Guangdong and Sichuan.

Table 5 Efficiency evaluation result table of typical innovation experimental area

City	Comprehensive technical efficiency		Pure technical efficiency		Scale efficiency		Returns to scale	
	2016 Year	2015 Year	2016 Year	2015 Year	2016 Year	2015 Year	2016 Year	2015 Year
Bei jing	**0.185**	**0.134**	**1**	**1**	**0.185**	**0.134**	**drs**	**drs**
Tian jin	**0.294**	**0.243**	**0.472**	**0.486**	**0.623**	**0.499**	**drs**	**drs**
Hei bei	**1**	**0.815**	**1**	**1**	**1**	**0.815**	**-**	**drs**
Shang hai	0.207	0.133	0.652	0.636	0.317	0.209	drs	drs
An hui	0.352	0.273	0.728	0.731	0.484	0.374	drs	drs
Gunag dong	0.541	0.287	1	1	0.541	0.287	drs	drs
Si chuan	0.745	0.589	1	1	0.745	0.589	drs	drs
Wu han	1	1	1	1	1	1	-	-
Xi an	1	1	1	1	1	1	-	-
Shen Yang	0.995	1	1	1	0.995	1	irs	-
Mean value	0.632	0.547	0.885	0.885	0.689	0.591		

(2)Analysis of Innovation Development Speed

By calculating the growth rate, from the perspective of dynamics，the average growth rate of investment from 2013 to 2016 is higher in Wuhan, Xi 'an, Anhui province and Guangdong province. In the middle are Sichuan, Hebei and Shanghai; the average growth rate of input is lower in Tianjin, Beijing and Shenyang.

The average growth rate of output is higher in Wuhan, Beijing and Xi 'an；In the middle are Guangdong province, Tianjin city and Hebei province；Shanghai, Sichuan, Anhui and Shenyang have the lower average output growth rates.（According to the ranking; the 10 cities are divided into three levels）

Table 6 The moving average growth rate of input and output indicators in typical regions

City	Average growth rate of input indicators					Average growth rate of output indicators				
	Internal expenditure of R&D fund（100 million Yuan）	Ranking	Financial expenditure on science and technology（100 million Yuan）	Ranking	Comprehensive Ranking	Number of patent applications granted (pcs）	Ranking	GDP（100 million Yuan）	Ranking	Comprehensive Ranking
Bei jing	6.18%	8	7.19%	9	9	17.35%	5	9.60%	2	2
Tian jin	5.36%	9	10.63%	7	8	18.04%	3	7.58%	8	5
He	9.88%	5	17.54%	5	6	22.00%	2	4.29%	9	5

bei										
Shanghai	6.63%	7	10.38%	8	7	9.91%	9	9.29%	3	7
An hui	14.41%	3	35.91%	4	2	8.12%	10	8.66%	5	8
Gunag dong	10.65%	4	39.20%	3	2	15.67%	6	9.17%	4	4
Si chuan	15.06%	2	13.48%	6	5	12.01%	8	7.86%	7	8
Wu han	15.26%	1	49.96%	2	1	17.72%	4	9.78%	1	1
Xi an	8.26%	6	55.81%	1	2	34.52%	1	8.48%	6	2
Shen yang	-0.34%	10	-6.89%	10	10	12.43%	7	-5.47%	10	10

(3)Analysis of Regional Innovation Level (Typical Areas)

The input-output indexes of 10 typical areas were normalized（Detailed data are shown in schedule 3），Take the mean values of input and output indicators as the origin. See attached table 3 for specific data. We can get figure 1，It can be found that the pilot areas of innovation and reform with high input and high yield are Guangdong province and Beijing，medium input and medium output is An hui province，With low input and low output are Hebei, Tianjin, Xi 'an, Wuhan and Shenyang province. Sichuan province is an innovation and reform pilot zone with low input and high yield, and Shanghai has a high input level and output level is intermediate.

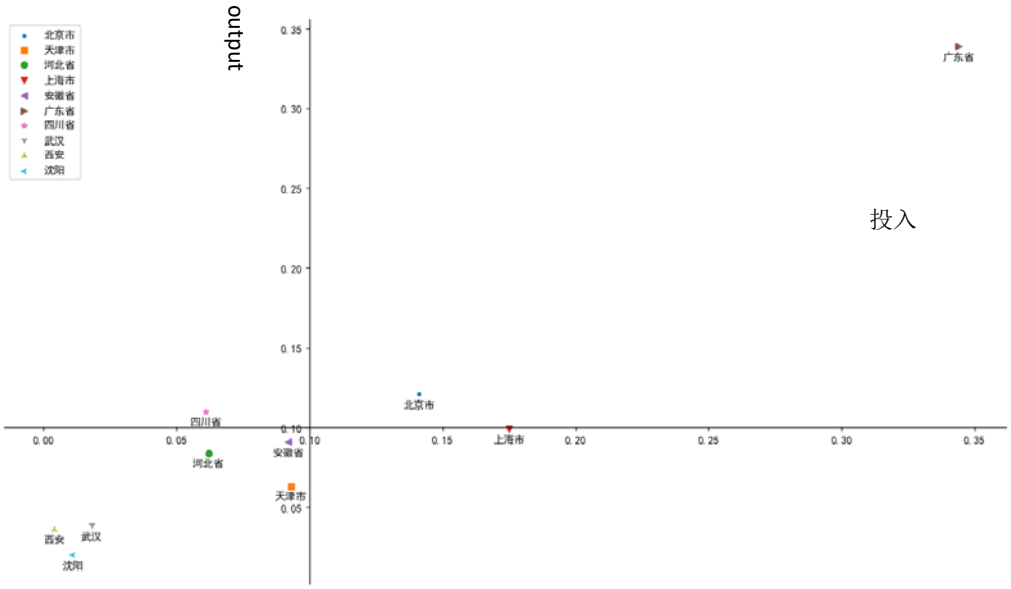

Figure 1 Quadrants of input and output in all pilot areas of innovation and reform

It should be noted that the comparison objects of typical comprehensive innovation reform pilot zones are some provinces and some cities, and there are differences in administrative levels, so the absolute level of reference is weak.

(4)Regional Innovation Status Positioning

To sum up，comparison of 10 typical areas（The Beijing-Tianjin-Hebei region is regards as three regions），It can be found that the four cities with better innovation efficiency (basically balanced input-output) are：Wuhan, Xi 'an, Hebei, Shenyang. Comparatively speaking, Wuhan and Xi 'an are low input and low output areas with high speed development and low balance，Hebei province is a

low-end balanced region with low input and low output in medium-speed development, while Shenyang is a low-end balanced region with low input and low output in low-speed development.

Guangdong province is a high level developing region with high input and high yield. Beijing is a high level developing region with high input and high output and the average growth rate of output is higher than the average growth rate of input. Tianjin is a developing area with medium input and low output and the average output growth rate is higher than the average input growth rate. Shanghai is a developing city where the input level is higher than the output level and the average growth rate of innovative resource input is higher than the average growth rate of output. Sichuan province is a developing region with low input and high output and the average input growth rate is higher than the average output growth rate. Anhui province is a medium level developing region with medium input and medium output, and the average input growth rate is higher than the average output growth rate.

3.Conclusions and Suggestions

From the perspective of national scope，In terms of the average of input-output，Beijing is a balanced city with high input and high output, with increasing development rate and good level of innovation city, Tianjin is a medium level city with medium input and output, medium speed of development and unbalanced innovation，Hebei province is a balanced province with general input and output, medium speed promotion and medium innovation level.

Comparison with 10 typical areas, compared with the comprehensive reform and innovation pilot area, Hebei province is a medium balanced area with low input and low output，it is only stronger than Xi 'an, Wuhan and Shenyang，compared with other provinces and developed cities still have some distance

Therefore, no matter in the Beijing-Tianjin-Hebei region, or compared with other innovative pilot areas，for Hebei province, although it is in the basic balance state of input and output, there is still a big difference between it and developed regions, and it should reach a new balance state in the rapid development. Hebei must maintain the high speed development foundation, make efforts in the system and the management，through changing the system mechanism, to achieve a high speed, high level of high-end balance state.

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