A study on the operational efficiency of China's Public Innovation Space

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Abstract With the gradual deepening and expansion of research questions, the research on the development of public innovation space in China in recent years has been transformed from the original qualitative analysis of connotation, function, service path and development mode to the exploration of combination of qualitative and quantitative. In this paper, data envelopment analysis was used to determine the operating efficiency of the national record-setting public innovation space in 29 provinces and regions in China in 2016. The research shows that the provincial region with a comprehensive efficiency of 1 is only 28% of the total, and there are some efficiency defects in other regions. Then, the k-value clustering is used to classify the operating results of China's provincial-level public innovation space and put forward improvement direction, hoping to provide reference for the construction and development and the advancement of China's scientific and technological progress.
Key words Public innovation space; Operational efficiency; K-value clustering.

1 Introduction

Currently, scientific and technological innovation has become an important engine for improving efficiency, increasing employment and promoting development. In 2014, China put forward the strategy of "mass entrepreneurship and mass innovation". As a new startup service platform under the strategy, the number of public innovation space has grown from less than 50 in 2014 to nearly 5,000 in 2016 [1]. It has a positive and far-reaching influence on optimizing innovation environment, gathering innovative talents, enhancing innovation ability and integrating innovative resources.

The concept of crowd sourcing space originates from overseas maker space. It is a platform to realize innovation spontaneously with Internet resources as the carrier. The operating mechanism is also highly similar to China's model. At present, foreign researches mainly focus on the characteristics of maker space [2], interpretation of maker culture [3, 4] and operation mode of maker space [5]. As the innovation and development strategy plays an increasingly important role in promoting the high-tech industry in China, the domestic research on the development status of public innovation space is also developing and deepening. Current research can be divided into three categories. Above all is the connotation of public innovation space and development. Research contents include concept and policy analysis [6], spatial classification [7] and differentiated development [8], etc. The second part is the analysis of spatial ecosystem of public innovation [9]. The last type is the regional population-based innovation space development research, mainly based on local analysis and policy recommendations [10, 11]. Therefore, the research on innovation space mainly focuses on the connotation, function and development mode of qualitative research. While quantitative research focuses on efficiency evaluation of individual provinces and cities, the analysis and comparison of results are not available in the innovation space of the overall operation of Chinese population, which is not conducive to the overall planning of national development. Therefore, this paper intends to discuss the operational efficiency of China's provincial-level crowd-creation space.

2 Empirical methods and models

2.1 Methodology

2.3.1 Data Envelopment Analysis

Data Envelopment Analysis (DEA), established by famous American operational research scientist A.Charnes [12], is a major non-parametric method to evaluate the efficiency of decision unit (DMU). This paper uses data envelopment analysis to determine the spatial efficiency of mass innovation in China. According to the variable return of scale in DEA, the basic model of DEA can be divided into the CCR model with constant return of scale [12], and the BCC model with variable return of scale [13]. Among them, the scale return of CCR model is unchanged, which means that output can be expanded by increasing the proportion of input, and the change of input scale will not affect its efficiency. The variable return on scale of

BCC model means that the output can be expanded by increasing input, and the change of input scale will affect its efficiency.

In view of the fact that the input variable of the public innovation space is easier to control than the output variable, and the data is easier to obtain, this paper chooses the input-oriented BCC model to analyze the operation performance of the public innovation space in the province. Assuming that n provincial regions in China are analyzed, there are n decision units corresponding to them, whose mathematical expression is $DMU_j(j = 1,2,3 \ldots\ldots, n)$, and each DMU corresponds to an input m, and the resulting output S. Therefore, in this paper, the mathematical expression of input vector is set as $X_j = (x_{1j}, x_{2j}, \ldots\ldots x_{mj})$ and the mathematical expression of output vector is set as $Y_j = (y_{1j}, y_{2j} \ldots\ldots y_{sj})$. According to the construction principle of the mathematical model and the series of hypothesis parameters, the following BCC mathematical model is constructed in this paper:

$$
\begin{cases}
\min\left[\theta - \varepsilon\left(e^T s^- + \hat{e}^T s^+\right)\right] \\
\sum_{j=1}^{n} y_j \lambda_j + s^- = \theta x_0 \\
\sum_{j=1}^{n} y_j \lambda_j - s^+ = y \\
\sum_{j=1}^{n} \lambda_j = 1 \\
\lambda_j \geq 0, j = 1, \ldots, n \\
s^+ \geq 0, s^- \geq 0, \theta \text{ unlimited}
\end{cases}
$$

2.3.2 K-mean clustering

K-mean clustering also known as fast clustering method. The principle is: the sum of the square distance from each research object to the cluster center, which satisfies the minimum clustering index. The operation method is to randomly select K research objects as the initial clustering center, and then calculate the distance between each research object and the initial clustering center, then assign each research object to the nearest clustering center again, forming the initial classification. The unreasonable classification is adjusted according to the object similarity and the nearest distance principle until the final classification is formed. It is applicable to the secondary analysis of the operating efficiency of public innovation space.

3 Analysis of experimental results

3.1 Determination of indicators and data sources

The index selection in this paper follows the general selection principle, combines the characteristics of public innovation space and the availability and accuracy of data, and establishes the following index system: input index, taking into account the resources required for the normal operation of public innovation space.It mainly focuses on the three aspects of human, financial and material. The output index is mainly reflected in the services provided by public innovation space for entering the entrepreneurial team, as well as the economic and social benefits generated. In order to evaluate objectively, social, economic, hatching and innovation benefits are all taken in this paper, and the specific indicators are shown in table 1.

Table 1: Evaluation index system of national record-setting mass innovation space efficiency

Category	Direction	Indicators
Input indicators	Human input	Number of service personnel (per person)
	Financial investment	Financial support (RMB 1000)
	Material input	Number of work positions (pieces)
Output indicators	Social benefits	Employment situation (per person); The number of teams served that year (pieces)
	Economic benefits	Total amount of investment (RMB 1000)
	Incubating ability	Number of newly registered enterprises (pieces)
	Innovation efficiency	patent for invention (pieces)

Considering the standardized samples and authoritative sources ,this paper selects the national archival crowdfunding space in 29 provincial-level regions of China in 2016 as the sample (the statistical data of Tibet and ningxia are incomplete)., the data are all from the China torch statistical yearbook 2017.The data are all from the 《China torch statistical yearbook 2017》.

3.2 Efficiency measurement and analysis

This study uses the DEAP2.1 software, through the BCC model of data envelopment analysis, input the provincial state for the record the spatial data, averaged to measure efficiency, obtained China 29 provincial national archival filing of the gen space 2016 comprehensive efficiency, pure technical efficiency and scale efficiency and scale benefits, specific results are shown in table 2.

Table 2: Evaluation index system of national record-setting mass innovation space efficiency

Region	Combined Efficiency	Pure Technical Efficiency	Scale Efficiency	Return to Scale
Beijing	1	1	1	—
Tianjin	0.578	0.755	0.765	↓
Hebei	1	1	1	—
Shanxi	0.811	0.813	0.998	↑
Inner Mongolia	0.667	1	0.667	↓
Liaoning	1	1	1	—
Jilin	0.298	0.339	0.879	↑
Heilongjiang	0.768	0.846	0.908	↓
Shanghai	1	1	1	—
Jiangsu	0.719	0.814	0.883	↑
Zhejiang	1	1	1	—
Anhui	0.412	0.844	0.488	↓
Fujian	0.829	0.832	0.996	↓
Jiangxi	1	1	1	—
Shandong	0.497	0.655	0.759	↑
Henan	0.802	0.94	0.854	↓
Hubei	0.649	1	0.649	↓
Hunan	0.769	0.825	0.932	↓
Guangdong	0.732	0.735	0.997	↑
Guangxi	1	1	1	—
Hainan	0.82	1	0.82	↑
Chongqing	0.677	0.951	0.712	↓
Sichuan	0.613	0.613	1	—
Guizhou	0.703	0.843	0.834	↑
Yunnan	0.507	0.776	0.653	↑
Shaanxi	0.498	0.511	0.975	↑
Gansu	0.538	0.543	0.991	↑
Qinghai	1	1	1	—
Xinjiang	0.902	0.943	0.956	↑
The mean	0.751	0.848	0.887	

Table 2 shows that:

(1) From the perspective of comprehensive efficiency, there is still room for expansion. The average value of the comprehensive efficiency of public innovation space in 29 provinces and autonomous regions was 0.751, with 24.9% less than the effective frontier. Among them, 8 provinces and cities in Beijing, Shanghai, Zhejiang, Hebei, Liaoning, Jiangxi, Guangxi and Qinghai are in the effective state of DEA, which indicates that under the existing technical level, the above provincial operation input and the output income obtained match, and the optimal factor allocation has been achieved. The comprehensive efficiency of Jilin, Anhui, Shandong and Shaanxi is less than 50%, and there is still huge room for improvement. The difference between average efficiency and effective frontier is shown in figure 1.

(2) from the perspective of technology effectiveness and scale effectiveness, the development of provincial crowdfunding space is extremely unbalanced (see figure 2). The pure technical efficiency in Inner Mongolia, Hubei and Hainan is 1, and the scale efficiency is less than 1, which means the input resources are not fully utilized and the output remains to be improved. The technical efficiency and scale efficiency of the other 17 provinces are all in an invalid state, which indicates that the crowdsource space resources in these provinces have not been effectively allocated and the scale benefit is difficult to display.

(3) from the perspective of scale return, nearly 2/3 of the provincial resource utilization is not reasonable (see figure 3). Eleven provinces, such as Shanxi, Jilin, Jiangsu, Shandong, Guangdong, Hainan, Yunnan, Shaanxi, Gansu and Xinjiang, are in the stage of increasing returns to scale, which means that appropriate increase of resource input will promote the improvement of operating efficiency of public innovation space in these provinces. The remaining 19 provinces have the same or lower compensation for scale. The DEA's effective scale return of 8 provinces is unchanged, while the other 9 provinces are in the stage of diminishing scale return. Increasing input resources will not bring about a proportional increase in output, so it is not appropriate to increase input. The industrial structure of crowd-creation space should be optimized on the current basis, and existing resources should be reasonably and fully utilized.

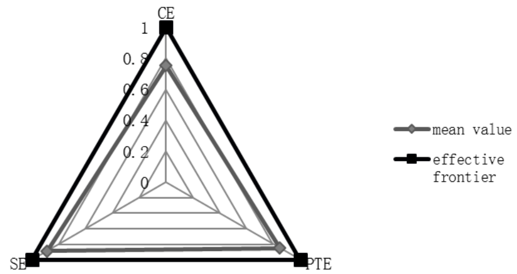

Figure 1 :Difference between effective mean and effective frontier of national-level public innovation space

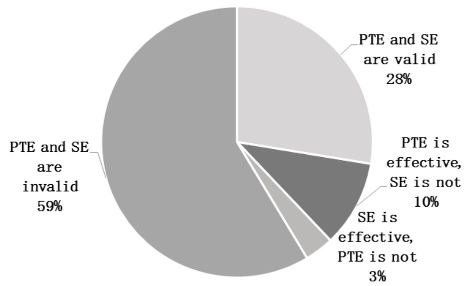

Figure 2 :efficiency and effectiveness analysis of national-level public innovation space

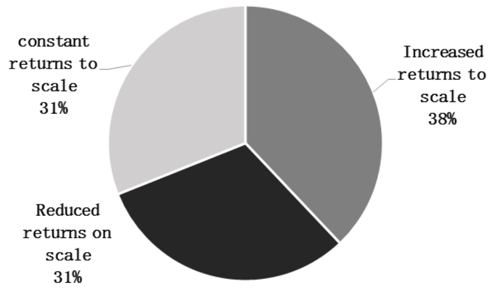

Figure 3: trend of scale return of national-level public innovation space

3.3 Spatial efficiency measurement of public innovation

In order to further study the provincial national level for the record the difference between the efficiency and the space, we measure the results of the DEA method for K value clustering analysis.

Due to the comprehensive efficiency of scale efficiency and pure technical efficiency of the product, can not meet the needs of variables are independent of each other, so we choose pure technical efficiency and scale efficiency as the research variables. SPSS24.0 software was used for k-value clustering, and the results are shown in table 3:

Table 3：Results of cluster analysis

Variable	Initial clustering				Final clustering			
	I	II	III	IV	I	II	III	IV
PTE	1.000	0.655	1.000	0.339	0.989	0.791	0.914	0.502
SE	1.000	0.759	0.649	0.879	0.966	0.897	0.634	0.961

We can see that the pure technical efficiency and scale efficiency of class I province are close to 1, and both factors are at a higher level. Category II provincial pure technical efficiency and scale efficiency are relatively low. Category III provincial pure technical efficiency is significantly higher than scale efficiency; Category IV provincial pure technical efficiency is significantly higher than scale efficiency. We conduct variance analysis of the results to assess reasonableness. It is known from table 4 that both variables in the table show obvious significance in the k-value cluster variance analysis, indicating that the above clustering results can be used as the basis for the analysis of the efficiency difference of the provincial public innovation space.

Table 4：Results of variance analysis

	Clustering		Error			
	Mean square	Degree of freedom	mean square	Degree of freedom	F	Significant
PTE	0.250	3	0.005	25	52.673	0.000
SE	0.138	3	0.006	25	22.394	0.000

Considering the intuitiveness, this paper drew the provincial quartile after k-value clustering, as shown in figure 4.

Figure 4: Efficiency classification of national-level public innovation space

(1) Relatively efficient provincial domain, as shown in class I. Its scale efficiency and pure technical efficiency are equal to or close to 1. There are 10 regions with better operational efficiency. Among them, Beijing, Shanghai, zhejiang and other provinces and regions, as the leading regions in China's economic development, have large investment in innovation, and have achieved the optimal level in resource allocation and scale structure. The province of qinghai, jiangxi, guangxi, hainan and liaoning has less space for mass innovation and can concentrate the province's resources to cultivate high-quality products to achieve efficient operation.
(2) Relatively inefficient province, as shown in class II. Its pure technical efficiency and scale efficiency are both in the state of "double low", and the pure technical efficiency is lower than scale efficiency. This type includes nine provinces and municipalities. It is mainly because of the large difference in operation that it is difficult to achieve the efficiency of overall operation.
(3) Inefficient provincial regions of scale, as shown in class III. This type is characterized by high technical efficiency and low scale efficiency, including 5 provinces. On the one hand, due to the limited

scale of public innovation space, the scale effect cannot be exerted; On the other hand, the input-output mismatch leads to the imbalance of resource demand and actual input-supply.
(4) Configure inefficient provincial regions, as shown in class IV, where pure technical efficiency is low and scale efficiency is high. This type includes four provinces and municipalities. The main problem in such areas is the inefficiency of resource allocation.

5 Conclusion

In this paper, we studied the operation of the national registered mass innovation space in 29 provinces and regions in China, used data envelopment analysis (DEA) to determine the comprehensive efficiency, pure technical efficiency and scale efficiency in 2016, and used cluster analysis to observe the differences in the regional public innovation space in China. The results show that: all the provinces in our country domain and space operation is still in the primary stage, and there is no accumulation effect. The number of provinces with effective DEA, weak DEA and invalid DEA were 8, 4 and 17 respectively, accounting for 27.5%, 13.79% and 72.41%, presenting an unbalanced development structure. 48.2% of the provincial regions did not reach the average of comprehensive efficiency, and nearly half of the provincial regions did not reach the average operating efficiency.

To sum up, there is a large room for improvement in the operation of China's public innovation space. In order to accelerate the development of the space, we also need to implement the strategy of differentiation, support policy implementation, reform mechanism, build strong innovation atmosphere, improve innovation ability，integrate resources and enhance innovative talents. Only do so,we can make change "made in China" to "created in China".

References

[1] Torch high-tech industry development center, ministry of science and technology. China torch statistical yearbook. China statistics press,2017
[2] MOILANEN J. Emerging hackerspaces-peer-production generation/ /IFIP International Conference on Open Source Sys-tems. Springer Berlin Heidelberg,2012: 94-111
[3] Farr N. Respect the past, examine the present, build the future[EB/OL]. [2011-10-27] http://blog.hackerspaces.org/2009/08/25/Respect-the-Past-Examine-the-Present-Build-the-Future
[4] Anderson C. Makers: The New Industrial Revolution. New York: Crown Business, 2012.
[5] ALLEN D. The positive political anarchy of innovation: hackerspaces. Available at SSRN 2749016,2016
[6] Liu zhiying, Chen qingxiang, xu yi. Conceptual model and theoretical analysis of zhongchuang. Science of science and technology management,2015 (2) : 52-61
[7] Wang jiaxiang, tian feng, sheng ya. Research on the positioning of zhongchuang space platform and its development strategy evolution logic -- taking alibaichuan as an example. Scientific and technological progress and countermeasures,2016 (11): 1-6
[8] Chen dejin. Comparative analysis and experience inspiration of overseas crowd-creation space business model [J]. Scientific management research,2017(3):110-113
[9] Li yanping, Chen wu. Research status and prospects of China's public innovation space [J]. China science and technology BBS,2017(5):12-56
[10] Chen zhangwang, sun xiangxiang, ke yuzhen. Study on industrial efficiency evaluation of zhongchuang space [J], journal of fuzhou university (philosophical and social science edition),2018 (1):33-40
[11] Zhang danning, fu xiaoyuns, yi pingtao. Study on the development path of zhongchuang spatial industrial cluster in shenyang -- based on operation efficiency measurement [J], journal of Northeastern University (social science edition),2017 (1):34-40
[12] Charnes A,Cooper W.W,Rhodes E. Measuring the effi-ciency of decision making units.European Journal ofOperational Research,1978,2(6):429-444
[13] Banker, R.D., Charnes, A., Cooper, W.W. Some models forestimating technical and scale inefficiencies in data envel－opment analysis. Management Science, 1984, 30(9): 1078-10920