China’s Incubator Industry Efficiency Evaluation——Based on DEA Analysis of Provincial Data

Jin Lanqing
School of Economics and Management, Beijing Jiaotong University, Beijing, 100044, China
Jinlq1995@outlook.com

Abstract. This paper evaluates the efficiency of China’s incubator industry based on DEA (Data Envelopment Analysis) of provincial data in 2017. We use DEA method to test the efficiency of industrial input-output. Through the empirical test we find that the overall efficiency of China's incubator development is high, while the efficiency of various regions is not balanced, and some provinces are inefficient. In the end, we put forward suggestions at government level, the intermediary organization level and incubator level. At the government level, the systems and mechanisms should be innovated, market-oriented reforms should be put forward, and the enthusiasm for investment and participation should be stimulated. The intermediary organizations should actively establish cooperation platform and invest with the incubator. The incubators should enhance their own value-added ability, give play to the advantages of the group to attract more investment.

1. Introduction
In the 21st century, such an era of innovation globalization, the global industrial structure from the dominant position of the industrial economy to the dominant role of the service economy, and scientific and technological innovation has become an important tool to promote the release of economic vitality. As a platform for innovation and entrepreneurship, business incubator plays a crucial role in this process. Therefore, it is particularly necessary to systematically study the role of incubators in promoting scientific and technological entrepreneurship, and to make an empirical study on the effectiveness of the current input-output of incubators in China according to the latest data of incubators.

The researches on incubators can be traced back to 1984, when Temali and Campbell (1984)[1] conducted a pioneering survey on 55 business incubators operating in the United States. Afterwards, Rice and Matthews (1995)[2] suggested that an incubator is a business that generates service income by providing services to new entrepreneurs that contribute to their success. Incubators are essentially makers of start-ups. Aernoudt (2004)[3] pointed out that the role of an incubator is to provide an environment for growth and a business service system.

In this paper, it is believed that the incubator industry is a collection of incubators or incubators engaged in incubator services, including incubators, accelerators, university science parks, incubator groups etc. Based on the availability of data, the incubator industry is divided into two categories: national science and technology business incubator and university science and technology park.

2. China’s Incubator Industry Efficiency Evaluation
To use limited input to create more output value requires us to use operational methods for analysis. In this paper, we find out the specific reasons for the differences about efficiency of incubators in various
provinces by investigating the operating efficiency of incubators, and then propose measures to improve it. In order to solve this problem, this paper uses DEA (Data Envelopment Analysis) for empirical research.

2.1. Incubator overall efficiency evaluation

Based on the existing literatures (Kou, 2017; Wu, 2002; Zhang and Yin, 2010; Wang, 2012[4-7]), we evaluate the overall efficiency of the incubator industry by the method of DEA (Data Envelopment Analysis). According to the principle of authenticity, availability and ease of use of data, we use input and output data of the national incubator of science and technology in "China Torch Statistical Yearbook 2018". In the selection of specific indicators, taking the principles of availability and consistency into account, we select "managers in management organizations (X1)", "total amount of incubation funds (X2) " and " Incubator Site Area (X3) " as input indicators, and " Number of Incubated Entities (Y1) ", " Number of Employees in Incubated Enterprises (Y2) ", " Total Incubated Entities (Y3) " as output indicators. According to the six indicators, the data were sorted out, and the blank data was eliminated. A total of 30 samples of provinces (except for Tibet, where there is no incubator data found) were sorted out. Since the original variable observation units of input and output are different, it is inconvenient to conduct direct comparison, so the typical correlation model data obtained after standardization is used for analysis. This paper conducts a typical correlation analysis on the input and output data of the sample incubators mentioned above through R, and obtains the following empirical results (see Table 1)

| Mean | Standard Error | Min | Max | Median | DEA Efficiency Count |
|------|----------------|-----|-----|--------|----------------------|
| TE   | 0.75           | 0.21| 0.26| 1      | 0.77                 | 11(19.64%)            |
| PTE  | 0.85           | 0.2 | 0.27| 1      | 0.98                 | 26(46.43%)            |
| SE   | 0.88           | 0.14| 0.47| 1      | 0.93                 | 14(25.00%)            |

As we can see in table 1. The average technical efficiency value is only 75%, which is still some distance from the effective value. Under the condition of not reducing the output, the proportion of various inputs can be reduced by 25%, indicating that the input-output efficiency (te) of China's incubator industry can still be improved. From the two efficiency values, the scale efficiency and the pure technology efficiency of the incubator industry are both high, but the scale efficiency is better than the pure technology efficiency. From this point of view, the main reason for the low efficiency of incubator industry in China is the low efficiency of incubation technology or resource allocation. Through the analysis of the overall sample standard deviation, it is found that the difference of sample mean is obvious, the efficiency of different provinces in the industry fluctuates greatly, and the efficiency state is not stable.

Further analysis found that the current efficiency of China's incubator industry's input-output has the following characteristics:

We can draw from technical efficiency that the average technical efficiency is 0.75, China's incubator industry is in a high efficiency stage. The proportion of DEA efficiency is 20%. In comparison, pure technical efficiency is higher than others. Low scale efficiency indicates that the industry's resource allocation capacity is in low level.
Fig. 1. Scatter plot of operating efficiency distribution in China provinces

As we can see from figure 1, the operating performance of incubators in all provinces gather on the top right, that is, the scale efficiency and the pure technical efficiency are both on high level, the scale efficiency is 1 or close to 1, Meaning that the incubator is closest to the optimal scale.

However, there are still some provinces in the upper left and lower right sections of the figure. The top left incubator is purely technically inefficient and high scale efficient, which means that the existing input-output portfolio is not optimal, this may be due to its low management capabilities. For these incubators, we should reduce the redundancy and waste in the resources invested and improve management skills.

In the lower right part of the figure shows that pure scale efficiency value is lower than the pure technical efficiency value, which means that there are the resource allocation and input-output combination problems, and the reason is as follows: Firstly, the incubator itself is at small scale, need to put more resource to form a scale effect; Secondly, incubators expand too fast, due to lack of internal coordination and low management capabilities, returns on scale diminish; Beijing national science and technology incubator, Xinjiang University Science Park belongs to this. We can improve incubator efficiency from operation situation, management system which should combine with their own situation.

2.2. Incubator Provincial Efficiency Evaluation
There are regional differences in the development of incubator in China. The average technical efficiency in the western region with a small number is generally high. The reason why the eastern and central regions are relatively low in technical efficiency is the low level of purely technical efficiency and the insufficient capacity of resource allocation to meet the scale expansion. We use R software to make the technological efficiency (te), pure technology efficiency (pte), and scale efficiency (se) of national incubators and university science parks in various provinces shown in Figure 2 to 4:

Fig. 2. Technical efficiency (te) of National science and technology incubator (a) & University Science Park (b)
As we can see from the geographical distribution map of the technology efficiency (te) of national scientific and technological incubators on the left, it is obvious that the technology efficiency of incubators in Ningxia, Sichuan, Chongqing, Henan and Tianjin is high and Guizhou, Beijing, Xinjiang is low. It is not difficult to find the technical efficiency (te) distribution map of the University Science Park in Ningxia, Guizhou, Chongqing, Guangxi, Hubei, Jiangxi and Jiangsu is high while Shaanxi, Heilongjiang, Anhui and Beijing are low.

As we can see from the left and right maps above, in terms of technical efficiency, the gap between the national incubator and the national university science park is obvious in the eastern and central regions. The efficiency of national scientific incubators is generally lower than that of the university science park. Qinghai and Tibet have less science parks and incubators. This is consistent with the unbalanced country's current economic development and the distribution of High-quality talent.

![Fig. 3. Pure technology efficiency (pte) of National science and technology incubator (a) & University Science Park (b)](image)

We can see from the figure on the left, the pure technical efficiency of China's national technology incubators is generally high, with Beijing, Shanghai, Shaanxi, Jilin, Inner Mongolia, Jiangsu, Guangdong, Hainan, Zhejiang, Yunnan, Anhui, Tianjin, Henan and Chongqing, Sichuan, Ningxia reached DEA efficiency. There are some provinces close to DEA efficiency; we can see from the right figure, our university science park in Xinjiang, Shanxi, Jilin, Jiangsu, Jiangxi, Hubei, Guangxi, Chongqing, Guizhou, Ningxia are in pure technical efficiency reached DEA efficiency, while Shaanxi, Anhui, Heilongjiang, Beijing purely are in pure technical inefficiency.

![Fig. 4. Scale efficiency (se) of National science and technology incubator (a) & University Science Park (b)](image)

From the left figure, we can see that the scale efficiency of national technology incubators in China reaches DEA efficiency in Ningxia, Sichuan, Chongqing, Henan and Guizhou. While in Beijing, the pure technical efficiency is 0.47. The figure on the right shows that the scale efficiency of university science parks in China reaches DEA efficiency in Anhui, Henan, Jiangsu, Jiangxi, Hubei, Guangxi, Chongqing, Guizhou and Ningxia, while the scale efficiency in Xinjiang is at 0.47.
By contrast we can see that, although in the scale efficiency, the University Science Park slightly is higher than the incubator. However, as for pure technical efficiency, the average value of incubators is higher than that of university science parks. That is, under the same input conditions, incubator create more output; And University Science Park on average closer to the optimal size.

3. Suggestions on China’s Incubator Construction Counter Measures

3.1. Government Optimization Measures

Firstly, it is important to balance resource inputs and promote the balanced development of incubators in various regions. According to DEA efficiency analysis, we can easily know that there are obvious differences in efficiency among different regions, the central and eastern regions are obviously superior to the western regions, and the southern regions are better than the northern regions. The reason is both politic and economic. Since Reform and Opening-up, the government has vigorously supported the south-eastern coastal provinces and encouraged some people to get rich first. The policy support for the western region is relatively weak. These policies are themselves related to the geography of the provinces.

Secondly, more attention should be paid to the university science park, to encourage researchers and students to start their own businesses. Through the above analysis, we find that although the scale efficiency of university science park is on high-level, its pure technical efficiency is on low-level, which means the output for the same input is relatively low. The main problem of university science and technology park is the relatively weak ability to transform scientific and technological achievements to profit. Some local administrative departments and universities lack understanding of the status and role of the National University Science Park in the national innovation system. The formulation and implementation of relevant policies are not in place. The management system and operating mechanism of the National University Science Park need to be improved. To solve these problems, we not only rely on the role of policy makers, but also need to have flexible operation under the institutional framework of the university science park, which should fully bring along the innovative spirit of researchers and the high output of research and development.

Thirdly, the government should implement the market-oriented reform and stimulate the innate vitality of the incubator industry innovation. Government investment dominates in the current incubator industry in our country. Under this mechanism, the incubator industry is confronted with the shortcomings of lack of innovation capability and inefficiency. Objectively speaking, only raising the efficiency of incubators can we improve the overall innovation capability of the industry.

At last, the government should also pay more attention to policy coordination. The government must effectively and properly use policies. The current entrepreneurship issues are mainly concentrated in the government approval threshold, policy support and concessions. Although governments at all levels have formulated many preferential policies, some policies have not yet been put in place. For example, local returned parts can’t be fully returned. In addition, government policy requirements specification construction content, but in the specific management, it often can’t be strictly bound by the content, and therefore forms a passive working mechanism which relies on preferential policies. Therefore, governments at all levels should encourage the development of relevant policies, emphasis on effectively implementing the incentives and constraints policy; at the same time focusing on policy collaboration.

3.2. Intermediary Organization Measures

It can produce huge social and economic benefits if incubators run well. However, the effective operation of incubators depends on the support of the intermediary system. Intermediary optimization measures can be from the following aspects:

Firstly, intermediary organizations should actively cooperate with incubators to build a complete network of services in incubation enterprises, and realize the sharing of resources such as services, information, knowledge and funds, and raise the quality of incubation to obtain the high-yield returns of high-tech projects. Various kinds of social intermediary organizations should integrate social
resources and strengthen the service ability, gathering ability and resource integration ability of incubators to obtain better hatching benefits.

Secondly, intermediaries should also strengthen the construction of information platform, to solve such issues as old information sources, unreliable sources of information and missing information communication channels, and to establish a platform that integrates various information resources, communicates information on supply and demand of various intermediaries, and promotes business collaboration and improve intermediary public information network for intermediaries to reduce costs, and improve service quality and strengthen collaboration to create a good information environment.

3.3. Incubator Optimization Measures

At present, China's incubators face both challenges and opportunities. Based on the above empirical conclusions, we can see that there is an uneven regional development in the efficiency of business incubators in our country. In some areas, there are cases of purely technical efficiency and economies of scale inefficiency. In addition, according to related reports, the incubator "basement" in Nanshan District of Shenzhen was transferred out; the problems of the pioneer cafes due to operating difficulties and wage arrears may be brought to an end; the two shareholders of Shanghai 863 software incubator delisted and listed to transfer their shares. Therefore, the incubators are suggested to raise profits in the following areas:

Firstly, incubators should deal well with the government departments at all levels, strive for more financial support. The incubators should also make more efforts to enhance their own strength, looking for a strong "backing", make good use of quality projects to impress the government and large enterprises, in order to get more support. At present, government policy support and capital subsidy efforts are of great help. In recent years, national policies have become more rational, and investment has been given more targeted incubation institutions in the market.

Secondly, incubators should not be overly dependent on the government to enhance the incubator service ability and their own value-added capabilities. They should establish good relations with scientific research institutes, investment institutions, legal institutions and other third-party companies. On the one hand, incubators should rely more on the enterprise-type platform, abundant funds and market resources, such as Baidu, Tencent and other Internet companies to set up the platform; On the other hand, they could also rely on the service area of the university, which has rich alumni and other resources the form the industrial chain. Therefore, incubators could enhance their own hard and soft power with the power of these kind of platforms.

References

[1] Temali, M. and C. Campbell, 1984, Business Incubator Profiles: A National Survey, Minneapolis: University of Minnesota, Hubert H. Humphrey Institute of Public Affairs.
[2] Rice M P, Mathews J B. Growing New Ventures, Creating New Jobs: Principles and Practices of Successful Business Incubation[M]. Westport, CT: Center for Entrepreneurial Leadership, Inc, 1996.
[3] Aernoudt R. Incubator: Tool for entrepreneurship? [J]. Small Business Economics, 2004(23):127-135.
[4] Kou Y. Connotation definition, efficiency evaluation and transformation countermeasures of business incubator industry [J]. Jianghan academic, 2017 (1).
[5] Wu S. Discussion on market operation of business incubator [J]. China science and technology forum, 2002 (2) : 47-50.
[6] Zhang J, Yin Q. Research on operational efficiency differences of business incubators in China -- based on DEA and cluster analysis [J]. Science of science and technology management, 2010 (5) : 171-177.
[7] Wang X. Research on the performance evaluation of science and technology business incubator [D]. Tianjin: tianjin university, 2012.