Research on the Operation Performance Evaluation of Makerspaces in Zhejiang Province -- Based on Super-efficiency DEA Model

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Abstract: The number of makerspaces in Zhejiang Province continues to rank among the top in China, many makerspaces have also incubated many start-ups, incubating many start-ups. However, due to the short development time of China's makerspace and the immature operation mode, the actual operation situation remains to be explored. Therefore, this paper focuses on the evaluation and analysis of the operation performance of makerspaces in Zhejiang Province to evaluate the operation performance of the makerspace by building a super efficiency DEA model, using the relevant data of the makerspaces in 30 provinces in China from 2016 to 2020. The study found that the operation performance of makerspaces in Zhejiang Province was low. Therefore, this paper puts forward targeted suggestions from two aspects of optimizing input and improving output to improve the operation performance of makerspaces in Zhejiang Province.

Keywords: Makerspace; Super Efficiency DEA Model; Operation Performance

1 Introduction

Since the proposal of "mass entrepreneurship and innovation" was put forward in 2014, innovation and entrepreneurship activities in China have been developing in full swing, and the makerspace is booming. Although the time for the development of makerspace in China is relatively short, thanks to the active promotion of a large number of fiscal and tax subsidies and various tax relief policies, the number of makerspaces in various regions are rising, and the performance is gradually important, which has successfully incubated many start-ups.

According to the statistics of the national makerspace released by the Ministry of Science and Technology in China, by the end of 2020, there are 8507 makerspaces in China. However, despite the rapid development of China's makerspace under the support of various policies, there are problems such as insufficient fiscal and tax incentives, financing difficulties, single operation mode [1], and insufficient internal motivation.

In terms of the number of national makerspaces in recent years, in 2020, Zhejiang Province ranked third with 735 makerspaces. At the same time, in the development process, Zhejiang's makerspaces also show the characteristics of diversification of outstanding innovation spaces, marketization of mass innovation services, diversification of mass innovation models, and openness of mass innovation organizations [2], which is typical compared with other provinces' makerspaces. Therefore, this paper uses the super efficiency DEA model to evaluate the

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operation performance of makerspaces in Zhejiang Province, and studies the key factors that affect the operation performance of makerspaces in Zhejiang Province, so as to find out the policy measures to improve the operation performance of makerspaces in Zhejiang Province.

2 Literature review

Scholars have done rich research on the construction of the operation performance evaluation system of makerspace. Shan et al. [3] used the Analytic Hierarchy Process to build a criteria layer focusing on development capacity, innovation service capacity, service management capacity and the ability to gather entrepreneurs, and 14 indicator layers to evaluate the performance of 13 makerspaces in Beijing. Xu et al. [4] based on economic support, technical support, social support input indicators and economic achievements, social achievements. The operation efficiency of makerspace in 31 provinces of China from 2016 to 2017 was measured by 11 indicator levels consisting of the standard level system of innovation achievements and service achievements output.

At present, there are rich evaluation methods for the operation performance of makerspaces. Gao et al. [5] used PP-SFA model to conduct empirical analysis on the operation efficiency of makerspace in various provinces of China. Lee [6], Kao [7] chose the two-stage DEA model.

In general, DEA method is a commonly used evaluation method, but there are few super-efficient DEA methods, this method has the advantage of ranking each decision-making unit. Furthermore, although there have been studies on the operation performance of makerspaces in Zhejiang Province, there is no comparative study on the makerspace in various provinces across the country. Therefore, based on the super efficiency DEA model, this paper selects the operation data of makerspace in 30 provinces of China from 2016 to 2020, evaluates the operation performance of makerspaces in Zhejiang Province through comparative analysis, finds out the influence factors that affect its operation performance, and then gives feasible suggestions to improve the operation performance of makerspaces in Zhejiang Province.

3 Research design

3.1 Research methods

Anderson and Petersen [8] proposed the super efficiency DEA model. In this paper, the super efficiency DEA model is used for analysis. This model is no longer limited to the calculation within the range of 0-1, but allows the efficiency value to exceed 1, that is, the decision-making units with the efficiency value of 1 can be sorted and compared. Among them, the greater the super efficiency value is, the higher the efficiency is.

3.2 Indicator selection

It is very important to build a scientific input-output index system for the evaluation of the operation performance of makerspaces. Based on the literature review, this paper takes the financial, human, material and other aspects necessary for the settled enterprises as the secondary indicators [9], specifically including the amount of financial support (X_1), the number of teams and enterprises that provided technical support services that year (X_2), the number of

entrepreneurial mentors (X_3), the number of workstations provided (X_4), and entrepreneurship education and training (X_5).

The goal of the operation of makerspace is to serve the newly established enterprises and promote their innovation. The effect of the service is reflected in economic achievements, social achievements, innovative achievements, etc. [10]. This paper selects the total income of makerspace (Y_1), the total investment and financing amounts of teams and enterprises in the current year (Y_2), the number of employees absorbed by start-ups (Y_3), and the number of effective intellectual property rights owned by resident enterprises and teams (Y_4) as output indicators. See Table 1 for the specific indicator system.

Table 1. Input-output indicator system of makerspaces in Zhejiang Province.

Category	Level I indicator	Level II indicator
Input index	Financial input	financial support obtained X_1
	Manpower input	Number of teams and enterprises providing technical support services in the year X_2
		Number of entrepreneurial tutors X_3
	Material input	Number of workstations X_4
	Other inputs	Launch entrepreneurship education and training X_5
Output indicators	Economic achievements	Total income of makerspace Y_1
		Total amount of investment and financing obtained by the team and enterprise in the current year Y_2
	Social outcomes	Number of employees hired by start-ups Y_3
	Innovative achievements	Number of valid intellectual property rights owned by resident enterprises and teams Y_4

3.3 Select DMU and data source

In this paper, 30 provinces (excluding Tibet, Hong Kong, Macao and Taiwan) in China from 2016 to 2020 are selected as decision-making units, and the non-state filing makerspace owned by each province is taken as the research object.

The data in this paper are all from China Torch Statistical Yearbook (2016-2020) and China Science and Technology Statistical Yearbook (2016-2020). DEAP2.1, EMS1.3 and other software are used to calculate and analyze the input-output index data.

4 The operation performance evaluation of makerspaces in Zhejiang Province

4.1 The calculation results of the operation performance of makerspaces in Zhejiang Province

From the perspective of horizontal comparison, in 2016, the super efficiency value of Zhejiang's makerspaces was 0.734, ranking 23rd, while Qinghai, Tianjin and Jiangxi, the top three in that year, were 4.236, 2.753 and 1.978 respectively. In 2017, the super efficiency value of Zhejiang's makerspaces was 0.562, ranking 21st, and Inner Mongolia, Beijing and Heilongjiang ranked first three with 4.203, 2.6 and 2.176 respectively. In 2018, the super efficiency value of Zhejiang's makerspaces was 0.77, ranking 11th, and Beijing, Heilongjiang and Qinghai ranked

the top three with 6.241, 1.572 and 1.528 respectively. In 2019, Zhejiang Province ranked 27th with the space efficiency value of 0.564, while Beijing, Liaoning and Ningxia ranked the top three with 4.742, 1.299 and 1.225 respectively. In 2020, the super efficiency value of Zhejiang's makerspaces was 0.548, ranking the 26th, while Beijing, Xinjiang and Qinghai ranked the top three with 8.624, 1.783 and 1.565 respectively. In general, Zhejiang Province is relatively low in ranking and has a large gap with the top provinces.

From the perspective of vertical comparison, on the one hand, the DEA value of makerspace in Zhejiang Province in 2016-2020 was less than 1, but the DEA value of makerspace in Beijing, Heilongjiang and Qinghai provinces were more than 1 for five consecutive years. During the five years, there were 12, 9, 6, 7 and 6 provinces with the DEA value of super efficiency greater than 1, which means that compared with those provinces with higher operational performance of makerspace. The operation performance of makerspaces in Zhejiang Province is low. On the other hand, its super efficiency value fluctuates and declines. In comparison, Beijing and other provinces are on the rise, which means that compared with other provinces, Zhejiang's makerspace has a poor development trend.

Table 2. Evaluation results of super efficiency DEA model for the operation performance of makerspaces in 30 Provinces from 2016 to 2020.

province	2016	ranking	2017	ranking	2018	ranking	2019	ranking	2020	ranking
Beijing	1.431	5	2.600	2	6.241	1	4.742	1	8.264	1
Tianjin	2.753	2	0.521	26	0.562	24	0.711	19	0.498	29
Hebei	0.762	21	0.428	29	0.435	30	0.871	10	0.547	27
Shanxi	1.184	7	1.253	8	0.563	23	0.660	22	0.620	24
Inner Mongolia	1.133	10	4.203	1	0.476	29	0.467	30	0.680	17
Liaoning	1.841	4	0.917	10	0.648	18	1.299	2	0.623	23
Jilin	0.833	18	1.528	6	0.562	25	0.597	26	1.023	5
Heilongjiang	1.124	11	2.176	3	1.572	2	1.011	7	1.137	4
Shanghai	1.142	9	1.880	5	0.813	10	0.845	11	0.762	11
Jiangsu	0.696	28	0.686	16	0.679	15	0.629	25	0.671	19
Zhejiang	0.734	23	0.562	21	0.770	11	0.564	27	0.548	26
Anhui	0.744	22	0.777	12	1.190	4	0.672	21	0.688	16
Fujian	0.707	27	0.520	27	0.668	17	0.731	18	0.442	30
Jiangxi	1.978	3	2.079	4	0.567	22	0.773	15	0.642	20
Shandong	0.783	19	0.541	23	0.531	28	0.530	28	0.516	28
Henan	0.966	13	0.623	17	0.750	12	0.684	20	0.629	22
Hubei	1.292	6	1.387	7	1.142	5	0.759	17	0.703	14
Hunan	1.032	12	0.551	22	0.732	14	0.773	16	0.789	9
Guangdong	0.713	25	0.594	19	0.614	21	0.832	13	0.725	13
Guangxi	0.845	16	0.317	30	0.733	13	0.495	29	0.860	8
Hainan	0.944	14	0.718	14	0.923	7	0.836	12	0.886	7
Chongqing	0.682	29	0.566	20	0.542	27	0.643	23	0.703	15
Sichuan	1.170	8	0.522	25	0.678	16	0.798	14	0.635	21
Guizhou	0.778	20	0.612	18	0.816	9	1.033	6	0.764	10
Yunnan	0.521	30	0.523	24	0.633	20	0.917	9	1.015	6
Shaanxi	0.711	26	0.457	28	0.644	19	0.639	24	0.555	25

Gansu	0.836	17	0.720	13	0.915	8	1.059	5	0.760	12
Qinghai	4.236	1	1.028	9	1.528	3	1.077	4	1.565	3
Ningxia	0.729	24	0.833	11	0.544	26	1.225	3	0.677	18
Xinjiang	0.917	15	0.712	15	1.134	6	0.990	8	1.783	2

4.2 The reasons of the low operation performance of makerspaces in Zhejiang Province

The operation performance of makerspaces in Zhejiang Province is low, and there is still a big gap compared with that of other provinces, which is basically consistent with the research results of Xu et al. [11]. This may be due to the short development time of makerspaces in Zhejiang Province and the immature operation mode, which leads to redundant input and low output performance.

According to Table 3, there are many problems in the input and output slack variables of the operation performance of makerspaces in Zhejiang Province. In terms of input variables, during 2016-2020, only the number of workspaces provided was a reasonable input variable, and the remaining four input variables were over invested, resulting in redundancy; In terms of output variables, the output variable of the number of employees hired by start-ups is relatively reasonable and effective, while the other three output variables have the problems of less output and low efficiency. In general, in 2016-2020, only the input variable of the number of workstations provided and the output variable of the number of employees absorbed by start-ups in makerspaces in Zhejiang Province are relatively effective. The remaining input variables are redundant, while the output variables are relatively poor, which is the main reason for the low performance of makerspaces in Zhejiang Province.

Table 3. Input-output slack variables of the super efficiency DEA model for the operation performance of makerspaces in Zhejiang Province in 2016-2020.

Year	slack variable of input index					slack variable of output index			
	X_1	X_2	X_3	X_4	X_5	Y_1	Y_2	Y_3	Y_4
2016	0	0	0	0	824	0	0.04	0	0
2017	0.09	959	2 037	0	2 864	0	0	0	0
2018	177685.9	1728	3786	0	1956	0	11856201.6	0	0
2019	76084.38	0	1726	0	2120	178420.7	13000335.1	0	12803
2020	143782	377	0	0	518	0	7953262.18	0	21583

5 Research conclusions and suggestions

5.1 Research conclusion

This paper mainly uses the super efficiency DEA model to evaluate the operation performance of makerspaces in Zhejiang Province. It is known that the operation performance of makerspaces in Zhejiang Province is low. The super efficiency DEA values of the operating performance of Zhejiang's makerspaces in 2016-2020 ranked 23rd, 21st, 11th, 27th and 26th respectively among the 30 provinces, ranking relatively low. From the perspective of relaxation variables, it is mainly because of input redundancy and insufficient output.

5.2 Countermeasures and suggestions

First, optimize the input of makerspaces in Zhejiang Province and improve the efficiency of resource use. First of all, appropriately adjust the financial support for makerspaces in Zhejiang Province, and effectively improve the use efficiency of financial funds. Secondly, re-examine the organizational structure of the makerspace, streamline the management department, optimize the human input, and reduce the waste of resources due to the redundancy of human capital.

Second, stimulate the vitality of makerspaces in Zhejiang Province and improve output performance. First of all, makerspaces in Zhejiang Province can attract more customers by improving the quality of services, reduce investment risks and increase investment income by investing in more different industries, and increase the total income of makerspace by optimizing the utilization rate of financial subsidies; Secondly, increase investment and financing channels and reduce operational risks. Finally, pay attention to the improvement of quality while improving the quantity of intellectual property, and give full play to the positive role of effective intellectual property in improving the operation performance of makerspaces.

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