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Research on the Evaluation and Prediction of the Operation Efficiency of China's Science and Technology Business Incubators

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Abstract: Based on the division of the three major economic regions in the east, the middle and the west, the operational efficiency of science and technology incubators in 31 provinces (cities) from 2010 to 2019 and 2019 is analyzed by DEA-BCC model, and the development trend of science and technology incubators in the next six years and their contribution to GDP are predicted by using the grey model GM (1,1). It is concluded that while giving consideration to fairness, we should pay attention to the total allocation of scientific and technological resources between the eastern, central and western regions to improve the efficiency of scientific and technological resources allocation, promote the development of high-tech in late-developing regions, accurately allocate resources and stabilize regional economic development.

Keywords: Technology incubator, Data envelopment analysis, Grey prediction, Operating efficiency.

1. Introduction

In the context of globalization and the advent of the era of knowledge economy, science and technology are increasingly closely linked with the economy. Scientific and technological innovation has become an important force to promote the economic transformation and industrial upgrading of countries and regions. As a test field for China's scientific and technological innovation, science and technology business incubators (hereinafter referred to as "incubators") mainly provide services such as physical space, infrastructure, technical consultation, investment and financing for small and medium-sized high-tech enterprises that have not yet formed, reduce entrepreneurial risks, improve enterprise innovation capabilities, promote enterprise growth, drive employment by entrepreneurship, promote regional economic development level and economic structure transformation. This paper evaluates the operational efficiency of science and technology incubators from 2010 to 2019 at the level of the three major economic regions in the east, west and middle of China, and forecasts the demand for science and technology resources in China, providing reference for optimizing the operation of science and technology incubators.

2. Indicator Selection and Data Source

According to the three major economic regions in the east, middle and west of China, and combined with the input and output indicators, the operation efficiency of the incubator is evaluated. This paper will select input indicators from three perspectives of incubator resources, material resources and human resources, and output indicators from three perspectives of incubator process resources, economic benefits and incubation results, as shown in Table 1.

Table 1. Incubator indicator system

Grade I index	Grade II index	Grade III index
Input indicators	Incubators Input	number of incubators
	material resources	Site area
	human resources	Number of employees
Output indicators	incubated resources	incubated enterprises
	incubated enterprises	Total income
	Graduated enterprises	Graduated enterprises

3. Analysis Results of DEA-BCC Model

The operational efficiency of incubators in China from 2010 to 2019 is calculated by using Deap2.1 software. The analysis results are as follows.The comprehensive efficiency value is a key indicator reflecting the allocation of incubator resources. The effectiveness of the allocation of various scientific and technological resources can be measured according to the ratio of its input and output. The closer the comprehensive efficiency value is to 1, the better the allocation of various incubator resources is. The analysis results of DEA-BCC model show (see Table 2) that the average comprehensive efficiency of incubator allocation in China from 2010 to 2019 is 0.9851, which is in a good level overall, but there is still a large room for improvement. From the perspective of each year, except 2012, 2013, 2015 and 2016, DEA is effective in all other years, indicating that the input matches the expected output and the incubator's input-output resources are fully utilized. In 2012 and 2015, DEA was weak, that is, the growth rate of output was lower than that of input, and the allocation of resources was redundant; In 2013 and 2016, DEA was invalid, the return to scale was increasing, and the total amount of incubator resources was insufficient.

Table 2. Operation efficiency of incubators in China from 2010 to 2019

Annual	comprehensive efficiency	Pure technical efficiency	Scale efficiency	Scale return
2010	1.000	1.000	1.000	--
2011	1.000	1.000	1.000	--
2012	0.979	1.000	0.979	drs
2013	0.945	0.995	0.950	irs
2014	1.000	1.000	1.000	--
2015	0.998	1.000	0.998	drs
2016	0.929	0.952	0.976	irs
2017	1.000	1.000	1.000	--
2018	1.000	1.000	1.000	--
2019	1.000	1.000	1.000	--
Average	0.9851	0.9947	0.9903	--

From the specific analysis of 31 provinces (cities) (see Table 3), taking 2019 as an example, Beijing, Shanghai, Fujian and Hainan in the eastern region, Heilongjiang in the central region, and Tibet and Ningxia in the western region are DEA effective, scientific and technological resources are reasonably allocated, and are in a leading position in the development of incubators in China; Tianjin, Jiangsu, Zhejiang, Shandong and Guangdong in the eastern region, Henan and Hubei in the central region, and Yunnan and Xinjiang in the western region are weak and effective in DEA, that is, the input resources under the current scale can still be fully utilized, and there is resource redundancy; The DEA of Hubei, Liaoning and Guangxi in the eastern region, Shanxi, Inner Mongolia, Jilin, Anhui and Jiangxi in the central region, and Chongqing, Sichuan, Guizhou, Shaanxi, Gansu and Qinghai in the western region is invalid, indicating that the utilization of scientific and technological resources has not reached the optimal output. In 24 provinces, the ratio of input and output is unreasonable due to the inefficiency of pure technical efficiency or scale efficiency. It can be seen that there are obvious differences in the operating efficiency of incubators among regions in China, and the allocation of scientific and technological resources is uneven.

Table 3. Allocation efficiency of incubators in 31 provinces (cities) of China in 2019

Provincial	comprehensive efficiency	Pure technical efficiency	Scale efficiency Scale return	Scale return
Beijing	1.000	1.000	1.000	--
Tianjin	0.833	0.951	0.875	drs
Hebei	0.720	0.758	0.949	irs
Shanxi	0.784	0.793	0.989	irs
Neimenggu	0.673	0.704	0.956	irs
Liaoning	0.940	0.965	0.974	irs
Jilin	0.594	0.627	0.947	irs
Heilongjiang	1.000	1.000	1.000	--
Shanghai	1.000	1.000	1.000	--
Jiangsu	0.754	1.000	0.754	drs
Zhejiang	0.828	1.000	0.828	drs
Anhui	0.778	0.831	0.937	irs
Fujian	1.000	1.000	1.000	--
Jiangxi	0.709	0.836	0.849	irs
Shandong	0.898	1.000	0.898	drs
Henan	0.689	0.849	0.812	drs
Hubei	0.900	1.000	0.900	drs
Hunan	0.751	0.866	0.868	irs
Guangdong	0.785	1.000	0.785	drs
Guangxi	0.857	0.879	0.974	irs
Hainan	1.000	1.000	1.000	--
Chongqing	0.951	0.954	0.996	irs
Sichuan	0.825	0.905	0.912	irs
Guizho	0.564	0.580	0.973	irs
Yunnan	0.980	1.000	0.980	drs
Xizang	1.000	1.000	1.000	--
Shanxi	0.517	0.669	0.774	irs
Gansu	0.773	0.815	0.948	irs
Qinghai	0.866	0.873	0.992	irs
Ningxia	1.000	1.000	1.000	--
Xinjiang	0.939	0.986	0.952	drs

4. Grey Prediction Model

The grey prediction model GM (1,1), as a typical model of grey prediction theory, has the characteristics of less samples, incomplete sample information and high prediction accuracy. At present, it is widely used in agriculture, energy and economy, and has solved a lot of practical problems. The GM (1,1) model is used to predict the development trend of the incubator resource input and output indicators from 2020 to 2025, and the fitting degree of the grey prediction model is judged according to the fitting degree test standard.

Table 4. Grey prediction model and test results of incubators in China from 2020 to 2025

Index	parameter		value fitting	equation C	value P	value model accuracy grade
Count the number of incubators	a=-0.0724	b=5246.3363	$73359.2086e^{0.072k}$-72463.2086	0.0177	1	1
Site area	a=-0.0613	b=15357.8063	$253579.076e^{0.061k}$-250535.176	0.0316	1	1
Incubated enterprises	a=-0.0644	b=234271.5378	$3694138.79e^{0.064k}$-3637756.79	0.045	1	1
Total income of incubated enterprises	a=-0.0477	b=10335.8281	$220013.525e^{0.048k}$-216684.025	0.1569	1	1
Number of employees in incubated enterprises	a=-0.0478	b=375.3833	$7971.001e^{0.048k}$-7853.2071	0.0707	1	1
Cumulative graduation enterprise	a=-0.0635	b=170292.9751	$2718264.13e^{0.064k}$-2681779.13	0.0264	1	1
GDP	a=-0.0881	b=432306.8424	$b=5319120.91e^{0.0881k}$-4907001.6	0.0017	1	1

According to the test, the average relative error of various economic indicators and GDP of incubators in China is 10.04%, 6.72%, 11.96%, 14.85%, 14.85%, 9.28%, 9.45% and 10.05% respectively, and the model fitting accuracy is high, which is level 1; The C values of the fitting equation are 0.0177, 0.0316, 0.045, 0.1569, 0.0707, 0.0264 and 0.0017, respectively, which are less than 0.34. The model is judged as good, and the grade is grade 1; The small error probability P is 1, greater than 0.95, and the accuracy level is 1. To sum up, the GM (1,1) model has a high fitting accuracy and can be used for the medium and long term forecast research of China's incubator development trend and GDP.The prediction results of GM (1,1) model show that the input-output indicators of China's incubator resources are increasing year by year from 2020 to 2025, and the average annual growth rates of the six indicators are 19.24%, 15, 56%, 14.42%, 9.46%, 9.61% and 15.99% respectively. It can be seen that with the increase of the number of incubators and the area of their sites, the total income of incubating enterprises and the cumulative graduation enterprises and other output indicators will also increase accordingly, indicating that the number of incubating enterprises and their employees in China's future incubators may still increase.

Table 5. Predicted Values of Incubator Indicators

Year	Number of incubators	site area	incubating enterprises	employees of incubating enterprises	cumulative graduates enterprises
2020	6109	16083.621	247595	328	173279
2021	6959	17934.021	278485	358	195171
2022	7872	19901.373	311429	390	218496
2023	8853	21993.07	346564	424	243350
2024	9909	24216.971	384036	459	269833
2025	11043	26581.431	424000	496	298050
Average annual growth rate	10.37%	8.73%	9.38%	7.14%	9.46%

5. Conclusion

5.1. Significant differences in the operating efficiency of incubators between the eastern, central and western regions

The analysis results based on the DEA-BCC model show that the overall operational efficiency of China's incubators showed an upward trend from 2010 to 2019, but the operational efficiency difference was significant and the resource utilization rate of some provinces (cities) was low. Among the provinces where DEA is effective, five provinces are in the central and eastern regions of China, including Beijing, Shanghai, Fujian and Hainan; The central region is Heilongjiang. About half of the 24 provinces in which DEA is invalid have large incubators and insufficient total income

of incubating enterprises. Most of these provinces are concentrated in the central and western regions, which indicates that there is a regional imbalance in the operation efficiency of incubators in China that cannot be ignored. Guided by national policies, actively improve the construction of high-tech industry service system, balance the total allocation of scientific and technological resources in the eastern, central and western regions, while taking into account fairness, and improve the allocation efficiency of scientific and technological resources. First, control the areas with excessive allocation of scientific and technological talents, transfer personnel to areas with less allocation, and avoid talent waste; The second is to appropriately reduce the area of the incubator, and optimize the allocation scale and proportion on the basis of the existing investment scale, combined with policy guidance and scientific and technological resources planning, taking into account the key factors affecting the low allocation efficiency.

5.2. Accurately configure incubator resources

The forecast results show that the number of incubators, the area of the site, the number of incubating enterprises and the number of employees of incubating enterprises in China will increase year by year, and the total income of incubating enterprises and the cumulative graduation enterprises will increase simultaneously. Among them, the annual contribution rate of total income GDP of incubated enterprises is about 0.8%, indicating that the operation of incubators can stimulate economic growth stably. With the arrival of the era of "big data" and "5G", the demand for scientific and technological talents such as information technology, biotechnology, new material technology and new energy technology is increasing, and the incubator resource allocation is facing huge challenges. In this regard, the precise allocation of incubator resources is particularly important. First, reduce the operation area of incubators in some provinces (districts, cities), allocate the redundant employees of incubating enterprises reasonably, actively introduce high-tech talents, and improve the utilization rate of resources. The second is to take the equalization of scientific and technological resources as the goal, supplemented by government subsidies, to encourage the export of scientific and technological resources from areas with high allocation of resources to areas with scarce resources, but it must be controlled reasonably to promote the development of science and technology in China.

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