Quest Journals
Journal of Research in Business and Management
Volume 12 ~ Issue 9 (2024) pp: 47-55
ISSN(Online):2347-3002
www.questjournals.org

Research Paper

Research on Operational Efficiency of Science and Technology Business Incubators in China

Dongyan Chen, Baixuan Sun, Pengbin Gao*
School of Economics and Management, Harbin Institute of Technology China, Weihai, Shandong, China
Corresponding Author: Pengbin Gao

ABSTRACT: *In recent years, science and technology business incubators have gradually expanded in scale and number. However, in the process of operation, there are many problems, such as improper utilization of resources, different levels of services, and varying quality of services and shared resources, which constitute a serious challenge to the development of science and technology business incubators. In this paper, based on the DEA method and the Malmquist index method, the science and technology business incubators in 29 provinces and regions in China from 2019-2023 were selected as samples. The K-means cluster analysis was used to make an inter-regional analysis of incubator variability, and at the same time, the incubators were subjected to a geographic area variability analysis based on the classification of the four major economic regions. The results show that the operational efficiency of China's science and technology business incubators performed well in 2019-2023 as a whole, but there are still problems, such as redundant inputs and insufficient outputs in individual regions. Combined with the incubator efficiency influencing factors, the research in this paper will be synthesized to make targeted countermeasures and suggestions on practices to improve the operational efficiency of incubators.*

KEYWORDS: *Technology Business Incubators, Operational Efficiency Evaluation, Data Envelopment Analysis, Cluster Mean Method, Input-output Indicator System*

***R**eceived 02 Sep., 2024; **R**evised 13 Sep., 2024; **A**ccepted 15 Sep., 2024 © The author(s) 2024.*
P**ublished with open access at **www.questjournas.org

I. INTRODUCTION

Strengthening technological innovation is now the critical strategy for China to enhance its international competitiveness. In the process of economic development in the next few decades, science and technology business incubators will be the key driving force to promote regional economic growth and high-tech innovation. Nevertheless, despite the quick rise in the number of incubation platforms, a thorough analysis of their functional positioning, mode of operation, and service capacity reveals that their actual incubation effect, capacity to attract creative resources, and contribution to the social and economic development of the region have not reached the expected goals. These problems affect the sustainable development of the incubation platform and the function of scientific and technological innovation but also restrict the implementation of the innovation-driven development strategy of the regional economy and the improvement of the efficiency of the transformation of scientific and technological achievements. Therefore, how to improve the operational efficiency of science and technology incubators has become an urgent issue that needs to be solved.

In the current research on analyzing the operational efficiency of incubators, numerous researchers have analyzed and evaluated the operational efficiency of incubators at a certain static point in time only based on the Data Envelopment Analysis (DEA) method. In terms of constructing the indicator system, this literature has overly favored the selection of traditional input variables and might neglect one of the most significant features of science and technology business incubators, namely, the function of providing a full range of services for incubates. Moreover, there is a large degree of overlap and crossover in the selection of indicators in the existing literature, and there is a high degree of correlation between many of the indicators, which will inevitably have a negative impact on the scientificity and objectivity of the evaluation results.

Given this, this study analyzes incubator efficiency through a dynamic perspective, promotes the time horizon of the study, and forms an efficiency evaluation system that lasts across time to obtain a complete analysis and understanding of the operational efficiency of incubators. Based on the deep study of the working mechanism and operation mode of China's science and technology business incubators, we strive to make innovation and optimization in the process of constructing the performance evaluation index system and strive to provide a more scientific, reasonable, and comprehensive evaluation framework for evaluating the performance of China's science and technology business incubators, which help to provide a solid theoretical foundation and practical path for the construction of the relevant policy frameworks and the improvement of the management process of business incubators.

II. THEORETICAL FRAMEWORK AND RESEARCH DESIGN

2.1 Theoretical Framework

The resource-based view theory emphasizes that the sustainability of a company's competitive advantage depends on the inimitability of its resources. A technology enterprise incubation platform can build competitive advantages by strategically allocating and integrating resources. From the resource utilization and integration perspective, Barbero et al. explored the driving factors of technology business incubator development[1]. Jean and Vilmos et al. proposed that strategically integrating resources profoundly impacts the graduation rate of incubators[2][3]. Moreover, based on the stakeholder theory and the diversified development trend of science and technology enterprise incubation institutions, it is imperative to balance the needs of multiple parties. When constructing the performance evaluation system of science and technology business incubators, it is necessary to fully consider the impact on the incubators, incubators, and their employees. Urbano and Aparicio proposed policy factors for the hatching rate[4]. Hausberg and Xia Xing et al. studied the operational efficiency of science and technology business incubators considering multi-stakeholders of enterprises[5][5].

Growth pole theory has been widely applied to explain the function principle of science and technology business incubators, taking urban development zones as the core of economic growth, and science and technology business incubator is regarded as the core driving force of growth poles. Cheng Hongyi et al. used stochastic frontier analysis (SFA) to analyze the operational efficiency of science and technology business incubators in Guangdong Province from 2015 to 2017 [7]. Some scholars use the AHP method for evaluation index system construction[8][9]. The DEA method has also been adopted to construct the evaluation index system[10][11]. Chang Mei et al. adopted the two-stage SBM model to evaluate business performance[12]. Measures to improve the operation efficiency of science and technology business incubators have also attracted wide attention. Scholars have put forward constructive opinions from the perspectives of tax policy[13][14][15], innovation atmosphere[16][17], resource investment[18][19], talent training[20], etc.

This study also relies on the theory of comparative advantage, which can well explain the interactive relationship between technology business incubators and start-ups. With the support of science and technology business incubators, start-ups can develop rapidly, and the incubation success rate of incubators will also be improved, enhancing social benefits, and eventually, both sides will achieve a win-win situation.

2.2 Research Design

Data Envelopment Analysis (DEA) is a method for evaluating the efficiency of multi-input and multi-output systems[21], which is especially suitable for efficiency analysis in the presence of multiple Decision-Making Units (DMUs) compared with each other. Based on the evaluation needs of science and technology business incubators and the advantages of the DEA method, this study chooses the DEA method to evaluate the performance of technology business incubators, explicitly using the CCR model and the BCC model. The CCR model is based on the constant returns to scale, while the BBC model adopts the framework of variable returns to scale[22]. Meanwhile, researchers usually use the Malmquist index combined with the data envelopment analysis (DEA) method to study the dynamic evolution of efficiency in-depth and systematically evaluate total factor productivity[23]. Therefore, this paper chooses DEA-BCC, CCR model, and Malmquist index as the primary research methods.

Data from the Science and Technology Business Incubator chapter of the China Torch Statistical Yearbook for the last five years (2019-2023) are selected. In the process of provincial data collection and organization, some data, including Ningxia and Tibet, are missing. Therefore, the scope of the empirical test does not include these two provinces; it selects 29 other provinces and regions for assessment.

III. MEASURE INDEX CONSTRUCTION

In recent years, the indicator system adopted for evaluating incubator efficiency has been divided into two main directions: input and output. In assessing the operational efficiency of incubators in 29 provinces across China, scholars such as Liu [24] used input indicators in terms of human, financial, and material resources and output indicators in terms of incubation capacity, innovation capacity, and economic capacity. Based on the principles of scientificity, wholeness, and feasibility, this study referred to the research of scholars such as Liu [24], Xu [25], and He [26]in the selection of indicators and came up with the following indicators:

The input indicators are organized into three main components containing three secondary and four tertiary indicators, of which the input of physical, human, and financial resources are the key elements. The output indicators cover three major secondary indicators and corresponding tertiary indicators. The secondary indicators are divided into three categories: economic benefits, incubation effectiveness, and social impact. The number of people working in an incubator reveals its role in promoting regional employment development. Table 1 shows the specific indicators:

Table1 Efficiency measurement index of science and technology business incubator

Category	First Level Index	symbol	Secondary index
Input	Human resources	x1	Number of practitioners in regulatory agencies
		x2	Number of people trained for incubates
	Material resources	x3	Total space area of incubator
	Financial	x4	Total incubation fund for state-level technology business incubators
		x5	Investment in public technology platforms for state-level science and technology business incubators
		x6	Amount of venture capital received by state-level technology business incubators
Output	Social effect	SE	Total number of personnel of enterprises under incubation in state-level science and technology business incubators
	Incubation effectiveness	HP	Number of state-level science and technology business incubators graduated in the year
	Economic performance	EC	Total revenue of state-level science and technology business incubators

IV. EMPIRICAL RESULTS AND ANALYSIS

4.1 STATIC ANALYSIS

4.1.1 CCR MODEL EVALUATION

In this paper, the DEAP2.1 software was applied and the CCR model (input-oriented) was chosen to organize the output results in Table 2. As can be seen from Table 2, the DEA values of incubators in 18 provinces and regions fall into the category of effective DEA, indicating that these regions can obtain the maximum output with the minimum input under the premise of constant scale, i.e., the operation of incubators is more satisfactory. In contrast, the DEA of science and technology business incubators in 11 other provinces and regions is ineffective.

Table 2 DEA Effective and Ineffective Area Classification

DEA Effective	DEA Ineffective
Beijing; Tianjin; Jiangsu; Zhejiang; Fujian; Shandong; Henan; Hunan; Guangdong; Guangxi; Hainan; Chongqing; Sichuan; Guizhou; Yunnan; Qinghai; Xinjiang	Hebei; Inner Mongolia; Liaoning; Heilongjiang; Jilin; Shanghai; Anhui; Jiangxi; Hubei; Shaanxi; Gansu

4.1.2 BBC MODEL EVALUATION

Using DEAP 2.1 software, the BCC model is selected, and the results are shown in Table 3. It shows that in 2023, there are 19 provinces and regions where the comprehensive technical efficiency value of China's national-level incubators measured by DEA is 1, i.e., the DEA is effective. There are 10 provinces and regions with ineffective DEA, among which, the DEA values of Tianjin, Liaoning, and Shanghai are greater than 0.9, which is close to the state of effective, comprehensive technical efficiency, and it will be very likely to reach the highest value of efficiency after a bit of improvement. The DEA value of Gansu Province is less than 0.8, which is still a certain distance from reaching comprehensive technical efficiency, and there are more places to be improved. As a result, incubators in Gansu Province should strengthen their management in future development, improve the existing management system, and pay attention to the ratio of inputs and outputs. The relevant government departments should also focus on and cooperate with them.

Table 3 Technical Efficiency of National Technology Business Incubators by Province, 2023

Province	Comprehensive technical efficiency	Pure technical efficiency	Scale efficiency	Return to scale
Beijing	1	1	1	-
Tianjin	0.975	1	0.975	irs
Hebei	0.872	0.872	1	-
Shanxi	1	1	1	-
Inner Mongolia	1	1	1	-
Liaoning	0.993	1	0.993	irs
Jilin	0.861	0.872	0.988	irs
Heilongjiang	0.897	1	0.897	irs
Shanghai	0.963	1	0.963	drs
Jiangsu	1	1	1	-
Zhejiang	1	1	1	-
Anhui	0.852	0.865	0.985	drs
Fujian	1	1	1	-
Jiangxi	1	1	1	-
Shandong	0.86	1	0.86	drs
Henan	1	1	1	-
Hubei	0.849	0.871	0.974	drs
Hunan	1	1	1	-
Guangdong	1	1	1	-
Guangxi	1	1	1	-
Hainan	1	1	1	-
Chongqing	1	1	1	-
Sichuan	1	1	1	-
Guizhou	1	1	1	-
Yunnan	1	1	1	-
Shaanxi	1	1	1	-
Gansu	0.768	1	0.768	irs
Qinghai	1	1	1	-
Xinjiang	1	1	1	-

Pure technical efficiency (PC) and scale efficiency (SC) affect combined technical efficiency, and inefficiency in either of them will cause ineffectiveness in combined efficiency. The PC and SC of Hebei, Jilin, Anhui, and Hubei Provinces are ineffective, indicating that these four regions have inappropriate input-output structures and production scales, and they should make comprehensive improvements. The PC of Tianjin, Liaoning, Heilongjiang, Shanghai, Shandong, and Gansu provinces are 1, which shows the DEA is effective, indicating that these regions have already obtained the maximum output under the state of certain inputs and should consider the adjustment measures in terms of scale in the face of the comprehensive efficiency which is still low.

It can be seen from the remuneration of incubator scale in each province and city that the remuneration of scale in the five regions of Tianjin, Liaoning, Jilin, Heilongjiang and Gansu should be incremental, in which the pure technical efficiency of Tianjin, Liaoning, Heilongjiang and Gansu is 1, which indicates that the maximum output is currently achieved in the state of the minimum inputs, but due to the small scale of the incubator, it leads to the low comprehensive efficiency. DEA calculations show that Shanghai, Anhui Province, Shandong Province, and Hubei Province should have diminishing returns to scale. In contrast, Shanghai and Shandong Province have a pure technical efficiency of 1 and are inefficient due to excessive scale. The pure technical efficiency of Hebei, Jilin, Anhui, and Hubei Provinces is DEA ineffective, indicating that the various inputs in such areas have not yet brought better benefits and that the input-output ratios should be adjusted and the spatial scale of the sites should be reduced, etc., to make the comprehensive efficiency improve.

According to the calculation results of the BCC model, it has been concluded that the comprehensive technical efficiency of 10 regions has not yet reached the effective DEA, and the pure technical efficiency and scale efficiency of 4 regions, including Hebei Province and Jilin Province, have not reached the effective. The ineffectiveness of pure technical efficiency suggests that the ratio of inputs to corresponding outputs of the incubators in these four regions is not ideal. Therefore, there is a need to project the districts where DEA is not effective (Table 4) to analyze possible input redundancy or output shortfalls.

In Table 4, HP+, EC+, and SE+ represent the indicators that need to increase the output, which respectively means the number of graduates of national science and technology business incubators in each province and city in the year (number), total income (thousand yuan) and the total number of employees in incubating enterprises (people). T denotes the indicators that can reduce the number of inputs.T1-T5 denote the number of entrepreneurial mentors (persons), the total number of managers (persons), the number of entrepreneurial mentors (persons), the cumulative amount of investment in common and fair technology platforms (thousands of dollars), the amount of technological investment in public platforms (thousands of dollars), and the amount of venture capital investment (thousands of dollars) of the national-level scientific and technological business incubators in each province and city, respectively.

Analyzing the output insufficiency of non-DEA effective regions, the incubation capacity of Hebei, Jilin, Shanghai, Zhejiang, Anhui, Fujian, Hubei, Sichuan, and Shaanxi are not up to the standard expected at the time of inputs. The problem of Anhui and Hubei is that the number of mentors in incubating enterprises is too small, and the problem in Jilin is that the number of graduate incubating enterprises is insufficient and there is a large upside down. Therefore, attention should be given to multiple considerations to comprehensively increase the total income of incubators and further enhance pure technical efficiency.

Table 4 Input redundancies and output insufficient in non-DEA effective areas

Province	Input redundancy						Output insufficient		
	T1	T2	T3	T4	T5	T6	SE+	HP+	EC+
Tianjin	0	0	0	0	0	0	0	0	0
Hebei	0	28.809	0	0	0	0	0	0	0
Liaoning	0	0	0	0	0	0	0	0	0
Jilin	0	0	174149.9	0	0	0	0	123.13	0
Heilongjiang	0	0	0	0	0	0	0	0	0
Shanghai	0	0	0	0	0	0	0	0	0
Anhui	0	47.052	0	1702509	157603.2	49897.84	12492.84	0	0
Shandong	0	0	0	0	0	0	0	0	0
Hubei	0	53.619	0	0	128510.9	0	7294.586	0	0
Gansu	0	0	0	0	0	0	0	0	0

4.2 Dynamic Analysis

4.2.1 Incubator DEA-Malmquist Total Factor Productivity Analysis

The Malmquist index and decomposition of incubators in each province and region for 2019-2023 are shown in Table 5. In the table, effch is comprehensive technical efficiency, techch is technical progress, pech is pure technical efficiency, sech is scale efficiency, and tech is total factor productivity.

Table 5 2019-2023 Average Malmquist index and its decomposition for incubators in China by year

Year	effch	techch	pech	sech	tfpch
2019-2020	0.999	0.987	0.994	1.006	0.986
2020-2021	0.998	1.029	0.996	1.003	1.027
2021-2022	1.004	1.12	1	1.004	1.124
2022-2023	1.003	0.992	1.007	0.996	0.995
Mean	1.001	1.031	0.999	1.002	1.032

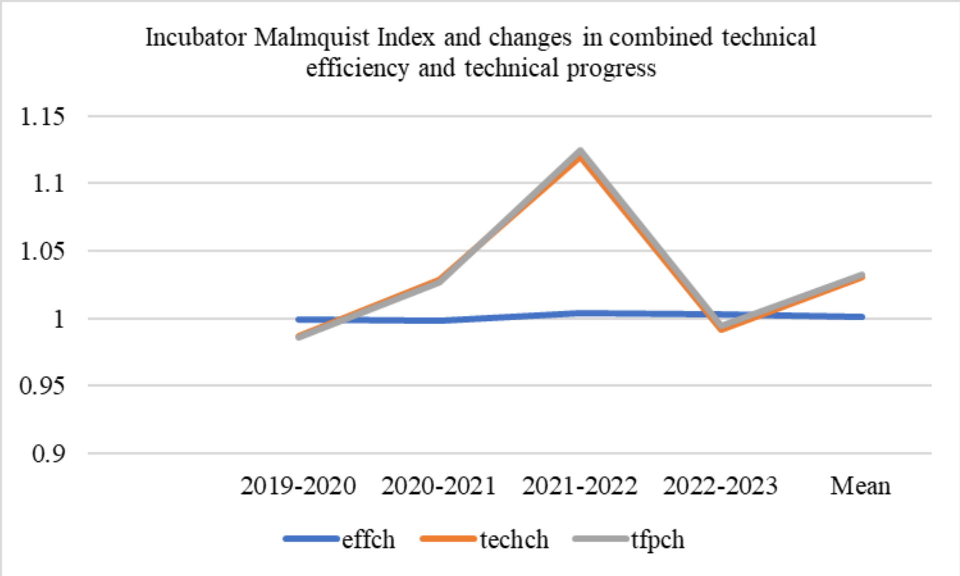

Figure 1: Changes in Incubator Malmquist Index by Year

Figure 1 demonstrates the changes in the Malmquist index and combined technical efficiency and technical progress of incubators by year. As can be seen from the figure, in the past five years, the total factor productivity of the operational efficiency of incubators across China has fluctuated greatly. Except for 2019-2020, when the Malmquist index is less than 1, the overall is substantially improved compared with previous years, especially in 2021-2022, when the Malmquist index reaches 1.124. Since total factor productivity is affected by both comprehensive technical efficiency (effech) and technological progress (techch), and the performance of comprehensive technical efficiency is relatively flat in the five-year period 2019-2023, it can be seen that the great fluctuations in total factor productivity are mainly caused by fluctuations in technological progress and that technological improvements can directly contribute to the improvement of incubator efficiency.

4.2.2 Total Factor Productivity Analysis of Incubators by Provinces and Regions in China

Table 6 shows the average Malmquist index and its decomposition of science and technology business incubators in each province of China in 2019-2020. In terms of provinces and regions, total factor productivity (TFP) generally performed well nationwide in 2019-2023, with Shanxi Province experiencing the fastest TFP growth rate, rising at an average annual rate of 11.9%. At the same time, there are also provinces and municipalities such as Zhejiang and Anhui, where the total factor productivity index is less than 1, with Xinjiang experiencing the fastest decline at 27.2%. The root cause is the decline in the index of technological progress. In today's economic development from quantity to quality, only through the large-scale rough production to achieve economic efficiency can no longer meet the modernization construction, and with the original purpose of science and technology business incubators have deviated. How each region can grasp the advantages of their respective locations and realize sustainable technological progress is the primary issue in front of each national science and technology incubator.

Table 6 Average Malmquist Index and Decomposition by Province and Region, 2019-2023

Province	effch	techch	pech	sech	tfpch
Beijing	1	1.023	1	1	1.023
Tianjin	1.006	1.046	1	1.006	1.053
Hebei	1.035	1.083	1.035	1	1.12
Shanxi	0.978	1.144	0.998	0.98	1.119
Inner Mongolia	1.002	1.112	1	1.002	1.114
Liaoning	1.035	1.048	1.035	1	1.085

Jilin	0.994	1.034	0.985	1.009	1.027
Heilongjiang	1.009	1.043	1	1.009	1.053
Shanghai	1	1.004	1	1	1.004
Jiangsu	1	1.006	1	1	1.006
Zhejiang	0.995	0.961	0.992	1.004	0.957
Anhui	1	0.996	1	1	0.996
Fujian	0.978	1.016	0.995	0.983	0.993
Jiangxi	1.038	0.991	1	1.038	1.03
Shandong	1	1.043	1	1	1.043
Henan	1.042	0.997	1.035	1.006	1.038
Hubei	1	1.032	1	1	1.032
Hunan	1	0.997	1	1	0.997

4.3 Analysis of Regional Variations

4.3.1 Analysis of Variance Based on K-Means Cluster Analysis

In this study, clustering analysis is based on the values of technical efficiency and scale efficiency, and the K-means algorithm is used to determine the K-value, which represents the number of categories, i.e., N samples are divided into K categories, and the mean value represents the average value. In this process, this study draws in-depth on the findings of Zhang Jiao[27]and Gao Qiang[28] and others in the area of operational efficiency of technology business incubators, whose studies concluded that technology business incubators can be effectively categorized into four different categories based on operational efficiency. The clustering results are shown in Table 7.

After a systematic assessment and comparison of the technical and scale efficiencies of incubators, the first group of incubators has achieved a high level of resource allocation and scale operation, demonstrating their high performance; their current state of operation requires little adjustment, and maintaining their return on investment ratio is essential for sustainable growth. In contrast, the second type of incubator needs to improve in both technical and scale efficiencies and requires significant reforms to improve operational effectiveness. The third category, its scale efficiency, is significantly better than technical efficiency, showing that there is more room for improvement in resource allocation and that particular attention should be paid to reducing waste and preventing overcrowding. The fourth type of incubator, on the other hand, needs to improve scale efficiencies to match technical efficiencies, which requires optimization of scale activities to achieve an optimal balance of resource inputs and outputs. In summary, this study classifies incubators into four types based on the statistical analysis of the mean values of pure technical efficiency and scale efficiency of incubators.

Table 7 Cluster analysis results

Clustering	Type	Province
1	All-around efficient	Beijing; Tianjin; Shanxi; Inner Mongolia; Liaoning; Shanghai; Jiangsu; Zhejiang; Fujian; Jiangxi; Henan; Hunan; Guangdong; Guangxi; Hainan; Chongqing; Sichuan; Guizhou; Yunnan; Shaanxi; Qinghai; Xinjiang
2	Continuous Improvement	Jilin; Hubei;
3	Configuration Inefficiency	Hebei; Anhui;
4	Scale Inefficiency	Heilongjiang; Shandong; Gansu

4.3.2 DEA-Malmquist Analysis for the Four Major Economic Regions

To better compare and analyze the efficiency of China's science and technology business incubators in terms of differences, we also analyzed the Malmquist index for the four major regions. The provinces with comprehensive data for 2019-2023 were divided according to the four major economic regions, and the results of the division into the four major economic regions were obtained. Table 8 presents the average Malmquist index and the decomposition of technology business incubators in various regions of China from 2019 to 2020. From the table, it can be seen that from 2019 to mid-2023, various regions performed well in terms of comprehensive technical efficiency, technological progress, and pure technical efficiency, while the poor performance of total factor productivity was due to the low efficiency of technological progress.

Table 8 Average Malmquist Index and Decomposition of Technology Business Incubators by Region

Region	effch	techch	pech	sech	tfpch
Eastern Region	1	0.956	1	1	0.956
Central Region	1	0.956	1	1	0.956
Western Region	1	0.955	1	1	0.955
Northeastern Region	1	0.977	1	1	0.977
Mean	1	0.961	1	1	0.961

V. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

First of all, this paper examines the operational efficiency of incubators in China's provinces and cities from 2019 to 2023 through static analysis methods, and the results show that the overall operational efficiency of incubators nationwide shows a declining trend year by year. When these non-DEA influential provinces and regions are projected and analyzed, it's found that there are various problems, such as insufficient income and insufficient number of graduated incubators. Therefore, in order to increase the total revenue of the incubators in general and to further improve the pure technical efficiency, these issues should be analyzed in depth and paid attention to.

Secondly, this study further utilizes a combination of Data Envelopment Analysis (DEA) and Malmquist index modeling to delve into the dynamic change in the efficiency of China's science and technology business incubators from 2019 to 2023. By continuously tracking and analyzing the efficiency of incubators within this period, the findings reveal that within the past five-year time span, science and technology business incubators across China have shown significant volatility in the evolution of their efficiency and that, as a whole, incubator efficiency performance has not been satisfactory. Specifically, the inefficiency of incubators stems mainly from the lag in technological progress, which is well captured in the Malmquist Index analysis. In the process of research and analysis, it can be found that there are certain deficiencies in technological innovation and technological efficiency in the regions, which, to a large extent, play a negative role in improving the performance of science and technology business incubators during the period. Therefore, technological progress plays a crucial role in influencing changes in the dynamic efficiency of incubators and is a critical element that regions should focus on and improve in enhancing incubator services' effectiveness and promoting the healthy development of science and technology enterprises.

Finally, it analyzes the differences in incubator performance among provinces, cities, and the four major economic zones from the individual and group levels. At the individual level, incubators are classified into four categories according to the difference. At the group level, it concludes that the Northeast region should continue to emphasize technological innovation, while the Eastern region should promptly reflect on the reasons for the plunge. The central region and the western region should actively ride on national policies and, at the same time, draw on the lessons learned from the northeastern region to improve technological innovation.

5.2 RECOMMENDATIONS

In light of the foregoing, the following recommendations are offered. First, it’s necessary to build a policy environment conducive to regional development. The Tax Bureau, the Science and Technology Bureau, the Finance Bureau, and other departments can provide policy support to enterprises in the incubator bases through a variety of ways, such as policy subsidies and tax and fee reductions, to promote their development and operational capabilities, thus leading to the improvement of the overall performance of science and technology business incubators. Second, the scale of capital investment should be expanded, and the government should be encouraged to effectively guide the flow of capital and to bring in social investment forces. Third, it’s advisable to create a favorable innovation environment. It can improve the provincial and municipal areas, help branding, and lead the development of quality incubators.

REFERENCES

[1]. Barbero J, Casillas J C, Ramos A. Revisiting incubation performance: How incubator typology affects results[J]. Technology Forecasting and Social Change,2012,79(5):888-902.
[2]. Jean Luc Arregle. Family Ties in Entrepreneurs Social Networks and New Venture Growth[J]. Entrepreneurship Theory and Practice .2015(2):84-96.
[3]. Vilmos F. Misangyi. Embracing Causal Complexity[J]. Journal of Management .2017(1):142-156.

[4]. Urbano D, Aparicio S. Entrepreneurship capital types and economic growth: International evidence[J]. Technology Forecasting & Social Change,2016,102:34-44.
[5]. Piet Hausberg. Business incubators and accelerators: a co-citation analysis-based, systematic literature review[J] .The Journal of Technology Transfer .2020(1):102-114.
[6]. Xia X, Zhang Z. Measurement on Operating Efficiency of Technology Business IncubatorsBased on Three-stage DEA Model [J]. Statistics and Decision Making,2020,36(24):156-160.
[7]. Cheng H, Ruan B, Yang S, et al. Current Situation and Operation Efficiency Evaluation ofTechnology Business Incubatorsin Guangdong Province [J]. Science and Technology Management Research,2020,40(11):29-37.
[8]. Michael Schwartz. A control group study of incubators impact to promote firm survival[J]. The Journal of Technology Transfer .2013(3):118-126.
[9]. David Urbano. Entrepreneurship capital types and economic growth: International evidence[J]. Technological Forecasting & Social Change. 2015(9):105-114.
[10]. Franco Mário. Exploring Factors in the Success of Creative Incubators: a Cultural Entrepreneurship Perspective[J] . Journal of the Knowledge Economy. 2018(1):37-48.
[11]. Du S, Li Z. Incubation capacity and efficiency of science and technology innovation in Guangdong Province[J]. Research on Science and Technology Management,2020(7):75-80.
[12]. Chang Mei, Wang Meiqiang, Tu Dan. Inter-temporal Performance Assessment of Science and Technology Business Incubators [J]. Systems Engineering,2022(02):140-150.
[13]. Cheng Y, Cui J. Evaluation of the conduction effect of incubator tax incentive [J]. Science Research Management,2016,37(03):101-109.
[14]. Cui J, Cheng Y. The incentive effect of incubator tax preferential policy on innovation service [J]. Studies in Science of Science, 2016,34(01):30-39.
[15]. Guan C, Qiu Y, Yuan X. Fiscal Policy Tools and Efficiency of China's Science and Technology Incubators [J]. Public Finance Research,2018(12):48-61.
[16]. He Y, Hu P. Research on the Development of Hi-tech Incubators in Guangdong Province [J]. Science and Technology Management Research,2016,36(02):101-105.
[17]. Jiang Q, Tang Z. The lmpact of Network Capability under the Framework o"Resource-CapabilityRelationship" on Service InnovationPerformance of Science and Technology Business IncubatoMediating Function of Knowledge Accumulation andModerating Function of Knowledge Base [J]. Science & Technology Progress and Policy,2018,35(05):126-133.
[18]. Du E, Xu F, He J. The Research of High-tech Business Incubator and Venture Capital Cooperation Based on Internet Financial [J]. Science and Technology Management Research,2016,36(17):106-111.
[19]. Qiao H. Analysis and promotion of the performance of enterprise intellectual property service by technology incubator [J]. Scientific Management Research,2018,36(01):61-64.
[20]. Li Y, Li Y. Spatial Agglomeration and Its Influencing Factors of China's Science and Technology Business Incubators [J]. Research on Financial and Economic Issues,2018(12)：52-59.
[21]. Sarrico S C. Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software[J]. Journal of the Operational Research Society, 2001, 52(12):1408-1409.
[22]. Liu S, Qian S. Study on Operation Efficiency of Business Incubator in Anhui Based on DEA [J]. Technology Economics, 2011, 30(6): 6-10.
[23]. Grilo A, Santos J. Measuring Efficiency and Productivity Growth of New Technology-Based Firms in Business Incubators: The Portuguese Case Study of Madan Parque[J]. The Scientific World Journal, 2015, 2015:1-11.
[24]. Liu X, Song Y, Liu H. Efficiency Assessment of S&T Incubators Using DEA: A Case Study on Incubators of 29 Provinces [J]. Science and Technology Management Research, 2018(22): 50-57.
[25]. Xu H, Shi X. Research on the Operational Efficiency and Regional Differences of State-level Science and Technology Business Incubators [J]. finance and accounting monthly, 2018(4): 43-48.
[26]. He H, Huang H, Fang K. Research of Operation Efficiency of Business Incubator in Guangdong Province [J]. Science and Technology Management Research, 2018, 407(13):91-96.
[27]. Yin Q, Zhang J. Study on the performance of enterprise incubator in the region of Yangtze River Delta [J]. Scientific Research, 2010 (1): 86-94.
[28]. Gao Q. Evaluation of the Operational Efficiency of Business Incubators Based on DEA Effectiveness Analysis--The Case of 30 State-level Business Incubators in the Western Region [J]. Modern Enterprise, 2015 (9): 23-24.