

The Promoting Effect of Regional Incubator Operational Efficiency on Regional Industrial Structure Upgrading

Yuhan Qin

*School of Humanities and Social Science, Beihang University, Beijing, China
719625802@qq.com*

Abstract: Since the 1980s, Western countries have utilized business incubators with notable success. In China, research on incubators remained largely theoretical in the 1990s, and practical implementation did not occur until around 2010. However, their impact on the economy, society, and technology remains unclear. Using panel data from 30 provinces in China between 2014 and 2023, this study examines how the operational efficiency of regional business incubators affects industrial structure upgrading. The study finds that: First, the operational efficiency of regional business incubators significantly promotes industrial structure upgrading and is an important driving force for high-quality economic development. Second, there is a U-shaped relationship between the operational efficiency of business incubators and the level of industrial structure upgrading. In the early stages of incubator development, efficiency may inhibit industrial upgrading, but as efficiency improves, its positive impact becomes more evident. Third, the effect of business incubator operational efficiency on industrial structure upgrading varies across regions, with more pronounced effects in the eastern region. The paper recommends enhancing incubator efficiency, improving infrastructure, and fostering regional cooperation to optimize industrial structures and support sustainable economic development.

Keywords: Business Incubator, Industrial Structure Upgrading, Regional Economy

1. Introduction

Since the Third Plenary Session of the 11th Central Committee in the 1970s, China has prioritized economic development, progressing from the establishment of special economic zones in 1992 to achieving a moderately prosperous society by 2021. Economic activities are inherently linked to specific regions, giving rise to the concept of “regional economy,” which is crucial for national economic goals and strategies. Thus, addressing issues related to regional economic development is vital for both theoretical advancements and practical policy formulation.

The advancement of regional economies is closely tied to the transformation and upgrading of industrial structures. As a new industrial revolution emerges globally, China finds itself at a pivotal point for economic development and structural optimization. Adjustments to regional industrial structures should be informed by local conditions to foster high-quality growth. A range of policies has been introduced, including support for manufacturing transformation, high-tech industries, and regional collaboration, with business incubators playing a significant role in facilitating innovation among enterprises.

Business incubators in China originated in the late 1980s but gained widespread adoption after 2010. They have since become essential for promoting innovation and supporting local economic growth. This paper seeks to examine the operational efficiency of business incubators, their influence on industrial transformation, and the regional variations in their effectiveness.

2. Literature review

2.1. Operational efficiency of business incubators in China

Business incubators have been in operation for over ten years, and opinions among Chinese scholars regarding their effectiveness vary. Some researchers express skepticism about their performance. For instance, Chang [1] conducted a study across multiple provinces and found that incubators in China generally demonstrate low performance, with significant regional disparities. Eastern provinces tend to have better-performing incubators, while those in the central and western regions exhibit lower operational efficiency. Cheng & Ruan [2] focused on a specific incubator in Guangdong Province and observed a decline in both human and material resources allocated to science and technology incubators, along with inconsistent financial support. Although the economic and innovative benefits showed a “U-shaped” trend, social benefits consistently decreased, indicating overall low operational efficiency.

On the other hand, some scholars contend that the development of business incubators in China is progressing as anticipated. They highlight that the technical efficiency of science and technology incubators in many provinces is above average. Additionally, China's incubators are seen to maintain a relatively reasonable scale regarding resources and enterprise incubation, with efficiency improving after accounting for scale factors.

International studies have also pointed out regional variations in incubator performance, especially in emerging economies and mid-sized countries. Factors such as local economic conditions and policy support play a crucial role in these disparities. For example, Sofouli and Vonortas [3] examined incubators in Greece and found that their success heavily depends on ongoing government support and the enhancement of regional innovation ecosystems. Hackett [4] proposed a theory of business incubation based on real options, emphasizing the need for flexibility and adaptability for effective incubator operations.

To address the challenges faced by incubators in China's central and western regions, it is vital to enhance their efficiency. This can be achieved by optimizing resource allocation, improving policy support, and learning from international best practices. This paper begins by analyzing the efficiency of business incubators using DEA envelope analysis, providing regional data from the past decade, and subsequently investigates the causal relationships involved.

2.2. The condition of industrial structure upgrading in China

In recent years, the transformation and upgrading of the industrial structure have emerged as a central strategy for China's economic growth. Many domestic researchers emphasize the importance of technological innovation in driving this change. Jiao & Yang [5] argued that technological innovation has a non-linear effect on the global value chain in manufacturing, with enhanced technological capabilities significantly contributing to industrial structure optimization. Du [6] also highlighted that breakthrough innovations are vital for advancing industrial transformation amid the new industrial revolution.

International research has offered additional perspectives. Deng [7] pointed out that a conducive business environment, characterized by a stable economy and fair market competition, promotes technological innovation and resource allocation, thus facilitating industrial upgrades. Wang [8-9] further noted that green technological innovation, particularly advancements in environmental

technology, plays a crucial role in reducing carbon emissions and aiding the greening of the industrial structure. Moreover, globalization and technological spillovers have been shown to impact the industrial upgrading and sustainable development of emerging economies.

However, significant regional disparities exist in China's industrial transformation. Xu [10], using provincial data, revealed that the eastern region excels in technological innovation and industrial upgrading, while the central and western regions face more substantial challenges. Zhang [11] analyzed the impact of government policies and found that excessive government intervention in the micro-economy and slow industrial adjustment are key obstacles to upgrading. Moving forward, it is essential to optimize the relationship between government and market roles and promote financial system reforms to ensure balanced regional development.

2.3. The impact of business incubator operational efficiency on industrial structure upgrading

In recent years, business incubators have become a focal point for both domestic and international scholars as critical tools for promoting innovation, entrepreneurship, and industrial transformation. Studies show that the operational efficiency of these incubators is vital for the growth of start-ups, with significant impacts on improving regional industrial structures and fostering high-quality economic development.

Business incubators provide services like physical space, infrastructure, consulting, and financial support, which reduce entrepreneurial costs and increase start-up success rates. These services contribute to industrial transformation and upgrading. Wang & Duan [12] emphasized the importance of cultivating entrepreneurial environments within incubators to enhance the incubation process. Furthermore, incubators foster emerging industries and upgrade traditional ones by promoting knowledge exchange and technology transfer. Chen [13] noted that technology-based incubators are central to advancing high-tech enterprises, reshaping industrial sectors, and shifting development models in China.

Despite this, much of the research on the effectiveness of business incubators in driving industrial upgrading in China has been limited to smaller-scale studies, often focused on single provinces like Guangdong or Zhejiang. This paper aims to broaden this scope by examining data from 30 provinces, analyzing the role of incubator efficiency in regional industrial transformations, and providing valuable insights for policy development.

3. Theoretical mechanism and hypotheses

Business incubators are crucial in promoting innovation and entrepreneurship, playing an essential role in the transformation and upgrading of regional industrial structures. The theory of industrial agglomeration states that geographically clustered businesses can improve efficiency by sharing resources, information, and markets. Incubators often support such clusters, driving industrial change. The market-oriented theory [14] highlights that incubators, through their market-driven approach, identify demand and guide innovation, which helps optimize industries. According to the enterprise life cycle theory, businesses undergo various developmental stages, and incubators provide vital support—capital, management, technology, and market access—especially during early growth phases, facilitating industrial upgrading. Additionally, by aiding technology-based SMEs with these resources, incubators play a significant role in continuously upgrading the industrial structure.

H1: The operational efficiency of regional business incubators has a promoting effect on the transformation and upgrading of the regional industrial structure.

Recent research on business incubator efficiency emphasizes their key role in industrial structure upgrading. The capital accumulation theory argues that economic growth and industrial change rely

on accumulating capital, especially technological and human capital. Business incubators drive this process by supporting enterprise growth and innovation, thus speeding up regional industrial upgrades. In contrast, the theory of market imperfection suggests that firms operate in imperfectly competitive environments, especially in innovation. Due to information asymmetry or technical barriers, some companies gain market advantages. Business incubators help start-ups overcome these challenges by offering critical resources and support, boosting their competitiveness and aiding industrial transformation.

H2: The operational efficiency of regional business incubators promotes the transformation and upgrading of the industrial structure by improving the level of innovation and entrepreneurship in the region.

Regional differences in business incubator efficiency are significant, influenced by economic development levels, policy support, and the distribution of innovative resources. Resource-based theory suggests that regions with differing resource availability will experience varying efficiencies in their incubators, impacting industrial transformation. In economically advanced areas, incubators benefit from abundant resources, strong infrastructure, and higher marketization, which enhance technological innovation and industrial upgrading. In contrast, central and western regions face greater challenges [15]. These disparities emphasize the varying effects of incubator efficiency on industrial transformation across regions.

H3: The impact of the operational efficiency of regional business incubators on the transformation and upgrading of the regional industrial structure has regional heterogeneity.

4. Research design

4.1. Model specification

To investigate the relationship between the operational efficiency of regional business incubators and the level of industrial structure upgrading, the regression model shown in Equation (1) is constructed.

$$Ind_{it} = \alpha_0 + \alpha_1 BIE + \theta X_{it} + \mu_i + \omega_t + \varepsilon_{it} \quad (1)$$

In model (1), Ind represents the level of industrial structure upgrading, BIE represents the operational efficiency of business incubators, X_{it} represents a series of control variables, i represents the province, t represents the year, α is the coefficient to be estimated, μ_i is the province - fixed effect, ω_t is the time - fixed effect, and ε_{it} represents the random error term.

Secondly, to further explore whether the innovation and entrepreneurship index plays a mediating role between the operational efficiency of regional business incubators and the level of industrial structure upgrading, the following mediating effect model is constructed based on Equation (1).

$$INO_{it} = \beta_0 + \beta_1 BIE_{it} + \eta X_{it} + \mu_i + \omega_t + \varepsilon_{it} \quad (2)$$

$$Ind_{it} = \gamma_0 + \gamma_1 INO_{it} + \gamma_2 BIE_{it} + \xi X_{it} + \mu_i + \omega_t + \varepsilon_{it} \quad (3)$$

In model (2) and (3), INO represents the innovation and entrepreneurship index.

4.2. Variable selection

4.2.1. Dependent variable

The level of industrial structure upgrading is used as the dependent variable in this study, measured by the square of the ratio of the output value of the tertiary industry to the secondary industry.

4.2.2. Independent variables

The main independent variable in this study is the operational efficiency of business incubators, which is assessed using DEA envelopment analysis. Following Li's [16] methodology, this research uses the number of incubator staff, total incubation funds, and office area as indicators for human, financial, and material inputs, respectively. The number of enterprises graduating in the current year is used as a quantity indicator of incubation results, while employment and total revenue of incubated enterprises are chosen as quality indicators. The detailed indicators are listed in Table 1.

Table 1: Evaluation index system for the efficiency of technology transfer institutions

Indicator Type	Indicator Name	Indicator Connotation
Input Indicator	Number of Staff	Number of personnel in the incubator management institution
	Total Incubation Fund	Total amount of incubation funds held by the incubator
	Office Area	Total area of entrepreneurship provided by the incubator (m ²)
	Number of Graduated Enterprises	Number of enterprises graduating from the incubator in the current year
Out Indicator	Number of People Employed	Number of people employed by incubated enterprises
	Total Revenue of Incubated Enterprises	Total revenue of incubated enterprises

4.2.3. Mediating variable

The square of the number of authorized invention patents (in ten thousand pieces) is selected as the mediating variable to more accurately reflect the innovation and entrepreneurship index and better fit with the dependent variable.

4.2.4. Control variables

This study selects the level of human capital (h, number of college students per hundred thousand people), the level of urbanization (urban, the ratio of built - up area (m²) to total area (km²)), and the level of economic development (economy, per capital consumption expenditure (ten thousand yuan)) as control variables.

Table 2: Descriptive statistics of variables

Variables	Mean	SD	Min	Max
Ind	2.553	4.104	0.444	32.374
BIE	0.696	0.210	0.236	1.000
h	10.221	6.178	0.529	29.562
urban	23.072	36.772	0.230	195.884
economy	2.055	0.788	0.930	5.251
INO	6.329	20.3547	0.000	204.894

4.2.5. Data sources and descriptive statistics

This study utilizes panel data from 30 Chinese provinces between 2014 and 2023, excluding Tibet, Hong Kong, Macao, and Taiwan. The primary data sources include various editions of the China Statistical Yearbook and the China Torch Statistical Yearbook. Table 2 presents the descriptive statistics of the variables.

5. Empirical analysis and results

5.1. Benchmark regression analysis

5.1.1. Multicollinearity test

Prior to the regression analysis, this study performs a variance inflation factor (VIF) test (Table 3), with all variables showing VIF values below 10, suggesting no multicollinearity in the model. Subsequently, the relationship between regional business incubator efficiency and industrial structure upgrading is analyzed using model (1), progressively adding control variables.

Table 3: Multicollinearity test

Variables	VIF	1/VIF
BIE	1.03	0.968
h	1.06	0.943
urban	2.80	0.357
economy	2.81	0.355

5.1.2. Benchmark regression analysis

Before adding control variables, the study first regresses the independent variable on both the dependent variable and its square. The results show that the coefficients for business incubator efficiency are positive, supporting Hypothesis 1.

Table 4 presents the benchmark regression results of regional business incubator efficiency on industrial structure upgrading. Columns (1) to (4) show results with control variables progressively included. Column (1) reports results with only business incubator efficiency as the independent variable, while Columns (2) to (4) incorporate control variables. The findings indicate a significantly positive coefficient for business incubator efficiency. While the effect diminishes as control variables are added, it remains statistically significant at the 10% level, suggesting a positive impact on industrial upgrading. Specifically, a one-unit increase in business incubator efficiency leads to a 0.838-unit rise in the square of industrial upgrading. For the control variables, urbanization and economic development positively influence industrial transformation, while human capital has a negative effect, showing no significant contribution to the upgrading process. Lin's research [17] also highlights that mismatches between human capital structure and industrial upgrading paths can cause path dependence, hindering industrial transformation. This may explain why human capital does not significantly promote industrial upgrading in this context.

Table 4: Regression results of the impact of the operational efficiency of regional business incubators on the level of industrial structure upgrading

Variables	Ind			
	(1)	(2)	(3)	(4)
BIE	1.418*** (0.486)	1.198** (0.480)	1.114** (0.480)	0.838* (0.476)
h		-0.225*** (0.065)	-0.210*** (0.065)	-0.262*** (0.066)
urban			0.034* (0.018)	0.005 (0.019)
economy				2.322*** (0.665)
Constant	19.415*** (0.643)	20.610*** (0.719)	17.765*** (1.656)	12.903*** (2.137)
Time Fixed				
Province Fixed			Yes	
R ²	0.926	0.930	0.931	0.934
N	300	300	300	300

Note: The numbers in parentheses are robust standard errors, which indicate significance levels of 1%, 5%, and 10%, respectively. The same applies below.

5.2. Robustness test

This study employs three methods to test the reliability of the findings. First, to account for factors like production stagnation, traffic control, and personnel restrictions during the pandemic, which could affect business incubator efficiency calculations, the 2020 data is excluded from the regression, following the approach of Wang [18] and others. The results in column (1) of Table 5 show a significantly positive coefficient at the 10% level. Second, to address variations in business incubator construction across provinces and municipalities with special administrative status, Beijing, Shanghai, Tianjin, and Chongqing are excluded. The results in column (2) of Table 5 confirm that the impact of incubator efficiency on industrial upgrading remains consistent with the benchmark regression. Third, additional control variables related to regional industrial transformation, such as local general fiscal expenditure (trillion yuan), are included in the regression. The results in column (3) of Table 5 show a significantly positive coefficient at the 10% level. These tests further validate the robustness of the study's benchmark regression results.

Table 5: The result of robustness test

Variables	Excluding Special Years	Excluding Special Municipalities	Adding Government Fiscal Expenditure
	(1)	(2)	(3)
BIE	0.795*(0.452)	0.560**(0.233)	0.837*(0.4712)
government			3.403**(1.327)
Control variables		Control	
Constant	-3.934*(2.101)	-0.264(0.524)	-4.672(3.229)
Time Fixed		Yes	
Province Fixed			
R ²		0.891	0.935
N	270	260	300

5.3. Mediating effect test

Based on Equations (2) and (3), the mediating effect of the innovation and entrepreneurship index is tested, with results presented in Table 6. Column (1) shows a positive and significant regression coefficient for the operational efficiency of regional business incubators on the innovation and entrepreneurship index at the 10% level, suggesting that incubator efficiency boosts regional innovation and entrepreneurship. In column (2), the regression coefficients for incubator efficiency and the innovation and entrepreneurship index are 0.624 and 0.020, respectively, with the index being significant at the 1% level. This confirms that incubator efficiency contributes to industrial upgrading by enhancing innovation and entrepreneurship, supporting Hypothesis 2.

Table 6: Mediating mechanism analysis results

Variables	(1) INO	(2) Ind
BIE	1.068*(5.464)	0.624(0.468)
INO		0.020*** (0.005)
h	2.033*** (0.752)	-0.302*** (0.065)
urban	-0.349(0.221)	0.012(0.019)
economy	48.220*** (7.624)	1.352*(0.697)
Constant	-128.241*** (37.184)	-1.118(3.232)
Time Fixed		Yes
Province Fixed		

Table 6: (continued).

R ²	0.645	0.937
N	300	300

5.4. Heterogeneity test

Due to varying stages of development across regions, there are notable differences in the intensity of business incubator construction and the level of industrial structure transformation and upgrading. This study categorizes the provinces into two regions based on China's four major geographical divisions, placing the three northeastern provinces in the eastern region and combining the central and western regions into the central-western region. A fixed-effect model is utilized to evaluate Hypothesis 3, with regression results presented in Table 7. Findings indicate that in the eastern region, the coefficient for the operational efficiency of business incubators is 2.217, which is statistically significant at the 10% level. This suggests that a 1% increase in the operational efficiency of business incubators leads to a 2.217% rise in the level of industrial structure transformation and upgrading in this area. In the central-western region, while the coefficient for operational efficiency is positive, it is significantly lower than that of the eastern region. This implies that both regions benefit from the operational efficiency of business incubators in promoting industrial transformation and upgrading, although the effect is more pronounced in the east. Hypothesis 3 is thus supported. This disparity may stem from the eastern region's more advanced economy, greater marketization, and a more robust innovation and entrepreneurship ecosystem, leading to higher operational efficiency in business incubators that more effectively drive industrial transformation. Conversely, the central and western regions face challenges such as weaker economic foundations, less complete industrial chains, and lower aggregation of innovation resources, resulting in a diminished impact of incubators.

Table 7: Heterogeneity analysis results

Variables	Ind	
	Central - Western Region	Eastern Region
BIE	0.584** (0.274)	2.217* (1.121)
Control variables		Control
Constant	-1.541*** (0.581)	16.718*** (3.624)
Time Fixed		Yes
Province Fixed		
R ²	0.911	0.944
N	170	130

6. Conclusions and recommendations

6.1. Research conclusions

This study investigates how the operational efficiency of regional business incubators influences the transformation of China's industrial structure, utilizing panel data from 30 provinces covering the period from 2014 to 2023. The key findings are as follows:

First, the operational efficiency of business incubators plays a crucial role in facilitating industrial transformation and upgrading, thereby contributing to high-quality economic growth. Second, the relationship between incubator efficiency and industrial transformation exhibits a U-shaped curve. Initially, the costs associated with infrastructure and incubation exceed the benefits, which restricts their influence on industrial upgrading. However, as incubators mature, their efficiency increasingly enhances industrial transformation, resulting in greater marginal effects. Lastly, there are notable

regional disparities in both the quantity and quality of business incubators, with the eastern region demonstrating higher operational efficiency, which leads to a more pronounced effect on industrial transformation.

6.1.1. Policy recommendations

To optimize industrial structure and achieve high-level economic development in China's provinces, the following policy recommendations are proposed:

First, improve the operational efficiency of business incubators to revitalize secondary and tertiary industries. This includes enhancing operational models, professional teams, and tailored services, fostering cooperation between industry, academia, and research, and building digital platforms for better resource allocation. Expanding financial services and promoting regional collaboration will further support industrial transformation and high-quality growth.

Second, enhance incubator infrastructure. The government should invest in improving infrastructure, supporting high-tech enterprises, encouraging private capital, and establishing early-stage funds. An "incubation + acceleration + industrialization" model will drive continuous innovation. Optimizing the regional layout and accelerating incubator development in key areas like "Three Cities and One Zone" will promote cooperation between incubators and industrial parks.

Third, strengthen regional cooperation and leverage the eastern region's role as a model. The eastern region, a leader in China's reform, should share successful incubator models with central and western regions. Promoting cross-regional incubation models and refining regional development strategies will enhance overall efficiency, supporting China's modernization and offering replicable experiences nationwide.

References

- [1] Chang, M., Wang, Mei, Q. & Tu, D. Y. (2022). Cross - Period Operational Performance Evaluation of Science and Technology Business Incubators. *Systems Engineering*, 40(02):140-150.
- [2] Cheng, H.Y., Ruan, B. & Yang, S.W.(2020). Development Status and Operational Efficiency Evaluation of Science and Technology Business Incubators in Guangdong Province. *Science and Technology Management Research*, 40(11):29-37.
- [3] Sofouli, E., & Vonortas, N. S. (2007). S&T parks and business incubators in middle-sized countries: the case of Greece. *The Journal of Technology Transfer*, 32(5):525-544.
- [4] Hackett, S. M., & Dilts, D. M. (2004). A Real Options-Driven Theory of Business Incubation. *The Journal of Technology Transfer*, 29(1), 41-54.
- [5] Jiao, Y. & Yang, H.X. (2020) The Non - Linear Transmission of Technological Innovation on the Global Value Chain Climbing of Manufacturing. *Modern Economic Exploration*, (7):1-10.
- [6] Du, C.Z., Jin, H.W. & Jin, W.H. (2019). Breakthrough Technological Innovation and Industrial Structure Upgrading in the Context of the New Round of Industrial Revolution. *Science and Technology Progress and Countermeasures*, (24):1-7.
- [7] Deng, J. (2021). The influence of environmental regulation on industrial structure upgrading: Based on the strategic interaction behavior of environmental regulation among local governments. *Science Direct*.
- [8] Wang, K. L., Xu, R. Y., Cheng, Y. H., Miao, Z., & Sun, H. P. (2024). Understanding the overall difference, distribution dynamics and convergence trends of green innovation efficiency in China's eight urban agglomerations. *Ecological Indicators*. 2024, 148, 110101.
- [9] Wang, K. L., Zhang, F. Q., Xu, R. Y., Miao, Z., Cheng, Y. H., & Sun, H. P. (2024). Spatiotemporal pattern evolution and influencing factors of green innovation efficiency: A China's city level analysis. *Ecological Indicators*. 2024, 146, 109901.
- [10] Xu, S.X., Liu, Q. & Lu X.L. (2021). Spatial and Temporal Evolution Characteristics and Influencing Effect Analysis of Regional Development Imbalance in China: Based on the Perspective of Industrial Structure Upgrading. *Finance and Trade Research*, 32(10):14-26.
- [11] Zhang J. (2016) Obstacles, Dilemmas, and Reform Prospects in China's Industrial Structure Upgrading. *Journal of Renmin University of China*, 30(5):29-37.

- [12] Wang, D.D. & Duan, J.L. (2020). *How to Promote the Enhancement of Incubation Effects through Institutional Entrepreneurship: A Case Study of ZSSK Incubator*. *Science of Science and Management of S & T*, 41(11):48-67.
- [13] Chen, L.G. (2023). *Research on the Operational Efficiency Evaluation and Prediction of Science and Technology Business Incubators in China*. Tianjin University of Technology and Education.
- [14] Liu, Y. (2009). *The Relationship between Entrepreneurial Orientation, Market Orientation, Product Innovation and Enterprise Performance*. Jilin University, (09)
- [15] Song, Y. (2014). *Research on the Influencing Factors of Innovation in Small and Medium - sized Enterprises from the Perspective of Resource based Theory*. *Development Research*, (09):60-65.
- [16] Li, G.C. (2024). *Measurement and Analysis of the Incubation Efficiency of National Science and Technology Business Incubators in China*. *Science and Technology Management Research*, 44(17):47-55.
- [17] Lin, C.Y., Kong F.C. & Meng X.Y. (2017). *The Spatial Effect of Human Capital on Industrial Structure Upgrading: Based on the Dynamic Spatial Durbin Model*. *Economic and Management Review*, (6):122-129.
- [18] Wang, J.J. & Sun, P.P. (2024). *The Impact of Double Environmental Regulation on Regional Ecological Efficiency: Evidence from Provincial Panel Data*. *China Environmental Management*, 16(05):58-67.