Proceedings of Business and Economic Studies, 2026, Volume 9, Issue 7
http://ojs.bbwpublisher.com/index.php/PBES
Online ISSN: 2209-265X
Print ISSN: 2209-2641

A Study on the Evaluation of Policies for Technology Business Incubators Based on the "Subject-Tool-Feedback" Framework

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Abstract: Technology business incubators play a crucial role in cultivating technology-based firms and promoting the commercialization of research results. Consequently, the importance of establishing supportive policies for incubators is self-evident. Conducting a systematic evaluation of the implementation effectiveness of incubator policies is not only a prerequisite for helping small and medium-sized technology-based enterprises reduce costs and improve efficiency, but also a central priority in aligning with the prevailing trend of deepening the integration between national scientific and technological innovation and industrial innovation. This study takes state-level incubator policies as the evaluation object. By applying the Analytic Hierarchy Process and the fuzzy comprehensive evaluation method, it constructs an incubator policy evaluation index system from three dimensions: policy actors, policy instruments, and policy feedback. The study then assesses the implementation effectiveness of these policies, aiming to provide references and recommendations for the future formulation and improvement of incubator policies.

Keywords: Incubator policy; Analytic Hierarchy Process; Fuzzy comprehensive evaluation

Online publication: July 27, 2026

1. Introduction

Achieving high-quality development relies on fostering new drivers through scientific and technological innovation. Technology-based small and medium-sized enterprises (SMEs), as the main force in the commercialization of research results in China, undoubtedly constitute a vital component in promoting national technological progress. However, existing SMEs generally face problems such as a lack of innovation vitality and severe innovation constraints. Technology business incubators (TBIs) can ignite their innovation enthusiasm and unleash their creative potential. Consequently, the development of TBIs has also become a top priority for alleviating the cost pressures faced by SMEs and accelerating the cultivation of new quality productive forces.

In recent years, with the advancement of the "mass entrepreneurship and innovation" initiative, the construction of TBIs has once again attracted extensive attention. So it is necessary to evaluate the effectiveness of previous incubator policies, conduct an assessment of these policies, and truthfully reflect

their implementation outcomes, so as to provide useful references for the formulation and execution of future incubator policies.

2. Literature review

Li et al. [1] constructed a fourdimensional evaluation framework encompassing policy intensity, instruments, targets, and the incubator life cycle, thereby analyzing the characteristics and patterns of incubator policies across different development stages. Xu and Li [2] investigated the effectiveness of incubator policies in Wuhan, establishing a twodimensional model of policy instruments and the incubator construction process. Li et al. [3] assessed the effects of government policies on incubator development markets, technological innovation, and internal operations, while also comparing regional differences. Yue and Gao [4] revealed that the development of policies related to university science parks has undergone three stages: an exploratory stage, a development stage, and a collaborative development stage. Sun et al. [5] examined the positive impact of government policies on firms' technological progress. Cui and Cheng [6] showed that policy implementation effectiveness is constrained by regional economic development levels, and that government tax policies play a significant role in enhancing incubator capacity and improving incubator service quality. Liang et al. [7] found that both government financial support and tax incentives have a positive impact on incubation performance, and that the combination of the two produces a stronger effect.

3. Constructing an indicator system for evaluating technology business incubator policies

3.1. Indicator selection

To evaluate the implementation effectiveness of incubator policies, it is necessary to establish an evaluation indicator system. This paper draws on the evaluation criteria proposed by Liu and Li, designing a first-level indicator framework consisting of "policy actors–policy instruments–policy feedback." The final results are presented in **Table 1**.

Table 1. Incubator policy evaluation index system

Target layer	Criterion layer	Indicator layer
Incubator Policy Implementation Effectiveness (R)	Policy Actors (A)	Hierarchical Level (A1)
		Detailed Measures (A2)
		Implementation Intensity (A3)
	Policy Instruments (B)	Scientific Rigor (B1)
		Reasonableness (B2)
		Operability (B3)
	Policy Feedback (C)	Incubation Capacity (C1)
		Economic Benefits (C2)
		Social Benefits (C3)
		Innovation Benefits (C4)

3.2. Weight assignment

Once the incubator policy evaluation system was established, it was necessary to determine the weight assigned

to each indicator. This study adopted a combined approach of expert scoring and the Analytic Hierarchy Process. First, expert evaluations were collected. These expert scores were then aggregated to construct a judgment matrix. Finally, the judgment matrix was computed and subjected to a consistency test, yielding the weight for each indicator, as shown in **Table 2**.

Table 2. Indicator weights in the incubator policy evaluation index system

Target layer	Criterion layer	Indicator layer	Global weights
Incubator Policy Implementation Effectiveness (R)	Policy Actors (A) (0.17)	Hierarchical Level (A1) (0.13)	0.0221
		Detailed Measures (A2) (0.43)	0.0731
		Implementation Intensity (A3) (0.44)	0.0748
	Policy Instrument (B) (0.42)	Scientific Rigor (B1) (0.40)	0.1680
		Reasonableness (B2) (0.18)	0.0756
		Operability (B3) (0.42)	0.1764
	Policy Feedback (C) (0.41)	Incubation Capacity (C1) (0.10)	0.0410
		Economic Benefits (C2) (0.47)	0.1927
		Social Benefits (C3) (0.26)	0.1066
		Innovation Benefits (C4) (0.17)	0.0697

4. Implementation, statistical analysis, and interpretation of results

4.1. Fuzzy comprehensive evaluation

1. Establish evaluation indicators and a comment set, determine the corresponding indicator weights

Let the indicator set for the main criterion layer be $U=\{U_1,U_2,U_3\}$, where U represents the indicator set, and U_1, U_2, U_3 denote policy actors, instruments, and feedback. The indicator set for the sub-criterion layer is $U_1=\{U_{11},U_{12},U_{13}\}$. By analogy, the evaluation indicator set corresponding to each indicator can be obtained. This study sets the number of comment grades at five, the comment set is $V=\{V1,V2,V3,V4,V5\}$, where V represents the overall comment set, and V1 denotes very unsatisfactory, and so forth Table 2 we have W=(w1,w2,w3)=(0.17,0.42,0.41).

2. Determining the evaluation matrix

First, quantify each evaluation indicator $u_i(i=1,2,3,4)$ of the evaluation object, and determine the membership degree r_{ij} of the evaluation object to each evaluation grade $V_j(j=1,2,3,4,5)$ from the perspective of evaluation indicator u_i. This yields the singleindicator evaluation set for the i-th evaluation indicator u_i:$r=(r_{i1},r_{i2}...r_{i5})$. Consequently, the overall fuzzy evaluation matrix R is obtained as follows:

$$R=(r_{ij})_{m*n}\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix},(i=1,2...m,\ j=1,2...n)$$

3. Comprehensive calculation

Apply fuzzy mathematical operations to perform the final calculation, i.e.:

$$B=W*R=(w_1,w_2...w_m)*\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}=(b_1,b_2...b_m)$$

Normalize B and obtain the final evaluation result according to the principle of maximum membership

degree.

4.2. Statistical analysis

This study collected evaluations of the implementation effectiveness of incubator policies from various groups of respondents through a questionnaire survey. The detailed statistical results are presented in **Table 3**.

Table 3. Statistical table of incubator policy evaluation results

Number	Evaluation criteria	Very unsatisfactory	Unsatisfactory	Moderate	Satisfactory	Very satisfactory
A1	Hierarchical Level	4	5	6	6	5
A2	Detailed Measures	3	2	6	9	6
A3	Implementation Intensity	7	5	10	2	2
B1	Scientific Rigor	11	1	7	5	2
B2	Reasonableness	8	2	10	6	0
B3	Operability	6	4	13	3	0
C1	Incubation Capacity	5	5	1	10	5
C2	Economic Benefits	5	6	3	9	3
C3	Social Benefits	7	4	12	3	0
C4	Innovation Benefits	7	6	11	1	1

According to the statistical table of evaluation results, singlefactor evaluation matrices C1, C2, C3 for each category of evaluation indicators are established. Then, using the weights of each firstlevel indicator R1, R2, R3, the firstlevel fuzzy comprehensive evaluation vector is obtained as follows:

$$B_i = R_i \circ C_j (i = 1,2,3)$$

Let $\circ$ denote a generalized operator. The weighted average approach is adopted here [8]. From Table 3, the evaluation matrices C_1, C_2, C_3 for policy actors (A), policy instruments (B), and policy feedback (C) can be obtained.

$$C1 = \begin{bmatrix} 0.1538 & 0.1923 & 0.2308 & 0.2308 & 0.1923 \\ 0.1154 & 0.0769 & 0.2308 & 0.3462 & 0.2308 \\ 0.2692 & 0.1923 & 0.3846 & 0.0769 & 0.0769 \end{bmatrix} \quad C2 = \begin{bmatrix} 0.4231 & 0.0385 & 0.2692 & 0.1923 & 0.0769 \\ 0.3077 & 0.0769 & 0.3846 & 0.2308 & 0.0000 \\ 0.2308 & 0.1538 & 0.5000 & 0.1154 & 0.0000 \end{bmatrix} \quad C3 = \begin{bmatrix} 0.1923 & 0.1923 & 0.0385 & 0.3846 & 0.1923 \\ 0.1923 & 0.2308 & 0.1154 & 0.3462 & 0.1154 \\ 0.2692 & 0.1538 & 0.4615 & 0.1154 & 0.0000 \\ 0.2692 & 0.2308 & 0.4231 & 0.0385 & 0.0385 \end{bmatrix}$$

From Table 2, the local weights of each indicator factor within the evaluation categories—namely, policy actors, policy instruments, and policy feedback—are obtained.

$$R1 = (0.13, 0.43, 0.44)$$
$$R2 = (0.40, 0.18, 0.42)$$
$$R3 = (0.10, 0.47, 0.26, 0.17)$$

Following the fuzzy comprehensive evaluation model: $B_i = R_i \circ C_j (i = 1,2,3)$, the weighted average method is applied to compute the evaluation matrices (C_1,C_2,C_3) together with the corresponding weight vectors of the indicators (R_1,R_2,R_3), yielding the firstlevel fuzzy comprehensive evaluation vector B1,B2,B3.

From the firstlevel fuzzy comprehensive evaluation vector, the secondlevel fuzzy comprehensive evaluation vector C—i.e., the satisfaction evaluation matrix for the overall incubator policy—is derived.

$$B1 = R1 \circ C1 = (0.1880,0.\ 1427,0.298\ 4,0.2127,0\ .1580)$$
$$B2 = R2 \circ C2 = (0.3215,0.\ 0938,0.386\ 9,0.1669,0\ .0308)$$
$$B3 = R3 \circ C3 = (0.2254,0.\ 2069,0.250\ 0,0.2377,0\ .0799)$$

$$C = \begin{bmatrix} B1 \\ B2 \\ B3 \end{bmatrix} = \begin{bmatrix} 0.1880,0.1\ 427,0.2984\ ,0.2127,0.\ 1580 \\ 0.3215,0.0\ 938,0.3869\ ,0.1669,0.\ 0308 \\ 0.2254,0.2\ 069,0.2500\ ,0.2377,0.\ 0799 \end{bmatrix}$$

From Table 2, we can obtain: $R = (0.17,0.42,0.41)$

Through the transformation process of the fuzzy comprehensive evaluation model, the overall fuzzy comprehensive evaluation vector for satisfaction is obtained as follows:

$$B = R \circ C = (0.2594,0.1485,0.3157,0.2037,0.0726)$$

4.3. Evaluation results

As derived from the above, we obtained: $B = R \circ C = (0.2594,0.1485,0.3157,0.2037,0.0726)$

According to the principle of maximum membership, the satisfaction evaluation value of the incubator policy is 0.3157, and the satisfaction level is classified as moderate. Meanwhile, following the analytical approach of scholars [9], numerical scores are assigned to the evaluation grades, where the grade set V=(very satisfactory, satisfactory, moderate, unsatisfactory, very unsatisfactory)corresponds to the values (5,4,3,2,1), yielding the comprehensive evaluation score for overall policy endorsement. Specifically, the comprehensive evaluation score is as follows: E=5*0.2594+4*0.1485+3*0.3157+2*0.2037+1*0.0726=3.3181. The comprehensive evaluation score for the policy actors dimension is: E1=5*0.1880+4*0.1427+3*0.2984+2*0.2127+1*0.1580=2.9894. The policy instruments dimension is: E2=5*0.3215+4*0.0938+3*0.3869+2*0.1669+1*0.0308=3.5080. The policy feedback dimension is: E3=5*0.2254+4*0.2069+3*0.2500+2*0.2377+1*0.0799=3.2599.

5. Research conclusions and recommendations

5.1. Research conclusions

1. Incubator policies have achieved certain results, but there remains room for improvement.

Through analyses, this study finds that the overall implementation effectiveness level of incubator policies is moderate, with a score of 3.32. This indicates that the implementation of incubator policies has achieved certain results. However, as the score lies between moderate and satisfactory, there is still room for policy improvement. Future efforts should be based on actual social conditions and aim to formulate supportive policies that facilitate innovative development.

2. The policy instrument and feedback dimensions perform well, whereas the policy actor dimension is less satisfactory.

The scores for the policy instrument and policy feedback dimensions are 3.5080 and 3.2599, while the policy actor dimension scores only 2.9894. This suggests that the policy instruments are valid, rational, and operable, and they effectively support incubator development. However, the less satisfactory score for the policy actor dimension indicates that policy actors need to pay attention to the details and implementation intensity of policies to ensure their efficient operation.

5.2. Policy recommendations

1. Synthesize multiple methods to strengthen the whole-process evaluation

Incubator policies represent a key instrument for ensuring the effective allocation of market resources. Problems arising at any stage can significantly undermine the intended effectiveness. Therefore, it is essential to implement a whole-process evaluation of incubator policies.

2. Strengthen the top-level design of incubator policies

In recent years, environmental-side policies have played a significant role in promoting incubator

development. However, the implementation of supply-side and demand-side policies remains incomplete, forming a closed loop. So it is necessary to proceed from actual needs, reinforce government functions, and optimize the market's investment and financing environment.

3. Improve the functions of policy actors and enhance the convenience of policy implementation

Throughout the process of policy formulation and implementation, it is essential to strengthen the understanding and learning of all components of incubator policies among government personnel at various levels, enhance policy synergy, and promote precise and targeted policy implementation.

Funding

2025 Student Research Project of Guizhou University of Finance and Economics, titled "Research on the Mechanism of Technology Business Incubators in Promoting the Commercialization of Scientific and Technological Achievements" (Grant No.: 2025BAZYSY282)

Disclosure statement

The author declares no conflict of interest.

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