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Performance and efficiency evaluation of technology business incubators

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Abstract

Purpose – Technology business incubators (TBI) are strategic for developing innovative businesses, which have attracted attention from both professionals and researchers. While the scientific literature has typically focused on investigating performance indicators to evaluate TBI, there is also an emerging approach focusing on the efficiency concept for such performance assessment. Therefore, this study aims to analyse the research progress of performance and efficiency evaluation of TBIs and provide a combined approach.

Design/methodology/approach – This research adopts a systematic literature review that resulted in the abstract analysis of 945 documents from the Web of Science and Scopus databases, and the selection of 159 studies for full analysis.

Findings – The research identified patterns that guided the definition of four TBI archetypes (i.e. basic research, university, socioeconomic development and private), and a compilation of critical success factors, impact factors, and indicators on performance and efficiency. These findings resulted in the development of a framework that synthesises the state-of-the-art on the topic of performance and efficiency of TBIs. This article also developed a research agenda to foster progress on the topic.

Originality/value – This study contributes to expanding the current understanding of performance and efficiency in TBIs and BIs in general by providing three main contributions: (1) insights into the current state-of-the-art of research on the topic; (2) a framework designed in a circular approach for periodical application and suggested indicators for different TBI archetypes – which is entirely new in comparison with the previous research, overcoming limitations from other design approaches, and easing its adoption by researchers and professionals, and; (3) a research agenda to promote continuous progress on the topic.

Keywords Technology business incubator, Entrepreneurship, Systematic literature review

Paper type Research article

1. Introduction

Two key events initiated the discussion of business incubators (BIs): the establishment of the Stanford Research Park in California in 1951 and the Industrial Center of Batavia in New York in 1959 (Mian *et al.*, 2016). Since then, BIs followed a steady growth trajectory and become an integral part of the modern entrepreneurial ecosystem worldwide (Hausberg and Korreck, 2020). According to Sohail *et al.* (2023), as of 2023, the number of BIs has surpassed 10,000 globally.

The US National Business Incubation Association (NBIA, 2010) underscores the role of BIs in helping new enterprises form and facilitating their survival during their initial stages, promoting entrepreneurship and regional socioeconomic growth. Hackett and Dilts (2004a) noted that BIs provide a shared space and an incubation program to enhance the success rates

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of new enterprises. BIs also help mitigate the risks associated with new ventures and serve as a crucial tool for accelerating the entrepreneurial process (Dee *et al*., 2011). In this context, a specific subcategory of BI, the technology business incubator (TBI), appears as an entity dedicated to fostering enterprises focused on technological innovation (Rathore and Agrawal, 2021; CSES, 2023). Their operational models typically involve closer integration with universities, research centres, and innovation ecosystems, frequently relying on specialised mentorship, access to advanced infrastructure, and collaborative networks with multiple stakeholders (Rathore and Agrawal, 2021; CSES, 2023).

The growing relevance of incubation in the entrepreneurship environment has evoked the need for TBI evaluation due to its potential contributions to socioeconomic development (Phan *et al.*, 2005). Pattanasak *et al.* (2022) also stated that performance evaluation is a strategic action that identifies opportunities to improve the competitive advantage TBIs can offer. Nevertheless, Mian *et al.* (2016) noted that the main challenge in TBI research is the need for a consensus on the definitions of incubation mechanisms and processes, which affects the construction of models and the adoption of criteria for evaluating the results of TBI. More recently, Hausberg and Korreck (2020) highlighted that despite various studies conducted on the subject, a consensus is still needed on a construct for evaluating TBI. The authors argued that previous research has considered different approaches, indicators, and methodologies. Some studies compared the results of incubated enterprises with those of similar non-incubated enterprises (Colombo and Delmastro, 2002), whereas others adopted a set of indicators to compare (benchmark) the results achieved by TBI (Dhochak *et al.*, 2019; Aerts *et al*., 2007). According to Bergek and Norrman (2008), the choice of indicators must be aligned with the incubators' objectives. Therefore, some evaluation studies recommend comparing only the results from incubators of the same archetype; otherwise, they may incur biased results (Barbero *et al.*, 2012; Aernoudt, 2004). However, Carlsson *et al.* (2002) recommended the adoption of multiple combinations of indicators for a more assertive evaluation, since business incubation involves complex interactions between management, services, resources, and the enterprises themselves (Hackett and Dilts, 2008).

Some studies have focused on the "performance evaluation of TBIs", which, according to Dee *et al*. (2011), refers to evaluating the impact of an incubator's operation. These authors proposed classifying TBI performance evaluation into three categories: (1) control group, including studies that aimed to compare the results of incubated enterprises with those of similar non-incubated enterprises; (2) benchmarking, encompassing studies aimed at identifying the best practices and references for purposes of performance comparison and improvement; and (3) *in situ* evaluation, comprising studies addressing aspects of the incubation process such as the incubation program, relationship network with partners, and selection process. Nevertheless, a few recent studies (Sun and Cheng, 2021; Guan and Fan, 2020) have sought to expand this focus and evaluate TBI performance based on efficiency. While performance evaluation seeks to measure outcomes, the efficiency approach assesses the relationship between these outcomes and the inputs consumed (Aaboen *et al*., 2008). Most of these studies used the efficiency frontier concept and data envelopment analysis (DEA) method to evaluate TBI performance (e.g. Cooper *et al*., 2011). Given recurring resource constraints in many productive sectors, evaluating performance outcomes and measuring how efficiently they are achieved is increasingly essential. This dual focus becomes especially relevant for incremental innovation, which involves continuous improvements and generally relies on resource optimisation (Ardito *et al*., 2019).

Considering the relevance of TBIs and the recent progress in research on their performance and efficiency, this study aims to analyse the research progress of performance and efficiency evaluation of TBIs and provide a combined approach. This study contributes to the advancement of TBI research and practice in two ways. First, it provides a comprehensive understanding of the scientific literature addressing TBIs. Unlike previous literature reviews that primarily focus on proposing key performance indicators (KPIs) to assess the performance of TBIs (e.g. Sarwono and Trisetyarso, 2017; Torun *et al*., 2018) or BIs in general (e.g.

Pattanasak *et al.*, 2022), this study offers a more comprehensive understanding of TBI assessment practices by integrating both performance and efficiency perspectives. Second, it classifies existing studies to provide a framework outlining their main contributions, focusing on an integrative perspective of both performance and efficiency evaluations of TBIs, and a research agenda based on the identified gaps. Therefore, the results are relevant for researchers, managers, and policymakers involved or interested in TBIs or BIs in general.

The remainder of this article is organised into four sections. Section 2 outlines the methodological procedures used to perform a systematic literature review (SLR). Section 3 presents a bibliometric analysis and classification of the existing literature. Section 4 provides a framework for synthesising the findings, presents a research agenda, and discusses research contributions. Finally, Section 5 presents the final considerations.

2. Methodology

This study adopted an SLR based on the procedures defined by Thomé *et al.* (2016). It encompassed eight steps: planning and problem formulation, literature search, data gathering, quality assessment, data analysis and synthesis, interpretation, presentation of the results, and review updating.

The first step was to define the central research questions of this study. Considering the context presented in Section 1, this study addressed the following research questions: What are the TBI archetypes according to their objectives? What are the key measurement indicators for TBI performance and efficiency evaluations? What are the research gaps and opportunities for progress in TBI performance and efficiency evaluations?

The second step focused on searching the literature. Given the heterogeneity of the terms that authors have used to designate a BI (Torun *et al.*, 2018; Mian *et al.*, 2016), this research considered the combination with AND within the four keyword groups: (1) business OR university OR company OR enterprise, (2) incubator OR incubation, (3) performance OR effectiveness OR efficiency, and (4) measur* OR assess* OR evaluat*. This structure was used to focus on studies that evaluated the performance and efficiency of BIs in general, filtered to identify studies related to TBIs later in the abstract and full-text review steps. The initial search in the Web of Science and Scopus databases was conducted on 2 March 2023 and considered titles, abstracts, and keywords with no time restrictions. The results were filtered to include only papers in English and document types classified as journal articles, conference articles, books, book chapters, or technical reports. This approach returned 714 records: 419 from the Web of Science and 295 from Scopus. The combined search results from both databases were exported to an Excel spreadsheet for treatment. Next, 264 duplicate documents and studies with titles unrelated to the topic were eliminated.

Then, the following inclusion criteria were applied on the abstract review: studies explicitly focusing on the performance evaluation of TBIs, including literature reviews, proposed models, and applied empirical research. Studies were excluded if they did not directly address the topic of performance evaluation. Two researchers with more than 10 years of experience related to BIs evaluated a sample of 10% of the 450 studies chosen randomly by reading the title, abstract, and keywords, following the recommendation of Thomé *et al.* (2016). The concordance index was 91%, indicating nearly perfect agreement. Therefore, the inclusion and exclusion criteria were applied to the remaining documents. Ultimately, 160 studies were selected for full-text reading and excluded studies that mentioned TBI performance evaluation but primarily focused on other innovative environments. At this stage, 12 documents were excluded, resulting in 148 studies for review. This process was updated on 21 May 2025, resulting in the inclusion of 11 new studies. Consequently, the final portfolio comprised 159 studies. The entire process was conducted in compliance with PRISMA guidelines in Page *et al.* (2021), and Figure 1 presents the PRISMA flow diagram for this step of the SLR. The Supplementary material lists all 159 references considered in this SLR.

The third step was data collection, supported by an auxiliary table to register data related to the author, title, document type, source, year, research area, citations, type of study (e.g.

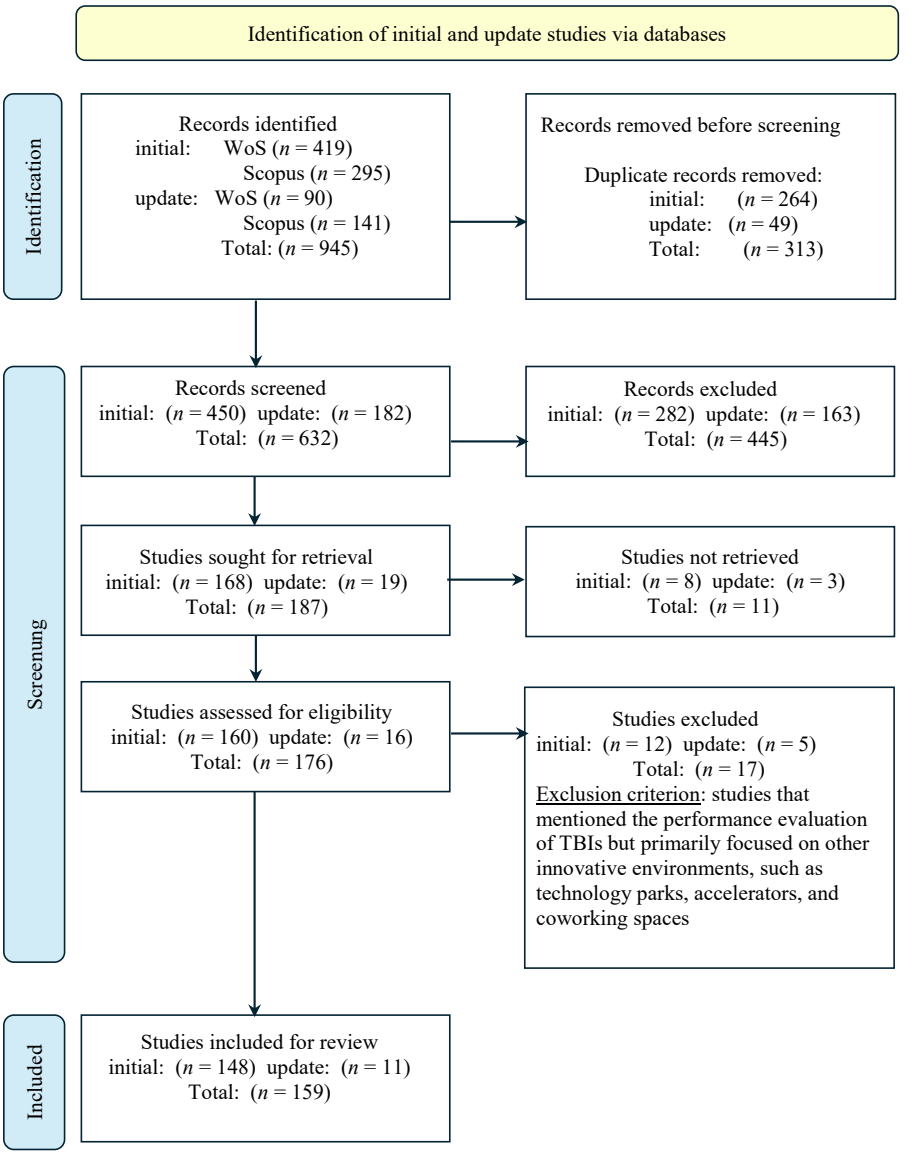


Figure 1. Summary of the literature search steps. **Source:** Authors' own work

literature reviews, model proposal studies for performance evaluation, and applied performance evaluation studies), research approach, objective, method (i.e. qualitative or quantitative), critical factors of success, impact factors, key indicators, TBI archetype, main findings, and future research agenda. The fourth step focused on quality assessment. Following the approach applied in other SLRs (e.g. Fontainha *et al.*, 2022; Cardoso *et al.*, 2023; Resende *et al.*, 2023), this research argues for quality assessment based on the presentation of a clear and structured procedure for deploying the SLR and for adopting the concordance index for selecting papers for review. However, it is fundamental to acknowledge that some papers selected were not peer-reviewed, which could represent a limitation of the findings, as indicated by Thomé *et al.*

(2016). Nevertheless, Thomé *et al*. (2016) also argue that considering documents beyond peer-reviewed papers eliminates biases related to focusing solely on mature research. In addition to the variation in the quality of the selected publications, this research acknowledges other methodological limitations. The decision to include only studies published in English and indexed in the Web of Science and Scopus databases may have limited the analysis of relevant research on the topic published elsewhere, and did not consider industrial reports. These limitations, however, may be addressed in future studies by expanding the range of databases and considering publications in other languages and formats.

The fifth step involved data analysis and synthesis, considered in the format of a taxonomy (e.g. classification of papers and adoption of VOSviewer for keyword co-occurrence maps), framework, and research agenda. These are some of the main deliverables of an SLR, as suggested by Torraco (2005). The sixth step focused on interpreting and addressing the contributions of the SLR for researchers, practitioners, theory, and practice. The seventh step involved presenting the results, focusing on both bibliometric and content analyses. The last step focused on updating the review and was performed on 21 May 2025, as indicated in the details provided regarding the second step. Nevertheless, it is also recommended for future research to investigate how performance and efficiency evaluations of TBIs have evolved after this SLR.

3. Bibliometric and content analyses

After analysing 159 studies, 114 applied studies were identified on TBI performance evaluation, 25 studies that proposed models for performance evaluation, and 20 that performed literature reviews. The applied studies predominantly used quantitative methods (73%), followed by qualitative methods (16%), and some that combined both approaches (11%). Figure 2 presents the evolution of publications per year, covering the period up to May 2025. Such results reveal that 81% of the papers were published from 2011 onwards, demonstrating that this topic is relatively new among researchers.

A total of 388 researchers affiliated with institutions from 52 different countries contributed to the 159 studies analysed in this review. The global distribution of authors is illustrated in the map in Figure 3. Notably, Europe accounts for the largest share, with 40% of the researchers, followed by Asia (34%), North America (13%), South America (6%), Africa (5%), and Oceania (2%).

A citation analysis of the 159 studies was conducted to identify the outliers. First, the studies were separated into two groups: one with studies published between 2020 and May 2025(44 papers) and the other with those published before 2020 (115 papers). Then, the interquartile range (IQR) of each group was used to filter the outliers. This analysis resulted in the identification of four outliers in the first group (Table 1) and sixteen outliers in the second group (Table 2). The outliers focus on the relevance of TBIs and why to evaluate their results

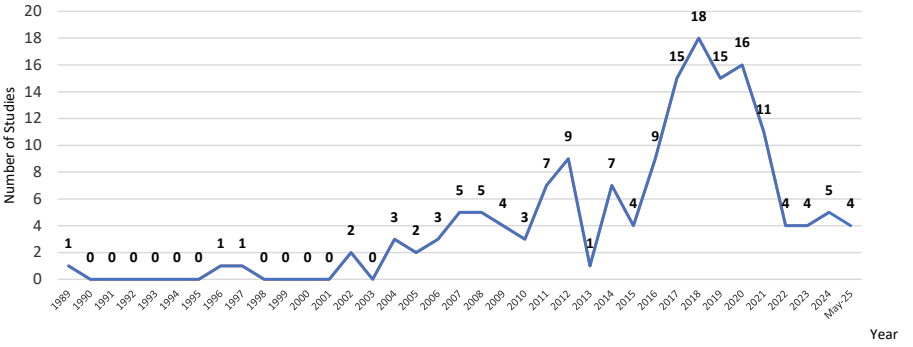


Figure 2. Evolution of publications per year. **Source:** Authors' own work

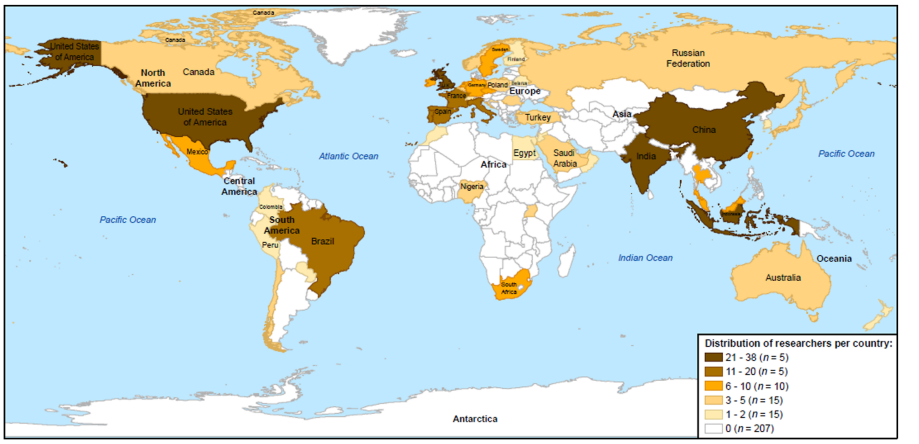


Figure 3. Distribution of researchers per country. **Source:** Authors' own work

Table 1. Distribution of studies by number of citations (up to 5 years)

Study	Year	Citations
Hausberg and Korreck (2020)	2020	588
Leitão *et al.* (2022)	2022	91
Kiran and Bose (2020)	2020	69
Gozali *et al.* (2020)	2020	58
The remaining 40 studies	–	355

Source(s): Authors' own work

Table 2. Distribution of studies by number of citations (greater than 5 years)

Study	Year	Citations
Hackett and Dilts (2004b)	2004	1992
Phan *et al.* (2005)	2005	1,478
Colombo and Delmastro (2002)	2002	1,289
Mian *et al.* (2016)	2016	811
Hackett and Dilts (2004a)	2004	604
Hughes *et al.* (2007)	2007	410
Lalkaka (2002)	2002	404
Bergek and Norrman (2008)	2008	390
Theodorakopoulos *et al.* (2014)	2014	333
Tamásy (2007)	2007	331
Voisey *et al.* (2006)	2006	330
Hackett and Dilts (2008)	2008	324
Mian (1997)	1997	264
Lukeš *et al.* (2019)	2019	251
Aerts *et al.* (2007)	2007	234
Rothaermel and Thursby (2005)	2005	213
The remaining 99 studies	–	2,675

Source(s): Authors' own work

(Phan *et al*., 2005; Mian *et al*., 2016), critical and impact factors of TBIs (Leitão *et al.*, 2022; Hausberg and Korreck, 2020; Lalkaka, 2002; Hughes *et al*., 2007), frameworks and indicators for performance evaluation (Kiran and Bose, 2020; Hackett and Dilts, 2004a), performance of incubated companies versus similar non-incubated companies (Colombo and Delmastro, 2002), links between incubated companies and universities (Rothaermel and Thursby, 2005), and incubation management practices (Bergek and Norrman, 2008; Aerts *et al*., 2007).

The map in Figure 4 shows keyword usage over time, considering three or more occurrences. Node size indicates the frequency of the term. Therefore, "business incubator" is the most commonly used keyword. Purple and dark green nodes indicate that the researchers used the terms "firms", "industry", "university incubators", "growth", and "technology transfer" at least ten years ago. Some of the newer terms include "survival", enterprises, "technology", "critical success factors", "impact factors", "performance measurement", and "efficiency", confirming the more recent concern regarding sustaining the performance and efficiency of BIs and TBIs.

The remain section focuses on presenting a state-of-the-art regarding TBI archetypes and research approaches adopted in 114 studies (Section 3.1), followed by a discussion of the other 20 SLR and 25 models identified in the current study (Section 3.2), and further details on the main issues related to TBIs performance (Section 3.3) and TBIs efficiency (Section 3.4).

3.1 TBI archetypes and research approaches to evaluating TBI performance

Among the 114 applied studies, four TBI archetypes were identified according to their objectives: basic research, university, socioeconomic development, and private. These four archetypes were defined based on the discussions presented in Aernoudt (2004), Barbero *et al*. (2012) and Sohail *et al*. (2023). Table 3 presents their objective, respective sponsors/ affiliations, and the number of studies identified in this SLR corresponding to each archetype.

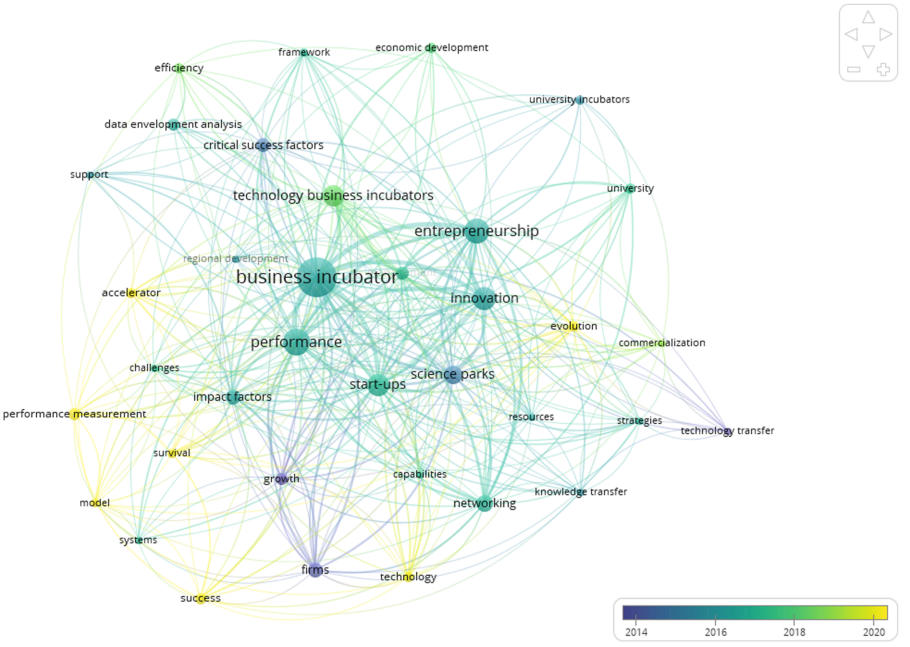


Figure 4. Keyword usage over the years obtained from VOSviewer. **Source:** Authors' own work

Table 3. TBI archetypes according to their objective and sponsors

TBI archetype	Objective	Sponsor/Affiliation	No. of studies
Basic research	TBIs that focus on translating fundamental research into commercial applications. They help researchers and scientists bring innovative ideas to market, usually in high-tech sectors	Research Centres and Laboratories	5
University	TBIs that focus on support students and faculty entrepreneurs in undertaking knowledge transfers and launching start-ups	University and Research Centres	63
Socioeconomic development	TBIs that primary goal is to promote regional economic growth, create jobs, and promote innovation within specific communities	Governments	37
Private	TBIs that focus on stimulating the creation of new businesses within an organisation as a form of corporate entrepreneurship	Corporations and private entities	11

Source(s): Authors' own work

These studies were classified according to their research approach and method in accordance with the taxonomy proposed by Dee *et al.* (2011): (1) *control group* – studies comparing incubated enterprises with similar non-incubated enterprises; (2) *benchmarking* – studies discussing best practices, references for comparison and performance improvement; and (3) *in situ evaluation* – studies addressing incubation program and relationships with partners, incubatees, and graduates, among others. Table 4 presents the distribution of the 114 studies based on this classification.

Among these studies, the ones classified as "*in situ evaluation*" require further analysis as they cover other aspects of TBI performance. Figure 5 shows the recurrence of these aspects. The "incubation program and management" includes management practices, TBI management staff, incubation support and services, selection processes, graduation processes, training, and internationalisation processes.

3.2 Literature reviews and models for BI and TBI evaluation

Previous literature reviews have focused on diverse aspects of TBIs' performance evaluation, yet none have addressed issues or indicators related to efficiency evaluation. Table 5 presents the classification of the 20 literature reviews identified in this study according to their focus. Most of these reviews concentrate on identifying the best approaches and performance measurement systems for TBIs, critical factors for achieving better results, and the impact generated on innovative entrepreneurship and regional development.

The current SLR also identified 25 studies that propose models and frameworks for TBI performance evaluation. Table 6 presents the structural representation of these frameworks,

Table 4. Distribution of the applied studies according to their research approach

Research approach	No.	%
Control group	7	6
Benchmarking	33	29
In situ evaluation	74	65
Total	114	100

Source(s): Authors' own work

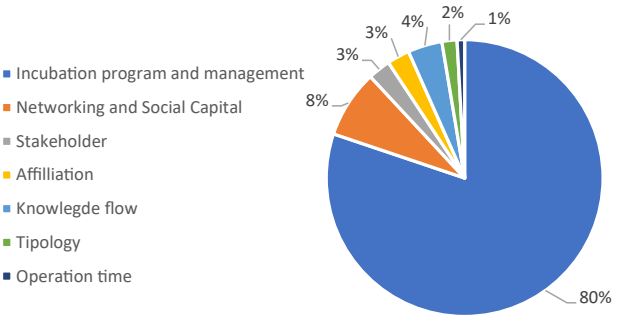


Figure 5. Aspects of TBI performance considered in studies classified as *in situ* evaluations. **Source:** Authors' own work

ranging from conceptual frameworks in different visual structures (i.e. process flow, single hierarchy, multiple hierarchy, multiple focal), to lists or mathematical models to evaluate TBI performance.

3.3 Main issues related to TBI performance

Considering that most studies discussed TBI performance, this section provides further details and content analysis on critical success factors, impact factors, research approaches for comparing the performance of incubated enterprises, and performance evaluation indicators. It is worth noting that any emphasis on specific studies does not suggest a contradiction or exclusion of others. Instead, the results are typically complementary, which results in the synthesis presented in the following subsections from 3.3.1 to 3.3.4.

3.3.1 Critical success factors. This research identifies several factors that authors noted as critical to the success of BIs and also relevant to TBIs, with some already focused on TBIs. Appendix 1 presents the detailed factors organised by category. Here, Table 7 shows the distribution of the categories that researchers most commonly emphasised in decreasing order of frequency. The results highlighted networking, social capital, service quality, funding, and governance as the main factors.

3.3.2 Impact factors. The analysed studies also provided several pieces of evidence regarding the positive impact of TBIs. Table 8 presents the main impact factors sorted by category. The primary factor highlighted in the studies is socioeconomic development (38%), followed by access to financial, organisational, and social capital resources through networking (36%), improvement in enterprises' survival and growth rates (15%), and the development of innovation in enterprises (11%).

Although most studies (95%) emphasised the positive impact of TBI, some authors offered a different perspective. According to Yu and Nijkamp (2009), despite the proliferation of TBI, no clear evidence exists of their positive impact. They argue that the leading causes of this include the use of biased indicators, underestimation of incubators' operating costs, and disregard for the heterogeneity between them. Kolympiris and Klein (2017) suggested that TBIs compete with technology transfer offices and other university programs, reducing universities' revenue from licensing. Based on empirical results, Tamásy (2007) suggests that TBIs do not positively impact enterprises' survival and growth rates or innovation levels. The same work argues that TBIs contribute little to regional development and must operate as private organisations without public funding. In a study of graduated enterprises from five TBIs in Germany, Schwartz (2011) found evidence of a significant impact on job creation only in the long term.

3.3.3 Comparison of incubated and non-incubated enterprises. This research identified seven studies (i.e. Colombo and Delmastro, 2002; Assenova, 2020; Stokan *et al.*, 2015; Lukeš

Table 5. Focus of literature review studies

Literature reviews	Development, challenges, and organizational aspects of the incubation process	Impact factors of TBIs on entrepreneurship, innovation, and regional development	Approaches, performance measurement systems, and key indicators for the evaluation of TBIs	Impact of business incubation on the creation and support of new ventures	Critical success factors of TBIs for achieving better results	Issues and key indicators for efficiency evaluation of TBIs
Hackett and Dilts (2004b)	✓					
Phan *et al.* (2005)	✓					
Tamásy (2007)		✓				
Vanderstraeten and Matthyssens (2010)			✓			
Dee *et al.* (2011)			✓	✓		
Theodorakopoulos *et al.* (2014)			✓			
Mian *et al.* (2016)	✓			✓	✓	
Cheng (2016)			✓			
Ceausu *et al.* (2017)					✓	
Sarwono and Trisetyarso (2017)			✓			
Gurgel *et al.* (2017)			✓		✓	
Torun *et al.* (2018)			✓			
Mungila Hillemane *et al.* (2019)				✓		
Gomathi and Gopinathan (2019)					✓	
Hausberg and Korreck (2020)			✓			
Msimango-Galawe and Hlatshwayo (2021)		✓				
Leitão *et al.* (2022)		✓				
Pattanasak *et al.* (2022)			✓		✓	
Egbetokun (2023)		✓	✓			
Hu *et al.* (2023)			✓			
Current SLR study	✓	✓	✓	✓	✓	✓

Source(s): Authors' own work

Table 6. Structural representation of the frameworks and models for TBI performance evaluation

Study	Process flow	Single hierarchy	Multiple hierarchy	Multiple focal	List	Mathematical model
Mian (1997)	✓					
Hackett and Dilts (2004a, b)	✓					
Yang and Pan (2006)						✓
Laric (2007)			✓			
Ferreira *et al.* (2008)	✓					
Hackett and Dilts (2008)	✓					
Yu and Nijkamp (2009)					✓	
Wulung *et al.* (2012)						✓
Vanderstraeten *et al.* (2014)				✓		
Samaeemofrad *et al.* (2016)	✓					
Amelia *et al.* (2017)	✓					
Alzaghal and Mukhtar (2017)				✓		
Indiran *et al.* (2017)		✓				
Galiyeva and Fuschi (2018)	✓					
Samaeemofrad and van den Herik (2018)	✓					
Seno Wulung *et al.* (2018)						✓
Galiyeva and Fuschi (2019)					✓	
Han *et al.* (2019)						✓
Binsawad *et al.* (2019)			✓			
de Esteban Escobar (2020)	✓				✓	
Tsygankov *et al.* (2020)			✓			
Butrón *et al.* (2020)						
Rathore and Agrawal (2021)			✓			
Gozali *et al.* (2021)	✓					
Yao (2024)					✓	

Source(s): Authors' own work

Table 7. TBI critical success factors according to the frequency in the reviewed studies

Critical success factors	%
Networking and Social Capital	17
Quality of Services	17
Funding	11
Staff Expertise and Experience	10
Governance, Management Policy, and Strategy	9
Infrastructure	7
Government Support	5
Selection Process Strategy	5
Research and Development (R&D)	5
Cooperation with Universities and Research Centres	5
Knowledge Development and Flow	5
Location and Potential of the Region	4

Source(s): Authors' own work

et al., 2019; Almeida *et al.*, 2021; Dvouletý *et al.*, 2018; Lasrado *et al.*, 2016) that directly compared the results of incubated enterprises and similar enterprises that did not undergo an incubation program (Table 9). Most of these studies (i.e. Colombo and Delmastro, 2002; Assenova, 2020; Stokan *et al.*, 2015; Almeida *et al.*, 2021; Lasrado *et al.*, 2016) found evidence of better results presented by incubated and graduated enterprises, highlighting the

Table 8. Main impact factors of TBIs

Category	Impact factor	%
Socioeconomic development	Creation of small and medium-sized enterprises Generation of income and employment Investment attraction through relationship networks	38
Resource access and sharing	Access to financial, organisational, and social capital resources	36
Business survival and growth	Growth and maturity of entrepreneurs Increased technological development capacity Improved enterprise survival rate	15
Development of innovation in incubated enterprises	Flow of knowledge to enterprises Driving innovation in enterprises Better results for innovation	11

Source(s): Authors' own work

following benefits of an incubation program: (1) higher growth rate (revenue and job creation), (2) higher level of technology absorption, (3) research and development (R&D), (4) higher level of collaborative arrangements, (5) more accessible public resources, (6) greater variety of services offered, and (7) higher return on assets (ROA).

Nevertheless, two studies presented a critical view of the benefits of incubation. Lukeš *et al.* (2019) evaluated the impact of TBI on the performance of Italian enterprises in terms of revenue and job creation. They found that incubation positively affects revenue only in the long term and suggested that policymakers should not have high expectations for job creation. Dvouletý *et al.* (2018) conducted a similar study on enterprises in the Czech Republic. Their findings demonstrated that non-incubated enterprises had better sales volumes, profit margins, total assets, and personnel costs. However, the authors attributed this to the country's recent experience with TBI operation.

3.3.4 Performance evaluation indicators. The analysis of the 159 studies led to the identification of 81 indicators presented in Table 10, classified into dimensions and organisational application levels. Some studies combined these indicators to evaluate TBI performance; however, these combinations are not presented here to maintain a concise list.

3.4 Main issues related to TBI evaluation efficiency

Among the studies that used a *benchmarking approach* (Table 4), ten studies used the efficiency frontier concept and the DEA method to evaluate incubator performance. The DEA method is a non-parametric technique used to measure the relative efficiency of productive units that perform similar tasks (Cooper *et al*., 2011). In the present context, the productive units are TBIs, which consume a certain number of sources (inputs) to produce a certain number of results (outputs) (Kaczmarska, 2010; Aaboen *et al.*, 2008). Using this methodology, the efficiency of a group of TBIs can be measured and classified according to their relative efficiency within that group (Aaboen *et al.*, 2008). Furthermore, sources of inefficiency can be identified and adjustments proposed to improve overall efficiency (Sun and Cheng, 2021). Appendix 2 shows the study indicators, dimensions, and results of TBI efficiency evaluations. Here, Table 11 shows the primary input and output indicators considered in these studies and the frequency of citations among the ten papers discussing efficiency evaluations of BIs and TBIs.

4. Integrating performance and efficiency evaluations of TBIs

This section provides a dedicated discussion on integrating performance and efficiency evaluations of TBIs by presenting a framework synthesising the state-of-the-art on the topic (Subsection 4.1), a research agenda (Subsection 4.2), and a discussion on the contributions to researchers, theory, practitioners, and practice involving TBIs and Bis (Subsection 4.3).

Table 9. Studies comparing incubated and non-incubated enterprises

Study	Purpose	Findings
Colombo and Delmastro (2002)	Evaluate the impact of TBI on enterprise growth. Compare the performance of 45 enterprises incubated in Italy with that of similar non-incubated enterprises	Incubated enterprises showed better results than similar non-incubated enterprises: a higher level of human capital (entrepreneur education and experience level), higher growth rate, higher level of technology absorption, higher level of R&D program participation, higher level of collaborative arrangements especially with universities, and higher accessibility of public resources
Assenova (2020)	Evaluate the performance of low-income enterprises and entrepreneurs in their business incubation initiatives in South Africa compared to similar non-incubated enterprises	Incubated enterprises grew 22% more in revenue and 15% more in job creation than similar non-incubated enterprises. Among the incubated entrepreneurs, those who received mentoring had better business growth results (higher revenue and profit)
Stokan *et al.* (2015)	Evaluate the impact of TBIs on enterprise growth. Analyse the results of 294 incubated enterprises in the United States compared to 395 similar non-incubated enterprises	TBIs showed a positive impact on job creation. Regarding services provided to enterprises, on average, incubated enterprises received 3.79 services, whereas non-incubated enterprises received only 0.75. Enterprises that received support from incubators tended to show better results than similar non-incubated enterprises
Lukeš *et al.* (2019)	Evaluate the impact of TBIs on the performance of Italian start-ups in terms of revenue and job creation, using a sample containing 2,544 start-ups, of which 606 are incubated	Incubation had a positive effect on revenue but only in the long term. Incubator affiliation and certifications showed little effect in the comparative analysis. Policymakers should have low expectations regarding job creation resulting from the incubation process
Almeida *et al.* (2021)	Evaluate the impact of TBIs on incubated enterprises compared to the performance of non-resident enterprises in the central region of Portugal using a sample containing 221 incubated and 2,959 non-incubated enterprises	Incubated enterprises performed better than non-incubated ones in terms of their return on assets and growth rate. However, this advantage decreased over time, which could be explained by the limitations of market dominance and lack of investments
Dvouletý *et al.* (2018)	Evaluate the impact of TBIs on enterprises in the Czech Republic. Compare the results of 205 incubated enterprises with similar non-incubated enterprises	Non-incubated enterprises had better average results than the incubated ones for analysed indicators. This can be explained by the need for more experience with TBIs in the Czech Republic, given the short time since the onset of the incubator movement in the country
Lasrado *et al.* (2016)	Analyse the impact of incubator affiliation on enterprise performance and answer the following key question: Do enterprises graduating from university-based incubators perform better than similar non-incubated enterprises?	Graduated enterprises from university incubators showed higher levels of job growth and sales compared to non-incubated enterprises

Source(s): Authors' own work

4.1 Framework for performance and efficiency evaluations of TBIs

The diverse research approaches and related indicators identified in this SLR indicate the lack of a standard framework for evaluating TBI performance. Most studies have adopted measurement indicators related to incubation programs and relationship networks to assess the

Table 10. Indicators for evaluating TBI performance

Level	Dimension	Indicators
Incubator	Infrastructure	physical area, facilities
	Competence	no. of incubated enterprises, occupancy rate, incubation period, new entrants' rate, no. of enterprises graduated, graduation rate, enterprise survival rate, mentoring, no. of internal mentors, no. of external mentors, training, no. of qualifications, no. of workshops held, no. of services provided, attraction of talent, ratio of tenants-staff, average incubation time
	Human capital	no. of people (staff), level of specialisation (staff)
	Social benefits	no. of jobs created, employment growth rate, no. of graduated students hired, no. of engaged students
	Financial resources	public funding, private funding, average implementation cost, average operating cost, no. of financial institutions associated with the TBI
	Economic results	ROI (return on investment), revenue from TBIs
	Governance, strategy, and policies	strategic planning, objectives, incubated enterprise follow-up policy, graduation policy, cooperation with a university and research centre, manager-incubated rate, incubated enterprise turnover rate, selection process strategy, program to support the internationalisation of enterprises, location in an area of intense economic activity and intense scientific production, tool for monitoring and evaluating results, activities associated with environmental sustainability, no. of sustainability activities, operating time, plan for risk management, entrepreneurs coming from academia, cooperation with innovation environments, ventures originating from university community
	Networking and social capital	network size, stakeholders participating in the network, degree of stakeholder interaction
Incubated enterprises	Financial resources	internal funding (TBI), external funding (public, private), access to venture capital
	Economic results	revenue, taxes generated, sales growth rate, profitability, personnel cost
	Social benefits	no. of jobs generated
	R&D	inserted in R&D activity, investment in R&D, participation of researchers, no. of registrations and patents, no. of scientists and engineers
	Competence	no. of products and services generated, technology, marketing, management
	Networking and social capital	resource sharing
Graduated enterprises	Economic result	growth rate, sales volume
	Social benefits	no. of jobs created
	Competence	turnover of new products, manufacturing capacity, technology, marketing, and management
Entrepreneurs	Human capital	level of qualification, entrepreneurial maturity, and degree of satisfaction
Government	Public policies and financial resources	public policy support, financial support, and organisational support

Source(s): Authors' own work

impact on incubated enterprises (Table 10). However, strengthening networking and implementing a rigorous financial plan associated with quality of service and governance models have been suggested as the basis for TBI success. These elements were also highlighted as critical success factors (Appendix 1). Besides that, concerning the studies

Table 11. Primary input and output indicators of TBI efficiency evaluation studies

Input indicators	Frequency	Output indicators	Frequency
Incubator area	9	No. of incubated enterprises employees	6
Funding	8	Cumulative number of graduated enterprises	4
No. of incubator employees	6	Incubated enterprises' revenue	4
No. of mentors	3	No. of incubated enterprises	4
Skill development	2	Annual graduation rate	2
Proximity of the incubator to the university	1	No. of patents	2
No. of technological assets	1	Cooperation with universities or research centres	1
		Average revenue of incubated enterprises	1
		Incubator operating costs	1

Source(s): Authors' own work

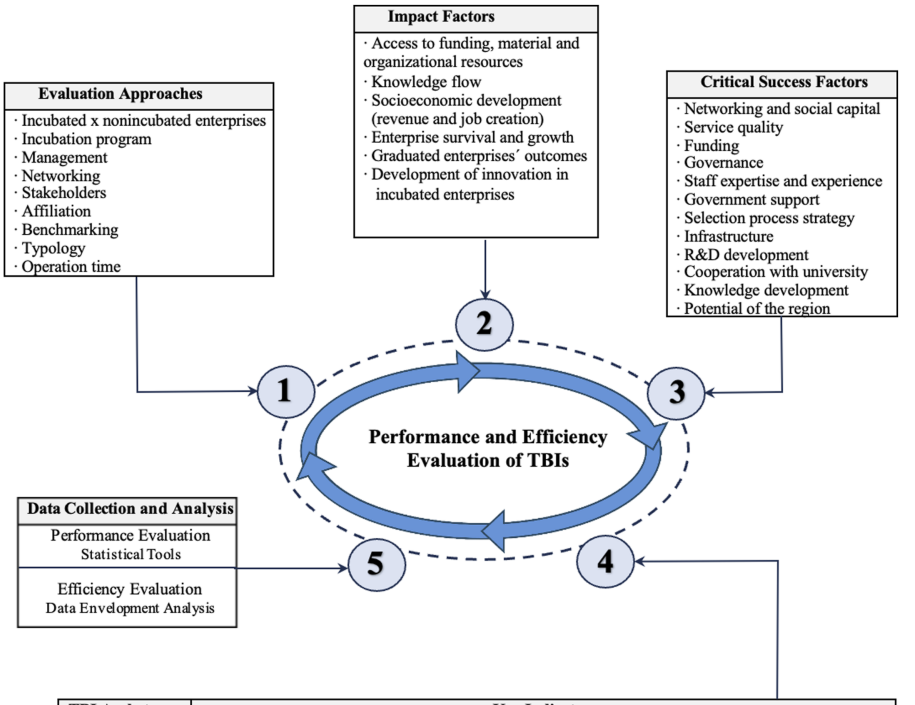
proposing models and frameworks for evaluating the performance of TBIs, two categories predominate: generic frameworks designed to assess the impact of the services provided by TBIs on the success of enterprises and those that incorporate indicators and dimensions according to the characteristics of the regional ecosystem.

When evaluating the performance and efficiency of TBIs, it is crucial to consider their objectives and define the measurement indicators accordingly. In this sense, there are some evidences that failure to do so can lead to biased results (Bergek and Norrman, 2008; Aernoudt, 2004). Another relevant point is that despite the various indicators identified among the 114 applied studies, only two (Barbero *et al*., 2012; Bergek and Norrman, 2008) considered the differences between TBI archetypes in their analyses. Regarding previous literature reviews, none have incorporated TBI archetypes to guide performance and efficiency assessment. The four TBI archetypes considered in this research were defined according to their objectives and sponsors/affiliations (Table 3).

Based on these findings, this research proposes a circular framework outlining the main findings of this review, including the primary critical and impact factors for TBIs and a set of 42 input and output indicators to evaluate the performance and efficiency of TBIs in line with their archetypes (Figure 6). Although the 24 studies that proposed models and frameworks for performance evaluation presented distinct formats (Table 6), none adopted a circular structure, suggesting a periodic application of the evaluation process. This gap inspired the formulation of the present framework, which aims to better align with the reality of professionals in management who continuously seek to assess results to improve their organisations' performance.

The framework illustrated in Figure 6 represents an advancement over prior studies that propose frameworks and models for TBI evaluation, as it suggests an integrated set of indicators for assessing TBIs' performance and efficiency according to their archetypes. Unlike linear or fragmented frameworks (Tables 5 and 6) identified in previous research, the proposed framework organises the performance and efficiency assessment process in a cyclical and recursive structure that reflects the continuous nature of TBI management and evolution. This comprehensive framework adopts a dual approach and presents a balanced array of input and output indicators for each TBI archetype: basic research, university, socioeconomic development, and private. These characteristics are fundamental to facilitating the real adoption of this framework.

Therefore, researchers and practitioners who wish to implement the framework proposed in this study (Figure 6) should follow a structured process. First, they must select an evaluation approach (step 1) and define the impact factors (step 2) to investigate, corresponding to the TBI outcomes. Next, they must assess the relationship between these outcomes and certain factors



TBI Archetypes	Key Indicators	
	Input	Output
Basic research	· physical area · funding ($) · R&D investment over sales · number of employees (TBI staff) · qualified employees over total employees (%)	· no. of patents · introduction of new products and services · sales growth
University	· physical area · funding ($) · number of employees (TBI staff) · no. of internal mentors (university) · no. of external mentors · qualified employees over total employees (%)	· student's participation in incubated enterprises (%) · no. of patents · new products based on technology transfer from the university . university labs sharing · incubation rate · graduation rate . incubated enterprises revenue · no. of jobs created
Socioeconomic development	· physical area · funding ($) · number of employees (TBI staff) · no. of mentors	· no. of jobs created (incubated enterprises) · no. of jobs created (graduated enterprises) · incubated enterprises' revenue · graduated enterprises' revenue · incubation rate · graduation rate
Private	· physical area · funding ($) · R&D investment over sales · number of employees (TBI staff) · qualified employees over total employees (%)	· sales growth · cost per job · new business creation rate · introduction of new products and services · no. of patents

Figure 6. Framework outlining the primary contributions of the TBIs' evaluation studies. **Source:** Authors' own work

considered critical to TBIs' success (step 3). Once the research target and approach are defined, the next step is determining the key indicators to apply (step 4). These indicators should be appropriately selected, and the TBI archetype should be considered to avoid biased performance evaluations. Finally, data must be collected and analysed from a performance perspective, using statistical tools, or from an efficiency perspective, considering the

relationship between inputs and outputs through appropriate methods, such as Data Envelopment Analysis (DEA) (step 5). This procedure must be adopted periodically, always considering the eventual need for adjustments in steps 1 to 4 to proceed to a new data collection and analysis as indicated in step 5.

An illustrative application of the proposed framework might consider a hypothetical case of a university-based TBI. In Step 1, the evaluation approach would involve benchmarking and affiliation-based analysis, reflecting its close connection to the academic environment. Step 2 would prioritise impact factors such as knowledge transfer, innovation development within enterprises, and student involvement in entrepreneurial ventures. Step 3 would focus on critical success factors like cooperation with the university, service quality, and staff expertise. In Step 4, input indicators such as the number of internal university mentors, TBI staff, and funding would be matched with output indicators like the number of patents, new products based on technology transfer, and graduation rates. Finally, in Step 5, performance could be assessed through statistical comparisons with similar university incubators, while efficiency could be evaluated using DEA.

Despite the illustrated simplicity, the framework application may also face some practical challenges. For example, professionals might have difficulties in defining the TBI's strategic objectives in alignment with managerial practices and expectations from sponsoring institutions. This alignment is critical in Step 1 and has a subsequent impact in the following steps that focus on defining the critical success factors, impact factors, and corresponding key performance indicators. Moreover, practical obstacles may arise during the data collection and analysis phases as many TBIs face constraints related to data availability, consistency, and reliability. Differences in data collection practices, limited resources for monitoring, and the lack of standardised reporting systems can also hinder accurate assessments.

4.2 Research agenda

Appendix 3 summarises the future research agenda proposed by the 20 reviews identified in this study. Despite the proliferation and evolution of BIs over the past 20 years, the need to deepen the understanding of the incubation process to identify better and analyse critical success factors remains one of the leading research suggestions (Hackett and Dilts, 2004b; Phan *et al.*, 2005; Mian *et al.*, 2016; Hausberg and Korreck, 2020), even by the most recent studies (Pattanasak *et al.*, 2022; Egbetokun, 2023). The other two research themes that also prevail among researchers are developing more comprehensive models and frameworks for performance evaluation and the impact of internal and external relationship networks on ventures (Phan *et al.*, 2005; Mian *et al.*, 2016; Torun *et al.*, 2018; Hausberg and Korreck, 2020; Egbetokun, 2023), reinforcing the importance of social capital in BI's outcomes. More recent studies (Leitão *et al.*, 2022; Pattanasak *et al.*, 2022; Wudhikarn *et al.*, 2025) also highlight the importance of investigating the impact of BI staff's intellectual capital on incubated enterprises' performance.

Based on the findings of the current SLR and the proposed framework (Figure 6), this study suggests a research agenda that complements the recommendations outlined in Appendix 3. The first suggestion reflects the need for further studies discussing the impact of TBIs in developing countries as they improved socioeconomic development through the generation of revenue, income, and employment (Table 8). However, among the studies addressing this topic, only seven (37%) targeted TBIs established in developing countries (UNDP, 2022). Most studies (63%) reported on TBIs in developed and Western countries. Therefore, further studies on TBI performance in developing and non-Western countries would contribute to broadening the knowledge about the theme and subsidise creating more effective public policies.

The second suggestion focuses on innovation in enterprises and non-profit organisations. Although several authors highlighted the positive effects of TBIs on innovation development

in incubated enterprises (Table 8), no studies have directly addressed the effects of innovation type (incremental × radical). Therefore, verifying the effects of TBIs based on the type of innovation developed by tenants would enrich this theme. Moreover, discussion of the specific characteristics of non-profit organisations developing technological initiatives represents a potential niche, which could provide a new archetype or combination owing to their particularities in the incubation process and position as a third-sector enterprise.

Regarding TBI efficiency evaluations, the analysed studies mainly focused on job and income generation, economic results, and networking. However, given that R&D in incubated enterprises is one of the main impact factors of TBI, the third suggestion for future research is to conduct efficiency evaluations to identify the most appropriate indicators and main factors of inefficiency. The fourth research suggestion involves developing further studies on adherence to the framework proposed in Section 4.1 (Figure 6). This might reinforce its external validity and provide possible refinements based on new findings or country-context aspects.

A fifth research recommendation is to conduct longitudinal studies assessing TBIs' performance and efficiency over time. While most existing evaluations offer a static and cross-sectional view, longitudinal studies are essential to capturing dynamic development patterns, sustainability, and the long-term impact of TBIs.

The sixth research recommendation involves expanding the scope of TBI research by overcoming certain methodological limitations faced in this current research. Considering that the review was limited to English-language publications indexed in the Web of Science and Scopus databases, this may have excluded relevant studies published in languages other than English or indexed in other academic or industry sources. Besides, some of the studies were not peer-reviewed, and the overall methodological rigour of the included literature may vary. These limitations highlight opportunities for future research, which may incorporate policy documents, industry reports, and regional publications. Furthermore, future studies may adopt complementary methods such as case studies of individual TBIs, surveys involving incubator managers, entrepreneurs, or policymakers, and comparative analyses across national or regional contexts to enhance the field's empirical grounding.

Finally, the seventh research suggestion is to perform an updated SLR in the future to identify how research and practice related to TBI performance and efficiency evaluations have evolved after the publication of this paper.

4.3 Research contributions

The growing number of studies on TBI performance and efficiency evaluation confirms the importance of this topic for academics, the government, and industry. As intermediaries between enterprises and external economic agents, TBIs work in a complex environment to foster strategic interactions through partnerships, mentorship, and funding. Besides that, most studies (95%) view TBIs as strategic for developing innovative entrepreneurship. The studies also pointed to key impact factors that include resource sharing, socioeconomic development, business survival and growth, and innovation development in incubated enterprises.

Based on the analysis of the patterns in the literature, this study offers valuable insights and benchmarks for TBI practitioners and policymakers. Moreover, the circular framework presented in Figure 6 helps TBI managers identify evaluation approaches, define critical success factors and impact factors, select appropriate input and output indicators based on their incubator archetype, with a proper indication to perform such evaluation periodically. This structured process can inform more effective strategies for aligning incubator dimensions, such as services, critical success factors, impact factors, and performance indicators, with regional industrial demand. This argument is in accordance with the propositions from Ceausus *et al.* (2017), who specifically emphasize that tailoring incubator strategies to the needs of regional industries enhances the performance of incubated enterprises.

From a policy perspective, this study clarifies the critical dimensions of TBIs that can guide governments and funding agencies in refining support programs for more efficient resource

allocation decisions. This is particularly valuable in emerging economies, where public support often plays a central role in sustaining incubation infrastructure and fostering innovation development. This study also offers practical implications for industries that rely on technology-based innovations, such as Information and Communication Technologies (ICT), Healthcare, Engineering, and Biotechnology (Fukugawa, 2018; Dee *et al.*, 2011; Fernandez *et al.*, 2019). For instance, drawing on the findings of Fukugawa (2018), which demonstrate that the ICT and Engineering industries particularly benefit from TBIs with strong human capital, the proposed framework can be considered in defining key indicators related to managerial expertise to support performance and efficiency evaluation based on a specific TBI archetype. Similarly, drawing on Fernández *et al.* (2019), who emphasize the influence of regional entrepreneurial ecosystems on the performance of incubators operating in high-tech industries such as biotechnology and health technology, the framework developed in this study can be considered as a source for defining indicators that reflect both internal capabilities and ecosystem conditions. These examples reinforce the framework's practical value in guiding evaluation and decision-making across various economic sectors.

From a scientific perspective, this study highlights notable gaps that present opportunities for further research, as discussed in the research agenda. In particular, it broadens the conceptualisation of incubator performance by introducing an efficiency lens, which has been largely absent from prior frameworks and literature reviews. By integrating efficiency and performance evaluation, the study contributes to advancing theoretical discussions and offers a foundation for more comprehensive entrepreneurship support structures.

Finally, compared with previous literature reviews, this study is the only one to address all six analytical dimensions, including efficiency assessment (see last row in Table 5). This comprehensive scope strengthens the proposed framework's originality and practical relevance for researchers, incubator managers, and policymakers.

5. Final considerations

The contributions of BIs and TBIs have evolved significantly, bringing attention to performance evaluation and, more recently, efficiency. Therefore, this study analysed the research progress in performance and efficiency evaluations of TBIs and provided a combined approach. The systematic literature review resulted in the full analysis of 159 documents retrieved from Scopus and Web of Science databases.

Considering the rising number of studies on TBI performance, especially in the last ten years, this research identified different perspectives on incubator dynamics. The analysis of previous research contributed to the definition of four TBI archetypes (Table 3); critical success factors (Table 7 and Appendix 1); impact factors (Table 8); and both performance (Table 10) and efficiency indicators (Table 11 and Appendix 2). Based on these syntheses, this study proposes a framework (Figure 6) featuring 42 indicators for evaluating TBI performance and efficiency. The novelty of this framework lies both in its circular approach for periodical application by professionals and researchers working with TBI and BI, and in the suggested indicators for different TBI archetypes. These characteristics are completely new in comparison with the previous research and contribute to facilitating its effective adoption. Another relevant contribution of this study lies in the research agenda (Section 4.2), outlined to guide continued scientific and practical developments in the topic. The last contribution of this research lies in the discussion on how researchers and practitioners might implement and adopt the proposed framework and consider the patterns of the state of the art in performance and efficiency of TBIs (Section 4.3). These findings reinforce that TBIs are key mechanisms for promoting economic development through innovative entrepreneurship, as they support the survival and growth of early-stage innovative enterprises.

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Appendix 1

Table A1. Critical success factors

Category	Critical success factors	Study
Infrastructure	Physical facilities, proper planning of facilities	Tang *et al*. (2014), Mian (1997), Ssekiziyivu *et al*. (2021), Kebbi and Valliere (2016), Kiran and Bose (2020), Arlotto *et al*. (2011), Lalkaka (2002), Rai *et al*. (2025), Panakaje *et al*. (2024), Elafqih and Messaoudi (2025)
Financial resources	Access to internal and external funding	Tang *et al*. (2014), Siddiqui *et al*. (2021), Ceausu *et al*. (2017), Kiran and Bose (2020), Saraireh (2021), Gozali *et al*. (2020), Lose and Tengeh (2016), Arlotto *et al*. (2011), Al-Mubaraki and Wong (2011), Rai *et al*. (2025), Elafqih and Messaoudi (2025)
	Efficient allocation of financial resources	Wen *et al*. (2020), Zapata-Guerrero *et al*. (2020)
	External investment, venture capital	Sun and Cheng (2021), Hong and Lu (2016)
Staff expertise and experience	Human capital	Tang *et al*. (2014), Sun and Cheng (2021), Ceausu *et al*. (2017), Fernandez *et al*. (2019), Loganathan and Subrahmanya (2021), Fukugawa (2018), Wudhikarn *et al*. (2025)
	Mentoring	Assenova (2020), Buckley and Davis (2016), Ssekiziyivu *et al*. (2021), Oliveira and Trento (2018), Kebbi and Valliere (2016), Meyer and Meyer (2016), Lalkaka (2002), Panakaje *et al*. (2024), Elafqih and Messaoudi (2025)
	TBI management	Lalkaka (1996), M'Chirgui *et al*. (2018), Arlotto *et al*. (2011), Sun *et al*. (2020), Zapata-Guerrero *et al*. (2020), Xu *et al*. (2018)
R&D activity	Collaboration with Universities and Research Centres	Cravo and Marques (2019), Wann *et al*. (2017)
	Greater investments in R&D	Fernandez *et al*. (2019), Oliveira and Trento (2018)
	Support for incubated enterprises' R&D activities	Rubin *et al*. (2015)
	Intellectual property	Hong and Lu (2016)
Cooperation with Universities and Research Centres	R&D development	Rothaermel and Thursby (2005)
	Cooperation	Kiran and Bose (2020), Gozali *et al*. (2020), Aaboen *et al*. (2008), Fukugawa (2018)
	Technology transfer to incubated enterprises	Rothaermel and Thursby (2005), Lanqing (2020)
	Knowledge flow to incubated enterprises	Rothaermel and Thursby (2005)
Government support	Financial, organizational	Sun and Cheng (2021), Sung (2007), Al-Baimani *et al*. (2021), Gozali *et al*. (2020), Feeser and Willard (1989), Xu *et al*. (2018)
	Public policy	Al-Baimani *et al*. (2021)
	Market-oriented public policies	Lanqing (2020)

(*continued*)

Table A1. Continued

Category	Critical success factors	Study
Governance, management policy, and strategy	Management policy and strategy	Mian (1997), Gamber *et al*. (2020), Oliveira and Trento (2018), Lalkaka (1996), McAdam and Keogh (2006)
	Alignment between the incubator's objectives and the enterprises' business strategy	Gamber *et al*. (2020), Feeser and Willard (1989)
	Focus on industry demand	Ceausu *et al*. (2017), Meyer and Meyer (2016), Xu *et al*. (2018)
	Sustainable business model	Ceausu *et al*. (2017), Olkiewicz *et al*. (2019)
	Develop ventures in technology-intensive industries	Fernandez *et al*. (2019)
	Adoption of Lean Start-up (LS)-based metrics	Tritoasmoro *et al*. (2024)
	Establish a board of directors	Meyer and Meyer (2016)
Quality of services	Set of services offered	Mian (1997), Siddiqui *et al*. (2021), Ssekiziyivu *et al*. (2021), Lalkaka (1996), Harper-Anderson and Lewis (2018), Kiran and Bose (2020), Arlotto *et al*. (2011), Al-Mubaraki and Wong (2011), Lalkaka (2002), Saraireh (2021), Oliveira and Trento (2018), Rai *et al*. (2025)
	Consultancy in strategic planning and training in financial management	Buckley and Davis (2016)
	Specialized technological support for tenants	Rubin *et al*. (2015), Saraireh (2021), Hong and Lu (2016)
	Post-incubation support	Ceausu *et al*. (2017), Wudhikarn *et al*. (2025)
	Mediation	Sedita *et al*. (2019)
	Marketing	Oliveira and Trento (2018)
	Monitoring and management close to the incubated enterprises	Samaeemofrad *et al*. (2016), Hackett and Dilts (2004a), Wudhikarn *et al*. (2025)
	Training	Meyer and Meyer (2016), Saraireh (2021), Bonfanti *et al*. (2025)
Networking and Social Capital	Strengthen internal and external networks	Siddiqui *et al*. (2021), Ceausu *et al*. (2017), Ssekiziyivu *et al*. (2021), Loganathan and Subrahmanya (2021), Sedita *et al*. (2019), Oliveira and Trento (2018), Sung (2007), Lalkaka (1996), Kebbi and Valliere (2016), Meyer and Meyer (2016), Gurgel *et al*. (2017), Al-Baimani *et al*. (2021), Kiran and Bose (2020), Gozali *et al*. (2020), Alzaghal and Mukhtar (2018), Chen *et al*. (2011), Lalkaka (2002), Aaboen *et al*. (2008), Azadnia *et al*. (2022), Bonfanti *et al*. (2025), Panakaje *et al*. (2024), Elafqih and Messaoudi (2025)
	Interaction with players from the segment in which enterprises operate	Samaeemofrad *et al*. (2016)
	Sharing resources and knowledge	Hughes *et al*. (2007), Castro *et al*. (2014)
	Access to financial and material resources	Loganathan and Subrahmanya (2021)
	Size of the relationship network	Guan and Fan (2020)

(*continued*)

Table A1. Continued

Category	Critical success factors	Study
Selection process strategy	Balanced (based on multiple criteria)	Aerts *et al*. (2007)
	Focus on ventures with high growth potential	Ceausu *et al*. (2017), Wen *et al*. (2020), Sun *et al*. (2020)
	Selection of ventures most likely to survive and grow	Lalkaka (1996)
	Relevant and rigorous treatment	Gozali *et al*. (2020), McAdam and Keogh (2006), Hackett and Dilts (2004a)
Knowledge development and flow	Sharing tacit technological knowledge between incubatees and graduates	Rubin *et al*. (2015), Kiran and Bose (2020), Hughes *et al*. (2007)
	Knowledge generation	Lose and Tengeh (2016), Lamperti *et al*. (2023), Aaboen *et al*. (2008)
Monitoring and performance assessment	Continuous monitoring and evaluation of results	Lalkaka (1996), Hackett and Dilts (2004a)
Location and potential of the region	Potential of the region (urbanization, social capital, financial potential, cooperation with Universities)	Harper-Anderson and Lewis (2018), Ceausu *et al*. (2017), Xiao and North (2017)
	Location in an area of intense scientific production and economic activity	Gurgel *et al*. (2017)

Source(s): Authors' own work

Table A2. Efficiency evaluation studies overview

Study	Focus	Input/Output	Dimension	Indicators	Findings
Wen *et al.* (2020)	Evaluate the efficiency of 4,848 government TBIs in 30 provinces in China, with data from 2018	Input	Social Capital Infrastructure Funding	No. of mentors Total incubator area Funding investments in the service platform	Seventeen provinces showed inefficiency; in 9, excesses were detected in the input resources and deficits in the output result
		Output	Competence Technology Economic result Social benefit	Cumulative number of graduates.Technology turnover Total revenue from incubators No. of enterprises with revenue in excess of 50 million Yuan Total number of jobs	
Aaboen *et al.* (2008)	Evaluate the performance of 16 Swedish TBIs from the perspective of incubated enterprises (189)	Input	Cooperation with a university Networking Funding Skill	Proximity to the universityAssistance by incubator managers Importance in obtaining external funding Training promoted by the incubator	Except for the university cooperation dimension, where the incubators were well evaluated and presented close efficiency results, the other three show a rather dispersed picture, with few incubators on the efficiency frontier
		Output	Cooperation with a universityNetworking Funding Skill	University cooperation activities Guidance from external mentors External funding External training in business and management	
Kaczmarska (2010)	Evaluate the efficiency of 19 TBIs in Poland, considering aspects of the social benefit generated and the environmental impact	Input	–	Constant = 1	Based on the results, the author proposes a methodology for grouping the TBIs into classes according to their degree of similarity, seeking to facilitate the identification of measures to increase the efficiency of the group
		Output	Competence Social benefit Infrastructure Sustainability	Number of incubated enterprises Total number of incubated enterprise employees Area occupied by enterprises No. of activities with environmental impact	

(*continued*)

Table A2. Continued

Study	Focus	Input/Output	Dimension	Indicators	Findings
Dai and Wang (2017)	Evaluate the efficiency of 14 government TBIs in China	Input	Social capital Funding Infrastructure	No. of incubator employeesFunding Total incubator area	The 14 TBIs had an average operational efficiency of 82.37%. Seven of them showed 100% efficiency. The other TBIs showed a low pure technical efficiency
		Output	Competence R&D Social benefit Economic result	Cumulative number of graduated enterprises Annual graduation rate No. of incubated enterprise employees No. of patents Average revenue of the enterprises	
Guan and Fan (2020)	Evaluate the impact of the network size, network tie strength, and network centrality on the operating efficiency of 1,202 TBIs from 30 provinces in China	Input	Infrastructure Social capital Funding Competence	Total area of the incubator No. of incubator employees No. of mentors Incubator operating costs Financial support Training and capacity	The network size and the players' degree of importance positively impact the TBIs' operational efficiency. In contrast, the relationship tie has an inverted U-shape effect. Therefore, from a certain intensity of action, operational efficiency decreases
		Output	R&D Economic result Funding Social capital	No. of patents Total revenue of incubated enterprises Investor funding No. of recent graduates absorbed	
Zapata-Guerrero *et al.* (2020)	Evaluate the efficiency of 25 TBIs linked to universities in Mexico with a dual approach: Incubator and enterprises. Focus: Survival and development of incubated enterprises	Input	Technology Infrastructure Social capital Competence Funding	Total technological assetsTotal incubator areaNo. of incubator employees (except mentors)No. of guaranteed institutions for fundingFull funding	Smaller TBIs showed better operational efficiency results. The operational efficiency of the incubator is determined by the adequate size of its facilities, a rigorous plan for using financial resources, and manager experience
		Output	Competence Social benefit	Annual rate of graduatesAnnual survival rate of the enterprises Annual rate of job growth	

(*continued*)

Table A2. Continued

Study	Focus	Input/Output	Dimension	Indicators	Findings
Wang and Li (2011)	Based on the efficiency evaluation of 21 TBIs with ties to universities in Taiwan, propose a methodology for establishing alliances between incubators to optimize their results and increase the overall performance	Input Output	Infrastructure Funding Competence Social benefit	Total area of the incubatorFull funding No. of incubated enterprises No. of employees in enterprises	The authors demonstrated that alliances among incubators could increase overall efficiency by up to 12%
Lanqing (2020)	Evaluate the performance of TBIs from 30 provinces in China and propose measures to increase the system's performance as a whole	Input Output	Social capital Funding Infrastructure Competence Social benefit	No. of incubator employees Funding from incubatorThe physical area of the incubator No. of incubated enterprises No. of employees	Overall efficiency can be considered high, but there are inefficient provinces and an imbalance between provinces in terms of results

(*continued*)

Table A2. Continued

Study	Focus	Input/Output	Dimension	Indicators	Findings
Sun and Cheng (2021)	Evaluate the efficiency of government TBIs in 30 provinces in China, with an approach focused on the internal organization of the TBI.	Input 1st. stage (investment attraction) Output 1st. stage Input 2nd. stage (incubation) Output 2nd. stage	Social capital Social benefit FundingCompetence Competence Social benefit Funding Economic result Competence	No. of incubator employees Incubator area FundingNew entrants No. of remaining enterprisesNo. of employees FundingNew entrants RevenueNo. of graduated enterprisesNo. of enterprises that remain incubated for the next period	Relatively low operational efficiency. The low efficiency of the incubation stage largely explains this. When considering the "remaining incubated enterprises" variable between periods, the efficiency values are greater than those obtained without the respective variable (static model). Greater government support and technological progress positively impact the efficiency of the investment attraction stage. In contrast, a higher level of FDI (foreign direct investment) positively influences the incubation stage (2nd stage). The human capital (personnel) factor directly impacts the efficiency of the two stages
Sun *et al.* (2020)	Evaluate the efficiency of 108 TBIs from China using a dynamic slacks-based model	Input Output	Social capital Funding Infrastructure Competence Competence Economic result Social benefit	No. of incubator employees Financing from the incubator Incubator area No. of new entrants No. of remaining enterprises No. of graduated enterprises No. of remaining enterprises Revenue No. of employees	Ignoring the number of incubated enterprises as an unwanted variable at the beginning of a new incubation cycle may result in underestimating the system's efficiency. Global technical efficiency (TE) is relatively low, impacted by pure technical efficiency. Operating efficiency (ET) shows a downward trend during the period studied (2010–2012). There is a considerable disparity between the efficiency results of TBIs

Source(s): Authors' own work

Table A3. Future research agenda suggested by SLR studies

Literature reviews (SLR)	Deepen the understanding of the incubation process to identify and analyse factors that influence the success of incubated ventures.	Greater emphasis on the needs of incubatees (services, internationalization, funding, R&D, and market access). Alignment with BI's strategic objective	Explore the outcomes and trajectories of graduated companies	A multi-dimensional and integrated evaluation approach (going beyond traditional metrics)	Explore the impact of internal and external networks on entrepreneurial ventures' performance, survival, and growth	Compare different regional incubation approaches, examining how open innovation, local factors, and resources affect incubation effectiveness	Investigate BI models to understand how financing mechanisms and operational strategies affect outcomes	Investigate the knowledge and skills (intellectual capital) that the incubator management team must possess to maximize the support provided to enterprises	Expand the geographical scope of studies. Most existing literature remains focused on North America, Europe, and Asia
Hackett and Dilts (2004b)	✓	✓							
Phan *et al.* (2005)	✓				✓				
Tamásy (2007)							✓		
Vanderstraeten and Matthyssens (2010)				✓					
Dee *et al.* (2011)			✓	✓		✓	✓		
Theodorakopoulos *et al.* (2014)									
Mian *et al.* (2016)	✓				✓				✓
Cheng (2016)		✓			✓				
Ceausu *et al.* (2017)	✓		✓	✓					
Gurgel *et al.* (2017)	✓			✓	✓	✓			✓
Torun *et al.* (2018)					✓				
Mungila Hillemane *et al.* (2019)	✓			✓	✓				
Gomathi and Gopinathan (2019)		✓							

(*continued*)

Table A3. Continued

Literature reviews (SLR)	Deepen the understanding of the incubation process to identify and analyse factors that influence the success of incubated ventures.	Greater emphasis on the needs of incubatees (services, internationalization, funding, R&D, and market access). Alignment with BI's strategic objective	Explore the outcomes and trajectories of graduated companies	A multi-dimensional and integrated evaluation approach (going beyond traditional metrics)	Explore the impact of internal and external networks on entrepreneurial ventures' performance, survival, and growth	Compare different regional incubation approaches, examining how open innovation, local factors, and resources affect incubation effectiveness	Investigate BI models to understand how financing mechanisms and operational strategies affect outcomes	Investigate the knowledge and skills (intellectual capital) that the incubator management team must possess to maximize the support provided to enterprises	Expand the geographical scope of studies. Most existing literature remains focused on North America, Europe, and Asia
Hausberg and Korreck (2020)	✔				✔				
Msimango-Galawe and Hlatshwayo (2021)		✔							
Leitão *et al*. (2022)						✔		✔	
Pattanasak *et al*. (2022)	✔							✔	
Egbetokun (2023)	✔				✔				
Hu *et al*. (2023)		✔		✔		✔			

Source(s): Authors' own work

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Supplementary material

The supplementary material for this article can be found online.

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