

## **Managing digital transformation through smart technology integration in technology business incubators in Maharashtra and India**

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## ABSTRACT

Technology Business Incubators (TBIs) have become central instruments of India's innovation policy, translating research, entrepreneurial talent, and government support into viable ventures. This review synthesises recent (2016–2026) peer-reviewed and institutional literature on how smart technologies, including Artificial Intelligence (AI), the Internet of Things (IoT), cloud computing, big data analytics, blockchain, and digital collaboration platforms, are reshaping incubation practice, with particular attention to Maharashtra, one of India's most active startup ecosystems. Building on this literature, the review sets out research objectives and questions, profiles Maharashtra-based incubators such as the Society for Innovation and Entrepreneurship (SINE), the riidl Foundation, Venture Center, and AIC Pinnacle Entrepreneurship Forum, and discusses barriers, including infrastructural, financial, cybersecurity-related, and cultural constraints, that hinder digital adoption. Drawing on this synthesis, the paper proposes a conceptual framework linking smart-technology adoption to incubation efficiency and startup outcomes, moderated by government support, funding, digital skills, and organisational culture, and recommends a mixed-methods design for future empirical validation of the framework across Maharashtra's TBI ecosystem.

**KEYWORDS:** Technology Business Incubators, Digital Transformation, Smart Technology, Artificial Intelligence, Maharashtra, Startup Ecosystem, India, Conceptual Framework

## 1. INTRODUCTION

Digital transformation drives innovation-led economic growth in India, with Technology Business Incubators

(TBIs) playing a vital role alongside entrepreneurship policies. TBIs provide early-stage startups with crucial resources such as infrastructure, mentorship, funding opportunities, and networking, greatly improving their prospects for survival and expansion <sup>[1,2]</sup>. As India's startup landscape has evolved, supported by flagship initiatives such as Startup India and the Atal Innovation Mission, the number and types of TBIs have grown significantly. These incubators now extend beyond major cities into states like Maharashtra, where the academic, government, and private sectors support industries ranging from healthcare to clean technology <sup>[3]</sup>. Simultaneously, TBIs are undergoing a similar transformation. Incubator managers increasingly rely on data-driven approaches to select startups, monitor portfolio companies in real time, and facilitate mentoring and networking primarily through digital platforms rather than in-person meetings <sup>[4,5]</sup>. This review examines the evidence of this transition, emphasising how technologies such as AI, IoT, cloud computing, big data analytics, blockchain, and digital collaboration tools are incorporated into incubation practices. It also considers the remaining obstacles to adoption and discusses the influence of these innovations on TBIs in Maharashtra. Furthermore, it consolidates this evidence into research objectives, a conceptual framework, and a methodology to guide future research.

### 1.1 Research objectives and questions

#### 1.1.1 Primary objective

To examine how the integration of smart technology drives digital transformation in Technology Business Incubators (TBIs) in Maharashtra and across India.

### 1.1.2 Specific objectives

1. To identify the key smart technologies adopted by TBIs, including AI, IoT, cloud computing, blockchain, and big data analytics.
2. To assess the impact of digital transformation on incubation efficiency and startup performance.
3. To examine the challenges impacting technology integration in TBIs.
4. To assess the role of government initiatives, such as Startup India and the Atal Innovation Mission, in driving digital transformation.
5. To propose a strategic framework for effective digital transformation management within incubators.

### 1.1.3 Research questions

1. How are smart technologies being incorporated into TBIs' incubation processes?
2. What advantages does digital transformation offer for startup incubation?
3. What obstacles prevent the adoption of smart technology?
4. Which strategies improve the success of digital transformation in TBIs?

## 2. REVIEW METHODOLOGY

This paper uses a narrative literature review rather than a formal PRISMA-style systematic review, aiming to synthesise a diverse, cross-disciplinary evidence base spanning information systems, entrepreneurship, and public policy, and to develop a conceptual framework rather than combine quantitative effect sizes.

### 2.1 Search strategy and sources

The literature was collected using databases such as Scopus, Web of Science, and Google Scholar, along with sources from institutions and government

agencies, such as Startup India, the Atal Innovation Mission, and the websites or annual reports of incubators, for detailed facts and policies. The search combined terms like 'technology business incubator', 'business incubator', or 'startup incubator' with keywords including 'digital transformation', 'artificial intelligence', 'Internet of Things', 'cloud computing', 'big data', 'blockchain', 'cybersecurity', and 'Maharashtra' or 'India'. It was restricted to English publications from 2016 to 2026, aligning with the launch of Startup India and the Atal Innovation Mission, to focus on the period when the adoption of smart technology in Indian incubation policies was most prominent.

### 2.2 Inclusion and exclusion criteria

Included are peer-reviewed journal articles, books or book chapters, and grey literature, such as government portals and incubator institutional pages, that specifically discuss incubator practices, smart technology adoption, or the startup policy context in India or Maharashtra.

Excluded: studies concerned solely with business incubation outside a technology or digital-transformation context, non-English sources, and opinion pieces without an identifiable evidentiary basis.

Because this is a narrative rather than systematic review, no formal risk-of-bias appraisal or PRISMA flow diagram was applied; sources were instead screened by the review author for direct relevance to the research questions in section 2.3.

### 2.3 Summary of key reviewed studies

Table 1 summarises the key studies supporting the conceptual framework in Section 5, highlighting each

study's focus and its main implication for TBI management.

**Table 1.** Summary of key reviewed studies underpinning the conceptual framework

| Ref. | Focus area                               | Principal implication for TBIs                                                                                                                               |
|------|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [2]  | TBI functioning across Indian states     | Efficiency depends on realigning operational and administrative procedures and sustained capacity-building investment.                                       |
| [3]  | Intra-organisational incubator networks  | The density and quality of internal social ties shape knowledge transfer and venture performance as much as formal services do.                              |
| [4]  | Incubator reputation and engagement      | Perceived reputation, credibility, and networking strength predict founder engagement more strongly than infrastructure alone does.                          |
| [5]  | Digital business incubator model         | Proposes virtual incubation dimensions — market sensing, unified digital systems, access to financing, mentoring — co-developed with practitioners.          |
| [6]  | AI/big data in entrepreneurial decisions | Gradient-boosting models accurately predict a firm's technology focus, with reputation and location being more influential predictors than firm size.        |
| [7]  | Cloud adoption (TOE framework, MSMEs)    | Relative advantage, organisational readiness, competitive pressure, and self-efficacy predict adoption; perceived complexity does not.                       |
| [8]  | Blockchain and startup financing         | Reduces information asymmetry and transaction costs in entrepreneur-investor matching, but regulatory uncertainty limits its mainstream adoption.            |
| [9]  | Online mentoring field experiment        | Structured platform interventions increase mentor outreach, with a stronger effect among women entrepreneurs; however, connection success is not guaranteed. |
| [10] | Digital transformation and cybersecurity | Digital transformation raises efficiency but expands risk exposure; recommends a staged cybersecurity-readiness framework.                                   |

### 3. LITERATURE REVIEW

#### 3.1 The role of technology business incubators in India

TBIs are intermediary organisations that transform early-stage ideas, often originating in academic or research settings, into market-ready businesses. In India, they have traditionally been linked to higher education institutions and public research agencies,

utilising programmes such as the Science and Technology Entrepreneurship Parks (STEPs), as well as the more recent NIDHI-TBI and Atal Incubation Centre (AIC) models <sup>[2,3]</sup>. A comprehensive study of TBIs across Indian states found that their effectiveness largely depends on realigning operational and administrative processes and on consistent investment in capacity development, as

many TBIs are still emerging organisations building infrastructure, mentoring networks, and alumni support systems. TBIs serve not only as infrastructure providers but also as social and knowledge networks. An exploratory study of intra-organizational networks within technology-based incubators revealed that the density and quality of internal social connections among incubated firms significantly influence knowledge transfer and venture success, beyond the formal services provided <sup>[3]</sup>. Similarly, research from management-institute-affiliated incubators in southern India indicated that students' perceptions of an incubator's reputation, credibility, and networking ability were stronger predictors of engagement and learning than infrastructure alone. This underscores that TBIs thrive as much through their relational and informational value as through physical assets <sup>[4]</sup>.

### **3.2 Smart technology integration in incubation practice**

#### **3.2.1 Artificial intelligence and big data analytics**

AI and big data analytics are increasingly utilised to enhance entrepreneurial and investment decision-making. Recent studies using machine-learning methods like decision trees, random forests, and gradient boosting indicate that gradient-boosting models can accurately predict a company's technological focus. Moreover, attributes such as company reputation and geographic location tend to influence AI adoption more significantly than firm size alone <sup>[6]</sup>. For incubators, these tools support a transition from subjective assessments to data-driven decisions for startup screening, milestone monitoring, and mentoring. Nonetheless, the literature highlights persistent challenges, including model interpretability, data quality issues, and overfitting.

#### **3.2.2 Cloud computing**

Cloud computing reduces the initial investment needed for early-stage ventures by offering scalable, pay-as-you-go services instead of large upfront infrastructure costs. A study using the Technology-Organisation-Environment (TOE) framework on cloud adoption among micro, small, and medium enterprises showed that factors like relative advantage, organisational readiness, competitive pressure, and individual computer self-efficacy significantly influenced adoption. In contrast, perceived complexity was not a major factor. This indicates that incubators can speed up cloud adoption mainly by boosting confidence and demonstrating peer success, rather than by making the technology itself simpler.

#### **3.2.3 Internet of Things (IoT)**

IoT technologies extend digital transformation into physical processes prototyping, manufacturing, logistics and healthcare devices that many hardware- and deep-tech-oriented incubates depend on. Incubators supporting IoT-focused ventures increasingly need to provide not just funding and mentorship but also access to testbeds, connectivity infrastructure and hardware prototyping labs alongside conventional business mentoring.

#### **3.2.4 Blockchain**

Blockchain applications in entrepreneurial finance are examined through the lens of transaction-cost economics. Since blockchain-based systems reduce information asymmetry and transaction costs associated with connecting entrepreneurs and investors, they may enhance transparency and decentralisation in early-stage funding <sup>[8]</sup>. In incubation ecosystems, this has led to testing blockchain-enabled record-keeping for equity and

milestone-based grants. However, regulatory uncertainty in India means that blockchain's adoption in mainstream TBIs remains largely exploratory.

### **3.3 Digital collaboration platforms and virtual mentoring**

Digital platforms are revolutionising how mentoring, an essential support service, is delivered. An international online mentoring trial found that structured approaches, such as sharing examples of successful mentor-mentee interactions, increased the likelihood that entrepreneurs would seek mentors, particularly among women entrepreneurs. Nonetheless, these strategies did not always lead to successful matches <sup>[9]</sup>. Moreover, research on digital business incubator models highlights the importance of organising virtual incubation around core elements such as market sensing, integrated digital enterprise systems, access to finance, team building, and structured mentoring. These should be developed collaboratively with incubator managers and founders to ensure practical relevance <sup>[5]</sup>.

### **3.4 Cybersecurity and digital risk in incubation**

The same technologies that boost efficiency also increase the attack surface for incubators and their portfolio companies. A review of digital transformation and cybersecurity research indicates that, while digital initiatives improve organisational efficiency and productivity, they also pose new risks such as data breaches, unauthorised access, and cyberattacks risks that organisations are often not fully prepared for. Consequently, it is recommended to incorporate a phased cybersecurity-readiness framework early in the digital transformation process <sup>[10]</sup>. For Technology Business Incubators (TBIs), which frequently manage sensitive intellectual

property, financial data, and founder information from many young, resource-constrained startups, this underscores the importance of fundamental cybersecurity guidance, secure shared infrastructure, and data governance training as critical parts of incubation support.

### **3.5 Technology business incubators in Maharashtra**

Maharashtra features one of India's most vibrant and diverse incubation ecosystems, supported by academic and government institutions. The Society for Innovation and Entrepreneurship (SINE), established at IIT Bombay in 2004 and registered under the Societies Registration Act, 1860, has incubated over 200 startups and supported nearly 1,000 innovators. It offers physical infrastructure, mentoring, and seed funding through a 'start-to-scale' model recognised by the Department of Science and Technology as a Centre of Excellence <sup>[11,12]</sup>. Likewise, the riidl Foundation at Somaiya Vidyavihar University supports early-stage ventures through structured incubation integrated with academic programs. Venture Center at NCL Innovation Park in Pune emphasises deep technology and science-based startups in healthcare, agriculture, and materials, providing laboratory facilities and business support <sup>[13]</sup>. The AIC Pinnacle Entrepreneurship Forum, under the Atal Innovation Mission, enhances the state's incubation infrastructure by linking it with a network of incubators in Pune and Mumbai, including the Bhau Institute of Innovation, Entrepreneurship and Leadership at COEP, MIT-WPU Technology Business Incubator, Science and Technology Park at Savitribai Phule Pune University, and JITO Incubation and Innovation Foundation in Mumbai <sup>[13,14]</sup>.

### 3.6 National Policy initiatives supporting digital transformation

India's national entrepreneurship framework actively encourages the technological growth of TBIs. The Startup India initiative, introduced by the Department for Promotion of Industry and Internal Trade (DPIIT) in 2016, simplified compliance procedures, established a Fund of Funds for startups, and launched platforms like the Startup India Seed Fund Scheme, Startup India Investor Connect, and the MAARG mentorship portal. By the mid-2020s, these efforts created a vibrant startup ecosystem with several hundred thousand registered entities <sup>[15]</sup>. Since 2016, the Atal Innovation Mission (AIM), overseen by NITI Aayog, has set up Atal Incubation Centres (AICs) at universities, institutions, and corporate locations. By the mid-2020s, more than seventy AICs were operational nationwide, incubating thousands of startups and generating jobs, with an expanded phase (AIM 2.0) providing additional funding through 2028 <sup>[16]</sup>. Collectively, these programmes form a vital support system that covers funding, recognition, and digital infrastructure such as MAARG and BHASKAR, helping TBIs, including those in Maharashtra, adopt smart technologies.

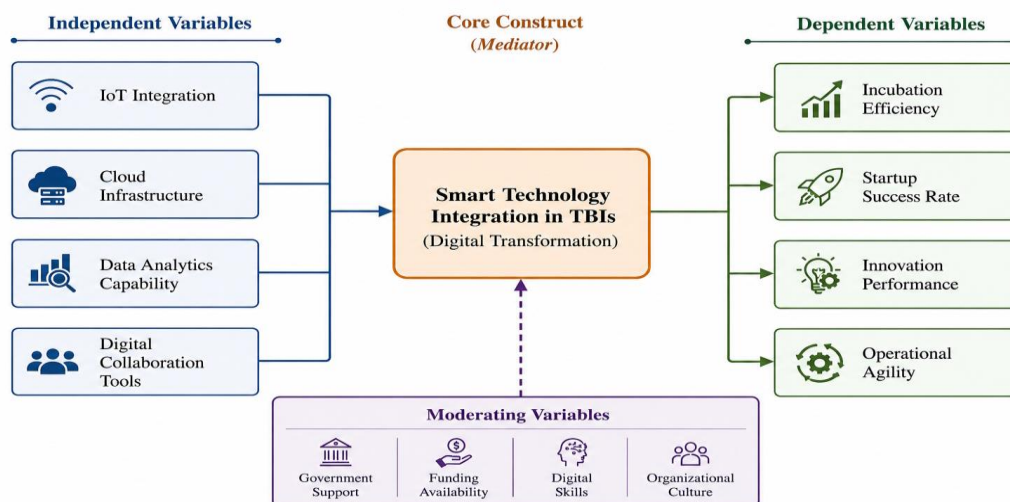
### 3.7 Challenges to digital transformation in TBIs

Despite supportive policies, digital transformation in TBIs continues to face obstacles. Many incubators, especially those outside major cities, lack the infrastructure and funding needed to invest in servers,

software licences, and specialised personnel for intelligent technologies. Staff and founders often have skill gaps that hinder effective use of AI, analytics, and cloud solutions, even when access is available. Resistance within organisations, whether from incubator management accustomed to manual processes or founders wary of algorithmic screening, can delay implementation despite technical readiness. Cybersecurity threats also present challenges that underfunded incubators may struggle to address <sup>[10]</sup>, while regulatory uncertainties surrounding innovations like blockchain-based financing restrict incubators' ability to experiment with new tools legally <sup>[8]</sup>.

### 3.8 Conceptual framework

This review synthesises existing research to develop a conceptual framework linking smart technology adoption with incubation and startup success. It highlights five key independent variables AI adoption, IoT integration, cloud infrastructure, data analytics capabilities, and digital collaboration tools that impact outcomes such as incubation efficiency, startup success, innovation, and operational agility. The framework also suggests that these relationships are moderated by factors like government support, funding access, digital skills, and organisational culture, supporting evidence that technological adoption results are heavily influenced by organisational readiness and policy environments, rather than solely by the technologies themselves <sup>[2,7,10,15,16]</sup>.



**Figure 1.** Proposed conceptual framework linking smart technology adoption to TBI and startup outcomes

## 4. RESEARCH METHODOLOGY

This paper is a literature review, and the outlined methodology is proposed as a mixed-methods approach for future empirical testing of the conceptual framework discussed in section 5. This approach aligns with commonly used designs in innovation-management and entrepreneurship research published in Scopus-indexed journals. Here, it is offered as a recommended research plan rather than as completed data collection.

### 4.1 Research design

- Mixed-method design combining quantitative and qualitative approaches.
- Descriptive and exploratory in orientation, appropriate for an emerging and heterogeneous field of study.

### 4.2 Study area

The proposed study area covers major TBIs in Maharashtra and selected incubators across India, including the Society for Innovation and Entrepreneurship (SINE), riidl Foundation, Venture Centre, and AIC Pinnacle Entrepreneurship Forum <sup>[11-13]</sup>.

### 4.3 Data collection

Primary data would be collected through structured questionnaires, semi-structured interviews, and expert discussions with incubator managers, startup founders, mentors, and investors. Secondary data would be drawn from Scopus-indexed research papers, government reports, TBI annual reports, and policy documents, including the Startup India portal, the Atal Innovation Mission portal, and SINE's institutional records <sup>[11,15,16]</sup>.

### 4.4 Sampling technique

A purposive sampling technique is recommended, targeting a total sample of 150–300 respondents, illustratively distributed as follows:

**Table 2.** Illustrative respondent distribution for proposed empirical validation

| Respondent group    | Indicative sample size |
|---------------------|------------------------|
| Incubator managers  | 50                     |
| Startup founders    | 150                    |
| Mentors / investors | 50                     |
| Total               | 250                    |

#### 4.5 Data Analysis Tools

Quantitative analysis using SPSS, R, or Python includes descriptive statistics, correlation analysis, regression modelling, and factor analysis.

Qualitative: Thematic analysis of interview and expert discussion transcripts.

#### 4.6 Expected outcomes and contribution

1. Identifying the key factors that drive digital transformation in TBIs.
2. A strategic plan for integrating smart technology tailored to Maharashtra's incubator ecosystem.
3. Policy suggestions concerning Startup India, the Atal Innovation Mission, and state-level innovation organisations.
4. A conceptual, scalable digital incubation framework with potential relevance to other emerging economies.

#### 4.7 Management Strategies for Digitally Enabled Incubation

Addressing the barriers outlined in section 4.6 requires intentional management strategies rather than random technology purchases. Providing structured digital-capacity building for both incubator staff and incubatees helps to bridge skill gaps and boosts confidence in adopting cloud and analytics solutions <sup>[7]</sup>. Using scalable, shared cloud infrastructure enables incubators to standardise tools across their portfolio while reducing costs for startups. Setting up clear data governance and cybersecurity frameworks should be considered core services, not secondary features <sup>[10]</sup>. When virtual mentoring or digital collaboration platforms are introduced, they should be intentionally designed to foster relationship-building, not just information sharing <sup>[9]</sup>. Ultimately, promoting a culture of ongoing innovation through regular technology audits, founder feedback, and phased experimentation with tools like blockchain-based

grants enables incubators to adopt smart technologies gradually and responsibly.

## 5. DISCUSSION

The existing literature suggests that incorporating smart technology into TBIs involves multiple simultaneous, technology-specific transitions rather than a single change. Each transition has its own evidence base, advantages, and potential risks. AI and big data analytics enhance decision-making but require careful attention to interpretability and data quality <sup>[6]</sup>. Cloud computing, being more mature and ready for implementation, depends mainly on organisational preparedness rather than technical challenges <sup>[7]</sup>. IoT and blockchain are still emerging, sector-specific, and influenced by regulations <sup>[8]</sup>. Digital mentoring platforms improve accessibility but do not inherently foster the trust seen in face-to-face interactions <sup>[9]</sup>. For Maharashtra's diverse incubator landscape, which includes deep-science incubators like Venture Center, university programmes such as SINE and riidl, and government-supported AICs, a customised digital transformation approach is likely more effective than a uniform one. Strategies should account for each incubator's sector focus, the maturity level of incubatees, and factors such as government support, funding, digital skills, and organisational culture, as outlined in the proposed conceptual framework.

## 6. LIMITATIONS

This review has several limitations that should temper its conclusions. First, as a literature-based, conceptual contribution, it has not empirically tested the proposed framework; the relationships in section 5 are theorised from reviewed evidence rather than statistically validated, and the methodology in section 6 has yet to

be implemented. Second, the search strategy (section 3), which was limited to English-language sources and based on Scopus, Web of Science, and Google Scholar, may under-represent Hindi- or Marathi-language policy discussions and practitioner knowledge within Maharashtra's incubator community. Third, the evidence base varies across technologies: cloud computing and AI/analytics are supported by a fairly established literature, whereas evidence for IoT and blockchain specific to Indian TBIs remains limited, making conclusions about these technologies more tentative. Fourth, the incubator profiles in section 4.4 depend partly on institutional websites and secondary sources rather than independently verified data, which might overlook recent organisational changes. Finally, because the review focuses on Maharashtra within the broader Indian policy landscape, its findings may not directly apply to other states or to incubation ecosystems in different emerging economies without further validation.

## 7. CONCLUSION

Technology Business Incubators are increasingly expected to serve not only as providers of physical infrastructure and mentorship but also as digitally advanced organisations. They should leverage AI, IoT, cloud computing, big data analytics, blockchain, and digital collaboration platforms to support startups more efficiently and fairly. Maharashtra's incubation ecosystem, supported by institutions like SINE, riidl, Venture Center, and AIC Pinnacle Entrepreneurship Forum, along with national initiatives such as Startup India and the Atal Innovation Mission, forms a strong base for this shift. Achieving its full potential will require ongoing investment in digital skills, strong data governance, cybersecurity, and management

approaches that view technology adoption as a continuous, customised process. The framework and methodology presented here offer a foundation for future research to examine these connections within Maharashtra's and India's broader innovation-driven economic development.

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## CONFLICTS OF INTEREST

The author declares no conflict of interest.

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