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The Digital Transformation of Business Incubators: A Systematic Literature Review

La transformation digitale des incubateurs d'entreprises : une revue systématique de la littérature

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Abstract

Business incubators are increasingly adopting digital technologies, yet research on this transformation remains fragmented. This systematic review, conducted according to PRISMA 2020 in Scopus and Web of Science and complemented by a search with alternative terminology and by citation searching, includes 23 studies published between 2010 and 2025. Their quality was appraised with the MMAT, and their findings were synthesised with the Antecedents–Decisions–Outcomes framework, distinguishing four levels of digital transformation and three levels of evidence. The field is young, accelerated by COVID-19 and dominated by case studies of university and virtual incubators. Three families of practices emerge: virtual incubation, digital tools integrated into incubation processes, and artificial intelligence. Most studies document changes in how support is delivered rather than demonstrated value creation: reported outcomes rest mainly on perceptions, and no study measures the economic effect of incubators' own digital practices. The article proposes an explanatory framework grounded in dynamic capabilities and legitimacy, a research agenda and a managerial decision grid.

Keywords: digital transformation; business incubators; virtual incubation; entrepreneurial support; systematic literature review.

Résumé

Les incubateurs d'entreprises adoptent de plus en plus les technologies numériques, mais la recherche sur cette transformation reste fragmentée. Cette revue systématique, conduite selon PRISMA 2020 dans Scopus et Web of Science et complétée par une recherche à terminologie élargie et par l'examen des bibliographies, retient 23 études publiées entre 2010 et 2025. Leur qualité a été évaluée avec le MMAT et leurs résultats synthétisés selon le cadre Antécédents–Décisions–Résultats, en distinguant quatre niveaux de transformation digitale et trois niveaux de preuve. Le champ est récent, accéléré par la COVID-19 et dominé par des études de cas d'incubateurs universitaires et virtuels. Trois familles de pratiques émergent : l'incubation virtuelle, les outils numériques intégrés aux processus d'incubation et l'intelligence artificielle. La plupart des études documentent une modification des modalités d'accompagnement plutôt qu'une création de valeur démontrée : les effets rapportés reposent surtout sur des perceptions et aucune étude ne mesure l'effet économique des pratiques numériques des incubateurs. L'article propose un modèle explicatif fondé sur les capacités dynamiques et la légitimité, un agenda de recherche et une grille de décision managériale.

Mots clés : transformation digitale ; incubateurs d'entreprises ; incubation virtuelle ; accompagnement entrepreneurial ; revue systématique de la littérature.

Introduction

Business incubators have become one of the most widespread instruments for supporting new ventures. By offering infrastructure, shared services, business support and access to networks, they aim to increase the survival and growth of start-ups during their most fragile years (Hackett & Dilts, 2004; Bergek & Norrman, 2008). Over the past four decades, their value proposition has shifted from the provision of physical space towards intangible services such as coaching, mentoring and networking (Bruneel et al., 2012; Mian et al., 2016). Universities, governments, corporations and private investors now run incubators in almost every country, including in emerging economies where they are expected to contribute to job creation and innovation.

A second shift is now under way. Digital technologies are transforming how organisations create and deliver value (Vial, 2019), and entrepreneurship itself is increasingly shaped by digital artefacts, platforms and infrastructures (Nambisan, 2017). The idea of a "virtual incubator" appeared more than twenty years ago (Nowak & Grantham, 2000), but it was the COVID-19 pandemic that pushed many incubators to move selection, training, mentoring and demo days online within a few weeks, while social media, cloud tools and, more recently, artificial intelligence (AI) entered their daily work. These changes raise the question of whether digital incubation delivers the same benefits as its physical predecessor.

Research on this topic has grown, but it remains fragmented. Existing reviews have mapped the incubation literature in general (Hackett & Dilts, 2004; Hausberg & Korreck, 2020), university incubators (Ríos Yovera et al., 2025), innovation intermediaries (Caloffi et al., 2023) and digital academic entrepreneurship (Secundo et al., 2020). Closer to our topic, Elia et al. (2021) derive a conceptual "digital society incubator" model, Vaz et al. (2022) review models of virtual business incubators and Rodrigues (2025) reviews performance indicators for digital accelerators (Table 1). To our knowledge, none synthesises why incubators digitalise, which digital practices they adopt, in fully virtual or physical incubators, and with what outcomes for incubators and start-ups.

Table 1. Comparison with previous reviews

Review	Scope	Method and corpus	Treatment of digital transformation
Hackett & Dilts (2004)	Business incubation research	Systematic review of incubation research since the 1980s	Not addressed
Hausberg & Korreck (2020)	Incubators and accelerators	Co-citation analysis-based systematic review	Marginal; digital practices not coded
Secundo et al. (2020)	Digital academic entrepreneurship	Structured review of 59 papers (Scopus)	Central, but incubation is one context among others
Elia et al. (2021)	"Digital society incubator" model	Conceptual model derived from 80 works (Scopus)	Central at ecosystem level; untested; not business incubators' practices
Vaz et al. (2022)	Virtual business incubator models	PRISMA review and bibliometric analysis (Web of Science); 12 studies synthesised	Central but limited to virtual models; drivers and outcomes not covered
Ríos Yovera et al. (2025)	University incubators and start-up development	PRISMA review of 50 studies (2018–2024)	Mentioned as an emerging theme only
Rodrigues (2025)	Digital accelerators	Critical review of performance indicators	Central but limited to accelerators' KPIs
This review	Digital transformation of business incubators of all types	PRISMA review of 23 studies (2010–2025) with MMAT appraisal	Central: drivers, practices by level of transformation, outcomes by level of evidence

Source: authors.

Beyond this mapping gap, a conceptual question remains open. Adopting an online platform is not, in itself, an organisational transformation: digital technologies may simply change how existing services are delivered, or they may reshape the incubation model and give incubators new capabilities to create entrepreneurial value. This review therefore addresses a central question: does the digital transformation of business incubators strengthen their capacity to create entrepreneurial value, or does it mainly modify how their services are delivered? Answering it requires distinguishing levels of transformation and levels of evidence, which previous reviews have not done.

This article addresses this question through a systematic literature review (SLR) of studies published between 2010 and 2025. It is guided by four research questions:

RQ1. How has research on the digital transformation of business incubators evolved in terms of publications, geographical contexts, methods and theories?

RQ2. What drives and what hinders the digital transformation of business incubators?

RQ3. Which digital practices do business incubators adopt, and at which level of digital transformation?

RQ4. What outcomes are reported for incubators and for incubated start-ups, with what level of evidence, and what gaps remain for future research?

To answer these questions, the review follows the PRISMA 2020 guidelines (Page et al., 2021), appraises the quality of the included studies and organises the findings with the Antecedents–Decisions–Outcomes (ADO) framework (Paul & Benito, 2018). It makes three contributions: a quality-appraised synthesis that distinguishes levels of digital transformation and levels of evidence; an explanatory framework, grounded in dynamic capabilities and legitimacy theory,

that links drivers, digital practices and outcomes through explicit mechanisms and contingencies; and a research agenda and decision grid that are particularly relevant for emerging economies, including North Africa, where no study was found in the corpus despite the rapid development of entrepreneurial support structures in the region.

1. Conceptual background

1.1. Business incubators and their evolution

A business incubator can be defined as an organisation that supports the creation and growth of new ventures by providing them with resources and services during a limited period (Hackett & Dilts, 2004). Bergek and Norrman (2008) identify five core components of incubation: the selection of incubatees, the provision of infrastructure, business support, mediation between incubatees and their environment, and graduation. These components remain a useful lens for examining how digital technologies affect each stage of the incubation process.

The literature commonly distinguishes several generations of incubators. First-generation incubators mainly offered affordable office space and shared facilities; the second generation added coaching and business support; the third-generation emphasised access to networks of investors, experts and partners (Bruneel et al., 2012). Incubators also differ in their sponsors and objectives, with university, public, corporate and private for-profit incubators pursuing different missions (von Zedtwitz, 2003; Mian et al., 2016). Each generation has moved further away from tangible resources towards knowledge and relationships, which are precisely the resources that digital technologies can transmit at a distance. In this sense, digitalisation can be read as a continuation of the long-term evolution of incubation models.

1.2. Digital transformation and its application to incubators

Digital transformation refers to a process in which an organisation uses combinations of information, computing, communication and connectivity technologies to bring about significant changes in its properties, structures and value creation (Vial, 2019). In entrepreneurship research, digital technologies are increasingly seen as shaping not only the products of new ventures but also the processes through which opportunities are pursued and supported (Nambisan, 2017).

Following Verhoef et al. (2021), digital transformation differs from digitisation, which converts analogue information into digital form, and from digitalisation, which uses digital technologies to change existing processes; transformation alters the business model and value proposition. Building on Warner and Wäger (2019), this review distinguishes four levels in incubators: (L1)

the digitisation of information and administrative tasks; (L2) the digitalisation of support processes such as selection, training, mentoring and networking; (L3) the transformation of the incubation model, for example a programme delivered entirely online to new target groups; and (L4) the creation of new capabilities and forms of entrepreneurial value. Only L3 and L4 are transformations in the strict sense.

Applied to incubators, digital transformation can take two organisational forms. The first is the virtual incubator, a largely dematerialised organisation that delivers its services at a distance, a model proposed by Nowak and Grantham (2000) for the software industry. A virtual incubator is not necessarily a digitally advanced one: some rely mainly on networks of partners rather than on sophisticated tools. The second is the digitalised incubator, which keeps its physical infrastructure while integrating digital tools, such as social media, cloud platforms or data analytics, into its processes (Rippa & Secundo, 2019; Secundo et al., 2020). Whether the two forms are distinct models or points on a continuum, and at which levels they operate, is one of the questions this review addresses.

1.3. Theoretical lenses

Two theoretical perspectives are used to explain, and not only to describe, the digital transformation of incubators. The resource-based view holds that organisations create value from valuable, rare and inimitable resources (Barney, 1991); it identifies what changes in the incubator's resource bundle when services move online. The dynamic capabilities perspective adds that organisations must sense opportunities, seize them and reconfigure their resources (Teece et al., 1997; Teece, 2007). It explains why incubators with access to similar, inexpensive tools reach different levels of digital transformation: what differs is their digital maturity, that is, their capability to integrate technologies into their routines (Warner & Wäger, 2019).

Legitimacy, the generalised perception that the actions of an organisation are desirable or appropriate within a social system (Suchman, 1995), offers a complementary institutional lens. It explains whether digital and virtual incubation models are accepted by the audiences incubators depend on: entrepreneurs, who must trust remote support; funders, who must finance it; and partners, who must recognise it. Because judgements at one level influence those at another (Bitektine & Haack, 2015), legitimacy can also create feedback effects, as visible results attract new resources.

Finally, the ADO framework is used as an organising device, not as an explanatory theory. It classifies findings into antecedents (the factors that lead to a decision), decisions (the choices

adopted) and outcomes (their consequences) (Paul & Benito, 2018): here, the drivers and barriers of digitalisation, the digital practices of incubators, and their effects on incubators and start-ups. The explanatory work is done by the two theoretical lenses, from which Section 5 derives propositions on the mechanisms linking these elements.

2. Methodology

2.1. Research design

The study adopts the systematic literature review method, which aims to identify, select and synthesise research on a defined question through a transparent and reproducible process (Tranfield et al., 2003). The reporting follows the PRISMA 2020 statement (Page et al., 2021). The review protocol defined the research questions, databases, search strings, inclusion and exclusion criteria and coding grid before the searches were run. The protocol was not registered in a public repository.

2.2. Search strategy

Two multidisciplinary databases were searched: Scopus and the Web of Science Core Collection. Both are widely used in management research and index peer-reviewed journals according to explicit quality criteria. The searches were run on 23 September 2026 in titles, abstracts and keywords, combining two blocks of terms with the Boolean operator AND: the first block captured incubators and the second the digital dimension. Truncation (*) was used to capture variants of each term. The exact strings, fields and filters, as executed in each database, are reported in Table 2 (Panel A).

Results were limited to peer-reviewed journal articles written in English and published between 2010 and 2025. In Scopus, the subject areas were restricted to business, management and accounting; economics, econometrics and finance; social sciences; and decision sciences. In Web of Science, the research area was restricted to business and economics. These restrictions improve relevance but may exclude studies from other disciplines and languages, a limitation that the complementary searches (Section 2.3) do not remove: they test the sensitivity of the search to terminology but apply the same language and subject-area filters. The searches returned 149 records in Scopus and 53 in Web of Science, for a total of 202 records.

Table 2. Search protocol: strings as executed (Panel A) and eligibility criteria (Panel B)

Item	Content
Panel A Scopus (main search, 23 Sept 2026; n = 149)	TITLE-ABS-KEY ("business incubat*" OR "virtual incubat*" OR "digital incubat*" OR "online incubat*" OR "e-incubat*" OR "university incubat*" OR "technology incubat*" OR "technology business incubat*" OR "startup incubat*" OR "start-up incubat*" OR "incubation program*" OR "incubation process*") AND TITLE-ABS-KEY (digital* OR virtual OR online OR "artificial intelligence" OR "information technolog*" OR ICT OR platform* OR "social media" OR "e-mentor*") AND PUBYEAR > 2009 AND PUBYEAR < 2026 AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "DECI"))
Web of Science Core Collection (main search, 23 Sept 2026; n = 53)	TS=("business incubat*" OR "virtual incubat*" OR "digital incubat*" OR "online incubat*" OR "e-incubat*" OR "university incubat*" OR "technology incubat*" OR "technology business incubat*" OR "startup incubat*" OR "start-up incubat*" OR "incubation program*" OR "incubation process*") AND TS=(digital* OR virtual OR online OR "artificial intelligence" OR "information technolog*" OR ICT OR platform* OR "social media" OR "e-mentor*"). Refined by: publication years 2010–2025; document type Article; language English; research area Business & Economics.
Complementary search (both databases, same day; n = 230 + 71)	Digital block extended to "digital transformation", digitali?ation, "digital technolog*", "digital platform*", "digital tool*", "virtual incubat*", "online incubat*", "virtual accelerat*", "online mentor*", "e-mentor*", "artificial intelligence"; support block extended to incubator*, accelerator*, "entrepreneurial support", "entrepreneurship support", "startup support", "start-up support", "business support", "science park*", "technology park*", technopole*. Same fields and filters as above.
Panel B IC1	The object of study is a business incubator (university, technology, virtual, social, corporate or other).
IC2	The study addresses digital technologies or practices adopted by or within the incubator, or the digital context shaping how incubators work.
IC3	Peer-reviewed journal article, empirical or conceptual, written in English and published between 2010 and 2025.
EC1	"Digital" refers only to the start-ups (their sector, skills or own use of digital tools), not to the incubator's practices.
EC2	The incubator is not the object of study (mentioned in passing, used only as a data source, metaphor), including accelerators without incubation framing.
EC3 / EC4 / EC5	No digital dimension / full text or sufficient information unavailable / literature review (kept aside to position the review).

Source: authors.

2.3. Complementary searches

Two complementary searches tested the sensitivity of the main string to terminology. First, a broader search run the same day combined the digital terms with alternative labels, such as accelerators, entrepreneurial support, digital platforms and online mentoring (Table 2, Panel A): of its 258 unique records, 48 had already been retrieved and 210 were screened. Second, backward citation searching (Wohlin, 2014) of 20 included studies identified 19 relevant works among 2,848 cited references, of which 17 were ineligible or already included. Two of the six reports assessed met the criteria (Figure 1). The low yield suggests that the main string captured most of the literature, but S22, labelled an "accelerator" while describing a virtual incubator, shows that terminology is a real source of omission.

2.4. Selection process

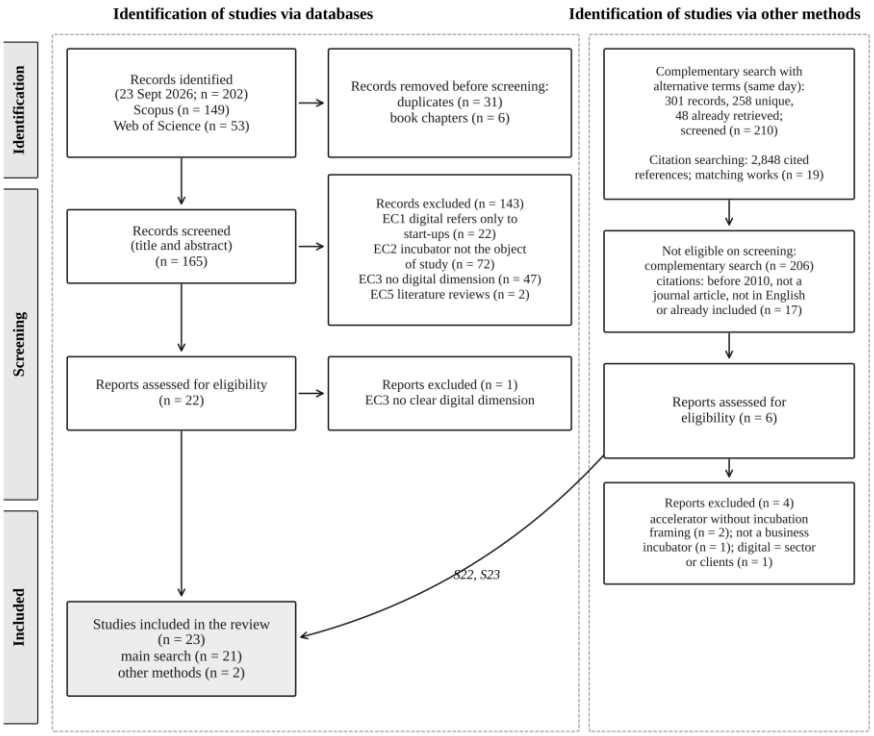
After merging the two exports, 31 duplicates were identified by matching DOIs and normalised titles and removed. Six records classified by Web of Science as book chapters were also removed, as the review was limited to journal articles. The remaining 165 records were screened on their titles, abstracts and keywords against the criteria presented in Table 2 (Panel B).

The screening excluded 143 records: 22 in which "digital" referred only to the start-ups (EC1), 72 in which the incubator was not the object of study (EC2), 47 without any digital dimension (EC3) and 2 literature reviews (EC5). Of the 22 reports assessed for eligibility, one was

excluded because its "technology support" could not be shown to refer to digital practices of the incubator (EC3). With the two studies identified by other methods (S22, S23), the final sample comprises 23 studies (Figure 1; excluded reports in Online Appendix B).

Two decision rules were made explicit. First, as the review focuses on incubation functions such as selection, support and networking, accelerator studies were eligible only if the programme was described as an incubation model or the authors extended their findings to incubators; this led to the inclusion of S4 and S22 and to the exclusion of two accelerator studies. Second, screening was performed by the first author assisted by an AI language model, which proposed a decision for each record that the author then checked. To assess reliability, a second author independently screened a stratified random sample of 33 records (20%; 5 retained and 28 excluded by the first reviewer), blind to the first decisions. The two reviewers agreed on all 33 records (agreement = 100%; Cohen's $\kappa = 1.00$; Cohen, 1960), so no disagreement had to be resolved (Online Appendix F).

Figure 1: PRISMA 2020 flow diagram of the selection process



Source: authors, based on Page et al. (2021).

2.5. Data extraction, coding and quality appraisal

A coding grid was used to extract the bibliographic information, country, type of incubator, method, digital practices, drivers and barriers, outcomes and theoretical framework of each study, following a codebook that defines each category (Online Appendix A). Each study was

assigned to the dominant family of digital practices it examines, secondary practices being recorded separately, and to the highest level of digital transformation it documents (L1 to L4, or C when only the external environment is examined), not the level it claims. Outcomes were coded by level of evidence: observed results such as use, costs or tool performance (E1), effects reported by participants or managers (E2), and measured economic effects such as revenue, innovation output, survival or funding (E3). Each study received a code (S1 to S23; Table 3). The analysis combined a descriptive analysis (RQ1) with a thematic synthesis organised according to the ADO framework (RQ2 to RQ4).

Full or partial texts were available for six studies and public descriptions for two others; the remaining fifteen were coded from their abstracts and keywords, and variables they did not report, such as the number of interviews or the theory used, were coded as "not reported" rather than inferred (Online Appendix C).

The quality of the empirical studies was appraised with the Mixed Methods Appraisal Tool (MMAT, version 2018), which provides five criteria for each type of design (Hong et al., 2018); conceptual and design studies, which it cannot appraise, were given the lowest evidential weight. Rather than a single score, which the MMAT discourages, each study received an evidential weight: high when at least four criteria were met, moderate when three were met, low when two or more were not met, and unclear when three or more could not be assessed, lowered by one level when the authors declared an involvement in the case studied (Online Appendix D). Conclusions resting only on studies of unclear weight are presented as tentative, and three sensitivity analyses test their dependence on the accelerator studies, on abstract-based coding and on quality (Online Appendix E). An AI language model (Claude, Anthropic) also assisted extraction, appraisal and the drafting of this revision; all outputs were checked by the authors, who remain responsible for the content.

3. Descriptive results

3.1. Evolution of publications

The 23 studies span the period 2013–2025 (Table 3). Before 2020, the topic attracted only sporadic attention (one study each in 2013, 2018 and 2019); after the COVID-19 pandemic, publications increased, and 14 studies (61%) were published between 2023 and 2025. This suggests a growing interest in digital incubation, but with only 23 studies the trend should be read with caution, as it may also reflect the growth of indexed journals and the restrictions of the search.

3.2. Sources and geographical contexts

The 23 studies were published in 20 different journals. Only three journals published two studies each: *Technovation*, *Sustainability* and *Environmental Science and Policy*. The dispersion of outlets, spanning entrepreneurship, management, education, environmental policy and information systems, indicates that no research community has yet been organised around the topic.

Geographically, Europe accounts for seven studies (30%) and Asia for six (26%). The Asian studies come from Indonesia (three), China (two) and Thailand (one), and the European studies from Poland, Italy, Portugal, Hungary, Sweden, Switzerland and France. North America and Africa account for two studies each, four studies cover several countries, and two do not state their context in the information available. No study in the corpus was conducted in North Africa or the Middle East; this absence may partly reflect the restriction to English-language publications, since research on the region is also published in French and Arabic.

3.3. Methods, incubator types and theories

Qualitative designs dominate the sample, with 13 studies (57%), most of them single or multiple case studies. Five studies are quantitative, four are conceptual or design-oriented, and one combines machine learning with interviews. University or education-based incubators are the most studied type (eight studies), followed by incubators operating mainly at a distance (seven), technology business incubators (two) and other or general incubators (six). Table 3 presents the included studies.

These distributions differ across contexts. None of the thirteen qualitative studies reports an Asian context (two do not state their context), whereas the six Asian studies are quantitative or design-oriented: three Indonesian studies design or test digital incubation systems (S1, S13, S14), and two Chinese studies use national panels of technology business incubators (S15, S19). Operating virtual incubators have been studied mostly in programmes run from Europe or North America (S5, S12, S16, S18, S22, S23), so the evidence on virtual incubation comes mainly from high-income countries.

Table 3. Overview of the 23 included studies

Code	Study	Country	Incubator type	Method	Practice	Level	Evid.	Weight
S1	Patmanthara et al. (2025)	Indonesia	University / education	Quantitative	Virtual incubation	L2	E2	U
S2	Berniak-Woźny et al. (2025)	Poland	Other / general	Conceptual	Digital tools	L2	–	NA
S3	Tsukanova et al. (2025)	Not stated	University / education	Qualitative	Digital tools	L2	E2	U
S4	Giuggioli et al. (2025)	Italy	Other / general	Mixed	AI	L2	E1	M
S5	Nafari et al. (2024)	Canada (intl.)	University / education	Qualitative	Virtual incubation	L4	E1, E2	M
S6	Sawasdee et al. (2023)	Thailand	Other / general	Quantitative	AI	L2	E2	U
S7	Vaz et al. (2023)	Portugal	Virtual / online	Qualitative	Virtual incubation	L3	E2	H
S8	Oyedele et al. (2023)	Several (developing)	University / education	Qualitative	Virtual incubation	L3	E2	U
S9	Tóth-Pajor et al. (2023)	Hungary	University / education	Quantitative	Virtual incubation	L3	E2	U
S10	Chan et al. (2022)	Canada	University / education	Qualitative	Digital tools	L2	E2	U
S11	Lose & Khuzwayo (2021)	South Africa	Other / general	Qualitative	Digital tools	L1	E2	U
S12	Mvulirwenande & Wehn (2020)	Africa (Dutch prog.)	Virtual / online	Qualitative	Virtual incubation	L3	E2	U
S13	Halim et al. (2020)	Indonesia	University / education	Conceptual	Virtual incubation	L1	–	NA
S14	Persada et al. (2019)	Indonesia	Virtual / online	Conceptual	Virtual incubation	L2	–	NA
S15	Feng et al. (2025)	China	Technology business	Quantitative	Digital environment	C	E3	M
S16	Bialski et al. (2025)	Switzerland	Virtual / online	Qualitative	Virtual incubation	L3	E2	M
S17	Almansour (2024)	Not stated	University / education	Qualitative	Digital tools	L2	E2	U
S18	Lemaire et al. (2023)	France	Virtual / online	Qualitative	Virtual incubation	L3	E2	U
S19	Chen et al. (2023)	China	Technology business	Quantitative	Digital environment	C	E3	U
S20	Lose et al. (2020)	International	Other / general	Qualitative	Drivers (COVID-19)	L2	–	U
S21	Ariza-Montes & Muniz (2013)	International	Other / general	Conceptual	Virtual incubation	L3	–	NA
S22	Gabrielsson et al. (2018)	Sweden	Virtual / online	Qualitative	Virtual incubation	L3	E2	U
S23	Reit (2022)	International	Virtual / online	Qualitative	Virtual incubation	L3	E2	U

Source: authors. Level: L1 digitisation; L2 digitalisation of support processes; L3 transformation of the incubation model; L4 new capabilities and value; C external environment. Evidence: E1 observed results; E2 reported effects; E3 measured economic effects; – no outcome. Weight (MMAT): H high; M moderate; U unclear; NA not appraised.

The theoretical foundations are fragmented. Only two frameworks are mobilised by more than one study: the resource-based view (S10, S15, S19) and knowledge transfer (S18, S23). Other studies draw on legitimacy theory (S5), technology acceptance (S6), impression management and emotional contagion (S4), resource dependence (S8), the triple helix (S14), innovation systems (S12), open innovation and network theory (S22) and science and technology studies (S16). Several studies do not rely on an explicit theoretical framework. This fragmentation is typical of an emerging field in which empirical exploration precedes theory building.

3.4. Levels of digital transformation and quality of the evidence

Coding the highest level of digital transformation documented in each study (Table 3) shows two studies at L1, nine at L2 and nine at L3. Only one documents new capabilities and entrepreneurial value (L4): the international virtual incubator of Nafari et al. (2024), which reached new groups of entrepreneurs and helped its university obtain new funding and partners. Two studies concern the digital environment (C). Being virtual does not imply a deep

transformation: virtual incubation spans all four levels, from an online administrative system (S13) to new capabilities (S5).

The quality appraisal shows a thin evidence base: one study has a high evidential weight (S7), four a moderate weight (S4, S5, S15, S16), fourteen an unclear weight, and four could not be appraised. All fourteen studies of unclear weight were coded from abstracts or public descriptions, so this rating reflects a lack of accessible information rather than demonstrated weaknesses. Recurrent weaknesses include very few successful cases (S4), single-group designs (S1) and authors' involvement in the cases studied (S5, S16).

4. Thematic synthesis

4.1. Antecedents: why incubators digitalise, and what holds them back

4.1.1. Drivers

The COVID-19 pandemic is the most frequently cited driver. Lose et al. (2020) identify technological adoption as one of six determinants of successful incubation during and after the pandemic, and several programmes were created in direct response to it, such as a university virtual incubator for marginalised entrepreneurs (Nafari et al., 2024), a classroom-run virtual incubator (Oyedele et al., 2023) and an online incubation platform in higher education (Tóth-Pajor et al., 2023). During the crisis, incubators also moved their support online and used social media to promote their incubatees (Chan et al., 2022), and virtual solutions gained importance (Reit, 2022).

The low cost and wide reach of digital tools constitute a second driver. Chan et al. (2022) emphasise that the technologies used by university incubators are inexpensive and readily available, and Nafari et al. (2024) report a cost of about US$150 per participant for a six- to twelve-week virtual programme, compared with annual budgets exceeding one million dollars for many physical incubators. Virtual incubation is also presented as a way to remove geographical barriers and reach entrepreneurs in distant or peripheral areas (Mvulirwenande & Wehn, 2020; Vaz et al., 2023).

A third driver is the policy and economic environment: government support for the digital economy in Indonesia (Halim et al., 2020), regional digital-economy development and digital inclusive finance in China (Chen et al., 2023; Feng et al., 2025) and, in complex sectors such as water, the need to organise public and private actors at a distance (Gabrielsson et al., 2018). Finally, several studies pursue an inclusion objective, presenting digital incubation as a way to reach immigrant, refugee or low-income women (Nafari et al., 2024), communities in

developing countries (Oyedele et al., 2023) or social entrepreneurs (Ariza-Montes & Muniz, 2013).

4.1.2. Barriers

The review also reveals significant barriers. The first is the under-use of available technologies: Chan et al. (2022) find that digital tools are important for incubation processes but remain underutilised, and Berniak-Woźny et al. (2025) identify the integration of Industry 5.0 technologies as an area for improvement in the incubator they assess. The second is the weakening of interpersonal ties. Entrepreneurs supported by a university incubator report that online elements reduce face-to-face interaction (Tsukanova et al., 2025), and incubator managers in Portugal recommend at least one physical event per year to maintain durable relationships (Vaz et al., 2023).

A third group of barriers concerns access and diversity. Participants in a virtual incubator lacked phones or mobile data, which the incubator had to finance, and language differences required multilingual content (Nafari et al., 2024). Virtual incubators recruiting internationally also face legal, tax and cultural differences between countries and must screen out applicants seeking only tax benefits or visas (Vaz et al., 2023). In an international virtual incubator, low engagement and heterogeneous contexts also hinder knowledge transfer between the incubator and its incubatees (Reit, 2022). Finally, AI-based tools raise ethical concerns, including possible bias against some demographic groups and risks for the privacy of applicants (Giuggioli et al., 2025).

4.2. Decisions: the digital practices of incubators

The digital practices identified in the literature can be grouped into three families, which differ in the degree to which digital technologies replace or complement physical incubation.

4.2.1. Fully virtual incubation

Fully virtual incubation is the most studied practice, addressed by thirteen studies. Some propose conceptual models or prototypes. Persada et al. (2019) design an e-incubator system based on the triple helix model, and Halim et al. (2020) propose a four-stage framework in which an online system supports enrolment, the submission of business plans and the monitoring of incubatees. Vaz et al. (2023) co-create with 23 incubator managers and founders a virtual incubator model with eight dimensions, from the purpose of the incubator to onboarding, mentoring, networking and the choice of digital tools.

Other studies examine virtual incubators in operation: the VIA Water programme in African cities (Mvulirwenande & Wehn, 2020), a university-based virtual incubator for marginalised women in several countries (Nafari et al., 2024), a French digital incubator for nascent women entrepreneurs (Lemaire et al., 2023), a Swiss online incubator running remote hackathons for climate start-ups (Bialski et al., 2025), a Swedish network-centred water incubator without a physical site (Gabrielsson et al., 2018) and an international virtual incubator transferring knowledge remotely (Reit, 2022). Education-based variants include web-based platforms for students (Patmanthara et al., 2025; Tóth-Pajor et al., 2023) and a classroom-run virtual incubator across borders (Oyedele et al., 2023). “Virtual” may thus refer either to digital delivery (S5, S18) or to a network-based model in which digital tools are not described (S22), which supports the distinction made in Section 1.2.

4.2.2. Digital tools in incubation processes

A second family concerns physical incubators that integrate digital tools into their existing processes. The most detailed study examines how social media, mobile, analytics and cloud technologies support the three core activities of Canadian university incubators: the search and selection of incubatees, business support and networking (Chan et al., 2022). Other studies show how incubators combine online and in-person support (Tsukanova et al., 2025), use digital marketing in their training programmes (Almansour, 2024), rely on technological tools to measure their performance with a balanced scorecard (Lose & Khuzwayo, 2021), and integrate digital transformation into their contribution to smart and sustainable cities (Berniak-Woźny et al., 2025).

4.2.3. Artificial intelligence and automation

The third family, still emerging, concerns AI. Sawasdee et al. (2023) study the acceptance of a chatbot that acts as incubator staff by answering start-ups' questions and providing basic business knowledge. Giuggioli et al. (2025) analyse 294 video pitches submitted to a European accelerator with text, audio and video analysis and show that a simple machine-learning model can predict admission better than chance. Although this study concerns an accelerator, its authors explicitly extend their findings to the selection processes of incubators, which justifies its inclusion under the rule stated in Section 2.4; it is nevertheless based on only ten admitted start-ups.

4.3. Outcomes

Outcomes are reported below for incubators and for start-ups, distinguishing three levels of evidence: observed results (E1), effects reported by participants or managers (E2) and measured economic effects (E3). Table 4 summarises them. These levels are not interchangeable: favourable perceptions do not show that digitalisation improves the performance of start-ups.

Table 4. Reported outcomes by level of evidence

Level of evidence	Outcomes for incubators	Outcomes for start-ups and entrepreneurs
E1 Observed results	Cost of about US$150 per participant; cohorts, partners and grants obtained (S5). AI screening of video pitches with a balanced accuracy of 78% (S4)	Participation of marginalised entrepreneurs from several countries (S5)
E2 Reported effects	Wider recruitment and geographical reach (S7, S10); better performance measurement (S11); perceived effectiveness of virtual incubation (S12, S22)	Access to resources and networks (S3, S10); skills, confidence and motivation (S1, S5, S9); knowledge transfer (S18, S23); acceptance of a chatbot advisor (S6)
E3 Measured economic effects	None	Higher revenue (S19) and innovation output (S15) of incubated firms, associated with the regional digital economy and digital inclusive finance, not with incubators' own practices

Source: authors. No study measures the effect of incubators' own digital practices on survival, growth, funding or jobs.

For incubators, the outcome most often reported is a wider reach, described by managers (Chan et al., 2022; Vaz et al., 2023) and observed in one case at a low cost per participant (Nafari et al., 2024). Digital tools are reported to improve performance measurement (Lose & Khuzwayo, 2021), and an AI model predicted admission decisions better than chance (Giuggioli et al., 2025), which suggests, but does not show, faster and more consistent selection. For start-ups, gains in networks, skills, confidence and motivation rest mostly on participants' accounts (Nafari et al., 2024; Tóth-Pajor et al., 2023; Tsukanova et al., 2025) and on one pre–post comparison without a control group (Patmanthara et al., 2025). The only measured economic effects come from associational studies of the external digital environment in China, linked to higher revenue (Chen et al., 2023) and innovation output (Feng et al., 2025) of incubated firms. Outcomes also depend on context. The benefits of knowledge transfer in a digital incubator vary with the education level and prior experience of entrepreneurs (Lemaire et al., 2023); virtual incubators cannot perform all the functions of local innovation systems and should be combined with locally embedded support (Mvulirwenande & Wehn, 2020); the perceived effectiveness of a network-based virtual incubator depends on the stage of the firms and on their proximity to its network (Gabrielsson et al., 2018); and the effect of digital finance varies across regions and incubator types (Feng et al., 2025). Some studies also adopt a critical perspective, showing that data-driven, agile incubation can reduce complex problems to questions of efficiency (Bialski et al., 2025).

The nature of the evidence calls for caution. Most outcomes are perceptions collected in single case studies, measured shortly after the programmes, and only five studies have a moderate or high evidential weight. The only studies that measure economic outcomes concern the external digital environment in China rather than the digital practices of incubators themselves. The effect of digital incubation on the survival and growth of start-ups therefore remains untested.

5. Discussion and research agenda

5.1. Tensions and divergences in the literature

Beyond its convergent findings, the literature contains four tensions. The first opposes reach and relational depth: studies of virtual incubators emphasise reach and low costs (S5, S7, S12), whereas entrepreneurs report weaker interpersonal ties with online support (S3) and managers recommend regular face-to-face events (S7). The two findings are compatible only if the relational component of incubation is a resource that digital tools do not easily replace.

The second tension opposes technologies and capabilities: inexpensive tools are underused (S10), advanced technologies remain an area for improvement even in a digitally committed incubator (S2), and the AI tool of Giuggioli et al. (2025) has not been tested in a real selection committee; the bottleneck lies in organisational capabilities rather than in access to technology.

The third opposes access and performance: several studies assess programmes through participation, satisfaction or perceived benefits (S1, S6, S9, S12), not their effect on the survival, growth or funding of start-ups.

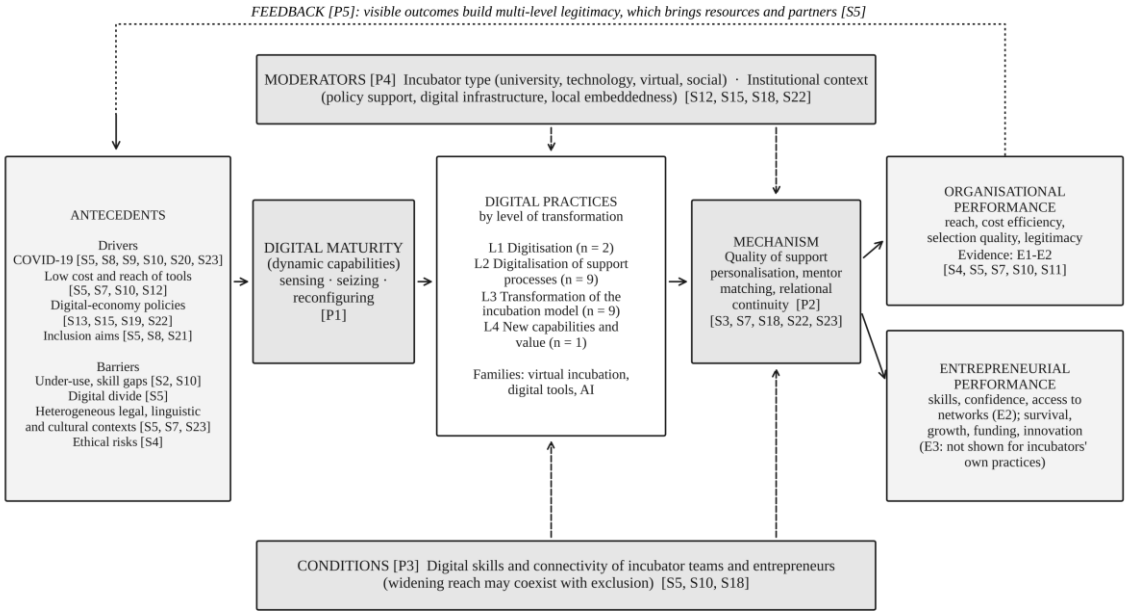
The fourth tension opposes efficiency and inclusion. Digital incubation is presented as a means to reach marginalised entrepreneurs (S5, S8, S21), but access depends on phones, data and language (S5), educated entrepreneurs seem to benefit most from online knowledge transfer (S18), and heterogeneous contexts hinder it (S23): widening reach and reproducing exclusion can occur together. Moreover, while most studies are optimistic, an ethnography of an online incubator warns that data-driven methods can reduce complex problems to questions of efficiency (S16).

5.2. An explanatory framework and propositions

Figure 2 turns these findings into an explanatory framework. Its starting point is that digital transformation is a continuum: physical incubators digitalise their processes, virtual incubators transform their delivery model, and AI tools can be added in both cases. The recurrent findings that online support weakens personal relationships (Tsukanova et al., 2025; Vaz et al., 2023) and that virtual incubators need local anchoring (Mvulirwenande & Wehn, 2020) suggest that

hybrid models, combining digital reach with occasional physical interaction, may be the most effective configuration, although they have rarely been studied as such.

Figure 2. Explanatory framework of the digital transformation of business incubators



Source: authors. P1–P5 refer to the propositions in Section 5.2; codes refer to the studies listed in Table 3.

The framework combines the two theoretical lenses presented in Section 1.3 and adds three elements that a descriptive ADO classification lacks: an explanatory variable (digital maturity), a mechanism (the quality of support) and contingencies (conditions and moderators). It also separates organisational from entrepreneurial performance and includes a feedback loop. Five propositions summarise it.

P1. Digital maturity, understood as the incubator's dynamic capabilities to sense, seize and reconfigure digital opportunities, explains why incubators with access to similar and inexpensive tools reach different levels of digital transformation (S2, S10; Warner & Wäger, 2019).

P2. The effect of digital practices on entrepreneurial outcomes is mediated by the quality of support (personalisation, mentor matching and relational continuity) rather than produced by the technology itself (S3, S7, S18, S22, S23).

P3. The digital skills and connectivity of incubator teams and entrepreneurs condition the effectiveness of digital practices; where they are weak, digitalisation widens reach while excluding the least equipped entrepreneurs (S5, S10, S18).

P4. The incubator type and the institutional context, including policy support, digital infrastructure and local embeddedness, moderate the relationships between digital practices, the quality of support and outcomes (S12, S15, S18, S22).

P5. Visible organisational outcomes build multi-level legitimacy for digital and virtual incubation models among entrepreneurs, funders and partners, which brings resources that strengthen digital maturity in turn (S5; Bitektine & Haack, 2015).

In answer to the central question of this review, digitalisation has mainly changed how incubators deliver their services (L2 and L3); evidence that it strengthens their capacity to create entrepreneurial value (L4, E3) is limited to one case and to studies of the external environment. The propositions specify the conditions under which this capacity could emerge and can be tested empirically.

5.3. Research agenda

The review points to five priorities for future research, summarised in Table 5.

Table 5. Research agenda

Theme	Gap identified	Example research questions
Performance and measurement	No study measures the effect of incubators' own digital practices on start-up survival, growth or funding; organisational and entrepreneurial performance are rarely distinguished.	Do start-ups supported by virtual, hybrid or physical incubators perform differently, other things being equal?
Hybrid models	Hybrid incubation is recommended but rarely studied.	Which combination of online and face-to-face services best supports learning and networking (P2)?
Artificial intelligence	Only two studies, mostly on selection; organisational adoption untested.	How do selection committees use AI, and how can bias and data risks be controlled?
Context	No study in the corpus covers North Africa or the Middle East; evidence on virtual incubation comes mostly from programmes designed in high-income countries.	How do Moroccan and other North African incubators digitalise, and with what constraints (P3, P4)?
Theory	Theoretical frameworks are fragmented or absent.	Do digital maturity (P1) and legitimacy (P5) explain differences in incubators' digital trajectories?

Source: authors.

Two priorities deserve emphasis. First, performance should be measured with indicators that separate organisational performance (reach, cost per participant, selection quality) from entrepreneurial performance (survival, growth, funding, innovation), using longitudinal, comparative or quasi-experimental designs that compare virtual, hybrid and physical incubators and a measure of digital maturity. Second, research should extend to under-represented contexts, including work published in French and Arabic: the absence of studies from North Africa and the Middle East is striking, given the strong demand for entrepreneurial support and the uneven digital infrastructure of these regions.

5.4. Managerial implications

Table 6 translates the findings into a decision grid for incubator managers, distinguishing for each activity what can largely be delivered online, what requires substantial human presence and what can be automated under conditions. Derived from the reviewed studies, it is a set of hypotheses to adapt to each context rather than a validated standard.

Table 6. Decision grid for the digitalisation of incubation activities

Activity	Can largely be delivered online	Requires substantial human presence	Can be automated under conditions	Studies
Information, applications, administration	Online forms, document submission, progress tracking	Limited	Routine processing and reminders, if personal data are protected	S7, S13, S14
Selection	Online calls, social media outreach, video interviews	Assessment of motivation and fit; final decision	AI pre-screening as decision support only, with a human final decision and a right to contest	S4, S7, S10
Training and knowledge transfer	Asynchronous modules, webinars, online platforms	Adaptation to entrepreneurs' education and context	Chatbots for frequent questions and basic knowledge	S1, S6, S7, S9, S18, S23
Mentoring and coaching	Remote sessions once trust is established	Mentor matching and relationship building	Scheduling only	S5, S7, S18
Networking and community	Online communities, virtual demo days	Periodic face-to-face events (at least once a year)	Not applicable	S3, S7, S10, S16
Monitoring and measurement	Digital data collection and dashboards	Interpretation and feedback	Computation of indicators	S9, S11

Source: authors, based on the studies cited.

AI-assisted selection requires specific safeguards: AI outputs should support, not replace, selection committees; applicants should be told that AI is used and on which criteria; their data should be minimised, secured and processed under applicable rules, such as Law 09-08 in Morocco (Royaume du Maroc, 2009) or, for applicants in the European Union, the General Data Protection Regulation, which grants a right to human intervention and to contest decisions based solely on automated processing (European Parliament & Council of the European Union, 2016, Art. 22); and models should be audited regularly for bias related to gender, accent or appearance, a risk explicitly identified by Giuggioli et al. (2025).

Conclusion

This article has reviewed the literature on the digital transformation of business incubators. The analysis of 23 studies published between 2013 and 2025 shows a young and growing field, accelerated by the COVID-19 pandemic and dominated by qualitative case studies of university and virtual incubators. Three families of practices emerge: fully virtual incubation, digital tools integrated into incubation processes, and AI. They are reported to extend incubators' reach, reduce their costs and improve start-ups' access to resources, but also to weaken interpersonal ties, expose incubators to the digital divide and raise ethical questions. Most studies document changes in how support is delivered; evidence that digitalisation strengthens incubators' capacity to create entrepreneurial value remains scarce.

The article contributes in three ways: a quality-appraised synthesis that distinguishes four levels of transformation and three levels of evidence; an explanatory framework and five propositions grounded in dynamic capabilities and legitimacy theory; and a research agenda. Its originality lies less in the classification of practices, which confirms earlier observations, than in this explanatory and evidential reading of the literature.

The practical implications are detailed in Section 5.4: digital tools can widen reach and improve processes if they are combined with personal interaction, adapted to entrepreneurs' skills and access, placed under human oversight for AI and, for policymakers in emerging economies, backed by connectivity and local anchoring.

The review has several limitations. First, it relies on two databases, on restricted subject areas and on articles in English; the complementary searches added only two studies, but non-English research is likely to be under-represented, which may explain part of the absence of studies from North Africa and the Middle East. Second, screening was carried out by a single reviewer assisted by an AI model; the reliability check, which showed full agreement on a 20% sample, reduces but does not eliminate the risk of classification errors in the records screened by one reviewer only. Third, fifteen studies were coded from their abstracts, so their barriers, methods and theories are probably under-reported. The sensitivity analyses (Online Appendix E) show that the typology and main barriers and outcomes hold for the eight studies read in full, in part or through public descriptions; that, among the five studies of moderate or high weight, conclusions on skills, motivation and acceptance become tentative; and that removing the two accelerator-labelled studies (S4, S22) mainly weakens the evidence on AI-assisted selection. Finally, the small sample makes the descriptive trends exploratory.

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