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Assessing the Evidence Connecting Digital Adoption to Durable SME Development through an Umbrella Review of Productivity, Capability Accumulation, and Ecosystem Dependence

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Abstract

Digital adoption is widely associated with improved SME performance, yet immediate operational gains do not establish durable development. This umbrella review examines whether digitalization translates into persistent SME development through three interconnected domains: productivity conversion, capability accumulation, and ecosystem dependence. Four structured search families and supplementary citation tracing identified 52 records; after deduplication, screening, retrieval, and full-text assessment, 15 review-level evidence units were included. Evidence indicates that digital adoption can improve productivity, innovation, market participation, resilience, and sustainability-related outcomes, but these benefits are conditional. Durable effects depend on whether firms convert technology into reusable organizational capabilities and whether external platforms, knowledge networks, infrastructure, and institutional complements remain usable without creating excessive dependence. The synthesis therefore supports a conditional relationship: digital adoption contributes to durable SME development when short-term gains are accompanied by capability accumulation, adaptable organizational routines, and sustainable ecosystem access.

Keywords Business ecosystems, Dynamic capabilities, Productivity, SME digital transformation, Digital adoption, Sustainable SME development

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Introduction

Digital transformation research increasingly treats technology adoption as an organizational phenomenon rather than as a discrete investment decision. Vial conceptualizes digital transformation as a process in which digital technologies generate disruptions that provoke strategic responses, alter value-creation paths, and interact with structural constraints [1]. Verhoef similarly distinguishes digitization and digitalization from broader transformation, emphasizing that the latter alters organizational capabilities, structures, and market relationships rather than merely converting information or individual processes into digital form [2]. This distinction is particularly important for small and medium-sized enterprises, because adoption can occur without producing durable organizational change.

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The wider transformation literature reinforces this concern. Hanelt *et al.* show that digital transformation is embedded in strategy, organizational change, and environmental interaction rather than reducible to technological acquisition [3]. Nadkarni and Prügl likewise identify multiple actor- and technology-related dimensions, with substantial variation in the organizational mechanisms through which transformation occurs [4]. These syntheses make a direct inference from "more digital technology" to "more development" difficult to sustain without specifying the intervening organizational conditions.

For SMEs, the problem is intensified by resource scarcity and managerial concentration. Li *et al.* show that digital transformation among SME entrepreneurs can depend on the accumulation of cognition, social capital, team capabilities, and organizational routines rather than on platform access alone [5]. Eller *et al*. similarly find that digitalization is associated with performance while also showing that human, strategic, and technological resources shape the extent to which digitalization is realized [6]. Adoption therefore represents only one part of a broader conversion process.

Evidence on dynamic capabilities provides a mechanism for understanding that conversion. Strategic renewal requires continuing sensing, seizing, and reconfiguration, while SME digital-strategy alignment develops through managerial and organizational microbehaviours rather than through a single implementation event. Customer-value creation can also require corresponding changes in business models and organizational routines [7–9]. These findings imply that a technology may produce a useful short-run outcome without leaving behind the capability required to sustain that outcome when markets, platforms, technologies, or competitive conditions change.

Existing review evidence already demonstrates that the SME digitalization literature is broad but fragmented. Ramdani *et al.* identify a large body of digital-innovation research spanning antecedents, capabilities, and outcomes [10], whereas Ghobakhloo *et al*. show that manufacturing-SME adoption of Industry 4.0 technologies depends on combinations of technological, organizational, and environmental drivers and barriers [11]. What remains less settled is whether these different strands collectively justify the stronger proposition that digital adoption produces durable SME development.

An umbrella review is appropriate because the analytical problem concerns the relationship among existing syntheses rather than the aggregation of one homogeneous primary-study effect. Review methodology must therefore preserve design differences, contradictions, and contextual boundaries while documenting how evidence was identified and appraised. The present review uses explicit review-design, reporting, and appraisal principles to distinguish evidence selection from interpretation and to prevent bibliography size, journal prestige, or repeated primary studies from being treated as evidence of greater certainty [12–14].

The review asks whether the existing synthesis literature establishes a durable link between digital adoption and SME development when three conditions are examined jointly: conversion into productive outcomes, accumulation of reusable capabilities, and dependence on external ecosystems. Durability is treated as a temporal and organizational property of the resulting development trajectory, not as a synonym for initial technology uptake or a one-period improvement in performance.

Digital Adoption and the Meaning of Durable SME Development

The SME literature contains several partially overlapping definitions of transformation. Bibliometric evidence shows that digital technologies, organizational capabilities, management practices, and business-model change have become increasingly intertwined within the SME transformation field [15]. A systematic review of technological transformation likewise finds that the literature has concentrated heavily on antecedents, drivers, and implementation while devoting comparatively less attention to transformation outcomes and to the persistence of those outcomes [16]. This imbalance matters because an enterprise can introduce digital tools, improve a particular process, and still remain unable to reproduce the resulting gains when technologies, markets, partners, or decision requirements change.

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In this review, digital adoption denotes the introduction and organizational use of digital technologies, digitally mediated practices, or digitally enabled processes. Durable SME development denotes improvement that extends beyond the immediate adoption event and is supported by organizational conditions that can persist, adapt, or be redeployed. Three analytical dimensions are therefore distinguished. Productivity conversion concerns whether adoption produces measurable operational, innovative, market, survival, or sustainability-related gains. Capability accumulation concerns whether firms acquire reusable knowledge, routines, managerial competence, analytical capacity, absorptive capacity, or dynamic capabilities. Ecosystem dependence concerns the extent to which realized outcomes depend on platforms, infrastructure providers, knowledge intermediaries, collaborators, financiers, public institutions, or other external complements.

Durability adds a temporal criterion to these dimensions. A short-run efficiency gain may represent successful adoption without constituting durable development if the capability that generated it is non-transferable, the firm cannot reproduce the gain after environmental change, or the outcome depends on an external relationship that the SME cannot meaningfully control. Conversely, external dependence is not inherently detrimental: ecosystems can supply knowledge, infrastructure, data, market access, and complementary expertise that would be inefficient for smaller firms to internalize. The analytical question is therefore whether adoption creates a development trajectory that remains productive, learnable, and adaptable under changing organizational and ecosystem conditions.

Umbrella Review Methodology

The study was designed as an umbrella review in which the principal evidence units were eligible review and synthesis articles addressing SME digitalization, transformation, digital innovation, Industry 4.0, digital sustainability, resilience, or closely related constructs. The purpose was not to pool heterogeneous primary-study effect estimates but to compare what existing reviews establish, where their conclusions converge, and where different definitions, methods, contexts, or periods produce incompatible interpretations. Reporting followed transparent review-selection principles, while methodological appraisal used review-quality domains adapted to the management literature [12–14].

Review Questions and Parameters

The review population comprised SMEs and MSMEs, including studies in which SME evidence was separately extractable from broader organizational samples. Eligible exposures included digital adoption, digitalization, digital transformation, digital innovation, Industry 4.0 technologies, advanced digital systems, and digitally enabled business-model change.

Four review questions guided extraction. First, what evidence links digital adoption to productivity, performance, innovation, trade, resilience, or other developmental outcomes? Second, what organizational capabilities accumulate during transformation and remain reusable beyond a single technological intervention? Third, which outcomes depend on external platforms, networks, knowledge intermediaries, infrastructure, or institutional support? Fourth, what evidence indicates persistence, adaptation, resilience, or deterioration over time?

Review eligibility was determined by these substantive and methodological parameters. Journal quartile was not used to decide whether a review belonged in the umbrella evidence set.

Search for Eligible Reviews

The search was executed on 3 October 2026 using four structured query families designed to capture overlapping but conceptually distinct parts of the SME digital-transformation literature. The search strings were: "small and medium enterprises" "digital transformation" "systematic review"; "SME" digitalization "systematic literature review" performance capabilities; "SME" "digital transformation" review ecosystem sustainability resilience; and "SME" "digital innovation"

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systematic review "Industry 4.0". The four routes returned 14, 12, 12, and 12 records, respectively. Two additional records were identified through citation chaining and publisher-level verification of high-relevance review articles.

The resulting 52 records were stored as title, source, year, and DOI-level records where available. Deduplication was performed first by DOI and then by normalized title comparison. Twenty duplicate or alternate-page records were removed, leaving 32 unique records for title and abstract screening.

The search and selection process deliberately separated retrieval from evidentiary judgment. Review articles were not excluded because they appeared in non-Q1 outlets, nor were high-prestige publications included merely because of journal status. Selection was determined by the review question and the extractability of relevant SME-level evidence.

The executed design is summarized in **Table 1.**

Table 1. Search and selection variables used to distinguish retrieval, eligibility, and review-level evidence status

Review-design element	Executed specification	Analytical role in this umbrella review
Search population	SMEs/MSMEs and separately extractable SME evidence	Prevents extrapolation from large-firm transformation evidence
Digital exposure	Digital adoption, digitalization, digital transformation, digital innovation, Industry 4.0, advanced digital systems	Captures alternative terminology for comparable transformation processes
Development outcome	Productivity, performance, innovation, market participation, resilience, sustainability, capability formation	Prevents adoption from being treated as the outcome itself
Durability dimension	Persistence, adaptation, capability reuse, resilience, repeated transformation, long-horizon development	Distinguishes one-period gains from durable development
Ecosystem dimension	Platforms, knowledge brokers, networks, collaborators, infrastructure, institutions	Identifies outcomes that depend on external complements
Screening unit	Review or synthesis report	Maintains umbrella-review design
Q1 status	Not used for evidence eligibility	Prevents journal prestige from substituting for evidence quality
Appraisal basis	Search transparency, eligibility clarity, extraction logic, synthesis transparency, limitation reporting	Evaluates review usefulness without imposing a false universal score

Inclusion and Exclusion Criteria

Records were eligible when they were peer-reviewed review or synthesis articles with a central focus on SMEs or with separately extractable SME evidence and when digital adoption or transformation formed a substantive analytical component. Reviews also had to report findings relevant to at least one of the four synthesis domains: productive outcomes, capability accumulation, ecosystem dependence, or temporal durability.

Records were excluded when digitalization was incidental to the principal topic, when the analytical unit was narrower than the review question without providing transferable evidence, when the publication was a book chapter or non-peer-reviewed source, when review-method status could not be established adequately, or when the record could not supply sufficient methodological information for review-level extraction.

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Of the 32 unique screened records, 10 were excluded at title or abstract stage. Twenty-two reports were sought for assessment; two could not be retrieved with sufficient methodological detail. Twenty full texts were assessed, and five were excluded because they addressed narrowly bounded digital-marketing capability, performance-measurement methodology, non-systematic narrative synthesis, circular-economy digital innovation without a sufficiently broad SME-development synthesis, or innovation-only evidence that did not support the durability and ecosystem question. Fifteen review-level evidence units remained.

Methodological Quality Appraisal

Quality appraisal emphasized methodological transparency rather than journal rank. Eight domains were examined: clarity of the review question; reproducibility of the search description; explicit eligibility criteria; transparency of selection; extractability of the coding or analytical procedure; use of evidence-quality assessment where appropriate; transparency of the synthesis procedure; and explicit acknowledgement of limitations and contextual boundaries.

The review did not apply a numerical quality score. Instead, evidence units were classified as methodologically robust or adequate for the purposes of this umbrella synthesis. Robust reviews described most critical domains sufficiently to permit replication or close reconstruction. Adequate reviews remained usable but showed weaker reporting in one or more domains, commonly quality appraisal, protocol detail, overlap assessment, or search reproducibility. AMSTAR 2 informed the principle of critical-domain appraisal but was not applied as a literal scoring instrument because the included management reviews did not share the intervention structures for which the tool was originally designed [14].

Review Overlap and Evidence Independence

The 15 included reviews were not treated as 15 statistically independent replications. Several synthesized overlapping SME transformation literatures and therefore could contain some of the same primary studies. Four broad overlap families were identified: general SME digital transformation and digital innovation; Industry 4.0 and technological adoption; sustainable digital transformation and sustainable development; and resilience or durability-oriented transformation.

A corrected covered area was not calculated because complete primary-study-by-review incidence lists were unavailable across the full evidence set. Assigning a numerical overlap coefficient without the underlying incidence matrix would create false precision. Review convergence was therefore interpreted conservatively: repeated conclusions across overlapping reviews increased the breadth of synthesis but did not multiply the effective number of independent observations.

Data Extraction, Coding, and Synthesis

Extraction was conducted at the review level. Each evidence unit was coded for review design, geographic and sector scope, organizational level, focal digital construct, outcome definition, capability mechanisms, ecosystem conditions, temporal treatment, principal findings, contradictory or null findings, limitations, and applicability boundaries.

The synthesis then mapped each review against four article-specific domains: productivity conversion, capability accumulation, ecosystem dependence, and temporal durability. Findings were treated as convergent only when substantively similar claims remained compatible after differences in review scope, sector, geography, and analytical method were considered. Contradictory evidence was retained rather than resolved by vote counting.

The article therefore uses an interpretive umbrella synthesis rather than a pooled meta-analysis. This choice reflects the heterogeneity of the review corpus: digital transformation, Industry 4.0, digital innovation, sustainability, resilience,

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business-model change, and ecosystem participation are related constructs but do not provide a commensurate effect-size base.

The complete executed selection sequence is shown in **Figure 1.**

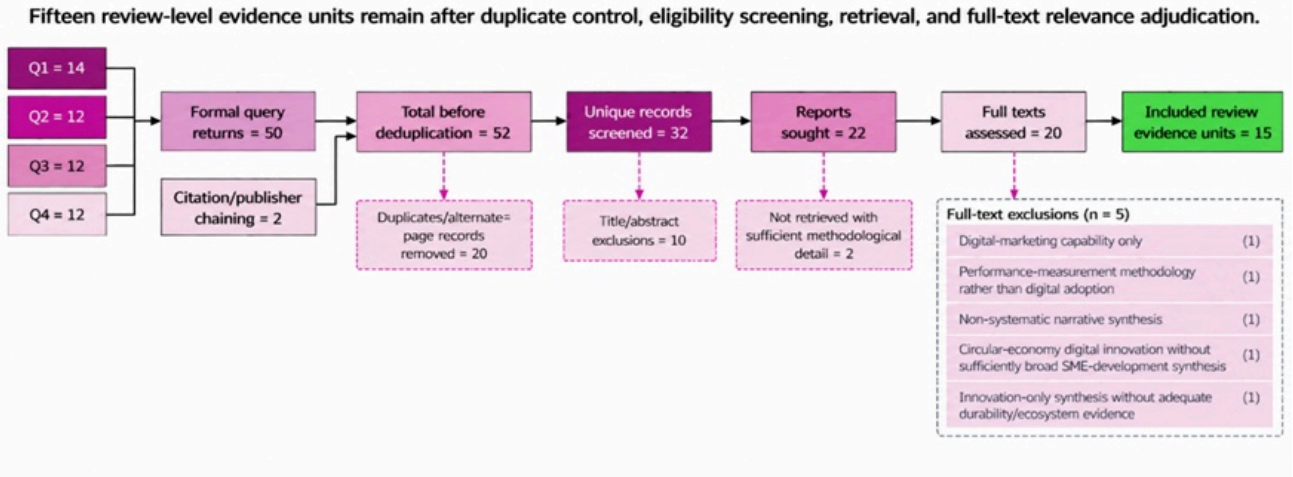


Figure 1. Fifteen review-level evidence units remain after duplicate control, eligibility screening, retrieval, and full-text relevance adjudication

Table 2 presents the analytical distinctions discussed here.

Table 2. Coding structure used to separate immediate digital outcomes from the conditions supporting durable SME development

Review-level coding unit	Productivity conversion	Capability accumulation	Ecosystem dependence	Temporal durability	Synthesis treatment
Broad SME digital transformation	Efficiency, competitiveness, innovation, market outcomes	Dynamic, managerial, learning and business-model capabilities	Platforms, infrastructure and external knowledge	Often implied more than directly measured	Separate adoption effects from organizational conversion
Industry 4.0 adoption	Production, quality, flexibility and innovation outcomes	Technical and organizational readiness	Suppliers, technology providers and institutional environment	Usually implementation-centred	Preserve technology- and manufacturing-specific boundaries
Sustainable digital transformation	Economic and environmental performance; some social outcomes	Data, analytical and strategic capabilities	Policy, infrastructure and partner ecosystems	Frequently framed as sustainability, less often tested longitudinally	Distinguish sustainability intention from demonstrated persistence
Resilience-oriented transformation	Survival, continuity and adaptive performance	Learning, reconfiguration and flexibility	External support and digital-resource access	Explicitly concerned with	Treat crisis survival as context-bounded

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				shocks or repeated adaptation	durability evidence
Business-model transformation	Revenue logic, customer value and innovation	Business-model experimentation and reconfiguration	Partners, platforms and market intermediaries	Durability depends on repeated adjustment	Separate value-creation redesign from technology acquisition
Bibliometric field evolution	Research emphasis rather than firm outcome	Reveals recurring capability themes	Reveals ecosystem and institutional themes	Tracks research evolution rather than firm persistence	Use only to map the knowledge base, not to infer effect magnitude

Review Findings

The 15-review corpus does not support a single uniform relationship between digital adoption and SME development. Reviews converge most consistently on the importance of organizational capability, contextual readiness, and complementary resources, while differing substantially in the outcomes they examine and in the time horizons they capture. General digital-transformation reviews, Industry 4.0 syntheses, sustainability reviews, resilience-oriented reviews, and bibliometric mappings therefore illuminate different parts of the same development problem rather than interchangeable measures of one effect.

Productivity Outcomes

Evidence supporting productive gains is substantial but heterogeneous. Among innovative SMEs, digital transformation is associated with performance partly through business-model innovation, indicating that technology contributes to performance when it alters how firms create or appropriate value rather than functioning as an isolated input [17]. Digitalization is also associated with stronger trade participation among SMEs, consistent with mechanisms involving productivity, information access, and reduced transaction frictions [18]. Management-control evidence similarly associates digitalization with improved communication, monitoring, and organizational performance in the studied firms [19].

These positive results do not imply monotonic improvement. Digital orientation can exhibit a U-shaped association with performance, suggesting that intermediate stages of digital commitment may impose coordination, investment, and learning costs before capabilities become productive [20]. A theoretical synthesis of incumbent SME competitiveness likewise argues that digital transformation may operate both as an antecedent and as a consequence of competitiveness, making causal ordering sensitive to the organizational starting point [21].

Advanced digital technologies provide additional evidence of heterogeneity. AI and robot adoption among European SMEs is associated with several forms of innovation, but effects vary across firm and sector conditions [22]. During the COVID-19 shock, diversification of digital-tool use was associated with stronger SME survival, although the same evidence cannot establish that crisis-period resilience translates directly into persistent normal-period growth [23]. Productivity conversion is therefore credible, but its strength and persistence depend on the mechanism through which adoption becomes embedded in the organization.

Capability Accumulation

Capability accumulation provides a stronger explanation for why similar digital investments can produce different developmental trajectories. Absorptive capacity strengthens the relationship between digital diffusion and product innovation in German SMEs, but equivalent moderation is not observed uniformly across all innovation outcomes [24].

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This selective effect indicates that learning capacity matters, while also cautioning against treating any single capability as a universal multiplier.

External knowledge arrangements can compensate for internal scarcity. Regional knowledge brokerage can support digital transformation by building trust, strategic alignment, and access to specialized resources that MSMEs cannot efficiently maintain in-house [25]. Configurational evidence reaches a complementary conclusion: several different combinations of technological, organizational, and environmental conditions can produce successful transformation, which is inconsistent with a single necessary sequence of readiness factors [26]. Open-innovation evidence similarly shows that SMEs can use external resources to accelerate transformation when those resources are accompanied by internal reconfiguration [27].

Managerial capabilities constitute another layer. CEO digital expertise, external connectivity, and leadership capabilities are associated with transformation and subsequent new-product-development performance among innovative SMEs [28]. Digital leadership can also operate through big-data analytical capability and green innovation, with AI change readiness modifying parts of that relationship [29]. Organizational learning contributes to digitalization capability in Chinese SMEs, although the strength of specific capability paths varies with environmental conditions [30]. Process evidence from emerging-market SMEs further shows that barriers and capability requirements change across transformation phases, implying that capability accumulation is iterative rather than a one-time readiness state [31].

Taken together, these findings support a developmental interpretation of digitalization only when adoption leaves behind reusable organizational competence. Technology that improves one task but does not strengthen learning, managerial judgment, analytical capacity, business-model adaptability, or reconfiguration ability may produce an operational gain without generating comparable developmental durability.

Ecosystem Dependence

The third evidence domain concerns the resources that remain outside the SME. Digital technologies can strengthen sustainability-related action, but relationships differ across data-gathering, data-analysis, and data-sharing technologies and are conditioned by firm size [32]. Digital platforms also enhance collaboration, yet bilateral collaboration and wider ecosystem collaboration do not have equivalent relationships with sustainability performance [33]. These findings indicate that external digital connectivity has value only insofar as the resulting relationships provide usable complements.

Dependence can also become excessive. Digital technology network embeddedness shows an inverted-U relationship with SME growth in the relevant evidence, indicating that the benefits of connection may decline when embeddedness restricts flexibility or increases coordination and dependency costs [34]. Regional innovation ecosystems likewise require active managerial engagement: the formal presence of public or collaborative support does not ensure that SMEs can recognize, access, and convert those resources into transformation benefits [35].

The risks are not limited to weak access. Digital transformation can redistribute bargaining power and resource dependence within interorganizational systems, generating unintended consequences alongside efficiency or circular-economy opportunities [36]. AI-based transformation can similarly coexist with a digital divide when financial, infrastructural, technical, or organizational capacity is distributed unevenly across SMEs [37]. Ecosystem participation therefore cannot be treated as an unqualified complement to internal capability.

This distinction is summarized in **Table 3.**

Table 3. Ecosystem configurations through which external complements can strengthen or weaken durable SME development

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Ecosystem configuration	External mechanism	SME-owned capability required	Developmental contribution	Dependency exposure	Durability implication
Knowledge-brokered transformation	Specialist knowledge and orchestration	Absorptive capacity and strategic alignment	Faster access to missing expertise	Reliance on intermediary availability and quality	Durable only if externally accessed knowledge becomes internally usable
Platform-enabled collaboration	Data exchange, coordination and partner access	Digital integration and relationship-management capability	Broader collaboration and possible sustainability gains	Platform rules, data dependence and switching constraints	Stronger when benefits extend beyond one bilateral relationship
Digitally embedded networks	Dense technology and partner connections	Network orchestration and boundary management	Information, opportunity and market access	Overembeddedness, lock-in and coordination burden	Can weaken after an optimal range of embeddedness is exceeded
Regional innovation support	Public, academic or intermediary resources	Managerial sensemaking and active engagement	Access to infrastructure, training and innovation resources	Fragmented or poorly matched support	Formal availability does not guarantee continued practical value
Digitally reconfigured supply ecosystems	New information flows and coordination structures	Negotiation, redesign and resource-reconfiguration capability	Efficiency and circularity opportunities	Shifts in bargaining power and resource control	Gains may be offset by new structural dependence
Unequal digital ecosystems	Uneven access to AI, infrastructure, skills or finance	Adaptive resource mobilization	Transformation opportunities for capable firms	Exclusion of resource-constrained SMEs	Digitalization may widen rather than reduce developmental divergence

Temporal Durability of Reported Outcomes

Durability is the least directly established component of the literature. Family-SME evidence indicates that entrepreneurial orientation and digital transformation are conditioned by leadership structure and generational involvement, showing that governance arrangements can affect whether transformation capability persists within the organization [38]. The sustainable-development review literature also demonstrates that SME digital transformation operates across macro-, meso-, and micro-level conditions, with economic, environmental, and social outcomes that do not consistently move in the same direction [39].

Evidence on the twin digital and green transitions further illustrates why persistence cannot be inferred from adoption alone. Among UK SMEs, advanced digital technology adoption is positively associated with net-zero innovation, supporting the possibility of complementarity between digital and environmental transformation [40]. Yet such evidence

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remains dependent on the observed institutional and temporal setting and does not establish that the same relationship will persist after technology, regulation, market demand, or organizational resources change.

The temporal question is therefore not whether a digital intervention produces any positive outcome, but whether the firm can reproduce or adapt the underlying productive mechanism. Evidence of survival during disruption, repeated capability reconfiguration, continuing learning, and mutually reinforcing digital and sustainability capabilities provides stronger support for durability than a single-period improvement in output.

Convergent and Conflicting Review Evidence

The strongest convergence across the umbrella evidence is not a universal positive effect but a recurring dependence on organizational and contextual conditions. Reviews repeatedly identify technology assimilation, capability formation, business-model change, environmental support, and implementation quality as intervening factors. At the same time, outcome-focused evidence remains less developed than adoption-factor research, and sustainable-development reviews continue to identify heterogeneous effects across levels and dimensions [16, 39, 40].

Conflicting evidence appears in at least four forms. First, relationships can be nonlinear, as demonstrated by digital orientation and network embeddedness. Second, moderators can operate for some outcomes but not others, as in the selective role of absorptive capacity. Third, crisis-specific resilience evidence may not generalize to ordinary competitive conditions. Fourth, ecosystem participation can create opportunities while simultaneously increasing dependence, bargaining asymmetry, or exclusion.

These differences argue against a vote-counting interpretation in which a larger number of positive studies would automatically establish durable development. The review instead distinguishes between adoption success, productive conversion, capability accumulation, and developmental persistence. Evidence is strongest for the first two, substantial but context-dependent for capability accumulation, and comparatively thinner for long-horizon persistence.

Integrated Digital Adoption–SME Development Framework

The synthesis supports a conditional developmental sequence rather than a direct digital-adoption effect. Digital adoption creates an initial technological opportunity set: new information-processing capacity, automation, analytics, connectivity, platform access, or digitally enabled business-model options. These opportunities can generate immediate operational benefits, but their developmental significance depends on whether they are converted into productive outcomes and retained as reusable organizational capability.

The first conversion mechanism is productive realization. Adoption must improve an economically or strategically meaningful outcome—such as efficiency, innovation, market access, resilience, or sustainability-related performance—rather than remain an underutilized technological asset. Evidence that business-model innovation mediates performance and that digital orientation can have nonlinear effects shows that productive realization cannot be inferred from adoption intensity alone [17]. Firms may incur learning and coordination costs before benefits emerge.

The second mechanism is capability retention. Durable development requires part of the value created during transformation to become embedded in organizational knowledge, managerial competence, analytical capability, absorptive capacity, learning routines, or reconfiguration ability. Configurational evidence indicates that firms may reach this state through different combinations of internal and external conditions rather than through a universal maturity sequence [26]. Capability accumulation therefore concerns the organization's ability to perform future adaptation, not simply its ability to operate the current technology.

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The third mechanism is ecosystem viability. SMEs commonly rely on external infrastructure, platforms, intermediaries, networks, suppliers, and institutions because internalizing all relevant digital resources is inefficient or impossible. Such dependence can expand developmental capacity when the SME retains sufficient ability to access, recombine, and redirect those resources. It becomes fragile when external participation creates lock-in, excessive embeddedness, information asymmetry, or practical inability to change partners or technological paths [34].

Durability arises when these three mechanisms remain mutually compatible over time. Productive gains without capability accumulation are vulnerable to technological change. Capability accumulation without viable ecosystem access can be constrained by missing infrastructure, data, finance, or specialized expertise. Ecosystem access without retained internal capability can leave the SME dependent on actors whose incentives, prices, standards, or availability may change.

The framework therefore defines durable SME development as a condition in which digital adoption repeatedly generates productive value, strengthens reusable organizational capability, and preserves workable access to external complements without allowing dependence to eliminate adaptive choice. The evidence does not establish this condition as the inevitable consequence of digitalization. It identifies it as the more defensible boundary for distinguishing temporary digital success from durable development.

Discussion

The umbrella evidence changes the interpretation of a familiar proposition: that greater digital adoption promotes SME development. The reviewed literature supports a relationship, but its most defensible form is conditional. Digital technologies can improve efficiency, innovation, market participation, organizational coordination, resilience, and sustainability-oriented activity, yet these outcomes differ in their persistence and in the organizational resources required to reproduce them. Digital transformation should therefore be evaluated according to what the firm becomes able to do repeatedly, not solely according to which technologies it acquires.

This interpretation is consistent with the theoretical ambiguity identified in SME competitiveness research. Digital transformation can strengthen competitiveness, while competitive firms may simultaneously possess the resources that make transformation possible [21]. The resulting endogeneity is analytically important: high-performing SMEs may adopt more sophisticated digital technologies precisely because they already possess managerial attention, financial resources, absorptive capacity, or market position that facilitate transformation. Cross-sectional positive relationships cannot by themselves establish that adoption created those underlying advantages.

Capability evidence provides a stronger basis for developmental interpretation. Absorptive capacity changes the contribution of digital diffusion to particular innovation outcomes [24], while managerial expertise, connectivity, and leadership affect the extent to which transformation is converted into new-product-development capability [28]. Organizational learning also influences digitalization capability under different environmental conditions [30]. These findings indicate that digitalization can become cumulative when one transformation episode improves the SME's ability to undertake subsequent adaptation.

External dependence complicates this accumulation process. Knowledge brokers can expand access to specialized competencies [25], and regional innovation ecosystems can provide infrastructure and support that smaller firms could not efficiently reproduce internally [35]. However, access to an ecosystem is different from practical control over the resources obtained through it. Excessive network embeddedness may reduce growth benefits [34], while digitally reorganized interorganizational relationships can redistribute bargaining power and dependency [36]. The relevant developmental question is therefore whether ecosystem participation enlarges future strategic options or makes the SME increasingly dependent on a technological, platform, intermediary, or institutional arrangement that it cannot readily redirect.

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Temporal evidence remains comparatively limited. Digital-tool use was associated with survival during a severe external shock [23], and transformation-process research shows that capability requirements change as SMEs progress through different phases [31]. These findings support adaptation as a component of durability, but they do not justify treating every digital performance improvement as persistent. Sustainable-development reviews likewise describe economic, environmental, and social consequences that vary across levels and institutional settings [39].

The evidence consequently supports a distinction among four states. Adoption means that a digital technology or practice is introduced. Productive conversion means that the technology produces an organizationally meaningful outcome. Capability retention means that learning, routines, expertise, analytical capacity, or reconfiguration ability remain available for subsequent use. Durable development exists only when those retained capabilities can continue producing or redirecting value under changing conditions while the firm's ecosystem dependencies remain manageable.

This interpretation also explains apparent contradictions in the literature. A study showing a positive productivity effect and another showing a nonlinear or context-dependent effect need not describe incompatible realities. They may observe firms at different points in the conversion process, with different capability stocks or different external dependencies. The umbrella synthesis therefore treats heterogeneity as substantive evidence about boundary conditions rather than as statistical noise to be averaged away.

Table 4 presents the analytical distinctions discussed here.

Table 4. Evidentiary boundaries for interpreting digital adoption as durable SME development

Analytical issue	Strongest evidence-supported inference	Inference that remains unsupported	Managerial or policy significance	Research requirement
Immediate productive outcomes	Digital adoption can improve efficiency, innovation, market access, coordination, or survival in specific settings	Every adoption generates a positive or linear performance effect	Evaluate realized business outcomes rather than technology possession	Repeated outcome measurement using comparable pre- and post-adoption periods
Capability accumulation	Learning, managerial, analytical, absorptive, and reconfiguration capabilities can mediate digital benefits	Capabilities accumulate automatically from technology use	Invest in organizational learning and reusable expertise alongside technology	Longitudinal observation of capability formation and decay
Ecosystem complementarity	Platforms, intermediaries, networks, and institutions can provide resources SMEs cannot efficiently internalize	Greater ecosystem participation is always beneficial	Assess usefulness, accessibility, substitutability, and dependency of external complements	Measure ecosystem access together with switching, bargaining, and redirection capacity
Excessive dependence	Dense embeddedness or asymmetric interorganizational arrangements can reduce strategic flexibility	External dependence is inherently harmful	Preserve alternative suppliers, knowledge channels, standards, and internal absorptive capacity	Compare beneficial complementarity with lock-in and power redistribution
Temporal durability	Resilience and repeated adaptation provide stronger	Short-run performance improvement	Track whether gains can be reproduced	Multi-wave and event-based designs

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	evidence of durability than one-period performance	establishes durable development	after technological or environmental change	spanning transformation cycles
Causal interpretation	Multiple organizational and contextual mechanisms plausibly connect adoption to development	The present review establishes a single causal effect size	Match investment decisions to identifiable mechanisms and context	Stronger longitudinal, quasi-experimental, configurational, and process evidence

Managerial and Policy Implications

For SME managers, the central implication is that technology portfolios should be assessed together with the capabilities required to use, adapt, and replace them. Investments that increase digital functionality without strengthening analytical competence, organizational learning, managerial judgment, or business-model adaptability may improve current operations while leaving future adaptive capacity largely unchanged. Evidence on absorptive capacity and managerial capability supports treating these complementary resources as part of the transformation investment itself [24]. Evidence on dynamic managerial capability further indicates that transformation quality can depend on who interprets technological opportunities and how those opportunities are connected to innovation activity [28].

External resources should be evaluated in the same manner. Knowledge intermediaries and open-innovation arrangements can reduce the cost of acquiring expertise and accelerate access to complementary capabilities [25]. Yet managers should distinguish between accessing an external capability and becoming unable to operate without a particular intermediary, platform, data source, or technological relationship. The inverted-U relationship reported for network embeddedness illustrates why additional connectivity can eventually create coordination or dependency costs [34].

Policy support should therefore extend beyond incentives for acquiring digital technologies. Infrastructure, skills, knowledge intermediation, interoperable systems, finance, and usable innovation ecosystems influence whether adoption can be translated into development. Unequal access to these complements can permit digital transformation to widen differences among SMEs rather than uniformly reduce them [37]. Public programs should consequently be evaluated according to whether SMEs can practically use the support, integrate it with internal capabilities, and retain meaningful strategic alternatives after the program or intermediary is no longer available.

Sustainability policy presents a similar challenge. Digital technologies can complement environmental innovation [40], but environmentally beneficial outcomes cannot be assumed from digitalization alone. Support instruments should distinguish adoption from verified changes in production, resource use, emissions-related practices, circularity, or other sustainability outcomes.

Research Agenda

The most important unresolved issue is temporal. Much of the literature establishes adoption conditions or contemporaneous performance relationships, while substantially fewer studies observe whether resulting capabilities and outcomes remain effective through subsequent technological, competitive, regulatory, or organizational change. Future work should follow SMEs through multiple transformation episodes and distinguish capability creation, capability reuse, capability erosion, and capability substitution.

Research should also measure external dependence more directly. Ecosystem participation is commonly represented through networking, collaboration, platform use, or institutional support, but these indicators reveal relatively little about substitutability. Future designs should examine whether SMEs can change providers, transfer data, retain expertise,

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substitute technologies, renegotiate terms, or continue operating when a critical external complement changes. Such measures would distinguish productive ecosystem participation from structural dependency.

Configurational research is particularly promising because successful digital transformation can arise from different combinations of technological, organizational, and environmental conditions [26]. Instead of searching for one universal sequence of digital maturity, future studies should identify alternative configurations capable of generating comparable durable outcomes and establish which configurations fail when environmental conditions change.

More precise outcome architecture is also required. Studies should separate immediate efficiency, innovation output, business-model renewal, organizational capability, resilience, environmental performance, and long-run firm development instead of combining them within broad performance constructs. This would allow evidence to show when an early digital gain becomes an accumulating development process and when it remains localized.

The remaining uncertainties and discriminating research implications are synthesized in **Figure 2.**

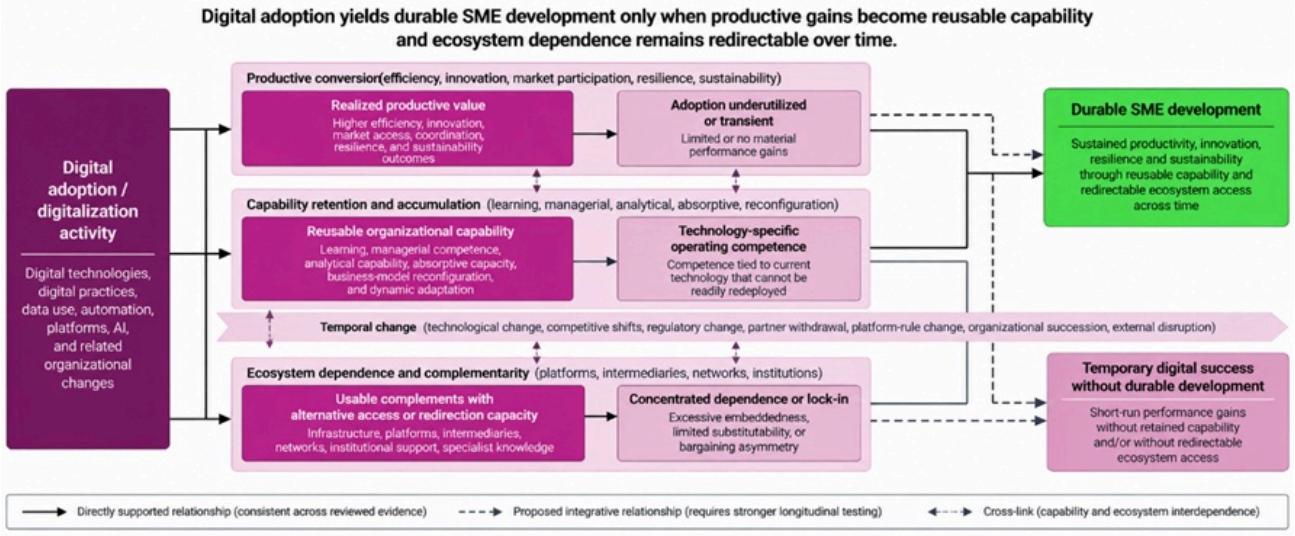


Figure 2. Digital adoption yields durable SME development only when productive gains become reusable capability and ecosystem dependence remains redirectable over time

Limitations

This umbrella review is constrained first by the heterogeneity of its evidence units. Reviews used different definitions of digital transformation, digitalization, Industry 4.0, digital innovation, sustainability, resilience, and business-model change. Consequently, apparent agreement can sometimes reflect broad conceptual overlap rather than measurement of the same construct.

Second, the primary-study populations summarized by different reviews are not fully independent. Several reviews cover overlapping publication periods and SME transformation domains. Because complete study-by-review incidence matrices were unavailable across all included reviews, a numerical corrected covered area could not be calculated without introducing unsupported precision. Review-level convergence was therefore interpreted conservatively.

Third, the evidence base remains uneven across the four synthesis domains. Productivity, innovation, adoption factors, and implementation conditions are comparatively well represented, while repeated measures of capability persistence, dependency reversibility, and long-horizon development are less common. Absence of extensive longitudinal evidence

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should not be interpreted as evidence that digital benefits are temporary; it means that persistence is less directly demonstrated.

Fourth, evidence from manufacturing, innovative firms, family firms, crisis periods, sustainability programs, and specific national ecosystems cannot automatically be transferred to all SMEs. Institutional infrastructure, firm size, sector, ownership, technological intensity, labor-market conditions, and access to finance can alter the relationship between adoption and subsequent development.

Finally, the search was a reproducible executed route rather than a claim of universal database exhaustiveness. The review therefore supports an evidence-bounded synthesis of the retrieved review literature, not a claim that every relevant synthesis published globally has been captured.

Conclusion

Digital adoption can contribute to durable SME development, but adoption alone does not establish durability. The evidence supports a conditional process in which digital technologies first have to generate meaningful productive outcomes, then contribute to capabilities that the organization can reuse, and remain connected to external resources without eliminating the firm's ability to adapt or redirect those relationships.

This distinction changes what counts as successful SME digitalization. A short-term performance gain demonstrates productive conversion. Durable development requires more: learning must accumulate, organizational competence must remain usable beyond the current technological configuration, and ecosystem participation must preserve sufficient strategic flexibility to withstand change.

The strongest conclusion is therefore conditional. Digital adoption is most plausibly connected to durable SME development when productive gains, capability accumulation, and manageable ecosystem dependence reinforce one another across time. Where one of these conditions is absent, digitalization may still be operationally valuable, but the evidence does not justify treating that value as durable development.

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