Technological Innovation Capability in SMEs: A Systematic Review and Future Research Agenda

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Abstract

This study conducts a systematic literature review of how organisational characteristics and environmental uncertainty jointly shape the technological innovation capability (TIC) of small and medium sized enterprises (SMEs). The review draws on the resource-based view, dynamic capabilities theory and contingency theory to build an integrative analytical framework. Relevant articles were retrieved from Scopus and Web of Science using a structured search strategy and screened with PRISMA 2020 procedures. Fifteen peer reviewed studies published between 2016 and 2024 met the inclusion criteria. Descriptive analysis shows growing but fragmented attention to TIC in SMEs and uneven coverage of market, technological and policy uncertainty. Thematic synthesis indicates that structural flexibility, learning orientation, networking capability and investment in human capital are recurring drivers of TIC. The evidence on environmental uncertainty is more ambivalent. Moderate levels of market and technological turbulence often stimulate TIC, while high and persistent uncertainty can erode innovation investment in resource constrained firms. The review identifies gaps in theory integration, the treatment of multilevel contexts and the use of longitudinal and mixed methods designs. It proposes a future research agenda and offers implications for SME managers who seek to align internal capabilities with shifting environmental conditions.

Keywords: Technological Innovation Capability, Small And Medium Sized Enterprises, Organisational Characteristics, Environmental Uncertainty, Systematic Literature Review

Introduction

Technological innovation capability (TIC) is a core strategic asset for small and medium sized enterprises that operate under rising global uncertainty (Lewandowska et al., 2023; Mollik & Ananna, 2024). SMEs face stronger exposure to demand shocks, input price volatility and supply chain disruption than large firms because of resource constraints (Lee et al., 2019; Roux et al., 2023). Empirical studies indicate that strong TIC improves process efficiency and product quality and supports faster responses to changing customer needs (Akinwale, 2020; J. Jin et al., 2022). TIC also helps firms absorb external knowledge and convert it into new offerings that sustain competitive advantage over time (Akinwale, 2020; J. Jin et al., 2022). In

unstable environments, it may buffer the negative effects of turbulence on performance (Lee et al., 2019; Roux et al., 2023). However, many SMEs still struggle to build and maintain TIC in a systematic way. This challenge is particularly salient for managers and policymakers who seek to improve resilience and upgrading in resource constrained firms. A clearer explanation of how TIC emerges and is sustained in SMEs is therefore necessary.

Existing research commonly defines TIC as the ability of a firm to mobilise and combine internal and external resources to generate new products, services or processes (Akinwale, 2020; J. Jin et al., 2022). One stream of work emphasises internal organisational characteristics such as structure, learning orientation, human resource practices and networking capability (Handiwibowo et al., 2020). Another stream examines how external conditions, especially market and technological uncertainty, shape innovation efforts in SMEs (Chege et al., 2020; Ekayani et al., 2023). Although these studies offer valuable insights, they often treat organisational factors and environmental uncertainty separately (Handiwibowo et al., 2020; Chege et al., 2020; Ekayani et al., 2023). This separation limits understanding of how internal features and external turbulence jointly influence TIC in SMEs. It also weakens the basis for actionable guidance on organisational alignment under uncertainty.

This separation has produced several gaps. First, conceptualisations and measures of TIC and related constructs vary across studies. This variation restricts cumulative knowledge building. Some studies emphasise process capabilities, while others treat TIC mainly as innovation outcomes. Second, theoretical integration remains limited. Many studies draw on the resource based view or dynamic capabilities theory, yet they do not connect these perspectives to a clear explanation of environmental fit (Lee et al., 2019; Mantulak et al., 2016). Third, studies do not always distinguish dimensions of environmental uncertainty. Market, technological and policy uncertainty are sometimes combined into broad indices, which can obscure their distinct implications for resource constrained SMEs (Li et al., 2023). These limitations reduce the utility of existing evidence for both theory development and managerial decision making.

To address these issues, this systematic review is guided by four research questions. RQ1 asks what evidence current studies provide on the effects of organisational characteristics on the TIC of SMEs. RQ2 examines how different forms of environmental uncertainty influence TIC. RQ3 considers how organisational characteristics and environmental uncertainty interact to shape TIC outcomes. RQ4 identifies the major gaps and inconsistencies in this body of work and clarifies how they inform a future research agenda. Together, these questions aim to consolidate dispersed findings and specify the conditions under which SMEs can develop and sustain TIC.

In answering these questions, the review integrates insights from the resource based view, dynamic capabilities theory and contingency theory. It synthesises empirical studies on TIC in SMEs published in the last decade, with a focus on how internal and external factors are combined in research designs. By mapping constructs, measures and theoretical links, the review proposes an integrative framework for studying TIC under environmental uncertainty. It also highlights promising directions for future work on theory development, research contexts and methodological approaches. Finally, it derives practical implications for SME

managers who need to align organisational structures, learning processes and external partnerships with volatile market and technological conditions.

Methodology

Research Design

This study uses a systematic literature review design. It follows guidance for evidence based reviews in management and organisation studies and adopts the three phase framework proposed by Rojon et al. (2021). The review also follows PRISMA 2020 reporting standards to improve transparency and replicability (Kahrass et al., 2021). The procedure documents each step in a clear way so that other researchers can assess and reproduce the review.

Database and Search Strategy

The review is based on two major databases, Scopus and Web of Science. These databases index a wide range of peer reviewed journals in management, innovation and organisational research. The search strategy combined three groups of terms. The first group captured TIC and related constructs such as technological innovation capability and technology innovation. The second group referred to organisational characteristics and environmental conditions, including organisational structure, organisational resources, environmental uncertainty, market uncertainty and technological turbulence. The third group restricted the search to small and medium sized enterprises by using terms such as SMEs, small and medium enterprises and small businesses.

In Scopus the search was applied to titles, abstracts and keywords, and was limited to business subject areas and journal articles. The exact search string was:
Scopus:

TITLE-ABS-KEY(("technology* innovation capability" OR "technology innovation") AND ("organisational characteristics" OR "organisational structure" OR "resources" OR "environmental uncertainty" OR "market uncertainty" OR "technological turbulence") AND ("SMEs" OR "small and medium enterprises" OR "small businesses")) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND (LIMIT-TO (SUBJAREA, "BUSI")) AND (LIMIT-TO (DOCTYPE, "ar"))

In Web of Science the search was applied to topic fields and restricted to English language journal articles. The exact search string was:

Web of Science:
TS=(("Technological Innovation Capability" OR "technological innovation capability" OR "technology innovation") AND ("organisational characteristics" OR "organisational structure" OR "organisational resources" OR "resources" OR "environmental uncertainty" OR "market uncertainty" OR "technological turbulence" OR "competitive turbulence") AND ("SMEs" OR "small and medium enterprises" OR "small businesses")) AND PY=(2014-2024) AND LA=(English) AND DT=(Article)

The time window was 2014 to 2024. This period covers a decade in which Industry 4.0 and digital transformation became central to SME innovation and in which environmental uncertainty intensified, especially during and after the COVID-19 pandemic. Conference papers, book chapters and other forms of grey literature were excluded to maintain a consistent level of academic quality.

Eligibility Criteria and Selection Process
Explicit inclusion and exclusion criteria were used to define the scope of the review (see Table 1). Studies had to meet three core conditions. First, TIC or a closely related construct had to be a central variable in the analysis. Second, the empirical setting had to focus on SMEs rather than large firms or whole industries. Third, the study had to examine at least one organisational characteristic or one dimension of environmental uncertainty, or both. Both empirical and conceptual contributions were eligible if they offered relevant insights into TIC in SMEs. Studies carried out only at macroeconomic level without firm level data were excluded.

Table 1
Inclusion and Exclusion Criteria

Phase	Screening Dimension	Inclusion Criteria	Exclusion Criteria
Abstract Screening	Research Object	Clearly focuses on SMEs / Small and Medium Enterprises	Non-SMEs (e.g., large firms, macro-level industry studies)
Abstract Screening	Research Theme	Focuses on Technological Innovation Capability or Technological Innovation	Irrelevant innovation types (e.g., market, green, or organizational innovation)
Abstract Screening	Variable Relevance	Involves organizational characteristics or environmental uncertainty	Focuses only on policy or macro-level institutions
Abstract Screening	Level of Analysis	Firm-level or CEO-level analysis	Macro, regional, or national-level analysis
Full-Text Screening	Precision of Research Object	Explicitly focuses on SMEs	Only mentions SMEs in passing
Full-Text Screening	TIC Focus	TIC is the core variable or key dependent/mediating variable	Mentions innovation but lacks TIC-specific framework
Full-Text Screening	Variable Alignment	Covers organizational characteristics or environmental uncertainty	Only covers finance, policy, or gender without relevance
Full-Text Screening	Theoretical Grounding	Applies RBV, Contingency Theory, or DCT	No theoretical framework or purely descriptive
Full-Text Screening	Research Quality	Published in SSCI/Scopus journals; clear methodology	Low-quality, unclear methods, or grey literature

The selection process followed PRISMA 2020 procedures (Kahrass et al., 2021). The initial search identified 41 records. After removal of seven duplicates and one retracted article, 33 records remained for title and abstract screening. Seventeen records were excluded at this stage because they did not match the focus on TIC in SMEs or did not examine organisational or environmental factors. Sixteen full texts were assessed for eligibility. One full text could not be retrieved. The final sample comprised 15 journal articles that met all criteria and were included in the synthesis (see Figure 1).

Figure 1. PRISMA Flow Diagram (Kahrass et al., 2021)

Data Extraction and Analysis
Data extraction was carried out by two reviewers who used a common template. The template captured the authors, year of publication, country or region, research design, theoretical framework, sample characteristics, key variables related to organisational characteristics, environmental uncertainty and TIC, and the main findings. Each reviewer coded all eligible articles independently. Any differences in coding were discussed until agreement was reached. This procedure reduced individual bias and increased the reliability of the extracted information.

The analysis used thematic content analysis. The extracted data were organised along five analytical dimensions. The first dimension captured the context of each study, including country, industry and firm size. The second dimension covered the main variables and their operationalisation, with attention to how TIC, organisational characteristics and environmental uncertainty were measured. The third dimension summarised the theoretical lenses used. The fourth dimension described the research methods, such as cross sectional survey, case study or mixed methods. The fifth dimension recorded the main empirical results and the implications noted by the authors for theory and practice.

A literature matrix was compiled to support this analysis (see Tables 2a and 2b). The matrix allowed comparison across studies and helped to identify patterns, convergent findings and gaps. The use of dual coding, a structured template and explicit themes strengthens the clarity and robustness of the synthesis.

Table 2a
Article Metadata and Theoretical Background

Author(s) and Year	Country / Context	Theory	Methodology	Sample Info
Akinwale (2020)	Saudi Arabia (F&B MSMEs)	RBV	Quantitative (SEM)	161 MSMEs (Dammam)
Yao et al. (2020)	China (Software SMEs)	Knowledge Enabling Theory	Quantitative (SEM)	457 software SMEs
Won (2016)	Korea (Materials SMEs)	RBV, Learning, Social Capital	Quantitative (PLS-SEM)	137 SMEs (Busan)
Roux et al. (2023)	Vietnam (Manufacturing SMEs)	POS, Dynamic Capabilities	Quantitative (SEM)	375 SMEs (Vietnam)
Panjaitan et al. (2022)	Indonesia (MSMEs)	Resource Advantage Theory	Quantitative (PLS-SEM)	177 MSMEs (Indonesia)
Mantulak et al. (2016)	Argentina (Sawmill SME)	RBV, Strategic Management	Qualitative (Case study)	1 SME (Argentina)
Li et al. (2023)	China (SMEs)	Dynamic Capabilities	Quantitative (SEM)	371 SMEs (China)
Lee et al. (2019)	Korea (Tech SMEs)	RBV	Quantitative (SEM)	17,806 SMEs (Korea)
Jin & Choi (2019)	Korea (IT & Services)	RBV (indirect), Innovation Theory	Panel Regression	160 firms (80 SMEs)
Jin et al. (2022)	China (High-tech SMEs)	RBV, Dynamic Capabilities, Absorptive	Qualitative (Case study)	2 SMEs (Nano-tech)
Indrawati et al. (2020)	Indonesia (Food SMEs)	Resource/Environmental view	Mixed methods	277 SMEs (Riau)
Handiwibowo et al. (2020)	Indonesia (Urban SMEs)	RBV	Quantitative (SEM-PLS)	178 SMEs (Indonesia)
Ekayani et al. (2023)	Indonesia (Bali SMEs)	RBV, Stakeholder Theory	Quantitative (PLS-SEM)	399 SMEs (Bali)
Dinku et al. (2024)	Ethiopia (SMEs)	RBV, Innovation Theory	Quantitative (CB-SEM)	425 SMEs (Ethiopia)
Chege et al. (2020)	Kenya (SMEs)	Growth Model, Innovation Model	Quantitative (SEM)	240 SMEs (Kenya)

Table 2b
Variable Focus and Key Findings

Author(s) and Year	Key Variables	Focus on TIC	Main Findings
Akinwale (2020)	Org. resources; Env. uncertainty (COVID)	Yes, mediator & outcome	Process innovation's most significant
Yao et al. (2020)	Org. characteristics (culture, IT)	Yes, core DV	Tacit knowledge is more impactful
Won (2016)	Learning, Social capital	Yes, key mediator	Learning → TIC → Export
Roux et al. (2023)	Skills, change capacity, turbulence	Yes, core variable	Change capacity → AI adoption
Panjaitan et al. (2022)	Resilience, disaster, resources	Yes, mediator	Resilience → TIC → Performance
Mantulak et al. (2016)	Strategic tech resources, SWOT	Yes, core concept	Framework for strategic tech resource
Li et al. (2023)	TIN, CR, BC	Yes, independent variable	TIC boosts performance, CR/BC mediate
Lee et al. (2019)	Innovation financing, TIC	Yes, mediator	TIC ↑ non-financial performance
Jin & Choi (2019)	Product/process innovation, R&D	Yes, main predictor	Product innovation key for SMEs
Jin et al. (2022)	Open innovation, patent, NPD	Yes, core object	Selective open innovation by stage
Indrawati et al. (2020)	Capital, financing, uncertainty	Yes, core construct	Financing biggest barrier
Handiwibowo et al. (2020)	Resource allocation, capability	Yes, main predictor	Marketing, R&D, strategy → NPD
Ekayani et al. (2023)	Intellectual capital, TIC, performance	Yes, mediator	Capital → TIC → Performance
Dinku et al. (2024)	Human capital, TIC	Yes, mediator	Human capital partially mediated by TIC
Chege et al. (2020)	Entrepreneurship, structure	Yes, main predictor	ICT innovation impacts performance

Results
Descriptive Analysis
The final sample consists of 15 journal articles published between 2016 and 2024. The studies differ in publication year, outlet, geographical and industry focus, research method and theoretical lens. This subsection describes these patterns and refers to Figures 2–6 and Tables 2a and 2b for detail.

Annual Publication Trend

Most of the included articles were published after 2018. There is a clear peak around 2020, when several studies on TIC in SMEs appeared (Akinwale, 2020; Panjaitan et al., 2022; Li et al., 2023). In other years the number of publications is lower and more scattered. This pattern suggests growing but still irregular attention to TIC in SMEs (Figure 2).
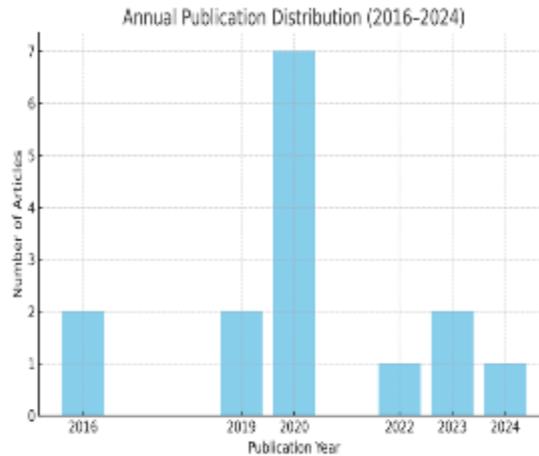

Figure 2. Annual Publication Trend of Included Studies

Journal Distribution

The articles are published in a range of journals in innovation, knowledge management and applied economics (Figure 3). Examples include Journal of Knowledge Management (Yao et al., 2020), Journal of Innovation and Knowledge (Roux et al., 2023) and Economic Analysis and Policy (Li et al., 2023). Some studies appear in engineering and sustainability outlets such as IEEE Transactions on Engineering Management (J. Jin et al., 2022) and Sustainability (S. Jin & Choi, 2019). This spread shows that research on TIC in SMEs is not confined to one disciplinary field.
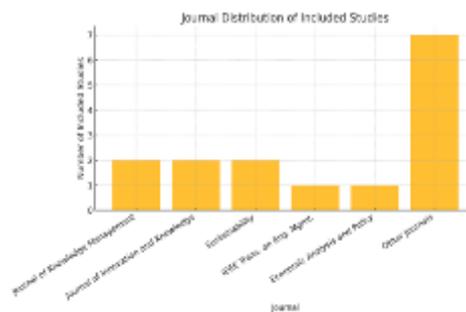

Figure 3. Journal Distribution of Included Studies

Geographical and Industry Distribution

Most studies focus on SMEs in Asian economies, including China, South Korea and Indonesia (Lee et al., 2019; Roux et al., 2023; Yao et al., 2020). A smaller number examine African and Latin American contexts (Chege et al., 2020; Dinku et al., 2024). The industry focus is mainly on manufacturing and technology intensive sectors such as textiles, software, IT services and nanotechnology (J. Jin et al., 2022; Yao et al., 2020). Figure 4 summarises these distributions.
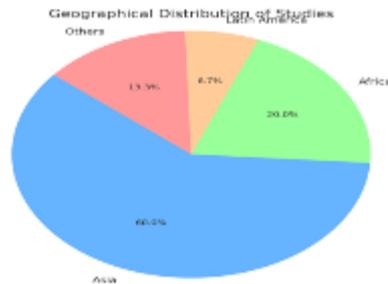
Figure 4. Geographical Distribution of Studies

Methodological Approaches
Quantitative survey designs dominate the sample. Most quantitative studies use structural equation modelling, either PLS-SEM (Panjaitan et al., 2022; Won, 2016) or CB-SEM (Dinku et al., 2024) (Figure 5). Two articles rely on qualitative case studies to analyse TIC processes in depth (J. Jin et al., 2022; Mantulak et al., 2016). One study combines survey data with interviews and uses a mixed methods approach (Indrawati et al., 2020). Overall, cross sectional designs are more common than longitudinal ones.
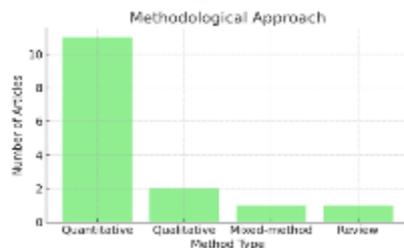

Figure 5. Research Methodologies Used

Theoretical Foundations
The most frequently used theoretical lens is the resource based view (Akinwale, 2020; S. Jin & Choi, 2019; Lee et al., 2019). Several studies also draw on dynamic capabilities theory to explain how SMEs adapt in changing environments (Li et al., 2023; Roux et al., 2023). Other frameworks appear only once or twice, such as Knowledge Enabling Theory (Yao et al., 2020) and Resource Advantage Theory (Panjaitan et al., 2022). Figure 6 shows that RBV remains the dominant perspective, with DCT and other theories playing a supporting role.
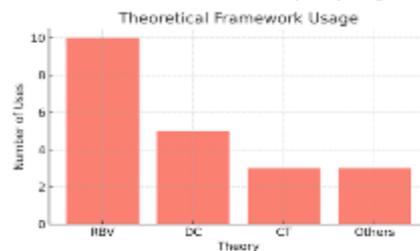

Figure 6. Theoretical Foundations of Included Studies

Thematic Analysis
This subsection summarises the main themes that emerge across the 15 studies. The themes are grouped into three areas: organisational characteristics and TIC, environmental uncertainty and TIC, and the interaction between organisational and environmental factors.

Organisational Characteristics and TIC
Across the sample, organisational characteristics are consistently linked to TIC outcomes. Several studies show that organisational culture, leadership support and internal communication promote knowledge sharing and idea generation, which in turn strengthen TIC (Yao et al., 2020). Lee et al. (2019) find that investment in R&D personnel and innovation finance relates positively to TIC, although the effects on financial and non-financial performance are not always aligned. Handiwibowo et al. (2020) report that marketing capability, R&D capability and strategic planning capability are important drivers of TIC in SMEs.

Human capital is another recurring factor. Dinku et al. (2024) show that education level and skills of employees are associated with higher innovation outputs. Won (2016) and Panjaitan et al. (2022) highlight the role of learning orientation and entrepreneurial resilience as internal resources that support experimentation and problem solving. Overall, the studies point to a cluster of organisational features – structure, resource allocation, learning systems and human capital – that help SMEs develop and sustain TIC, although the relative weight of each factor varies across contexts.

Environmental Uncertainty and TIC
Environmental uncertainty appears in the studies as both a constraint and a stimulus for TIC. Akinwale (2020) examines the COVID-19 period and shows that some SMEs increase innovation activities to cope with disruptions, while others reduce innovation due to resource shortages. Indrawati et al. (2020) report that economic instability and limited access to finance weaken SMEs' ability to invest in new technologies.

Other studies emphasise how SMEs respond to technological and competitive turbulence. Roux et al. (2023) analyse how firms adopt digital tools and artificial intelligence to manage unstable demand patterns. Chege et al. (2020) find that external environmental factors alone do not fully explain TIC; internal strategic capabilities condition how firms translate uncertainty into innovation. Taken together, the evidence suggests that moderate levels of uncertainty may stimulate TIC, while severe and persistent shocks can hinder it, especially when internal resources are weak.

Interaction between Organisational and Environmental Factors
Only a few studies model the joint effects of organisational characteristics and environmental uncertainty on TIC in an explicit way. Won (2016) reports that social capital moderates the link between learning orientation and TIC, with stronger effects in more dynamic environments. Li et al. (2023) find that the fit between organisational characteristics and market or technological turbulence is associated with better innovation outcomes.

Case based work also shows how SMEs adjust internal arrangements in response to external conditions. Mantulak et al. (2016) describe how firms in a nanotechnology cluster change resource mobilisation strategies when facing shifts in policy and market demand. J. Jin et al. (2022) observe that SMEs in engineering sectors combine formal R&D processes with flexible project management to deal with technological change. These studies indicate that the impact of organisational characteristics on TIC depends on the surrounding environment and

that alignment between internal capabilities and external uncertainty is an important feature of successful SMEs.

Discussion
The thematic analysis shows that TIC in SMEs is shaped by organisational characteristics, environmental uncertainty and their interaction. This section discusses how the reviewed studies address the first three research questions.

RQ1: Organisational Characteristics and TIC in SMEs
The findings confirm that internal organisational features are central to TIC. Structural flexibility, clear allocation of resources, learning orientation and high quality human capital all support the development of TIC. Several studies report that leadership support, innovation oriented culture and knowledge sharing routines promote experimentation and new product development (Yao et al., 2020; Lee et al., 2019; Dinku et al., 2024). R&D capability, marketing capability and strategic planning capability also appear as important drivers of TIC, although their relative strength differs across sectors (Handiwibowo et al., 2020; Jin & Choi, 2019; Akinwale, 2020).

Human capital and learning systems receive particular attention. Dinku et al. (2024) highlight the role of education and skills, while Won (2016) and Panjaitan et al. (2022) emphasise learning orientation and entrepreneurial resilience. These results suggest broad agreement that SMEs need bundles of complementary capabilities rather than single isolated resources. At the same time, differences in effect size and significance across studies indicate that the impact of a given organisational characteristic is contingent on industry conditions and strategic choices.

RQ2: Environmental Uncertainty and TIC in SMEs
The evidence also shows that environmental uncertainty has a dual role. Market volatility, technological turbulence and competitive pressure can stimulate innovation when firms have sufficient internal resources and adaptive capabilities. For example, Akinwale (2020) and Roux et al. (2023) describe SMEs that used the COVID-19 crisis to accelerate the adoption of new products and digital technologies. In these cases uncertainty pushed firms to mobilise latent capabilities.

However, uncertainty can also constrain TIC. Indrawati et al. (2020) report that economic instability and financial constraints reduce SMEs' ability to invest in new technologies. Chege et al. (2020) show that external pressures alone do not guarantee innovation; without strong internal capabilities the effect of turbulence on TIC may be weak or even negative. Taken together, these findings support a contingent view. The impact of environmental uncertainty on TIC depends on the firm's resource base, flexibility and strategic orientation.

RQ3: Interaction between Organisational Characteristics and Environmental Uncertainty
Only a smaller group of studies explicitly model the interaction between internal and external factors, but their results are consistent. Won (2016) finds that social capital moderates the relationship between learning orientation and TIC, with stronger effects in more dynamic environments. Li et al. (2023) show that alignment between customer retention strategies,

business continuity practices and environmental turbulence enhances innovation performance.

Case based research provides further illustrations. Mantulak et al. (2016) and Jin et al. (2022) describe how SMEs reconfigure resources, partnerships and project management routines in response to policy shifts and technological change. These studies portray TIC as the outcome of ongoing interaction between organisational capabilities and external conditions rather than as a fixed stock of resources. They support the idea that RBV and DCT need to be linked to contingency arguments when applied to SMEs operating under high uncertainty.

Implications and Contributions

This review contributes to theory by bringing organisational characteristics and environmental uncertainty into a single framework for understanding TIC in SMEs. Previous reviews often focus either on innovation capabilities in general or on dynamic capabilities without a detailed treatment of uncertainty (Akram et al., 2022; Yang et al., 2024). By integrating RBV, DCT and contingency perspectives, the present review clarifies how internal resource configurations and external conditions jointly shape TIC. Figure 7 summarises this integration and distinguishes process oriented capabilities from outcome oriented innovation results.
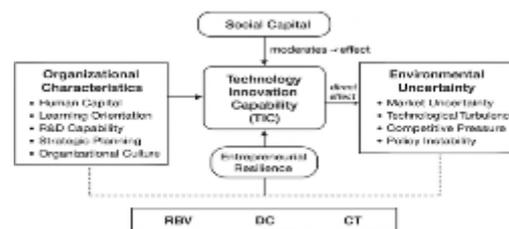

Figure 7. Conceptual Framework for TIC in SMEs

For SME managers the findings underline the need to invest in intangible resources. Human capital, learning orientation, R&D capability, marketing capability and strategic planning need to be developed as coherent bundles rather than in isolation. Managers should build routines for knowledge sharing and joint problem solving, and strengthen entrepreneurial resilience so that the firm can exploit moderate levels of uncertainty. At the same time they must monitor financial constraints and avoid overextending scarce resources in highly turbulent contexts.

For policy makers the review highlights the importance of an innovation friendly ecosystem. Targeted support programmes, access to finance, training schemes and platforms for inter-firm collaboration can help SMEs upgrade TIC. Policies that reduce unnecessary regulatory uncertainty while encouraging experimentation with new technologies may allow SMEs to turn environmental change into opportunities for innovation based growth.

Future Research Agenda

The future research agenda is structured using the TCCM framework. Table 3 provides a detailed summary; this subsection highlights the main directions that follow from the fourth research question.

Table 3
TCCM-Based Future Research Agenda for TIC in SMEs

TCCM Dimension	Current Research Status	Identified Gaps	Future Research Recommendations
Theory	Dominated by RBV and DC perspectives	Limited theoretical integration	Integrate Learning Theory, Stakeholder Theory, and Contingency Theory
Context	Focused on manufacturing sectors in emerging Asian economies	Geographical and industrial concentration	Explore service sectors, digital economy, and under-researched regions like Africa and Latin America
Characteristics	Emphasis on tangible resources	Neglect of intangible features such as organisational culture and leadership	Investigate CEO traits, digital capability, and ethical orientation
Method	Primarily, cross-sectional and quantitative studies	Lack of longitudinal, multi-level, and mixed methods	Promote longitudinal, qualitative, mixed-method, and multi-level research designs

Theory
RBV and DCT dominate current work on TIC in SMEs, but theoretical integration often remains implicit. Future studies should develop explicit multi-theory models that connect resource based arguments with organisational learning, stakeholder and contingency perspectives (Won, 2016; Roux et al., 2023). Such models can clarify how SMEs transform internal resources into innovation outcomes under different types and levels of uncertainty. The roles of knowledge enabling mechanisms and social capital in linking tacit and explicit knowledge also deserve closer theoretical attention (Yao et al., 2020; Jin et al., 2022).

Context
Most studies focus on manufacturing SMEs in Asian emerging economies. Research on service sectors, digital platforms and SMEs in under-researched regions such as Sub-Saharan Africa and parts of Latin America is limited (Akinwale, 2020; Panjaitan et al., 2022; Dinku et al., 2024). Comparative designs across countries and industries are needed to examine how institutional, cultural and sectoral factors condition the relationships between organisational characteristics, environmental uncertainty and TIC.

Characteristics
Existing work pays more attention to tangible resources, such as financial investment and physical R&D infrastructure, than to intangible characteristics. Future research should include organisational culture, leadership style, entrepreneurial orientation, ethical governance and digitalisation capability (Lee et al., 2019; Ekayani et al., 2023). These factors are likely to influence how SMEs interpret uncertainty and choose innovation strategies. More precise and consistent measures of process oriented and outcome oriented TIC would also improve comparability across studies.

Method
Most studies use cross sectional survey data and SEM techniques (see Table 3). This limits insight into how TIC develops over time. Longitudinal designs are needed to track how changes in resources and uncertainty affect TIC trajectories. Mixed methods approaches that combine quantitative surveys with qualitative case studies or interviews can reveal mechanisms that are not visible in survey data alone (Indrawati et al., 2020; Chege et al., 2020; Mantulak et al., 2016). Multi level analysis that links individual, organisational and industry level variables would further strengthen explanatory power.

Conclusion

This systematic review shows that TIC in SMEs is shaped by the interaction between internal organisational characteristics and external environmental uncertainty. Organisational culture, leadership, learning orientation, human capital and functional capabilities such as R&D and marketing emerge as central drivers of TIC. Environmental uncertainty can both stimulate and constrain innovation, depending on the firm's resource base and strategic response.

By integrating RBV, DCT and contingency theory, the review offers a coherent framework for understanding how SMEs build and adapt TIC under dynamic conditions. It also identifies key gaps related to theory, context, characteristics and methods, and proposes a TCCM based research agenda.

For practice, the findings suggest that SMEs should strengthen intangible capabilities and build flexible routines that allow them to respond to uncertainty in a proactive way, while policy makers should support innovation ecosystems that enable such capability building. Future research can extend this work through longitudinal, comparative and multi method studies that examine TIC as an evolving process in diverse SME contexts.

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