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Navigating the Fourth Industrial Revolution (4IR) Frontier: Strategic pathways for Artificial Intelligence (AI) adoption and entrepreneurial resilience in South African Small, Medium, and Micro Enterprises (SMMEs)

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ABSTRACT

The Fourth Industrial Revolution (4IR) presents both opportunities and challenges for Small, Medium, and Micro Enterprises (SMMEs) in developing economies, particularly in South Africa, where the digital divide and resource constraints remain significant. This study examines how adopting Artificial Intelligence (AI) can enhance entrepreneurial resilience and foster sustainable competitive advantage in SMMEs. Using a desktop research design, 38 academic and industry sources were systematically synthesised to identify drivers, barriers, and strategic pathways for digital transformation. The findings reveal that while AI technologies have substantial potential to improve operational efficiency, decision-making, and market responsiveness, SMMEs are hindered by financial limitations, inadequate technological infrastructure, skills shortages, and regulatory challenges. The study highlights the pivotal role of entrepreneurial leadership and dynamic capabilities in enabling firms to adapt to technological disruptions and sustain performance in volatile environments. Moreover, integrating supportive innovation ecosystems, including entrepreneurial universities and collaborative networks, is critical for knowledge transfer, capacity building, and access to innovation resources. A strategic framework is proposed that emphasises digital transformation, capability development, and ecosystem collaboration, providing actionable pathways for SMMEs to navigate the 4IR frontier. The research contributes to theory by contextualising the Resource-Based View (RBV), Dynamic Capabilities Theory, and Diffusion of Innovation Theory within resource-constrained, rural environments, thereby addressing the limitations of predominantly Western-centric models. In practice, it offers policymakers, business owners, and practitioners guidance on fostering innovation-driven growth, narrowing the digital divide, and building resilience among SMMEs.

Keywords: Artificial Intelligence, Digital Transformation; Entrepreneurial Leadership, Entrepreneurial Resilience, Fourth Industrial Revolution.

INTRODUCTION

According to Loonam et al., the emergence of the Fourth Industrial Revolution (4IR) has fundamentally transformed the global economic landscape by integrating advanced technologies such as Artificial

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Intelligence (AI), big data, and the Internet of Things.[1] These technological advancements are reshaping traditional business models and creating new opportunities for innovation and value creation.[2] Small, Medium, and Micro Enterprises (SMMEs) play a critical role in economic development, contributing significantly to employment creation and economic growth in both developed and developing economies. In South Africa, SMMEs are central to the objectives of the National Development Plan 2030, which identifies them as key drivers of job creation and poverty reduction.[3]

Despite their importance, SMMEs are increasingly required to adapt to a rapidly digitalising economy where innovation is no longer optional but essential for survival. Digital transformation has become a strategic necessity, enabling firms to improve efficiency, access global markets, and enhance competitiveness.[4]

Although recognised as essential to achieving the goals of the National Development Plan, SMMEs in South Africa face a staggering failure rate: approximately 70% of small firms fail within their first 5 to 10 years. This high mortality rate is significantly higher than in other middle-income economies, where SMMEs contribute up to 70% of GDP, compared to only 45–50% in South Africa. The literature identifies this underperformance as a direct result of an entrepreneurial environment that is not conducive to growth, characterised by limited access to finance and a persistent lack of adequate innovation. A critical dimension of this problem is the pronounced "digital divide" emerging in the wake of the 4IR. While 4IR technologies such as AI, the Internet of Things (IoT), and big data offer pathways for global competitiveness, systemic and infrastructural challenges marginalise South African SMMEs. These include inconsistent electricity and internet access, cybersecurity threats, the prohibitive costs of digital transformation, and a shortage of skilled manpower to navigate complex AI systems. Furthermore, there is scant empirical evidence specifically investigating the impact of innovation on SMME performance in the South African context, leaving business owners without data-driven guidance. This problem is compounded by the reliance on Eurocentric framework models (such as HEInnovate), which often fail to align with the unique cultural priorities, indigenous systems, and rural realities of developing African economies. Consequently, without clear, context-specific strategic pathways for AI adoption, South African SMMEs risk being excluded from the benefits of the digital economy, further widening the gap between them and larger, more resource-endowed corporations.

This study aims to investigate how adopting AI within the 4IR can enhance entrepreneurial resilience among South African SMMEs. It aims to develop strategic pathways that enable effective AI adoption to strengthen resilience and sustain competitiveness in South African SMMEs. This paper contributes to knowledge on digital transformation in developing economies by synthesising literature on AI adoption and entrepreneurial resilience in the context of the 4IR. It provides practical insights for policymakers, SMME owners, and practitioners on enhancing innovation capacity, adaptability, and bridging the digital divide in South Africa and broader Africa.

LITERATURE REVIEW

AI Adoption in SMMEs: Drivers and Barriers

A combination of drivers and barriers influences the adoption of AI in SMMEs. On the one hand, technological innovation improves productivity, supports job creation, and facilitates access to global markets.[5] Digital transformation enables SMMEs to innovate their business models and improve operational efficiency, thereby strengthening their competitive position.[6] On the other hand, financial constraints limit the ability of SMMEs to invest in digital technologies, while human capital deficiencies restrict their ability to implement and manage these technologies effectively.[7] Infrastructure challenges,

[1] John Loonam et al., "Towards Digital Transformation: Lessons Learned from Traditional Organizations," *Strategic Change* 27, no. 2 (2018): 101–9.
[2] Loonam et al., "Towards Digital Transformation: Lessons Learned from Traditional Organizations."
[3] National Planning Commission, *National Development Plan 2030: Our Future—Make It Work* (Pretoria: The Presidency, 2012).
[4] Digital Transformation Initiative, *Digital Transformation Initiative* (World Economic Forum Publications, 2018).
[5] Samwel Macharia Chege and Daoping Wang, "Information Technology Innovation and Its Impact on Job Creation by SMEs in Developing Countries: An Analysis of the Literature Review," *Technology Analysis & Strategic Management* 32, no.3(2020): 256–71.
[6] Loonam et al., "Towards Digital Transformation: Lessons Learned from Traditional Organizations."
[7] Haroon Bhorat et al., *SMMEs in South Africa: Understanding the Constraints on Growth and Performance* (DPRU, University of Cape Town Cape Town, 2018).

particularly unreliable internet connectivity and electricity supply, further constrain technological adoption in regions such as Limpopo and KwaZulu-Natal.[8] Additionally, cybersecurity and data protection concerns pose significant risks for small businesses transitioning to digital platforms.

Artificial Intelligence and Entrepreneurial Resilience

Entrepreneurial resilience refers to a firm's ability to adapt to environmental shocks and sustain performance amid uncertainty. The literature suggests that innovation plays a critical role in improving resilience by enabling firms to respond effectively to changing market conditions.[9] Entrepreneurial leadership is a key driver of this process, as it fosters innovative work behaviour and encourages employees to engage in creative problem-solving.[10] Leaders who exhibit transformational and entrepreneurial characteristics are better positioned to navigate uncertainty and drive organisational change.[11] Furthermore, intellectual agility has been identified as an important capability that mediates the relationship between leadership and innovation, ultimately contributing to improved business performance.[12]

Strategic Pathways for Artificial Intelligence Adoption in Small, Medium and Micro Enterprises

Successful AI adoption in SMMEs requires a strategic and integrated approach that encompasses digital transformation, capability development, and ecosystem collaboration. Digital transformation involves the restructuring of business processes to leverage information and communication technologies, enabling firms to operate more efficiently and competitively. Capability development is equally important, as firms must invest in continuous learning and skills development to build digital competencies. Entrepreneurial leaders play a critical role in creating learning-oriented organisations that support innovation and adaptability. Ecosystem collaboration further enhances the capacity of SMMEs to innovate by facilitating access to resources, knowledge, and support networks. The concept of the Triple Helix emphasises the importance of collaboration between universities, industry, and government in fostering innovation ecosystems. In this context, entrepreneurial universities serve as key institutions that provide incubation, mentorship, and research support for SMMEs.

Synthesis of Literature and Research Gap

Although there is extensive literature on AI and digital transformation, there is still a lack of context-specific research focusing on SMMEs in South Africa. Existing studies often overlook the unique challenges faced by rural-based enterprises and the role of indigenous business practices in shaping innovation processes. This study addresses this gap by synthesising literature on AI adoption, entrepreneurial leadership, and resilience to develop a contextually relevant framework for SMMEs in developing economies.

Theoretical Framework

The adoption of AI in SMMEs can be understood through several theoretical perspectives, including the Resource-Based View (RBV), Dynamic Capabilities, and Schumpeter's Theory of Innovation. The RBV posits that firm performance is determined by valuable, rare, and inimitable resources, with innovation serving as a critical intangible asset that improves competitive advantage. Building on this perspective, the Dynamic Capabilities framework emphasises a firm's ability to integrate and reconfigure resources in response to changing environments. In the context of 4IR, AI adoption represents a dynamic capability that enables firms to respond to technological disruptions and market volatility. Integrating

[8] Ismail Sheik, "Navigating the Digital Divide: Exploring the Multifaceted 4IR Challenges and Technological Disparities Encountered by SMMEs within Kwazulu-Natal, South Africa," *Technology Audit and Production Reserves* 5, no. 4/73 (2023): 6–11.

[9] Weliswa Matekenya and Clement Moyo, "Innovation as a Driver of SMME Performance in South Africa: A Quantile Regression Approach," *African Journal of Economic and Management Studies* 13, no. 3 (2022): 452–67.

[10] O. Fatoki, "Entrepreneurial Leadership and Employees' Innovative Work Behaviour in Small Firms: Mediating Role of Creative Self-Efficacy," *Academy of Strategic Management Journal* 20, no. 5 (2021): 1–9.

[11] Nerisa N Paladan, "Transformational Leadership: The Emerging Leadership Style of Successful Entrepreneurs," *Journal of Literature and Art Studies* 5, no. 1 (2015): 64–72.

[12] Marina Dabić et al., "Intellectual Agility and Innovation in Micro and Small Businesses: The Mediating Role of Entrepreneurial Leadership," *Journal of Business Research* 123 (2021): 683–95.

Schumpeter's Theory of Innovation, the Technology Organisation Environment (TOE) framework, and the RBV, including Dynamic Capabilities, provides a comprehensive theoretical foundation for understanding AI adoption in SMMEs. These frameworks collectively explain the progression from the motivation to innovate, to the internal capacity to implement innovation, and finally to the external conditions that influence adoption outcomes. Schumpeter's Theory of Innovation serves as the starting point by conceptualising innovation as a process of creative destruction, where firms must continuously transform their operations to remain competitive. In the context of AI adoption, this implies that SMMEs must replace traditional business models with technologically driven processes to survive in the evolving digital economy. This perspective is further supported by studies on digital transformation, which highlight how emerging technologies reshape business models and competitive dynamics.[13]

Building on this motivation, the RBV explains how firms can achieve competitive advantage by effectively utilising internal resources. According to Barney, firm performance is largely determined by valuable, rare, inimitable, and non-substitutable resources, such as knowledge, skills, and innovation capabilities.[14] For SMMEs, these resources are often constrained, particularly in developing economies such as South Africa, where financial and technological limitations restrict growth. The concept of Dynamic Capabilities extends RBV by emphasising a firm's ability to adapt, integrate, and reconfigure its resources in response to rapidly changing environments. This adaptability is crucial in the 4IR, where SMMEs must develop intellectual agility to respond to technological disruptions and leverage AI effectively. Empirical studies further demonstrate that innovation and adaptability significantly improve SME performance, particularly when firms engage in product and process innovation.[15] The Technology–Organisation–Environment (TOE) framework, originally described by Tornatzky and Fleischer, complements these internal perspectives by introducing the external and contextual factors that influence technology adoption.[16] It categorises these factors into technological, organisational, and environmental dimensions, providing a holistic view of the conditions necessary for successful AI implementation. Chege and Wang emphasise that even when firms have the motivation and internal capabilities to innovate, adoption may be hindered by environmental constraints such as inadequate infrastructure, limited access to finance, and regulatory challenges. In the South African context, these barriers are further exacerbated by the digital divide, which disproportionately affects SMMEs in rural and under-resourced areas. Policy frameworks such as the African Union's Digital Transformation Strategy and South Africa's National Development Plan recognise these challenges and advocate for improved digital infrastructure and innovation support systems to enhance SME competitiveness.[17]

Furthermore, integrating these frameworks highlights the critical role of entrepreneurial leadership as a unifying factor that drives innovation and adaptation. Entrepreneurial leaders are instrumental in identifying opportunities, mobilising resources, and navigating uncertainty within dynamic environments.[18] Their ability to foster innovation-oriented cultures within SMMEs enhances the firm's capacity to adopt AI and respond to external pressures. This aligns with Schumpeter's emphasis on the entrepreneur as the agent of change and with RBV's focus on intangible assets, such as leadership and knowledge, as key drivers of performance. Additionally, collaboration within innovation

[13] Michael Rachinger et al., "Digitalization and Its Influence on Business Model Innovation," *Journal of Manufacturing Technology Management* 30, no. 8 (December 9, 2019): 1143–60, https://doi.org/10.1108/JMTM-01-2018-0020; Swen Nadkarni and Reinhard Prügl, "Digital Transformation: A Review, Synthesis and Opportunities for Future Research," *Management Review Quarterly* 71, no. 2 (April 18, 2021): 233–341, https://doi.org/10.1007/s11301-020-00185-7.

[14] Jay Barney, "Firm Resources and Sustained Competitive Advantage," *Journal of Management* 17, no. 1 (March 1, 1991): 99–120, https://doi.org/10.1177/014920639101700108.

[15] Alfonso Expósito and Juan A. Sanchis-Llopis, "The Relationship between Types of Innovation and SMEs' Performance: A Multi-Dimensional Empirical Assessment," *Eurasian Business Review* 9, no. 2 (June 1, 2019): 115–35, https://doi.org/10.1007/s40821-018-00116-3; Matekenya and Moyo, "Innovation as a Driver of SMME Performance in South Africa: A Quantile Regression Approach."

[16] Louis G., Tornatzky and Mitchell Fleischer, *The Processes of Technological Innovation* (Lexington, MA: Lexington Books, 1990).

[17] African Union, "The Digital Transformation Strategy for Africa (2020-2030)," May 18, 2020, https://au.int/en/documents/20200518/digital-transformation-strategy-africa-2020-2030.

[18] Vipin Gupta, Ian C MacMillan, and Gita Surie, "Entrepreneurial Leadership: Developing and Measuring a Cross-Cultural Construct," *Journal of Business Venturing* 19, no. 2 (March 2004): 241–60, https://doi.org/10.1016/S0883-9026(03)00040-5.Fatoki, "Entrepreneurial Leadership and Employees' Innovative Work Behaviour in Small Firms: Mediating Role of Creative Self-Efficacy."

ecosystems, particularly through partnerships with universities and industry, further strengthens SMMEs' ability to overcome resource limitations and access critical knowledge.[19]

METHODOLOGY

Research Design

This study adopted an exploratory systematic literature review (SLR) design to provide a structured and rigorous synthesis of existing knowledge on AI adoption, innovation, entrepreneurial leadership, and entrepreneurial resilience among SMMEs. The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, which provides a transparent and replicable framework for identifying, screening, selecting, and synthesising relevant literature.[20] The systematic review approach allowed the identification of recurring patterns, theoretical developments, and research gaps related to AI adoption and entrepreneurial resilience within the context of the 4IR, without requiring primary data collection.

Literature Search Strategy

A comprehensive literature search was conducted using multiple electronic databases to ensure broad coverage of relevant scholarly literature. The databases searched included Emerald Insight, ScienceDirect, Google Scholar, and the World Bank Open Knowledge Repository. In addition, relevant policy documents and institutional reports were retrieved from organisations such as the Organisation for Economic Co-operation and Development (OECD), the World Economic Forum (WEF), the African Union (AU), and South Africa's National Planning Commission (NPC).

The search strategy employed Boolean operators (AND and OR) together with combinations of the following keywords:

- "Artificial Intelligence" OR "AI adoption"
- "SMMEs" OR "Small Business"
- "South Africa"
- "Fourth Industrial Revolution" OR "4IR"
- "Digital transformation"
- "Entrepreneurial leadership"
- "Innovation"
- "Entrepreneurial resilience"
- "Developing economies"

Reference lists of eligible studies were also examined to identify additional relevant publications that were not retrieved during the database search.

Screening Process

The study selection process followed a structured screening procedure aligned with the PRISMA framework. During the identification stage, approximately 120 records were retrieved from the selected databases. Duplicate publications were removed before titles and abstracts were screened against the study objectives. This process reduced the number of potentially relevant studies to 65. Subsequently, full-text articles were assessed for eligibility based on the predefined inclusion and exclusion criteria. Following the eligibility assessment, 38 sources were retained for the final review and thematic synthesis.

[19] Henry Etzkowitz and Chunyan Zhou, *The Triple Helix* (Routledge, 2017), https://doi.org/10.4324/9781315620183; Alain C. Nkusi et al., "The Role of the Entrepreneurial University in Building an Entrepreneurial Ecosystem in a Post Conflict Economy: An Exploratory Study of Rwanda," *Thunderbird International Business Review* 62, no. 5 (September 2, 2020): 549–63, https://doi.org/10.1002/tie.22165..

[20] Matthew J Page et al., "The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews," *BMJ*, March 29, 2021, n71, https://doi.org/10.1136/bmj.n71.

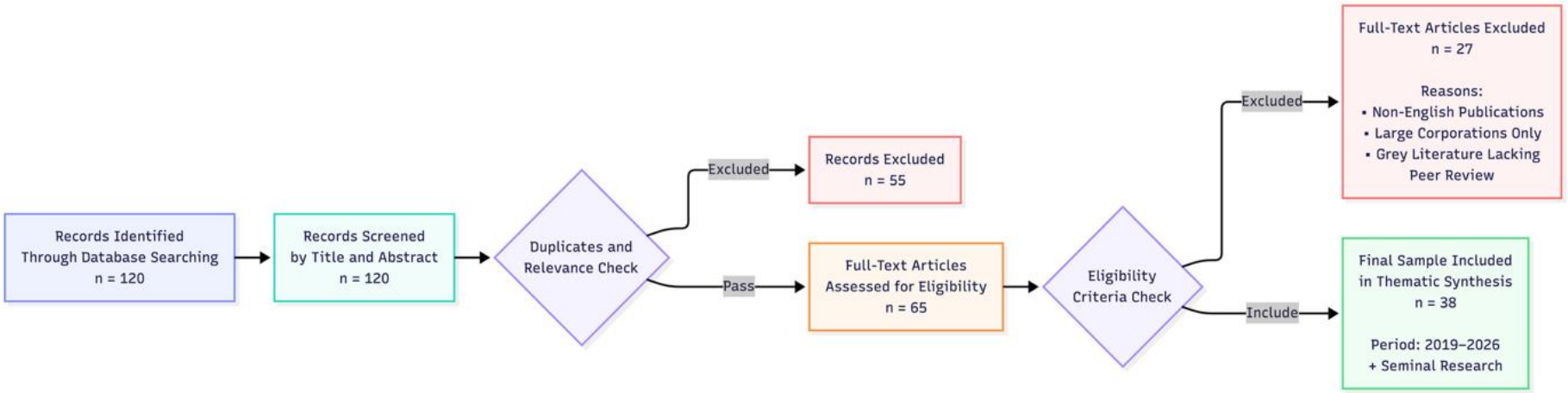


Figure 1: A PRISMA flow diagram illustrating the identification, screening, eligibility assessment, and inclusion process

Source: Researcher's own construct (2026)

Inclusion and Exclusion Criteria

Clear inclusion and exclusion criteria were applied to ensure the quality and relevance of the reviewed literature.

Studies were included if they:

- focused on AI adoption, innovation, entrepreneurial leadership, digital transformation, or entrepreneurial resilience;
- examined SMMEs or SMEs operating within developing or emerging economies;
- were published primarily between 2019 and 2026 to capture contemporary developments associated with the Fourth Industrial Revolution;
- were published in English;
- consisted of peer-reviewed journal articles, reputable conference papers, policy documents, or institutional reports.

Studies were excluded if they:

- focused exclusively on large multinational organisations;
- were not available in English;
- lacked sufficient methodological rigour or institutional credibility;
- consisted of opinion pieces or grey literature without identifiable scholarly or institutional review.

To provide theoretical grounding, seminal studies published between 1991 and 2018, including those underpinning the RBV, Schumpeter's Theory of Innovation, entrepreneurial leadership, and digital transformation, were intentionally retained. These studies established a historical baseline against which contemporary developments in AI adoption and digital agility could be interpreted.

Quality Appraisal

The methodological quality and credibility of the included studies were critically assessed before inclusion in the synthesis. Each source was evaluated according to its relevance to the research objectives, methodological rigour, credibility of findings, publication quality, and contribution to understanding AI adoption, innovation, entrepreneurial leadership, and entrepreneurial resilience among SMMEs.

Priority was given to peer-reviewed journal articles published in reputable academic journals, as well as reports produced by internationally recognised organisations such as the OECD, the World Economic Forum, the African Union, and South Africa's National Planning Commission. This appraisal process ensured that only high-quality and credible evidence informed the final synthesis.

Data Extraction and Analysis

A structured data extraction matrix was developed to record information from each of the 38 selected studies systematically. The information extracted included the author(s), publication year, country or study context, research design, theoretical framework, key variables, principal findings, and contribution to understanding AI adoption and entrepreneurial resilience. The extracted data were analysed using an integrated approach that combined content and thematic analyses. All selected sources were imported into Atlas. This facilitated systematic coding and organisation of the literature. Content analysis allowed the identification of explicit findings and implicit meanings in the reviewed studies, while thematic analysis grouped similar codes into broader themes. The coding process incorporated both deductive and inductive approaches. Deductive coding was guided by established theoretical frameworks, particularly the RBV, Schumpeter's Theory of Innovation, and the TOE framework. Inductive coding allowed additional themes to emerge directly from the literature, including digital agility, supportive ecosystems, innovation capability, entrepreneurial resilience, and barriers to AI adoption. The final thematic structure formed the basis of the Results section, where the

findings of the systematic review are presented before being interpreted in the subsequent Discussion section.

Trustworthiness of the Review

Several strategies were used to improve the trustworthiness of the review. Credibility was strengthened by triangulating evidence obtained from peer-reviewed journal articles, policy documents, and industry reports. A transparent, documented search strategy, predefined inclusion and exclusion criteria, systematic coding procedures, and a clear audit trail for study selection and theme development supported dependability. Collectively, these procedures improved the reliability, transparency, and replicability of the review process.

FINDINGS

The systematic thematic analysis of the 38 secondary sources identified **three primary themes** that characterise the current landscape of AI adoption, innovation, and resilience within SMMEs.

Theme 1: Innovation-Driven Performance and Firm Heterogeneity

The findings indicated that while innovation was a universal driver of performance, its application and impact were highly dependent on firm size and resource availability. Larger SMMEs with higher sales growth demonstrated a significant positive correlation between R&D expenditures and firm performance. In contrast, smaller, low-growth firms relied on incremental product and process innovations that did not require massive financial outlays. Furthermore, creativity and risk-taking emerged as significant determinants of performance in smaller industrial enterprises regardless of formal R&D budgets.

Theme 2: Digital Agility and Entrepreneurial Resilience

The review found that adopting AI and 4IR technologies directly enhanced entrepreneurial resilience by improving operational efficiency, decision-making, and market responsiveness. Data indicated that firms with high intellectual agility—the ability to be "quick on their intellectual feet"—were better positioned to respond to technological disruptions. Entrepreneurial leadership was identified as the core internal catalyst for this process, as it fostered a culture of innovation and encouraged employees to engage in innovative work behavior during periods of market volatility.

Theme 3: Strategic Pathways through Supportive Ecosystems

The findings emphasised that SMMEs, particularly those in rural or resource-constrained environments such as Limpopo and KwaZulu-Natal, could not navigate digital transformation in isolation. The literature identified external collaboration as a critical path to sustainability. Specifically, "Entrepreneurial Universities" and innovation hubs were found to be essential for providing the incubation, mentorship, and knowledge transfer required to bridge the digital literacy gap. Additionally, government-backed financial schemes (such as SEDA and SEFA) and multi-stakeholder partnerships were highlighted as vital for overcoming the high costs of digital transformation.

DISCUSSION

The discussion interprets the three themes in relation to the RBV, Dynamic Capabilities Theory, Schumpeter's theory of innovation, and the empirical literature already reviewed. The purpose is not to claim that the present desktop review independently tested causal relationships; rather, it considers how the 38 selected sources collectively explain the conditions under which SMMEs may use digital technologies to support innovation and resilience. This distinction is important because the reviewed studies vary in context, methods, and the extent to which they examine AI specifically.

Innovation-Driven Performance and Firm Heterogeneity

The first theme suggests that innovation and performance should not be treated as uniform across all SMMEs. This interpretation is consistent with Matekenya and Moyo's quantile-regression study of South African SMMEs, which examines how the innovation–performance relationship varies across performance levels.[21] Kijkasiwat and Phuensane also consider the roles of firm size and SME finance in the relationship between innovation and performance.[22] Together, these studies support a differentiated approach: firms with greater resources may be able to sustain formal research and development, while micro and smaller firms may depend more on incremental product, service, and process changes. From an RBV perspective, Barney explains that resources create advantage when they have the relevant strategic qualities; however, limited finance and skills can prevent SMMEs from developing or deploying those resources effectively.[23] The present review therefore supports matching innovation choices to firms' available resources, rather than assuming that a single innovation strategy will suit every enterprise. The reported 70% business-failure estimate should be interpreted cautiously and understood in relation to the specific source and definition of business failure used.

Digital Agility and Entrepreneurial Resilience as Dynamic Capabilities

The second theme links digital agility with the capacity to respond to disruption, but the evidence should not be interpreted as proving that AI adoption automatically causes resilience. Rachinger et al. describe how digitalisation can influence business-model innovation, while Nadkarni and Prügl synthesise research showing that digital transformation involves both technological change and organisational responses.[24] These contributions reinforce the argument that technology creates opportunities, but that benefits depend on how firms adapt processes, roles, and capabilities. Dabić et al. connect intellectual agility, entrepreneurial leadership, and innovation in micro and small businesses, while Fatoki examines entrepreneurial leadership and employees' innovative work behaviour through creative self-efficacy.[25] Gupta et al. further conceptualise entrepreneurial leadership as a construct relevant to identifying and pursuing opportunities in changing environments.[26] Read together, this literature suggests that leadership, learning, and employee involvement can help SMMEs make productive use of digital tools. Schumpeter's idea of creative destruction provides a useful interpretive lens for business-model change, but it should not imply that every SMME must replace traditional practices wholesale; adoption decisions need to reflect customer needs, risk, affordability, and the enterprise's existing capabilities.

Strategic Pathways through Supportive Ecosystems and Indigenisation

The third theme highlights that firm-level resources and leadership may be insufficient where the surrounding environment lacks reliable infrastructure, finance, or accessible expertise. Chege and Wang discuss the role of information-technology innovation in SMEs in developing countries, while Sheik focuses on the digital divide and technological disparities affecting SMMEs in KwaZulu-Natal.[27] These studies support treating connectivity, electricity, skills, and affordability as structural conditions rather than problems that individual entrepreneurs can solve alone. The Triple Helix perspective developed by Etzkowitz and Zhou (2017) emphasises interaction among universities,

[21] Matekenya and Moyo, "Innovation as a Driver of SMME Performance in South Africa: A Quantile Regression Approach."
[22] Ploypailin Kijkasiwat and Pongsutti Phuensane, "Innovation and Firm Performance: The Moderating and Mediating Roles of Firm Size and Small and Medium Enterprise Finance," *Journal of Risk and Financial Management* 13, no. 5 (2020): 97.
[23] Barney, "Firm Resources and Sustained Competitive Advantage."
[24] Rachinger et al., "Digitalization and Its Influence on Business Model Innovation"; Nadkarni and Prügl, "Digital Transformation: A Review, Synthesis and Opportunities for Future Research."
[25] Dabić et al., "Intellectual Agility and Innovation in Micro and Small Businesses: The Mediating Role of Entrepreneurial Leadership"; Fatoki, "Entrepreneurial Leadership and Employees' Innovative Work Behaviour in Small Firms: Mediating Role of Creative Self-Efficacy."
[26] Gupta, MacMillan, and Surie, "Entrepreneurial Leadership: Developing and Measuring a Cross-Cultural Construct."
[27] Chege and Wang, "Information Technology Innovation and Its Impact on Job Creation by SMEs in Developing Countries: An Analysis of the Literature Review"; Sheik, "Navigating the Digital Divide: Exploring the Multifaceted 4IR Challenges and Technological Disparities Encountered by SMMEs within Kwazulu-Natal, South Africa."

industry, and government, and Nkusi et al. examine the role and constraints of entrepreneurial universities in ecosystem development.[28] Iwara and Kilonzo provide a South African perspective on rural-based entrepreneurial universities.[29] Taken together, this literature supports partnerships that connect SMMEs with training, mentorship, incubation, and applied research. The proposal to incorporate locally grounded business practices, including community savings arrangements such as stokvels where appropriate, should be understood as a context-sensitive recommendation requiring engagement with entrepreneurs; it is not an outcome directly tested by the sources reviewed here.

Synthesis and Conclusion of Discussion

Overall, the literature points to a complementary rather than a single-factor explanation of SMME resilience: internal resources and leadership matter, but so do firm size, financial capacity, digital infrastructure, and access to external support. The findings are consistent with the RBV's attention to firm resources,[30] research on digital transformation and business-model innovation,[31] and work on entrepreneurial leadership and intellectual agility.[32] For policy and practice, this means that recommendations should be differentiated by enterprise needs and should combine affordable, incremental innovation with practical skills development and ecosystem support. Because this study synthesises secondary sources rather than collecting new field data, the proposed pathways should be treated as a literature-informed framework for further evaluation, not as a validated causal model.

Implications of the Findings

The findings of this study are of significant weight for the evolution of theoretical frameworks, the formulation of national policies, and the practical management of small enterprises within the digital economy.

Theoretical Implications

This research advances management theory by contextualising the Resource-Based View and Dynamic Capabilities within the specific realities of developing economies. It moves beyond a focus on tangible assets, establishing intellectual agility and digital literacy as core intangible resources that enable firms to navigate technological disruptions. Furthermore, the study validates Schumpeter's Theory of Innovation in the 4IR era, demonstrating that AI adoption serves as a form of "creative destruction" necessary to replace obsolete business models. A critical theoretical contribution is the identification of the "Eurocentric gap" in existing innovation models, arguing for a theoretical shift that incorporates indigenous knowledge systems as foundational elements of entrepreneurial resilience.

Practical Implications

For SMME practitioners, the findings imply that survival in a volatile environment is no longer possible through traditional management alone. There is a fundamental need for a paradigm shift toward Entrepreneurial Leadership, which emphasises vision and risk-taking. The research suggests that for most small firms, the path to competitiveness lies in leveraging "invisible assets"—such as creativity and employee empowerment rather than competing on capital-intensive research and development. The study also suggests that the high failure rate among small firms is closely related to a lack of strategic alignment between their leadership styles and the technological demands of the digital divide.

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[28] Etzkowitz and Zhou, *The Triple Helix*; Nkusi et al., "The Role of the Entrepreneurial University in Building an Entrepreneurial Ecosystem in a Post Conflict Economy: An Exploratory Study of Rwanda."

[29] Ishmael Obaeko Iwara and Beata Mukina Kilonzo, "Towards a Conceptual Understanding of an Effective Rural-Based Entrepreneurial University in South Africa," *Social Sciences* 11, no. 9 (2022): 388.

[30] Barney, "Firm Resources and Sustained Competitive Advantage."

[31] Rachinger et al., "Digitalization and Its Influence on Business Model Innovation"; Nadkarni and Prügl, "Digital Transformation: A Review, Synthesis and Opportunities for Future Research."

[32] Gupta, MacMillan, and Surie, "Entrepreneurial Leadership: Developing and Measuring a Cross-Cultural Construct"; Fatoki, "Entrepreneurial Leadership and Employees' Innovative Work Behaviour in Small Firms: Mediating Role of Creative Self-Efficacy."

Policy Implications

From a policy perspective, the study highlights that current support structures may be inadvertently widening the gap between large corporations and SMMEs. The findings imply that a "one-size-fits-all" approach to innovation incentives is ineffective, as smaller firms lack the financial threshold to benefit from traditional R&D tax breaks. Furthermore, persistent infrastructural deficiencies in rural regions mean that digital transformation remains unattainable for many enterprises unless foundational issues such as electricity and broadband access are treated as urgent national priorities.

RECOMMENDATIONS

Based on the evidence synthesised in this study, the following specific, actionable recommendations are directed at key stakeholders to foster a more inclusive and resilient SMME sector.

For SMME Owners and Practitioners

- **Prioritise Targeted Innovation:** Smaller firms should focus their limited resources on incremental product and process innovations that improve customer reach and service delivery rather than attempting high-cost, formal R&D.
- **Cultivate Intellectual Agility:** Leaders must actively create a learning environment by dedicating time to coach staff and update digital skills, ensuring the workforce is capable of navigating new AI-driven tools.
- **Leverage Digital Platforms:** To reduce overhead and physical infrastructure costs, practitioners should transition to cloud-based computing and utilise global online marketplaces to access wider consumer bases with minimal capital expenditure.

For Policymakers and Government Agencies

- **Redesign Innovation Incentives:** The government should move beyond R&D tax credits to establish a **Small Business Innovation Fund** that provides direct grants and low-interest loans specifically for digital transformation in low-growth and micro-enterprises.
- **Urgent Infrastructural Investment:** National and provincial governments must prioritise the rollout of high-speed broadband and consistent electricity in marginalised regions to provide the necessary "technological floor" for AI adoption.
- **Indigenize Support Programs:** Support agencies should replace Eurocentric training models with Afrocentric pedagogical frameworks that recognize and utilize local business patterns and community-driven funding systems.

For Educational Institutions and Entrepreneurial Universities

- **Adopt Engaged Scholarship:** Universities should shift from basic research to applied, solution-driven research that is co-designed with local entrepreneurs to ensure that knowledge transfer is culturally relevant and addresses specific community needs.
- **Establish Localized Incubation Hubs:** Higher education institutions should develop rural-based business incubators that provide specialized mentorship and serve as "talent hunts" for innovative student-led startups.
- **Integrate Entrepreneurship Curricula:** Institutions must make entrepreneurship education a compulsory component of all degree programs to breed a cohort of "academic-entrepreneurs" capable of turning disciplinary knowledge into viable digital business models.

CONCLUSION

This study demonstrated that the adoption of AI represents both a transformative opportunity and a significant challenge for the competitiveness and resilience of SMMEs in South Africa. Although the 4IR provides the tools necessary to bridge the productivity gap, the research concluded that successful integration depends on a firm's ability to navigate a landscape defined by a pronounced digital divide and severe resource constraints. The findings established that Entrepreneurial leadership is an important internal catalyst for this transformation. In an environment where 70% of small firms face

failure within their first decade, the transition from traditional management to intellectually agile leadership models is no longer optional. Leaders must act as the primary agents of "creative destruction," replacing obsolete manual processes with AI-driven efficiencies while simultaneously fostering a culture of creative self-efficacy among their employees. For smaller, low-growth enterprises, the most viable pathway to resilience lies in targeted, incremental product innovation rather than capital-intensive research and development. Furthermore, the research highlighted that SMMEs cannot bridge the digital chasm in isolation. Supportive Ecosystems and Rural-Based Entrepreneurial Universities play vital roles in providing the "venturing seed funds," mentorship, and specialised training required to survive in the digital economy. A recurring and fundamental conclusion of this paper is the need for the indigenisation of innovation strategies. South African SMMEs require Afrocentric pedagogical frameworks—integrating traditional business patterns and community-driven support—to ensure that technological advancements remain culturally relevant and economically impactful.

In final reflection, the strategic alignment of dynamic capabilities with a robust, inclusive innovation ecosystem offers a promising blueprint for national economic recovery. However, this potential will remain unrealised without urgent state intervention in foundational infrastructure, such as consistent electricity and high-speed broadband. By treating these deficiencies as national emergencies and fostering collaborative "Triple Helix" networks, South Africa can empower its SMME sector to evolve from survivalist entities into resilient, globally competitive engines of job creation and inclusive growth in the 4IR frontier.

Limitations and Future Research

This study is subject to several limitations inherent in its desktop research design. The reliance on secondary data limits the ability to capture real-time experiences and context-specific insights from SMME owners, particularly those operating in rural, under-resourced environments. Although the study synthesises evidence from a diverse range of academic and policy sources, variations in methodological approaches and contextual settings in the reviewed studies may affect the generalisability of the findings.[33] Furthermore, the rapidly evolving nature of Artificial Intelligence and 4IR technologies implies that some of the insights presented may become outdated as innovations emerge.

Future research should adopt empirical approaches, such as mixed-method or longitudinal designs, to validate the proposed strategic pathways and provide deeper insights into the practical realities of AI adoption in South African SMMEs. In particular, there is a need for context-specific studies on rural enterprises that explore how indigenous knowledge systems can be integrated with digital innovation strategies.

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