

Digital Infrastructure Barriers Faced by SMEs in Transitioning to Smart Business Models

Sandra Orobosa Idemudia¹, Onyeka Kelvin Chima², Onyinye Jacqueline Ezeilo³, Benjamin Monday Ojonugwa⁴, Akoche Ochefu⁵ Michael Olumuyiwa Adesuyi⁶

¹Independent Researcher, Abuja, Nigeria

²Africa Capital Alliance, Ikoyi, Lagos. Nigeria

³Independent researcher, Abuja, Nigeria

⁴Independent researcher, Lagos, Nigeria

⁵Benue State Civil Service Commission, Benue, Nigeria

⁶First Bank of Nigeria Ltd, Kano, Nigeria

Corresponding author: Sandra Orobosa Idemudia

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ABSTRACT

In the contemporary digital economy, Small and Medium-sized Enterprises (SMEs) are increasingly compelled to adopt smart business models to remain competitive and responsive to market dynamics. Smart business models leverage digital technologies to enhance operational efficiency, customer engagement, and innovation capacity. However, the transition to such models is fraught with challenges, particularly concerning digital infrastructure. This study investigates the specific digital infrastructure barriers that SMEs encounter in their pursuit of smart business models, aiming to provide a comprehensive understanding of these impediments and propose actionable solutions. The research employs a mixed-methods approach, combining quantitative surveys and qualitative interviews with SME owners and managers across various sectors. The quantitative component involves a structured survey distributed to 500 SMEs, assessing their current digital infrastructure, readiness for digital transformation, and perceived barriers. The qualitative component comprises in-depth interviews with 30 SME stakeholders, providing nuanced insights into the challenges and strategies related to digital infrastructure.

Findings reveal that SMEs face multifaceted barriers in transitioning to smart business models. Key challenges include limited financial resources to invest in advanced digital technologies, inadequate broadband connectivity, lack of in-house technical expertise, cybersecurity concerns,

and resistance to organizational change. These barriers are often interrelated, creating a complex landscape that hinders digital transformation efforts. Financial constraints emerge as a predominant barrier, with many SMEs unable to afford the initial investment required for digital infrastructure upgrades. This limitation is exacerbated by difficulties in accessing external funding or government support programs. Inadequate broadband connectivity, particularly in rural or underserved areas, further impedes the adoption of cloud-based services and real-time data analytics essential for smart business operations.

The lack of in-house technical expertise poses another significant challenge. SMEs often struggle to recruit and retain skilled IT professionals, leading to reliance on external consultants or suboptimal utilization of digital tools. Cybersecurity concerns also deter SMEs from embracing digital transformation, as they fear potential data breaches and lack the resources to implement robust security measures. Organizational resistance to change, rooted in established workflows and cultural inertia, further complicates the transition. Employees may be hesitant to adopt new technologies, and management may lack a clear digital strategy or vision. This resistance underscores the need for change management initiatives and leadership commitment to foster a digital-ready culture. This research contributes to the existing literature by providing an in-depth analysis of digital infrastructure barriers specific to SMEs and offering practical solutions to facilitate their transition to smart business models. By addressing these challenges, policymakers, industry stakeholders, and SMEs themselves can collaboratively pave the way for a more inclusive and resilient digital economy.

Keywords - Smart Business Models, Digital Infrastructure, Small and Medium-sized Enterprises (SMEs), Digital Transformation, Technological Barriers, Change Management

Introduction

In the contemporary digital economy, the adoption of smart business models has become imperative for enterprises aiming to maintain competitiveness, enhance operational efficiency, and meet evolving consumer expectations[1]. Smart business models leverage digital technologies such as cloud computing, data analytics, Internet of Things (IoT), and artificial intelligence (AI) to transform traditional business processes, enabling real-time decision-making, personalized customer experiences, and agile responses to market dynamics[2]. For Small

and Medium-sized Enterprises (SMEs), which constitute a significant portion of global economic activity, transitioning to smart business models offers opportunities for innovation, market expansion, and sustainable growth[3].

However, the journey toward digital transformation is fraught with challenges, particularly concerning digital infrastructure[4]. Digital infrastructure encompasses the foundational technologies and services that support digital operations, including high-speed internet connectivity, secure data storage, reliable hardware and software systems, and skilled human capital[5]. For SMEs, limitations in digital infrastructure can impede the adoption of smart technologies, restrict access to digital markets, and exacerbate competitive disadvantages relative to larger enterprises with more substantial resources[6].

The significance of digital infrastructure for SMEs has been underscored by recent global events, notably the COVID-19 pandemic, which accelerated the shift toward digital channels and remote operations[7]. Enterprises with robust digital infrastructures were better positioned to adapt to disruptions, maintain customer engagement, and explore new revenue streams[8]. Conversely, SMEs with inadequate digital capabilities faced heightened vulnerabilities, including operational disruptions, revenue losses, and market exclusion. This disparity highlights the critical role of digital infrastructure in enabling resilience and adaptability in the face of external shocks[9]. Despite the recognized importance of digital transformation, SMEs encounter a myriad of barriers in enhancing their digital infrastructure. Financial constraints often limit the ability to invest in advanced technologies and skilled personnel[10]. A study by Restrepo-Morales et al. (2024) identified insufficient financial resources and high investment costs as primary obstacles to digitalization in SMEs[11]. Additionally, a lack of in-house technical expertise hampers the effective implementation and management of digital systems. Many SMEs struggle to recruit and retain IT professionals, making it challenging to navigate the complexities of digital transformation[12].

Organizational culture and resistance to change further complicate the transition to smart business models. Employees accustomed to traditional workflows may exhibit reluctance toward adopting new technologies, fearing job displacement or increased complexity. This resistance can be particularly pronounced in SMEs with long-standing practices and limited exposure to digital innovation. Moreover, concerns about cybersecurity and data privacy deter some SMEs from embracing digital tools, especially when lacking the resources to implement robust security measures[13].

Infrastructure-related challenges, such as inadequate broadband connectivity and unreliable power supply, also pose significant barriers, particularly in developing regions. In Nigeria, for instance, SMEs have reported difficulties in accessing affordable IT devices, stable electricity, and high-speed internet, all of which are essential components of digital infrastructure[14]. These deficiencies hinder the adoption of cloud-based services, real-time data analytics, and other digital solutions integral to smart business models[15].

Given these multifaceted challenges, there is a pressing need to understand the specific digital infrastructure barriers that SMEs face in transitioning to smart business models[16]. While existing literature has explored various aspects of SME digital transformation, there remains a gap in comprehensive analyses that integrate the technical, organizational, and contextual factors influencing digital infrastructure development[17]. Addressing this gap is crucial for informing policy interventions, designing targeted support programs, and guiding SMEs in their digitalization efforts.

This study aims to investigate the digital infrastructure barriers encountered by SMEs in their pursuit of smart business models. By employing a mixed-methods approach that combines quantitative surveys and qualitative interviews, the research seeks to provide a holistic understanding of the challenges and identify actionable

strategies to overcome them. The findings are intended to contribute to the academic discourse on digital transformation and offer practical insights for SMEs, policymakers, and stakeholders committed to fostering inclusive digital economies[18].

The structure of the paper is as follows: the subsequent section presents a comprehensive literature review, synthesizing existing research on SME digital transformation and infrastructure challenges. The methodology section outlines the research design, data collection methods, and analytical approaches employed in the study. Following this, the results section presents the empirical findings, highlighting the key barriers identified. The discussion section interprets the results in the context of existing literature and theoretical frameworks, and the conclusion offers recommendations for practice and future research directions[19].

Literature Review

The transition of Small and Medium-sized Enterprises (SMEs) to smart business models is a critical component of the broader digital transformation sweeping across industries. Smart business models leverage digital technologies to enhance operational efficiency, customer engagement, and innovation capacity[20]. However, SMEs often face significant barriers in adopting these models, particularly concerning digital infrastructure. This literature review synthesizes existing research on the challenges SMEs encounter in digital transformation, focusing on digital infrastructure barriers, and identifies gaps for future investigation[19].

1. Digital Transformation in SMEs

Digital transformation refers to the integration of digital technologies into all areas of a business, fundamentally changing how organizations operate and deliver value to customers. For SMEs, digital transformation is not merely a technological upgrade but a strategic shift that impacts business models, processes, and organizational culture[21]. Despite the potential benefits, SMEs often lag in digital adoption compared to larger enterprises. Factors such as limited resources, lack of digital skills, and inadequate infrastructure contribute to this disparity. A systematic literature review highlights that SMEs' transformation to smart manufacturing is hindered by challenges categorized using the Smart Industry Readiness Index (SIRI) framework. These include process, technology, and organizational challenges, with digital infrastructure being a significant concern. The study emphasizes the need for SMEs to start their transition with minimal investment and existing resources, suggesting a phased approach to digital transformation.

2. Financial Constraints

Financial limitations are consistently identified as a primary barrier to digital transformation in SMEs. The high costs associated with implementing digital technologies, such as purchasing hardware, software, and training personnel, can be prohibitive for smaller firms. A study found that insufficient financial resources and high investment costs are significant obstacles to digitalization in SMEs.

Moreover, SMEs often face challenges in accessing external funding or government support programs designed to facilitate digital adoption[22]. The lack of awareness or complexity of application processes can deter SMEs from seeking financial assistance. This financial barrier not only delays digital transformation but also widens the digital divide between SMEs and larger enterprises[22].

3. Technological Barriers

Technological challenges encompass issues related to the availability, reliability, and compatibility of digital infrastructure. SMEs may struggle with outdated hardware, lack of access to high-speed internet, and limited interoperability between existing systems and new technologies. These issues can impede the seamless integration of digital tools necessary for smart business models[23].

Another study emphasizes the need for a holistic, hierarchical structure of digitalization enablers, offering a practical roadmap for SMEs to navigate their digital transformation process. The study identifies key enablers, including technological readiness, organizational culture, and external support, as critical factors influencing the success of digital transformation in SMEs[24].

4. Human Capital and Skills Gap

The lack of in-house technical expertise is a significant barrier to digital transformation in SMEs. Many SMEs struggle to recruit and retain skilled IT professionals, leading to reliance on external consultants or suboptimal utilization of digital tools. This skills gap can hinder the effective implementation and management of digital systems[25].

5. Organizational Culture and Resistance to Change

Organizational resistance to change, rooted in established workflows and cultural inertia, further complicates the transition to smart business models. Employees may be hesitant to adopt new technologies, and management may lack a clear digital strategy or vision. This resistance underscores the need for change management initiatives and leadership commitment to foster a digital-ready culture[26].

6. Cybersecurity Concerns

Cybersecurity concerns also deter SMEs from embracing digital transformation, as they fear potential data breaches and lack the resources to implement robust security measures. The increasing sophistication of cyber threats necessitates substantial investments in cybersecurity measures, which can pose challenges for many organizations. IT security and the associated requirements for protecting digital assets and data as significant barriers to digitalization[27]. The study aligns with previous research highlighting the importance of prioritizing cybersecurity in the digitalization process.

7. Policy and Support Mechanisms

Government policies and support mechanisms play a crucial role in facilitating digital transformation in SMEs. However, past efforts to boost the adoption of digital technologies, such as the UK's Help to Grow: Digital scheme, have been well-intentioned but ineffective. Design choices, limited eligibility, low awareness, and a disconnect from the realities of being a small business owner meant that uptake remained low and impact limited[28].

In contrast, the EU's digital transformation plan has demonstrated what works: ambitious, joined-up strategies that combine financial incentives, tailored support, hands-on and sustained public awareness campaigns. This approach underscores the importance of comprehensive, well-designed policies that address the specific needs and challenges of SMEs.

8. Research Gaps and Future Directions

While existing literature provides valuable insights into the barriers SMEs face in digital transformation, several gaps remain. There is a need for more research focusing on SMEs in developing countries, where digital infrastructure challenges may be more pronounced. Additionally, studies exploring sector-specific barriers and the effectiveness of different support mechanisms can inform more targeted interventions[29]. Further research is also needed to understand the interplay between various barriers and how they collectively impact the digital transformation journey of SMEs. Longitudinal studies tracking SMEs over time can provide deeper insights into the dynamics of digital adoption and the factors influencing success or failure[30].

Methodology

1. Research Design

This study adopted a mixed-methods research design, integrating both quantitative and qualitative approaches to comprehensively explore the digital infrastructure barriers faced by Small and Medium-sized Enterprises

(SMEs) in transitioning to smart business models. The mixed-methods approach was selected to leverage the strengths of both methodologies: the quantitative component provided measurable data on the prevalence and impact of various barriers, while the qualitative component offered in-depth insights into the contextual and experiential aspects of these challenges.

The research design was structured in two sequential phases:

1. **Quantitative Phase:** A structured survey was administered to a broad sample of SMEs to quantify the extent and nature of digital infrastructure barriers encountered.
2. **Qualitative Phase:** In-depth interviews were conducted with a purposive subset of survey respondents to gain nuanced understanding of the barriers identified in the quantitative phase.

This sequential explanatory design ensured that the qualitative data could be used to elaborate on and contextualize the quantitative findings, providing a richer and more comprehensive understanding of the research problem.

2. Population and Sampling

2.1. Population

The target population for this study comprised SMEs operating within Nigeria, with a particular focus on those in urban and semi-urban areas where digital infrastructure challenges are prevalent. SMEs were defined according to the criteria set by the Nigerian Small and Medium Enterprises Development Agency (SMEDAN), which classifies SMEs based on employee count and annual turnover.

2.2. Sampling Technique

A stratified random sampling technique was employed to ensure representation across various sectors (e.g., manufacturing, services, retail) and geographic locations. The stratification was based on industry sector and location to capture potential variations in digital infrastructure challenges across different contexts.

2.3. Sample Size

For the quantitative phase, a sample size of 500 SMEs was targeted to achieve statistical significance and generalizability of findings. This sample size was determined using Cochran's formula for sample size calculation, considering a 95% confidence level and a 5% margin of error.

In the qualitative phase, 30 SMEs were purposively selected from the survey respondents for in-depth interviews. The selection criteria included diversity in industry sector, size, and reported levels of digital infrastructure challenges.

3. Data Collection Methods

3.1. Quantitative Data Collection

A structured questionnaire was developed based on existing literature and frameworks related to digital transformation and infrastructure barriers in SMEs. The questionnaire comprised closed-ended questions using a Likert scale to assess the degree to which various digital infrastructure factors posed challenges to SMEs. The survey was conducted electronically via email and online survey platforms, as well as in-person where necessary, to accommodate varying levels of digital access among SMEs.

3.2. Qualitative Data Collection

Semi-structured interviews were conducted with the purposively selected SMEs to delve deeper into the specific digital infrastructure barriers they faced. An interview guide was developed, encompassing themes such as access to internet connectivity, availability of digital tools, technical expertise, and organizational readiness for digital

transformation. Interviews were conducted either face-to-face or via video conferencing platforms, depending on the preference and accessibility of the participants.

4. Data Analysis

4.1. Quantitative Data Analysis

The quantitative data collected from the surveys were analyzed using Statistical Package for the Social Sciences (SPSS) software. Descriptive statistics (mean, standard deviation, frequency distributions) were computed to summarize the data. Inferential statistics, including factor analysis and regression analysis, were employed to identify underlying patterns and relationships between different digital infrastructure barriers and the SMEs' readiness to adopt smart business models.

4.2. Qualitative Data Analysis

The qualitative data from the interviews were transcribed verbatim and analyzed using thematic analysis. This involved coding the data to identify recurring themes and patterns related to digital infrastructure challenges. The analysis was conducted using NVivo software to facilitate systematic organization and retrieval of data segments corresponding to specific themes.

5. Validity and Reliability

5.1. Validity

To ensure content validity, the survey questionnaire and interview guide were reviewed by experts in digital transformation and SME development. A pilot test was conducted with a small group of SMEs to refine the instruments for clarity and relevance.

5.2. Reliability

The internal consistency of the survey instrument was assessed using Cronbach's alpha. A Cronbach's alpha value of 0.85 indicated high reliability of the instrument. For the qualitative data, inter-coder reliability was established by having multiple researchers independently code a subset of the data and then comparing the coding to ensure consistency.

6. Ethical Considerations

Ethical approval for the study was obtained from the relevant institutional review board. Participants were provided with informed consent forms detailing the purpose of the study, the voluntary nature of participation, and assurances of confidentiality and anonymity. Data collected were securely stored and used solely for research purposes.

7. Limitations

While the mixed-methods approach provided a comprehensive understanding of the digital infrastructure barriers faced by SMEs, certain limitations were acknowledged. The reliance on self-reported data may introduce response bias. Additionally, the study's focus on SMEs in Nigeria may limit the generalizability of findings to other contexts without considering regional differences in digital infrastructure development.

Results

This section presents the findings from the mixed-methods investigation into the digital infrastructure barriers faced by Small and Medium-sized Enterprises (SMEs) during their transition to smart business models. The data analyzed herein were collected from 500 SMEs through structured questionnaires and further enriched by qualitative interviews with 30 selected SME representatives. The results are organized into quantitative and qualitative findings, with the integration of both offering a holistic view of the challenges and patterns observed.

1. Quantitative Findings

1.1 Respondent Demographics

Of the 500 SMEs surveyed, 48% were from the service sector, 32% from manufacturing, and 20% from retail and distribution. The majority (63%) were small enterprises (fewer than 50 employees), while the remaining 37% were medium-sized (51 to 199 employees). Geographically, 60% were located in urban centers, 30% in semi-urban areas, and 10% in rural settings.

1.2 Frequency and Severity of Barriers

Respondents rated several digital infrastructure challenges on a 5-point Likert scale (1 = Not a challenge, 5 = Major challenge). The top five challenges reported were:

- Inadequate internet connectivity (Mean = 4.3, SD = 0.7)
- High cost of digital technology acquisition (Mean = 4.1, SD = 0.8)
- Lack of skilled IT personnel (Mean = 3.9, SD = 1.0)
- Poor access to digital platforms and cloud services (Mean = 3.8, SD = 0.9)
- Unreliable power supply affecting ICT systems (Mean = 3.7, SD = 1.2)

Notably, 78% of respondents indicated that the lack of stable internet connectivity significantly hampered their efforts to adopt data-driven operations and cloud-based systems.

1.3 Sectoral Differences

The data revealed clear variations across industry sectors. For example, manufacturing SMEs reported a higher level of concern regarding outdated hardware and automation tools (Mean = 3.9) than service-based SMEs (Mean = 3.1). Conversely, service SMEs emphasized cybersecurity risks more heavily (Mean = 3.7) compared to manufacturing SMEs (Mean = 3.0).

1.4 Urban-Rural Disparity

Urban SMEs generally reported better access to broadband internet and cloud-based services compared to their rural counterparts. Rural SMEs cited infrastructural neglect, with 85% indicating they lacked access to enterprise-grade ICT tools and technical support.

1.5 Factor Analysis

A factor analysis (principal component analysis with varimax rotation) was performed to identify the latent dimensions underlying digital infrastructure challenges. The analysis yielded four primary components:

1. Connectivity and Technical Infrastructure
2. Digital Skills and Human Capital
3. Technology Costs and Financing
4. Cybersecurity and Data Governance

These four components accounted for 72% of the variance in responses. Each factor was internally consistent, with Cronbach's alpha values ranging from 0.78 to 0.87.

1.6 Regression Analysis

Multiple linear regression was conducted to determine the predictors of successful transition to smart business models (measured by digital tool adoption, process automation, and customer engagement through digital platforms). The regression model showed statistical significance ($R^2 = 0.61$, $p < 0.001$), and significant predictors included:

- Internet reliability ($\beta = 0.34$, $p < 0.01$)
- Access to technical training ($\beta = 0.28$, $p < 0.01$)
- Availability of financing for technology investment ($\beta = 0.22$, $p < 0.05$)

Interestingly, firm size was not a significant predictor ($\beta = 0.05$, $p = 0.34$), suggesting that both small and medium firms face similar digital infrastructure barriers when other conditions are held constant.

2. Qualitative Findings

In-depth interviews with 30 SME managers and IT staff offered deeper insight into the challenges identified quantitatively. Thematic analysis revealed six prominent themes:

2.1 “Infrastructure Exists, but Not for Us”

Many participants described a situation where digital infrastructure (e.g., fiber-optic broadband, mobile 5G services) was available in urban cores but did not extend to business parks or industrial estates. This selective availability hindered equal participation in the digital economy.

“Our business is just outside the city center, and there’s no broadband coverage here only mobile data, which is expensive and unreliable.” SME Owner, Abuja

2.2 Skills Gap and External Dependency

Respondents highlighted the scarcity of digital talent within the SME labor pool. SMEs often relied on external consultants or freelancers for tasks like software implementation, website management, and cybersecurity audits, which increased operational costs and limited internal learning.

“We tried adopting ERP software, but nobody here could manage it. We had to keep calling the vendor for support.” Operations Manager, Kano

2.3 Legacy Systems and Compatibility Issues

Several SMEs shared that their existing infrastructure—particularly legacy software and outdated hardware—was incompatible with newer smart tools. The cost of upgrading all systems to accommodate cloud services and automation tools was described as prohibitive.

“It’s not just buying new software; it’s replacing the entire ecosystem computers, routers, UPS systems. That’s a massive investment.” CEO, Lagos

2.4 Mistrust in Data Security

Participants expressed concern over data breaches and lack of control when using third-party digital platforms. This mistrust resulted in reluctance to fully adopt digital payment gateways, cloud-based CRMs, or remote work solutions.

“We still keep sensitive information on paper because we’ve heard too many stories of hacks and data loss.” — HR Manager, Port Harcourt

2.5 Lack of Government Support and Incentives

Many SMEs felt overlooked in national digital transformation plans. Participants called for policy reforms, financial incentives, and state-level programs to support their adoption of smart business technologies.

“We hear about innovation hubs and digital grants, but they seem to go to the big players or tech startups, not regular SMEs.” Retail Entrepreneur, Enugu

2.6 Innovation Under Constraint

Despite the barriers, several SMEs demonstrated ingenuity by using mobile platforms like WhatsApp Business, Facebook Marketplace, and POS-based accounting tools to engage customers and digitize operations, albeit informally.

“We don’t have an online store, but we use WhatsApp and Instagram to take orders. That’s our version of ‘smart’ business.” Fashion Retailer, Ibadan

3. Integration of Quantitative and Qualitative Data

The integration of both datasets reinforces key findings:

- Internet access and cost of technology are the most pressing infrastructural barriers, regardless of sector.
- Digital skills gaps are both a cause and consequence of limited infrastructure investment.
- Policy neglect and urban-centric development have created systemic disparities in SME digital readiness.

Quantitative results provided statistical grounding, while qualitative narratives humanized and contextualized the challenges, revealing adaptive strategies and unmet needs.

Discussion

The results of this study reveal a complex and multifaceted landscape of digital infrastructure challenges that hinder SMEs from effectively transitioning to smart business models. By employing a mixed-methods approach, the research sheds light not only on the frequency and severity of these challenges but also on the underlying systemic, socio-technical, and policy-level issues that shape the SME digitalization experience in the post-pandemic business environment[31].

1. Reconciling Infrastructure Readiness with SME Digital Maturity

At the heart of the findings is a clear misalignment between the available digital infrastructure in many regions and the actual digital maturity of SMEs. While digital transformation is widely promoted at national and international levels, SMEs remain constrained by basic infrastructural inadequacies such as unreliable internet connectivity, lack of power supply stability, and limited access to cloud computing facilities[32]. This undermines assumptions made in popular digital transformation frameworks that presume a baseline of digital readiness across all economic actors.

The results confirm that internet reliability remains the single most important infrastructural enabler of smart business operations[33]. Without stable connectivity, SMEs cannot access cloud-based enterprise resource planning (ERP) tools, adopt internet-of-things (IoT) solutions, or implement customer relationship management (CRM) platforms. In this respect, internet access is no longer a luxury but a fundamental business utility[34]. This aligns with prior findings (e.g., OECD, 2020) which identify broadband coverage as a critical driver of SME digital competitiveness.

2. Sectoral and Geographical Disparities

Another key finding is the differentiated impact of infrastructure barriers across industry sectors and geographical locations. Manufacturing SMEs, for instance, appear to be more affected by outdated legacy systems and the lack of integration with modern automation tools. This suggests that capital-intensive sectors may face a more complex and costly digital transition. Conversely, service-sector SMEs report higher sensitivity to cybersecurity concerns and data privacy risks due to their reliance on customer-facing digital tools and e-commerce platforms[35].

Geographically, rural SMEs are disproportionately disadvantaged in terms of access to infrastructure, echoing long-standing digital divide concerns. While urban SMEs benefit from public-private partnerships in digital

innovation clusters or access to startup hubs, rural and peri-urban enterprises often operate outside the reach of such ecosystems[36]. This exacerbates existing economic inequalities and limits the diffusion of digital capabilities across regions.

3. Financial Constraints and Innovation Under Resource Scarcity

The results also emphasize the financial dimension of digital infrastructure barriers. SMEs, especially in developing economies, often lack the capital reserves necessary for large-scale investment in modern ICT infrastructure. The high cost of hardware upgrades, subscription fees for enterprise software, and consultancy costs for implementation all pose significant hurdles[37].

However, qualitative findings show that many SMEs respond with creative workarounds—such as leveraging mobile platforms (e.g., WhatsApp Business) or adopting low-code/no-code tools for e-commerce integration. This aligns with the concept of “innovation under constraint”, where businesses find flexible, frugal solutions despite limited resources. Nonetheless, such adaptations are often tactical rather than strategic and may not lead to sustainable or scalable smart business models.

4. The Human Capital Gap

The digital skills gap emerged as both a cause and a consequence of infrastructural underdevelopment. SMEs frequently lack internal IT expertise, resulting in a reliance on external vendors who may not be cost-effective for long-term support. This human capital limitation undermines SME capacity to implement and maintain advanced systems such as AI-driven analytics, IoT, or blockchain[38].

Moreover, SMEs that attempt digital adoption without adequate training often face implementation failure, software misuse, or cybersecurity vulnerabilities. These findings support the call for integrated capacity-building programs that go beyond hardware provision to include staff training, mentorship, and digital literacy initiatives[39].

5. Policy Implications and Gaps

The qualitative data also reveals a gap in policy inclusiveness. Many SME respondents expressed frustration with the perceived inaccessibility of government digitalization support, including funding, training, or grants. Several cited eligibility requirements or bureaucratic barriers that disproportionately favor tech startups or large enterprises over traditional SMEs.

This suggests the need for a more targeted SME digital policy framework, one that is responsive to the sector’s heterogeneity and infrastructural limitations. A “one-size-fits-all” approach to digitalization will continue to leave many SMEs behind unless differentiated support strategies are adopted. For example, rural-specific subsidies for broadband installation or microgrants for tech tool acquisition could have a transformative impact[40].

6. Risk Perception and Trust Deficits

The study also uncovered an under-explored dimension of digital transformation: the perception of risk. Many SMEs remain hesitant to fully digitize due to mistrust of data security and skepticism about the dependability of third-party platforms. This perception of risk results in half-measures or avoidance of digital tools entirely particularly for functions involving sensitive data or financial transactions[41].

These findings align with other studies (e.g., EIB, 2021) which suggest that SMEs often lack the internal auditing or cybersecurity capacity required to build resilience against data breaches[42]. Addressing this trust deficit may require better regulatory assurances, industry-specific standards, and accessible cyber insurance products tailored for small businesses.

7. Theoretical Contribution

The findings contribute to the growing literature on digital transformation in SMEs by emphasizing that digital infrastructure is not merely a technical concern but a socio-economic and policy issue. The proposed framework, which integrates infrastructure, human capital, financial readiness, and policy environment, offers a holistic lens for evaluating SME digitalization potential[43].

Moreover, the identification of adaptive behaviors under constraint provides an empirical basis for expanding the theory of digital frugality a concept often applied to startups but increasingly relevant to legacy SMEs attempting to modernize without institutional support[44].

8. Limitations and Future Research Directions

While this study provides rich insight, it is not without limitations. First, it is geographically limited to SMEs operating within Nigeria, and while findings may have broader relevance, generalizations to other national contexts should be made cautiously. Second, the cross-sectional nature of the data limits the ability to capture longitudinal trends in digital transformation readiness.

Future research should consider longitudinal studies that track SME digital progression over time, as well as comparative studies across countries or regions. Additional focus on the gendered dimensions of SME digital barriers (e.g., women-led businesses) could also yield valuable policy implications[45].

In summary, this discussion highlights the pressing need to move beyond generic digitalization narratives and embrace a grounded, infrastructure-aware understanding of the SME transformation journey. Unless foundational barriers such as internet access, skills deficits, and financial constraints are addressed systemically, many SMEs will remain excluded from the smart business revolution.

Conclusion

The transition of small and medium-sized enterprises (SMEs) to smart business models is no longer a distant ambition but a pressing economic and technological imperative in today's rapidly evolving digital economy. As this study has demonstrated, the process of digital transformation for SMEs is complex and uneven, shaped fundamentally by the quality and accessibility of digital infrastructure[46]. In an increasingly globalized and digitized marketplace, the ability of SMEs to compete, innovate, and grow is directly tied to their technological preparedness and infrastructural environment. This conclusion synthesizes the study's key findings, their implications for business strategy and policy, and proposes actionable recommendations for future interventions.

1. Summary of Key Findings

This research, through a combination of quantitative surveys and qualitative interviews, has revealed that the most significant barriers faced by SMEs in transitioning to smart business models are deeply infrastructural. These include unreliable internet connectivity, high costs of ICT equipment and software, limited access to digital support services, and regional disparities in broadband availability. In many parts of the developing world and in underserved rural areas globally these constraints are not merely technical, but systemic, reflecting years of underinvestment and policy inattention[47].

Equally concerning are the internal organizational limitations within SMEs. The lack of digital literacy among employees, inadequate cybersecurity awareness, and insufficient financial resources to invest in transformative technology create a reinforcing cycle of digital exclusion. Many SMEs are forced to operate in a hybrid state partially digital, but not fully integrated leading to inefficiencies, fragmented operations, and limited scalability[48].

Furthermore, the study highlighted a mismatch between the digital transformation support structures offered by governments or development agencies and the practical realities faced by SMEs. Public support programs, where they exist, are often difficult to access, overly bureaucratic, or fail to consider the unique needs of micro-

enterprises and traditional small businesses. This policy blind spot is especially detrimental in economies where SMEs constitute the majority of employment and contribute significantly to GDP.

2. Strategic Implications for SMEs

The transition to smart business models is not only about adopting new technology but also about reshaping organizational culture, value chains, and customer engagement strategies. For SMEs, particularly those in resource-constrained environments, digital transformation must be approached as a phased journey, not an overnight overhaul. Strategic planning should involve:

- Conducting a digital maturity assessment to identify priority areas for investment.
- Leveraging low-cost, scalable solutions such as Software-as-a-Service (SaaS) platforms.
- Seeking strategic partnerships with technology providers, local universities, or business incubators.
- Investing in incremental staff training, especially in areas like data management, cybersecurity, and customer analytics.

These steps, though modest, can provide a foundation upon which SMEs can begin to develop smart capabilities in areas such as supply chain optimization, automated inventory tracking, customer segmentation, and predictive sales forecasting[49].

3. Policy and Ecosystem Recommendations

Given the pivotal role SMEs play in most national economies, enabling their digital transformation should be a strategic priority for governments and international development actors. Based on this study's findings, several policy recommendations emerge:

- **Infrastructure Investment:** Governments must prioritize last-mile broadband delivery, especially in rural and semi-urban areas. Public-private partnerships (PPPs) can be instrumental in accelerating infrastructure rollouts, reducing costs, and ensuring sustainability.
- **Targeted Financial Support:** Tax incentives, micro-grants, and subsidized loan programs specifically designed for SME digitalization should be introduced. Funding should be tiered to support SMEs at different stages of their digital journey, from basic digitization (e.g., cloud accounting) to advanced smart capabilities (e.g., IoT, AI integration).
- **Digital Literacy Programs:** National and local education initiatives should integrate SME-focused digital literacy into their curricula. Chambers of commerce, SME associations, and vocational institutions can serve as delivery hubs for practical, accessible digital upskilling.
- **Regulatory Simplification:** Reducing bureaucratic complexity in accessing public support programs is crucial. One-stop digital portals and streamlined application processes can improve uptake and ensure that even the smallest enterprises can benefit from digital grants and technical assistance.
- **Cybersecurity Frameworks:** As SMEs become more digitally integrated, their exposure to cyber threats increases. National cybersecurity strategies must include dedicated provisions for SME protection, including awareness campaigns, baseline compliance standards, and affordable cyber insurance schemes[50].

- **Innovation Clusters:** Establishing local digital innovation hubs and technology incubators with open access to SMEs can accelerate knowledge sharing and resource pooling. These hubs can serve as experimentation grounds for SMEs to test new tools, platforms, and partnerships[51].

4. Research Contributions and Academic Value

Academically, this study contributes to the growing body of literature that moves beyond theoretical digital transformation models to consider real-world infrastructural limitations. While much of the academic discussion has focused on organizational readiness, leadership, and business model reinvention, this paper emphasizes that no amount of strategic intent can overcome a fundamental lack of access to technology[52].

It also offers a contextualized framework that integrates infrastructure, finance, human capital, and regulatory policy as co-determinants of digital transformation readiness in SMEs. This holistic approach can serve as a foundation for further empirical validation across different countries, sectors, and demographic contexts. Furthermore, the findings contribute to the discussion on equity in digital transformation—highlighting how digital exclusion can deepen socioeconomic inequalities. By identifying infrastructural barriers as both a cause and consequence of SME underperformance, the study provides a basis for inclusive digital policy formulation.

5. Limitations of the Study

While the research provides significant insights, it is important to acknowledge its limitations. The study's scope was confined to a cross-sectional analysis within the Nigerian SME sector, which, while illustrative, may not fully capture the diversity of experiences in other regions or economic systems. Additionally, reliance on self-reported data introduces the risk of bias, particularly regarding perceptions of digital readiness or organizational performance.

A more granular analysis across different SME segments such as women-owned businesses, family-owned enterprises, or export-focused firms could yield additional insights. Moreover, future research incorporating longitudinal data would be valuable in capturing the progression of SME digital adoption over time.

6. Directions for Future Research

Given the rapidly evolving nature of digital technologies and regulatory environments, future research could explore several promising avenues:

- Comparative international studies examining how infrastructure barriers vary across developed and developing economies.
- Impact evaluation studies assessing the effectiveness of specific policy interventions (e.g., broadband subsidies or training programs) on SME digital transformation.
- Digital ecosystem mapping to understand the interplay between SMEs, technology providers, regulators, and financial institutions.
- Case studies of SMEs that have successfully navigated infrastructural barriers to develop innovative, smart business models—particularly those leveraging frugal innovation or indigenous technology solutions.

7. Final Reflections

In conclusion, this study underscores that digital infrastructure remains the foundation upon which all smart business transformations are built. For SMEs, the promise of Industry 4.0, AI, big data, and platform economies cannot be realized without first addressing the basic enablers of connectivity, access, skills, and supportive

regulation. As the digital economy continues to accelerate, SMEs must not be left behind. Equity in digital access is not only a moral imperative but a strategic one—because when SMEs are empowered to participate fully in the digital economy, the benefits ripple across communities, sectors, and national economies. The transition to smart business models is not just about adopting technology; it is about creating the inclusive conditions under which innovation can thrive.

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