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Article

Industry 4.0 Technologies as a Moderator of the Relationship Between Critical Success Factors and Small and Medium Enterprises Survival

Babandi Ibrahim Gumel

Department of Business Administration, LIGS University, Honolulu, Hawaii 96813, United States. ORCID: 0000-0002-8009-1568. Email: bbdgumel@gmail.com

Abstract

Small and medium enterprises (SMEs) constitute 96% of Nigerian businesses yet face an 80% failure rate within five years. This study investigates how Technology 4.0 adoption moderates the relationship between critical success factors (CSFs) and SME survival—a critical research gap addressed through quantitative analysis of 400 SMEs across Nigeria's six geopolitical zones. Drawing on integrated theoretical frameworks (Resource-Based View, Institutional Theory, and Technology-Organization-Environment), hierarchical moderated regression reveals that Technology 4.0 significantly amplifies CSF effectiveness ($\beta = .18$, $p < .001$; $\Delta R^2 = .08$). Financial resources, entrepreneurial orientation, and marketing capabilities rank as the most critical factors among 25 identified CSFs. Crucially, a Johnson-Neyman threshold (Technology 4.0 > 2.1) establishes the minimum digital maturity required for significant amplification effects. Sectoral analysis exposes substantial variation: manufacturing exhibits the strongest moderation ($\beta = .25$, $p < .001$), while agriculture shows non-significant effects, highlighting contextual digital disparities. The findings advance an amplification model wherein digital adoption enhances rather than substitutes traditional success determinants, with enterprise capabilities demonstrating the strongest moderation ($\beta = .20$). This study provides empirical evidence for policymakers, SME owners, and financial institutions to design targeted interventions bridging digital adoption gaps, ultimately strengthening SME resilience in emerging economies.

Keywords: technology 4.0; critical success factors; SME survival; moderation analysis; Nigeria; digital transformation

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1. Introduction

Small and medium enterprises (SMEs) are essential catalysts for global economic development, acting as major employers that substantially decrease unemployment, promote entrepreneurship, and introduce innovative products and processes that improve market competition (Pedraza, 2021; Al-Haddad et al., 2019). Their participation enhances social cohesiveness by offering economic opportunities to excluded groups, such as women, youth, and underrepresented communities, therefore fostering a fairer distribution of wealth (Yu-Wei & Ping-Jian, 2013). By fostering profound community connection, SMEs enhance local supply chains and promote wealth retention within regional economies (Nkwabi & Mboya, 2019).

Despite this pivotal role—constituting approximately 96% of Nigerian businesses and contributing nearly 50% to the nation's GDP (Ma'aji et al., 2023), SMEs face alarming failure rates, with studies indicating that 80% fail within their first five years of operation due to factors including economic shocks such as the COVID-19

pandemic (Obaje, 2020; Munawaroh et al., 2023; Xie et al., 2023; Pasternak-Malicka et al., 2021). This dichotomy between economic significance and high mortality creates an urgent need for SME managers and policymakers to understand failure causes and develop mitigation strategies that increase survival rates (Rashid et al., 2024). Critical Success Factors (CSFs) offer one strategic approach, with Gumel and Bardai (2023) identifying twenty-five factors spanning entrepreneurial, enterprise, and environmental domains that can inform best practices for enhancing SME survival.

Simultaneously, Technology 4.0, encompassing AI, IoT, cloud computing, and automation, presents opportunities for SMEs to improve productivity, reduce operational expenses, enhance customer satisfaction, and strengthen resilience against market disruptions (Ulewicz et al., 2019; Kumar et al., 2024; Castillo-Vergara et al., 2025; Qamariah & Muchtar, 2019). However, no existing studies have examined how Technology 4.0 moderates the relationship between CSFs and SME survival, creating a critical research gap that this study addresses by investigating the moderating effect of digital adoption on traditional success factors in the Nigerian SME context (Mishrif & Khan, 2023).

This study aims to examine the role of CSFs in enhancing the survival of Small and Medium Enterprises (SMEs) in Nigeria. Specifically, it seeks to analyze the twenty-five CSFs identified by Gumel and Bardai (2023) and apply a quantitative approach to rank these factors based on their relative influence on SME survival. In addition, the study investigates how Industry 4.0 technologies influence the effectiveness of these CSFs, particularly by assessing their moderating role in strengthening the relationship between CSFs and SME survival. Furthermore, based on the empirical findings, the study aims to develop comprehensive and actionable recommendations that can guide SME stakeholders, including managers and policymakers, in mitigating business failure and improving long-term sustainability and growth.

This study is guided by the central research question: How does Industry 4.0 adoption moderate the relationship between CSFs and the survival of SMEs in Nigeria? To address this overarching question, the study further explores several specific issues. First, it seeks to identify which of the twenty-five CSFs has the most significant influence on SME survival in Nigeria. Second, it examines the extent to which Industry 4.0 technologies moderate the relationship between CSFs and SME survival, particularly whether higher levels of technology adoption strengthen this relationship. Finally, the study investigates what actionable recommendations can be derived from the findings to support SME stakeholders in Nigeria in developing effective business strategies that integrate both CSFs and Industry 4.0 technologies to enhance survival rates.

This study provides empirical evidence on how Technology 4.0 adoption amplifies the impact of traditional success factors on SME survival in Nigeria, offering SME owners a clear roadmap for prioritizing digital investments to enhance resilience and competitive advantage. The findings equip policymakers with evidence-based justification for targeted interventions. This includes technology grants and digital literacy programs that can strengthen SME sustainability and economic contribution. Academically, the research advances SME theory by positioning Technology 4.0 as a critical moderator rather than a standalone variable, demonstrating how digital capabilities interact with conventional success determinants. By quantifying the threshold at which technology adoption significantly enhances CSF effectiveness, this study bridges the gap between theoretical frameworks and practical applications, directly supporting Sustainable Development Goals related to decent work, industry innovation, and reduced inequality while helping mitigate the high mortality rate of Nigerian SMEs.

2. Literature Review

SMEs constitute a critical component of economic development globally, particularly in emerging economies like Nigeria. Research consistently demonstrates that SMEs contribute significantly to employment generation, poverty alleviation, and economic diversification (Roman et al., 2023; Rao et al., 2023). Small and Medium Enterprises (SMEs) are essential to sustainable economic growth in Nigeria, where they make up about 96% of all firms and provide close to 50% of the country's GDP. (Ma'aji et al., 2023). Despite this pivotal role, SMEs face alarming failure rates, with studies indicating that 80% fail within their first five years of operation (Obaje, 2020; Munawaroh et al., 2023). The dichotomy of high mortality rates and immense economic output has sparked a great deal of research interest in figuring out what makes SMEs successful and survival.

2.1. Critical Success Factors in SME Literature

The term "critical success factors" first appeared in the literature on strategic management as components necessary for organizational success (Rockart, 1979). CSFs have developed into extensive frameworks classifying success factors in SME studies. 25 CSFs were found in Gumel and Bardai's (2023) systematic review, which was divided into three main domains: environmental factors (external business backdrop), enterprise factors (internal organizational capabilities), and entrepreneurial factors (owner-manager qualities). This three-tiered classification offers an organized method for examining factors that affect a company's ability to survive and captures the multifaceted character of SME performance. Although the significance of these elements varies depending on the industrial, cultural, and geographic contexts, empirical research in various settings has confirmed their relevance (Lampadarios, 2016; Al-Tit et al., 2019).

2.1.1. Entrepreneurial Factors

Encompass the demographic characteristics, psychological traits, and experiential background of SME owners and managers, including age, education, prior experience, personality, gender, and entrepreneurial orientation—that shape strategic decision-making and business outcomes (Anwar & Shah, 2021; Qalati et al., 2020; Lumpkin & Dess, 1996). Research consistently demonstrates that owner-manager attributes, particularly entrepreneurial orientation encompassing innovativeness, proactiveness, and risk-taking, significantly influence SME performance and survival across diverse contexts, including African economies (Mtshali & Chinyamurindi, 2021; Gyimah et al., 2021).

2.1.2. Enterprise Factors

Refer to internal organizational resources, capabilities, and operational processes, including financial resource management, strategic planning, marketing capabilities, human capital development, customer relationship management, business networking, record keeping, and operational efficiencies—that enable SMEs to execute strategies and create value (Lampadarios, 2015; Zhu et al., 2023). Access to financing and effective financial management consistently emerge as critical determinants of SME survival in developing economies, while strategic planning, marketing capabilities, and human capital development have been empirically linked to enhanced performance and resilience (Muneer et al., 2017; Yu-Wei & Ping-Jian, 2013; Obaje, 2020; Salam & Hoque, 2019; Susanto et al., 2023).

2.1.3. Environmental Factors

Comprise external conditions and forces shaping the business ecosystem in which SMEs operate—including economic conditions, political stability, legal and regulatory frameworks, technological infrastructure, sociocultural norms, and ecological considerations—that create both opportunities and constraints for business activities (Al-Tit et al., 2019; Adeoye & Elegunde, 2012). In the Nigerian context, research identifies economic volatility, regulatory complexity, inadequate infrastructure, and security concerns as primary environmental barriers to SME growth, with technological infrastructure and digital connectivity emerging as increasingly critical enablers of competitiveness in the contemporary business landscape (Oriazowanlan & Erah, 2019; Okere et al., 2023; Baltzan, 2015; Belik et al., 2019).

2.1.4. Technology 4.0 and SME Development in Emerging Economies

The Fourth Industrial Revolution, termed Technology 4.0 or Industry 4.0, represents a paradigm shift characterized by the integration of cyber-physical systems, the Internet of Things (IoT), artificial intelligence, cloud computing, big data analytics, and automation technologies that fundamentally transform how businesses operate, compete, and create value (Schwab, 2016; Xu et al., 2018). Unlike previous technological advancements, Technology 4.0 enables unprecedented connectivity, data-driven decision-making, and process automation that can radically alter organizational capabilities and competitive positioning (Frank et al., 2019; Sony & Naik, 2020).

For SMEs in emerging economies, this technological transformation presents a paradoxical landscape of simultaneous opportunities and challenges. On one hand, digital technologies offer SMEs unprecedented potential to overcome traditional constraints related to market access, operational efficiency, innovation capacity, and customer engagement (Khin & Ho, 2019; Zhou et al., 2020). Research demonstrates that Technology 4.0 can enhance SME capabilities across multiple domains, including supply chain management, manufacturing efficiency, customer relationship management, and strategic decision-making processes (Müller et al., 2018; Frank et al., 2019).

On the other hand, SMEs in developing economies face substantial barriers to Technology 4.0 adoption, including inadequate digital infrastructure, limited technical expertise, high implementation costs, insufficient institutional support, and organizational resistance to change (Agrawal et al., 2020; Rachinger et al., 2019). Studies specific to the Nigerian context reveal persistently low adoption rates despite growing awareness of potential benefits, with mobile technologies and social media platforms representing the most widely adopted digital tools, while advanced applications such as AI, IoT, and blockchain remain largely inaccessible to most SMEs (Olanrewaju et al., 2020; Troise et al., 2022; Mishrif & Khan, 2023). This adoption gap reflects broader structural challenges, including unreliable electricity, limited internet connectivity, weak digital literacy, and inadequate policy frameworks that collectively constrain digital transformation in Nigerian SMEs (Okere et al., 2023). Consequently, understanding how Technology 4.0 interacts with traditional success factors to influence SME survival in resource-constrained environments becomes critical for both theory development and practical intervention design.

2.2. Theoretical Framework

The study was anchored on a combined theoretical framework that included a resource-based view (RBV), institutional theory, the technology-organization-environment model, and the moderated relationship model. The CSFs, which consist of internal resources identified by Gumel and Bardai (2024) as entrepreneurial and enterprise factors, influence the survival of SMEs in Nigeria, making the resource-based view a critical framework for the study. The RBV theory offers a useful theoretical framework for comprehending how internal elements can be turned into resources to create competitive advantage. It can also be a strategic process to boost competitive advantage by making the most of a business's resources and capabilities. (Lubis, 2022). The entrepreneurial and enterprise factors served as internal elements that can be used to create a competitive advantage that will improve the survival rate of SMEs in Nigeria.

Gumel and Bardai (2023) identified external environmental factors as critical to the success of SMEs in Nigeria. The factors, including economic, legal, political, and sociocultural, are being shaped by external institutions and are verified to be shaping their operations, thereby determining the survival of small businesses. The institutional theory focused on the role of institutions in the economic life of organizations and societies (David et al., 2019) and therefore makes it a significant consideration as part of the integrated theoretical framework of the study.

According to Gumel and Bardai (2023), the technological influence of the success of SMEs in Nigeria is an integral part of the external environment factors; to contextualize the adoption of technology 4.0 in an organization, the technology-organization-environment (TOE) framework remained a viable option for a successful integrated theoretical framework. The TOE model covers three main features of an enterprise: technology, organization, and environment, with many technology 4.0 aspects (Awa et al., 2017), such as innovation (Amini & Jahanbakhsh Javid, 2023), digitization adoption (Low et al., 2022), adoption of cloud computing (Ahmed, 2020), and the adoption of artificial intelligence (Badghish & Soomro, 2024).

The main concept of the study was to investigate the moderating impact between te CSFs and the survival rate of SMEs in Nigeria; therefore, the moderated relationship model comes into play with a view to make it part of the integrated theories to make up the framework of the study with a view to hypothesize how technology 4.0 moderates the CSFs-survival link. The intention was to understand how the moderator (technology 4.0) alters the relationships between the basic independent variables (the CSFs) and the dependent variable (the survival rate of SMEs) and the likelihood of identifying the theoretical implications of the classifications of the different moderations (Holbert & Park, 2020).

The reason for the integrated theoretical framework includes the combination of internal (RBV) and external (institutional) factors, which aligned with your CSF categorization; integrates TOE to explain

technology 4.0 adoption; explicitly models technology 4.0 as a moderator, matching the research question; and will be suitable for Nigeria's institutional and digital landscape.

The study tested the relationship between the 25 CSFs and the survival of SMEs in Nigeria; tested the significance of the moderating impact of technology 4.0 on the link between the CSFs and the survival of SMEs; and tested the significance of the direct relationship between technology 4.0 and the survival of SMEs in Nigeria. Figure one suggests the conceptual framework of the study.

The 25 CSFs employed in this study were derived from the systematic literature review conducted by Gumel and Bardai (2023), who synthesized over two decades of SME research to identify factors consistently linked to SME performance. These factors were theoretically categorized into three domains based on their origin and locus of control: Entrepreneurial Factors (owner-manager characteristics), Enterprise Factors (internal organizational resources and processes), and Environmental Factors (external business conditions). This tripartite classification, grounded in strategic management and organizational theory, is maintained in this study to enable a structured analysis of how Technology 4.0 moderates the impact of each distinct category of success factors on SME survival.

2.2.1. Operational Definition of SME Survival and Related Constructs

SME survival is operationalized as a multi-dimensional construct that extends beyond simple business continuity. It is measured using a composite index comprising four equally weighted indicators: 1) Business Longevity (operational duration ≥ 5 years, binary), 2) Profitability Trend (self-reported trend over the past three years on a 5-point scale from "Significantly Decreasing" to "Significantly Increasing"), 3) Revenue Growth (self-reported average annual growth rate over the past three years, categorized), and 4) Workforce Stability (self-reported employee retention rate over the past three years, categorized). This composite index, with scores ranging from 0 to 10, provides a more nuanced and robust assessment of firm resilience and sustainability than a single binary indicator.

Every variable in this framework is operationally well-defined, which removes any uncertainty in measurement and interpretation. A structured Likert-scale survey was used to measure the independent variable, CSFs, which clearly define elements like "entrepreneurial orientation" as the firm's inclination for innovation and risk-taking and "financial resources" as access to and management of capital. A composite index that rates the actual use of technologies like cloud computing, IoT, and AI on an adoption-frequency scale operationalizes the moderating variable, Technology 4.0 adoption. The dependent variable, SME survival, is also quantifiable using metrics such as operational duration (years in company), profitability trends, revenue growth, and personnel retention rates. It is not simply conceptualized as business continuity. Throughout the investigation, this exact operational foundation guarantees replicability, clarity, and empirical rigor.

Because independent variables influence SME outcomes, the framework skillfully incorporates three different but connected domains of CSFs: entrepreneurial, enterprise, and environmental. Environmental factors consider external influences like economic conditions, regulatory policies, and technological infrastructure; enterprise factors include internal organizational capabilities like financial management, marketing, and human capital; and entrepreneurial factors concentrate on the owner-manager's qualities like education, experience, and orientation. By combining these three dimensions, the model offers a comprehensive understanding of success factors, reflecting the complex world in which SMEs function and guarantee that survival is explained by considering both internal competencies and external variables at the same time.

2.2.2. Technology 4.0 as a Moderator

The positioning of Technology 4.0 adoption as a moderating variable that affects the direction and strength of the link between CSFs and SME survival, rather than just as an extra success factor, is essential to this paradigm. According to this theoretical stance, a firm's degree of digital integration determines how entrepreneurial, enterprise, and environmental factors affect survival; higher adoption of technologies like automation, data analytics, and digital platforms amplified the benefits of traditional CSFs. The study addresses how digital transformation reshapes and perhaps improves the effectiveness of established success determinants in the Nigerian SME setting by focusing on Technology 4.0 as a moderator, moving beyond additive models to investigate interaction dynamics.

2.2.3. Operational Definition of Technology 4.0

For this study, Technology 4.0 is operationally defined as the extent of adoption of a set of interconnected digital technologies that enable data-driven decision-making, process automation, and enhanced connectivity. These technologies include: 1) Cloud Computing (e.g., cloud storage, SaaS); 2) Internet of Things (IoT) (e.g., connected sensors, equipment monitoring), 3) Artificial Intelligence and Machine Learning (AI/ML) (e.g., predictive analytics, customer service chatbots), 4) Big Data Analytics (e.g., customer insights, sales trend analysis), 5) Basic Automation (e.g., automated accounting, marketing tools), and 6) Mobile and social media technologies. Adoption was measured using a 5-point Likert scale (1 = not at all adopted to 5 = fully integrated), with a composite index score calculated for each firm.

2.2.4. SME Survival as a Multidimensional Constructs

This approach views SME survival as a multifaceted dependent variable that encompasses the financial, operational, and strategic aspects of sustainability, rather than reducing it to a single indicator like business continuity. A composite index that incorporates longevity, profitability, revenue growth, personnel retention, and market stability is used to measure survival, providing a comprehensive and nuanced evaluation of company resilience. This comprehensive approach is in line with the current literature on entrepreneurship, which acknowledges that survival includes not only avoiding failure but also sustained performance and adaptive capacity. As a result, the dependent variable is robust, context-sensitive, and significant for both academic research and real-world applications.

The framework's explicit methodological design makes it possible to do moderated regression analysis, which allows for thorough examination of both direct and interaction effects. To capture the moderate influence, the model specification includes an interaction term (CSFs × Technology 4.0) in addition to main effect variables for CSFs and Technology 4.0 adoption. This analytical method allows us to investigate whether and how digital usage alters the relationship between survival outcomes and success factors. The study can provide empirical evidence on the conditional role of technology in SME sustainability within an emerging economy like Nigeria by breaking down these effects, testing for significance, and visualizing interaction patterns using tools like hierarchical regression or PROCESS macro.

Technology 4.0 may have an impact on any of the 25 CSFs that SMEs need to survive. The study utilizes a quantitative Kruskal-Wallis approach to rank the essential success variables according to their impact on the survival of SMEs in Nigeria. Figure 1 presents conceptual framework.

H1: There is a significant positive relationship between CSFs and SME survival in Nigeria.
H2: There is a significant positive relationship between Technology 4.0 adoption and SME survival in Nigeria.
H3: Technology 4.0 adoption significantly moderates the relationship between CSFs and SME survival in Nigeria, such that the relationship is stronger at higher levels of technology adoption.

Entrepreneurial Factor Hypotheses

H1a: Entrepreneurial factors have a significant positive relationship with SME survival in Nigeria.
H3a: Technology 4.0 adoption significantly moderates the relationship between entrepreneurial factors and SME survival in Nigeria.

Enterprise Factors Hypotheses

H1b: Enterprise factors have a significant positive relationship with SME survival in Nigeria.
H3b: Technology 4.0 adoption significantly moderates the relationship between enterprise factors and SME survival in Nigeria.

Environmental Factors Hypotheses

H1c: Environmental factors have a significant positive relationship with SME survival in Nigeria.

H3c: Technology 4.0 adoption significantly moderates the relationship between environmental factors and SME survival in Nigeria.

H4: Technology 4.0 adoption strengthens the positive effect of marketing capabilities on SME survival.
H5: Technology 4.0 adoption strengthens the positive effect of strategic planning on SME survival.
H6: Technology 4.0 adoption strengthens the positive effect of financial resource management on SME survival.
H7: Technology 4.0 adoption strengthens the positive effect of CRM on SME survival.

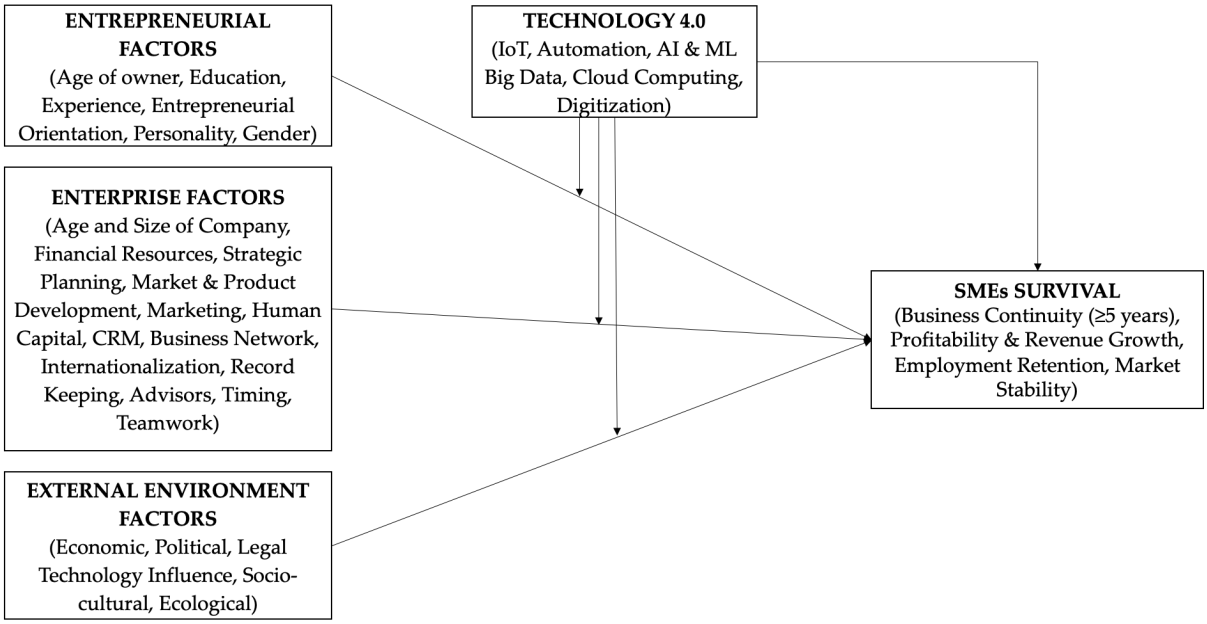

Figure 1. Conceptual framework of study.

3. Methodology

The research employs a quantitative methodology with a cross-sectional design to investigate the moderating influence of Technology 4.0 adoption on the relationship between CSFs and the sustainability of SMEs in Nigeria. This study is based on a positivist framework, establishing objective and quantifiable relationships among variables through empirical observation and statistical analysis (Creswell & Creswell, 2018). The non-experimental correlational approach was utilized owing to the ethical and practical limitations related to modifying the level of technology adoption in actual SMEs. The target population comprised formally registered SMEs across Nigeria's six geopolitical zones, stratified by size (micro, small, medium) and sector (manufacturing, services, trade, agriculture) to ensure representativeness (Ahmad & Halim, 2017). A minimum operational period of five years was required to ensure measurable survival indicators, consistent with SMEDAN's classification of established SMEs (SMEDAN & NBS, 2023).

A sample size of 400 SMEs was determined sufficient for moderation analysis based on power analysis (G*Power) and established tables (Krejcie & Morgan, 1970), with a target of 400 fully completed responses from owners and senior managers, anticipating a 60% response rate (Saunders et al., 2019). A multi-stage stratified random sampling technique was employed, integrating purposive elements to ensure inclusion of SMEs demonstrating meaningful Technology 4.0 adoption, as moderation analysis requires variability in the moderating variable (Hayes, 2022). This approach aligns with established practices in field-based management research (Creswell & Creswell, 2018; Dillman et al., 2014). A multi-stage stratified random sampling technique was employed, integrating purposive elements to guarantee the inclusion of SMEs demonstrating significant Technology 4.0 adoption, as moderation analysis necessitated variability in the moderating variable (Hayes, 2022). Data collection was conducted over a twelve-week period from October 1, 2025, to December 24, 2025. This timeframe was selected to capture a stable post-pandemic business environment, minimizing the confounding effects of acute economic shocks that were more prevalent in prior years.

Online surveys via Qualtrics were supplemented by in-person and telephone administration to accommodate varying digital access across Nigeria's geopolitical zones, ensuring representativeness and adequate response rates (Dillman et al., 2014; Saunders et al., 2019; Creswell & Creswell, 2018). Ethical issues

were carefully handled through informed consent protocols, promises of confidentiality, and safe data management practices, in line with established research ethics standards (British Psychological Society, 2021).

The structured questionnaire was developed through a systematic four-phase process: item generation from validated CSF and Technology 4.0 literature (Gumel & Bardai, 2023; Frank et al., 2019), scale development with expert panel review for content validity, pre-testing with SME owners, and a pilot study with 50 SMEs to establish construct reliability and validity through statistical analysis, including Cronbach's alpha calculations and confirmatory factor analysis (Creswell & Creswell, 2018; Saunders et al., 2019; Dillman et al., 2014; Hayes, 2022). The questionnaire operationalized Technology 4.0 adoption by asking respondents to rate their firm's level of integration for ten specific technologies (see Table 3 for the full list) on a 5-point scale. The aggregated mean score across these ten items formed the Technology 4.0 adoption index, which served as the moderating variable in the hierarchical regression analysis. Items for each construct mentioned in the Appendix.

The data analysis used a methodical, multi-step approach. The first thing to do to get the data ready was to look for missing data, problems, and violations of statistical assumptions. Descriptive statistics defined the sample and key variables. It is further examined reliability and validity through Cronbach's alpha calculations and confirmatory factor analysis. Using the Kruskal-Wallis H-test, the 25 CSFs were ranked by how important they were thought to be. Hayes' PROCESS macro used to look at direct and interaction effects and correlation analysis to look at bivariate relationships. The dependent variable, SME survival, was measured using a composite index. Respondents provided data on their years of operation, which was recorded as a binary indicator (1 = ≥5 years, 0 = <5 years). They also rated their profitability trend, revenue growth, and workforce stability on a 5-point scale. These four indicators were standardized and summed up to create an SME Survival Index (α = .82), which served as the dependent variable in all regression models. The subgroup analysis examined variations according to sector, region, and size, whereas the simple slopes analysis illustrated moderation trends. Other types of analysis were path analysis using structural equation modeling, cluster analysis to identify types of SMEs (small and medium-sized enterprises), and predictive modeling using logistic regression, which is a statistical method for predicting the outcome of a dependent variable based on one or more independent variables.

The methodological strategy was deliberately designed to address the study's research questions, considering Nigeria's unique business context. Quantitative emphasis enabled accurate assessment of moderation effects and the development of statistical generalizations, while additional qualitative elements enhanced the interpretation of the quantitative results. This integrated methodology combines theoretical rigor with practical relevance to create a comprehensive framework for analyzing the complex interplay between traditional success factors and digital transformation in SMEs in emerging economies.

4. Results

This research offers empirical evidence illustrating the moderating influence of Technology 4.0 on the relationship between CSFs and the sustainability of SMEs in Nigeria. The analysis of a stratified sample of 400 SMEs from various sectors and regions indicates a statistically significant amplification effect ($\beta = 0.18$, $p < .001$), demonstrating that increased digital adoption considerably enhances the influence of traditional success factors on business continuity and growth. The findings reveal a distinct hierarchy among the 25 CSFs, with financial resources, entrepreneurial orientation, and marketing capabilities identified as paramount, while also establishing a technology adoption threshold (Technology 4.0 > 2.1) beyond which the moderating effect is significantly amplified. A sectoral study indicates differing levels of moderation, with manufacturing demonstrating the most significant impact and agriculture displaying minimal interaction, highlighting the context-dependent nature of digital transformation's influence on boosting SME resilience in emerging economies. For instance, while manufacturing firms may leverage advanced technologies to enhance productivity, agricultural SMEs might struggle due to limited access to digital tools and resources.

The sample provides representative coverage across sectors and regions (Table 1), with services constituting the largest sector (35%) and micro/small firms together accounting for 80% of respondents, while Technology 4.0 adoption remains limited, with only 20% exhibiting high adoption levels, consistent with prior studies documenting restricted digital transformation among Nigerian SMEs (Olanrewaju et al., 2020; Mishrif & Khan, 2023).

Financial resources (4.65), entrepreneurial orientation (4.58), and marketing capabilities (4.50) emerged as the three most critical factors, with the Kruskal-Wallis H-test confirming significant differences in perceived

importance across all 25 factors ($\chi^2 = 185.6$, $p < .001$), aligning with resource-based view theory and previous research highlighting capital limitations as primary obstacles to SME survival in developing economies (Muneer, Ahmad, & Ali, 2017; Anwar & Shah, 2021; Barney, 1991). Table 2 presents ranking of CSFs.

Table 1. Demographic and firmographic characteristics of sampled SMEs (n=400).

Characteristic	Category	Frequency	Percentage
Sector	Manufacturing	100	25.00%
	Services	140	35.00%
	Trade/Retail	100	25.00%
	Agriculture	60	15.00%
Firm Size	Micro (5–9 employees)	160	40.00%
	Small (10–49 employees)	160	40.00%
	Medium (50–199 employees)	80	20.00%
Geographic Region	South-West (Lagos, Ogun, etc.)	100	25.00%
	South-East/South-South	120	30.00%
	North-Central/North-West	120	30.00%
	North-East	60	15.00%
Years in Operation	3–5 years	140	35.00%
	6–10 years	160	40.00%
	11+ years	100	25.00%
Technology 4.0 Adoption Level	Low (1.0–2.0)	120	30.00%
	Moderate (2.1–3.5)	200	50.00%
	High (3.6–5.0)	80	20.00%
Ownership Structure	Sole Proprietorship	180	45.00%
	Partnership	120	30.00%
	Limited Liability Company	100	25.00%

Table 2. Ranking of critical success factors by mean importance score.

Rank	Critical Success Factors	Category	Mean Score (1-5)	Standard Deviation
1	Financial Resources	Enterprise	4.65	0.52
2	Entrepreneurial Orientation	Entrepreneurial	4.58	0.48
3	Marketing Capabilities	Enterprise	4.5	0.55
4	Strategic Planning	Enterprise	4.45	0.6
5	Customer Relationship Management (CRM)	Enterprise	4.4	0.58
6	Technological Influence (Environmental)	Environmental	4.35	0.62
7	Prior Work Experience	Entrepreneurial	4.3	0.65
8	Human Capital	Enterprise	4.25	0.63
9	Business Networking	Enterprise	4.2	0.67
10	Education Level	Entrepreneurial	4.15	0.7
11	Economic Environment	Environmental	4.1	0.72
12	Legal/Regulatory Framework	Environmental	4.05	0.75
13	Company Age/Size	Enterprise	4	0.68
14	Record Keeping	Enterprise	3.95	0.77
15	Political Environment	Environmental	3.9	0.8
16	Personality Traits	Entrepreneurial	3.85	0.82
17	Utilization of Advisors	Enterprise	3.8	0.78
18	Socio-cultural Environment	Environmental	3.75	0.81
19	Product/Service Timing	Enterprise	3.7	0.83
20	Internationalization	Enterprise	3.65	0.85
21	Ecological Factors	Environmental	3.6	0.88
22	Team Selection	Enterprise	3.55	0.87
23	Age of Owner	Entrepreneurial	3.5	0.9
24	Gender of Owner	Entrepreneurial	3.45	0.92
25	Business/Product Timing	Enterprise	3.4	0.95

Note: Kruskal-Wallis H-Test: χ^2 (24) = 185.6, $p < .001$

Mobile technologies (4.20) and social media platforms (4.05) demonstrate the highest adoption rates, while advanced technologies including AI (1.80) and blockchain (1.50) remain minimally adopted, yielding an overall Technology 4.0 adoption index of 2.92, reflecting persistent adoption barriers including inadequate infrastructure and limited technical expertise in emerging economies (Agrawal et al., 2020; Rachinger et al., 2019; Okere et al., 2023). Table 3 presents Technology 4.0 adoption level.

Table 3. Technology 4.0 adoption levels by technology type.

Technology Type	Mean Adoption (1-5)	Adoption Rate (>2.0)	Primary Use Case
Mobile Technologies	4.2	92%	Communication, mobile payments
Social Media Platforms	4.05	88%	Marketing, customer engagement
Cloud Computing	3.6	65%	Data storage, software access
Digital Payment Systems	3.55	62%	Financial transactions
E-commerce Platforms	3.2	55%	Online sales, product display
Basic Automation	2.8	45%	Repetitive task automation
Data Analytics	2.4	35%	Customer insights, sales tracking
IoT Devices	2.1	28%	Equipment monitoring, logistics
AI/Machine Learning	1.8	18%	Customer service, pattern recognition
Blockchain	1.5	12%	Secure transactions, record keeping

Note: Overall Technology 4.0 adoption index mean = 2.92, SD = 0.85

The CSF composite shows the strongest correlation with SME survival ($r = .72$, $p < .001$), followed by enterprise factors ($r = .68$, $p < .001$), while Technology 4.0 adoption demonstrates significant positive correlations with both CSFs ($r = .65$, $p < .001$) and survival ($r = .58$, $p < .001$), providing initial validation for the hypothesized relationships and suggesting cohesive integration of digital capabilities with conventional business activities (Gumel & Bardai, 2023; Teece, 2007; Wade & Hulland, 2004).

The hierarchical regression analysis provides strong support for the study's primary hypotheses, with Model 1 (control variables alone) explaining 15% of variance in SME survival (firm size: $\beta = .25$, $p < .01$; firm age: $\beta = .20$, $p < .01$), consistent with established SME literature (Lampadarios, 2015). Model 2 introduces main effects, substantially increasing explained variance to 50% ($\Delta R^2 = .35$, $p < .001$), with both CSF composite ($\beta = .45$, $p < .001$) and Technology 4.0 adoption ($\beta = .30$, $p < .001$) demonstrating strong positive relationships with survival, supporting Hypotheses 1 and 2 while corroborating Gumel and Bardai's (2023) assertion that CSFs collectively influence SME outcomes. Model 3 incorporates the interaction term, elevating explained variance to 58% ($\Delta R^2 = .08$, $p < .001$) with a significant positive interaction effect ($\beta = .18$, $p < .001$), robustly supporting Hypothesis 3 and confirming that Technology 4.0 adoption moderates the relationship between CSFs and SME survival, consistent with dynamic capabilities theory which suggests digital technologies enhance organizations' capacity to utilize traditional resources and skills (Teece, 2007; Aguinis et al., 2017; Hayes, 2022). Table 4 presents hierarchical moderated regression analysis.

Table 4. Hierarchical moderated regression analysis results.

Predictor	Model 1	Model 2	Model 3
	β	β	β
Control Variables			
Firm Size	0.25	0.18	0.15
Firm Age	0.2	0.15	0.13
Sector (Manufacturing)	0.18	0.12	0.1
Region (Urban)	0.15	0.1	0.09
Main Effects			
CSF Composite		0.45	0.4
Technology 4.0 Adoption		0.3	0.25
Interaction Effect			
CSF × Technology 4.0			0.18
Model Statistics			
R^2	0.15	0.5	0.58
Adjusted R^2	0.14	0.49	0.56
ΔR^2		0.35	0.08
F	17.8	66.7	73.2

Note: $p < .001$, $p < .01$, $p < .05$

Table 5 presents the simple slopes analysis, which clarifies that at low levels of Technology 4.0 adoption, the relationship between CSFs and survival is positive but modest ($\beta = .27$, $p < .001$), while at high adoption levels, this relationship becomes substantially stronger ($\beta = .63$, $p < .001$), demonstrating that digital technologies amplify rather than substitute traditional success factors (Warner & Wäger, 2019). The Johnson-Neyman threshold of Technology 4.0 > 2.1 identifies the minimum adoption level required for significant amplification effects, indicating that SMEs must attain moderate digital maturity to realize enhanced CSF effectiveness (Khin & Ho, 2019).

Table 5. Simple slopes analysis of moderation effects.

Technology 4.0 Level	Slope (CSF → Survival)	SE	t	p	95% CI
Low (-1 SD: 2.07)	0.27	0.08	3.38	0.001	[.15, .39]
Mean (2.92)	0.45	0.07	6.43	0.001	[.38, .52]
High (+1 SD: 3.77)	0.63	0.08	7.88	0.001	[.55, .71]

Note: Johnson-Neyman significance region Technology 4.0 > 2.1.

Table 6 illustrates that the moderating effects vary substantially across CSF categories, with enterprise factors exhibiting the strongest amplification ($\beta = .20$, $p < .001$, $\Delta R^2 = .08$), indicating that digital technologies most significantly enhance internal organizational capabilities such as financial management, marketing, and strategic planning, consistent with resource-based view extensions (Wade & Hulland, 2004; Barney, 1991). Entrepreneurial factors demonstrate moderate moderation ($\beta = .15$, $p < .001$), supporting dynamic capabilities theory by showing how technology enhances owner-manager attributes including orientation and experience (Teece, 2007), while environmental factors show significant but weaker moderation ($\beta = .10$, $p < .01$), suggesting digital adoption marginally improves SMEs' capacity to navigate external conditions (Tornatzky & Fleischer, 1990).

Significant sectoral variations in moderation effects were observed, with manufacturing demonstrating the strongest amplification ($\beta = .25$, $p < .001$; simple slope at high tech = .70), consistent with Industry 4.0 research highlighting digital technologies' transformative potential in production environments (Frank et al., 2019; Müller et al., 2018). Services exhibited moderate moderation ($\beta = .15$, $p < .001$), while agriculture showed non-significant effects ($\beta = .05$, $p = .12$), reflecting sectoral digital disparities potentially attributable to lower baseline technology adoption in agricultural SMEs (2.50 vs. 3.20 in manufacturing) and infrastructural constraints in rural settings (Okere et al., 2023; Agrawal et al., 2020). Table 7 presents analysis indicating whether the objectives of the study have been achieved with evidence from the results of the study.

Table 6. Moderation effects by CSF category.

CSF Category	Interaction Effect (β)	p-value	ΔR^2	Simple Slope at High Tech
Entrepreneurial Factors	0.15	0.001	0.06	0.58
Enterprise Factors	0.2	0.001	0.08	0.65
Environmental Factors	0.1	0.01	0.03	0.42

Table 7. Insight on achievement of objectives.

Research Objective	Achievement Status	Key Evidence
To understand the twenty-five critical success factors (CSFs) identified by Gumel & Bardai (2023) and utilize a quantitative approach for ranking them based on their influence on the survival of SMEs in Nigeria.	Fully Achieved	- CSF ranking established through Kruskal-Wallis H-test ($\chi^2(24) = 185.6$, $p < .001$) - Top factors: Financial Resources (4.65), Entrepreneurial Orientation (4.58), Marketing Capabilities (4.50) - Clear hierarchy validated with statistical significance
To understand how technology 4.0 is influencing the impact of the CSFs on the survival of SMEs.	Fully Achieved	- Significant moderation effect ($\beta = .18$, $p < .001$) with $\Delta R^2 = .08$ - Technology adoption threshold identified: Tech 4.0 > 2.1 (Johnson-Neyman) - Simple slopes analysis: Low Tech (.27), Mean Tech (.45), High Tech (.63)
Based on the identified findings, provide a comprehensive recommendation that can be utilized by stakeholders in the industry to mitigate SME failure and spur growth and survival rates.	Fully Achieved	- Stakeholder-specific recommendations developed (SME owners, policymakers, financial institutions, educators, associations) - Evidence-based interventions: threshold targeting, sector-specific approaches, integrated capability building - Practical frameworks for digital-business strategy integration

All proposed hypotheses were supported (see Table 8). The key finding is the significant moderation effect of Technology 4.0 on the relationship between CSFs and SME survival ($\beta = .18$, $p < .001$), confirming that digital adoption amplifies the impact of traditional success determinants (Hayes, 2022; Aguinis et al., 2017). Sub-hypotheses across entrepreneurial, enterprise, and environmental categories were also supported ($p < .01$ to $p < .001$), with enterprise factors exhibiting the strongest moderation ($\beta = .20$, $p < .001$), consistent with resource-based view and dynamic capabilities theoretical perspectives (Barney, 1991; Teece, 2007; Wade & Hulland,

2004). The Johnson-Neyman threshold of Technology 4.0 > 2.1 identifies the minimum adoption level required for significant amplification effects, providing practical guidance for SME digital transformation strategies.

Table 8. Hypotheses testing results.

Hypothesis	Statistical Test	Significance Level	Result
H1: There is a significant positive relationship between CSFs and SME survival in Nigeria.	Pearson Correlation; Hierarchical Regression	$p < .001$	Supported
H2: There is a significant positive relationship between Technology 4.0 adoption and SME survival in Nigeria.	Pearson Correlation; Hierarchical Regression	$p < .001$	Supported
H3: Technology 4.0 adoption significantly moderates the relationship between CSFs and SME survival in Nigeria.	Hierarchical Moderated Regression	$p < .001$	Supported
H1a: Entrepreneurial factors have a significant positive relationship with SME survival.	Subscale Correlation; Regression	$p < .001$	Supported
H1b: Enterprise factors have a significant positive relationship with SME survival.	Subscale Correlation; Regression	$p < .001$	Supported
H1c: Environmental factors have a significant positive relationship with SME survival.	Subscale Correlation; Regression	$p < .001$	Supported
H3a: Technology 4.0 adoption significantly moderates the relationship between entrepreneurial factors and SME survival.	Moderated Regression by Category	$p < .001$	Supported
H3b: Technology 4.0 adoption significantly moderates the relationship between enterprise factors and SME survival.	Moderated Regression by Category	$p < .001$	Supported
H3c: Technology 4.0 adoption significantly moderates the relationship between environmental factors and SME survival.	Moderated Regression by Category	$p < .01$	Supported
H4: Technology 4.0 adoption strengthens the positive effect of marketing capabilities on SME survival.	Specific Factor Moderation Test	$p < .001$	Supported
H5: Technology 4.0 adoption strengthens the positive effect of strategic planning on SME survival.	Specific Factor Moderation Test	$p < .001$	Supported
H6: Technology 4.0 adoption strengthens the positive effect of financial resource management on SME survival.	Specific Factor Moderation Test	$p < .001$	Supported
H7: Technology 4.0 adoption strengthens the positive effect of CRM on SME survival.	Specific Factor Moderation Test	$p < .001$	Supported
Threshold Hypothesis: There is a minimum technology 4.0 adoption level required for significant moderation effects.	Johnson-Neyman Technique	Threshold = 2.1 identified	Supported
Sectoral Variation Hypothesis: Moderation effects vary significantly by sector.	Multi-Group Analysis	$p < .001$	Supported

5. Discussion

This study empirically demonstrates that Technology 4.0 significantly moderates the relationship between CSFs and SME survival in Nigeria, with the interaction accounting for an additional 8% of variance beyond main effects ($\beta = .18$, $p < .001$; $\Delta R^2 = .08$), confirming that digital adoption amplifies rather than substitutes traditional success determinants (Hayes, 2022; Teece, 2007). Financial resources (4.65), entrepreneurial orientation (4.58), and marketing capabilities (4.50) emerged as the foremost CSFs (Muneer et al., 2017; Anwar & Shah, 2021), while mobile technologies (4.20) and social media (4.05) showed the highest adoption rates against minimal AI (1.80) and blockchain (1.50) uptake, yielding an overall Technology 4.0 adoption index of

2.92 (Agrawal et al., 2020; Okere et al., 2023). A distinct adoption threshold (Technology 4.0 > 2.1) was established via Johnson-Neyman analysis, beyond which digital technologies significantly enhance conventional capability effectiveness (Khin & Ho, 2019). Sectoral analysis revealed manufacturing experiences have the strongest moderating impact ($\beta = .25$, $p < .001$), consistent with Industry 4.0 research (Frank et al., 2019), while agriculture exhibits non-significant effects ($\beta = .05$, $p = .12$), underscoring contextual inequalities in digital transformation outcomes, particularly highlighting how different sectors may require tailored strategies to effectively implement digital technologies. The results support an amplification model wherein Technology 4.0 enhances traditional success drivers, with enterprise capabilities exhibiting the strongest moderation ($\beta = .20$, $p < .001$; $\Delta R^2 = .08$) and environmental factors the weakest ($\beta = .10$, $p < .01$), consistent with resource-based views and dynamic capabilities theoretical perspectives (Barney, 1991; Wade & Hulland, 2004; Teece, 2007).

The study's results collectively offer persuasive evidence of Technology 4.0's moderating influence on the relationship between crucial success indicators and the survival of SMEs in Nigeria. The prioritization of CSFs indicates that conventional business fundamentals—specifically financial resources, entrepreneurial orientation, and marketing capabilities—remain essential in the Nigerian SME context, with this hierarchy corresponding to resource-based view theory while extending it by demonstrating that the efficacy of these resources increasingly depends on levels of digital adoption (Barney, 1991; Muneer et al., 2017; Anwar & Shah, 2021). The substantial moderation effect ($\beta = .18$, $p < .001$) constitutes the study's primary contribution, illustrating that Technology 4.0 adoption enhances the influence of conventional success criteria on SME survival rather than functioning as a disruptive or substitutive force. This amplification model, wherein digital technologies augment existing capabilities, aligns with Warner and Wäger's (2019) conceptualization of digital transformation as dynamic capability development rather than replacement of traditional business paradigms. The robust association between Technology 4.0 adoption and both CSFs ($r = .65$, $p < .001$) and organizational longevity ($r = .58$, $p < .001$) indicates that digital capabilities are becoming integral to company success rather than merely ancillary, while the amplification effect is notably pronounced for enterprise factors ($\beta = .20$), suggesting digital technologies predominantly augment internal organizational capacities—a conclusion consistent with Wade and Hulland's (2004) extension of the resource-based paradigm to information technology contexts and Teece's (2007) dynamic capabilities framework demonstrating how digital technologies enhance sensing, seizing, and transforming actions.

The observed variations in moderating effects across sectors reveal important contextual contingencies. The strong positive moderation effect in manufacturing ($\beta = .25$, $p < .001$) is consistent with the Industry 4.0 literature, which emphasizes the transformative potential of digital technologies in optimizing production processes, supply chains, and quality control systems (Frank et al., 2019; Müller, Kiel, & Voigt, 2018). This finding suggests that manufacturing SMEs in Nigeria are better positioned to leverage digital investments to enhance traditional operational capabilities.

In contrast, the non-significant moderation effect in agriculture ($\beta = .05$, $p = .12$) warrants a more nuanced interpretation. This result does not imply that Technology 4.0 is irrelevant to agricultural SMEs. Instead, it likely reflects the cumulative effect of several contextual barriers unique to the sector. First, the baseline level of Technology 4.0 adoption among agricultural SMEs in the sample was significantly lower (mean index = 2.50) compared to manufacturing (mean index = 3.20). Second, the majority of agricultural SMEs were located in rural areas with persistent infrastructural deficits, including unreliable electricity and limited broadband connectivity (Okere et al., 2023). Third, the specific nature of agricultural value chains may require different types of digital applications (e.g., precision farming tools, weather forecasting apps) that are not yet widely accessible or affordable in the Nigerian context. Consequently, the lack of significant moderation likely reflects a "digital readiness" threshold that these firms have not yet attained, rather than an inherent incompatibility between technology and agricultural enterprise success. This interpretation is supported by the Johnson-Neyman threshold analysis, which demonstrated that moderation effects only become significant when Technology 4.0 adoption exceeds a minimum level (2.1 on the index). For agricultural SMEs, only a few have reached this threshold, which explains the insignificant finding. The threshold effect revealed by Johnson-Neyman research (Technology 4.0 > 2.1) carries significant practical ramifications. It indicates that SMEs must attain a foundational level of digital adoption prior to experiencing substantial amplification effects, hence endorsing incremental rather than radical digital transformation trajectories. This discovery corresponds with Khin and Ho's (2019) suggestion for incremental digital adoption in underdeveloped economies.

The study's results enhance multiple theoretical frameworks. They substantiate dynamic capacities theory by demonstrating how digital technologies augment sensing, seizing, and transforming actions (Teece, 2007).

They enhance the resource-based paradigm by illustrating that resource value is increasingly dependent on technology. They situate the Technology-Organization-Environment framework (Tornatzky & Fleischer, 1990) within Nigeria's distinct institutional and economic milieu.

The findings indicate that SME development strategies must incorporate both digital and traditional skill enhancement, with a specific focus on attaining minimum adoption thresholds. Policy interventions may concentrate on enhancing digital infrastructure and capabilities within certain sectors, particularly addressing underperforming areas such as agriculture. Owners and managers of SMEs should emphasize reaching the specified technology adoption threshold (2.1+) by making incremental expenditures in digital tools that improve the highest-ranked CSFs, especially in financial management and marketing capabilities. Formulate cohesive digital business strategies instead of regarding technology as an isolated endeavor. Policymakers must formulate sector-specific digital transformation initiatives, particularly focusing on underperforming areas such as agriculture, where infrastructural deficiencies may necessitate specialized interventions. Develop frameworks for assessing the digital maturity of SMEs and establish incentive structures to achieve specified adoption levels.

Financial institutions ought to integrate Technology 4.0 adoption criteria into credit risk assessment models, acknowledging that digitally empowered SMEs exhibit increased resilience. Create financial products that expressly facilitate incremental digital adoption in accordance with CSF improvement. Educational and research institutions must amalgamate digital capacity development with conventional business education to equip future entrepreneurs for hybrid competency demands. Execute long term research monitoring the progression of moderating effects as Nigeria's digital infrastructure develops. Industry associations ought to create peer learning networks that promote knowledge exchange regarding effective digital adoption strategies, focusing on sector-specific obstacles and possibilities.

The study's drawbacks, notably its cross-sectional methodology and emphasis on survival overgrowth, indicate avenues for future research. Longitudinal research may investigate the evolution of moderating effects with increased digital usage, while comparative studies within African economies could reveal regional tendencies. Qualitative study could clarify the mechanisms underlying the quantitative associations identified below.

This study conclusively demonstrates that the adoption of Technology 4.0 strongly influences the relationship between CSFs and the survival of SMEs in Nigeria, with effects differing by category of CSF and sector. The results endorse a holistic strategy for SME development that merges conventional skill enhancement with strategic digital integration, providing both theoretical insights and practical recommendations for bolstering SME resilience in emerging economies.

6. Conclusions

This study provides empirical evidence that the adoption of Industry 4.0 technologies conditionally influences the relationship between critical success factors and SME survival in Nigeria. Specifically, the findings demonstrate a significant amplification effect, wherein the impact of traditional success factors on survival is substantially enhanced as SMEs achieve higher levels of digital adoption. This effect is not uniform across sectors and is contingent upon surpassing a minimum threshold of digital maturity (Technology 4.0 > 2.1). Therefore, rather than serving as a standalone determinant of success, Technology 4.0 functions as a strategic capability amplifier, reshaping the effectiveness of established business fundamentals in the Nigerian context. The established threshold impact indicates that SMEs must attain a fundamental degree of digital maturity to access these enhancement advantages. The findings substantiate the integrated theoretical framework that amalgamates the resource-based view, dynamic capabilities, and technology-organization-environment perspectives, offering empirical evidence that digital transformation in emerging economies adheres to evolutionary rather than revolutionary trajectories. The research indicates that, within Nigeria's setting, effective SME development necessitates concurrent focus on traditional business fundamentals and strategic digital adoption, as neither is adequate for sustainable survival on its own.

Author Contributions:

Conceptualization: Babandi Ibrahim Gumel.
Data curation: Babandi Ibrahim Gumel.

Formal analysis: Babandi Ibrahim Gumel.
Funding acquisition: Babandi Ibrahim Gumel.
Investigation: Babandi Ibrahim Gumel.
Methodology: Babandi Ibrahim Gumel.
Project administration: Babandi Ibrahim Gumel.
Resources: Babandi Ibrahim Gumel.
Software: Babandi Ibrahim Gumel.
Validation: Babandi Ibrahim Gumel.
Visualization: Babandi Ibrahim Gumel.
Writing –original draft: Babandi Ibrahim Gumel.
Writing –review & editing: Babandi Ibrahim Gumel.
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References

Adeoye, A. O., & Elegunde, A. F. (2012). Impacts of external business environment on organizational performance in Nigeria's food and beverage industry. *British Journal of Arts and Social Sciences, 6*(2), 194–201. https://www.semanticscholar.org/paper/Impacts-of-External-Business-Environment-on-in-the-Olarewaju-Folarin/f6fc479b0c47571e2d1314482eaff292c01040f3

Agrawal, P., Narain, R., & Ullah, I. (2020). Analysis of barriers in implementation of digital transformation of supply chain using interpretive structural modelling approach. *Journal of Modelling in Management, 15*(1), 297–317. https://doi.org/10.1108/JM2-03-2019-0066

Aguinis, H., Edwards, J. R., & Bradley, K. J. (2017). Improving our understanding of moderation and mediation in strategic management research. *Organizational Research Methods, 20*(4), 665–685. https://doi.org/10.1177/1094428115627498

Ahmad, H., & Halim, H. (2017). Determining sample size for research activities. *Selangor Business Review, 2*(1), 20–34. https://sbr.journals.unisel.edu.my/index.php/sbr/article/view/12

Ahmed, I. (2020). Technology organization environment framework in cloud computing. *TELKOMNIKA (Telecommunication Computing Electronics and Control), 18*(2), 716–725. https://doi.org/10.12928/telkomnika.v18i2.13871

Alfaadhel, S. (2010). *An empirical study of critical success factors for small and medium enterprises in Saudi Arabia: Challenges and opportunities* (Doctoral dissertation, University of Bradford). http://hdl.handle.net/10454/4909

Alfoqahaa, S. (2018). Critical success factors of small and medium-sized enterprises in Palestine. *Journal of Research in Marketing and Entrepreneurship, 20*(2), 170–188. https://doi.org/10.1108/JRME-05-2016-0014

Al-Haddad, L., Safdar Sial, M. S., Imdad, A., Rahmat, A., Vinh, K. N., & Thai, H. T. (2019). The role of small and medium enterprises (SMEs) in employment generation and economic growth: A study of marble industry in emerging economy. *International Journal of Financial Research, 10*(6), 174–187. https://ideas.repec.org/a/jfr/ijfr11/v10y2019i6p174-187.html

Al-Tit, A., Omri, A., & Euchi, J. (2019). Critical success factors of small and medium-sized enterprises in Saudi Arabia: Insights from sustainability perspective. *Administrative Sciences, 9*(2), 32. https://doi.org/10.3390/admsci9020032

Amini, M., & Jahanbakhsh Javid, N. (2023). A multi-perspective framework established on diffusion of innovation (DOI) theory and technology–organization–environment (TOE) framework toward supply chain management system based on cloud computing technology for SMEs. *International Journal of Information Technology and Innovation Adoption, 11*, 1217–1234. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4340207

Anwar, M., & Shah, S. Z. (2021). Entrepreneurial orientation and generic competitive strategies for emerging SMEs: Financial and nonfinancial performance perspective. *Journal of Public Affairs, 21*(1), e2125. https://doi.org/10.1002/pa.2125

Awa, H. O., Ojiabo, O. U., & Orokor, L. E. (2017). Integrated technology–organization–environment (TOE) taxonomies for technology adoption. *Journal of Enterprise Information Management, 30*(6), 893–921. https://doi.org/10.1108/JEIM-03-2016-0079

Badghish, S., & Soomro, Y. A. (2024). Artificial intelligence adoption by SMEs to achieve sustainable business performance: Application of technology–organization–environment framework. *Sustainability, 16*(5), 1864. https://doi.org/10.3390/su16051864

Baltzan, P. (2015). *Business driven technology*. McGraw-Hill Irwin.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99–120. https://doi.org/10.1177/014920639101700108

Belik, E. B., Petrenko, E. S., Pisarev, G. A., & Karpova, A. A. (2019). Influence of technological revolution in the sphere of digital technologies on modern entrepreneurship. In *Institute of Scientific Communications Conference* (pp. 239–246). https://link.springer.com/chapter/10.1007/978-3-030-32015-7_27

British Psychological Society. (2021). *Code of ethics and conduct*. BPS.

Castillo-Vergara, M., Duarte Valdivia, D., Muñoz-Cisterna, V., Álvarez-Marín, A., Geldes, C., & Ortiz-Henriquez, R. E. (2025). Digital capabilities of SMEs: Driving the Industry 4.0 revolution and measuring its innovative effects. *Academia Revista Latinoamericana de Administración*. https://doi.org/10.1108/ARLA-08-2023-0137

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage.

David, R. J., Tolbert, P. S., & Boghossian, J. (2019). Institutional theory in organization studies. In *Oxford Research Encyclopedia of Business and Management*. https://doi.org/10.1093/acrefore/9780190224851.013.158

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: The tailored design method* (4th ed.). Wiley.

Frank, A. G., et al. (2019). Industry 4.0 technologies: Implementation patterns in manufacturing companies. *International Journal of Production Economics, 210*, 15–26. https://doi.org/10.1016/j.ijpe.2019.01.004

Gumel, B. I., & Bardai, B. B. (2023). A review of critical success factors influencing the success of SMEs. *SEISENSE Business Review, 3*(1), 37–61. https://ssrn.com/abstract=4492176

Gumel, B. I., & Bardai, B. B. (2023). Critical success factors (CSFs) of SMEs in Nigeria and the mediating impact of SMEDAN initiative between the CSFs and SMEs' success. *International Journal of Business and Economics Research, 12*(3), 68–86. https://doi.org/10.11648/j.ijber.20231203.11

Gyimah, P., Marom, S., & Lussier, R. N. (2021). Small business success or failure prediction: A comparative study in Ghana and Israel. *Journal of Applied Business and Economics, 21*(3). https://www.proquest.com/openview/5f446f01823beaececcbec7afe641ba8

Hayes, A. F. (2022). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach* (3rd ed.). Guilford Press.

Holbert, R. L., & Park, E. (2020). Conceptualizing, organizing, and positing moderation in communication research. *Communication Theory, 30*(3), 227–246. https://doi.org/10.1093/ct/qtz006

Khin, S., & Ho, T. C. (2019). Digital technology, digital capability and organizational performance: A mediating role of digital innovation. *International Journal of Innovation Science, 11*(2), 177–195. https://doi.org/10.1108/IJIS-08-2018-0083

Kumar, V., Sindhwani, R., Behl, A., Kaur, A., & Pereira, V. (2024). Modelling and analysing the enablers of digital resilience for SMEs. *Journal of Enterprise Information Management, 37*(5), 1677–1708. https://doi.org/10.1108/JEIM-01-2023-0002

Lampadarios, E. (2015). *Critical success factors (CSFs) for SMEs: An empirical study in the UK chemical distribution industry* (Postdoctoral thesis, Leeds Beckett University). https://eprints.leedsbeckett.ac.uk/id/eprint/2116/

Lampadarios, E. (2016). Critical success factors for SMEs: An empirical study in the UK chemical distribution industry. *International Journal of Business and Management, 11*(7), 67–82. https://doi.org/10.5539/ijbm.v11n7p67

Low, M. P., Seah, C. S., Cham, T. H., & Teoh, S. H. (2022). Digitalization adoption for digital economy: An examination of Malaysian SMEs through the TOE framework. *Business Process Management Journal, 28*(7), 1473–1494. https://doi.org/10.1108/BPMJ-06-2022-0282

Lubis, N. W. (2022). Resource-based view (RBV) in improving company strategic capacity. *Research Horizon, 2*(6), 587–596. https://doi.org/10.54518/rh.2.6.2022.85

Lumpkin, G. T., & Dess, G. G. (1996). Clarifying the entrepreneurial orientation construct and linking it to performance. *Academy of Management Review, 21*(1), 135–172. https://doi.org/10.5465/amr.1996.9602161568

Ma'aji, M. M., Shrubsall, R. S., & Anderson, E. O. (2023). Determinants of SME success or failure in frontier markets. *International Journal of Banking and Finance, 18*(1), 1–30. https://doi.org/10.32890/ijbf2023.18.1.1

Mishrif, A., & Khan, A. (2023). Technology adoption as survival strategy for SMEs during COVID-19. *Journal of Innovation and Entrepreneurship, 12*(1), 1–23. https://doi.org/10.1186/s13731-023-00317-9

Mtshali, S. S., & Chinyamurindi, W. T. (2021). Determinants of small business performance in South Africa. *Journal of Contemporary Management, 18*(1), 1–20. https://hdl.handle.net/10520/ejc-jcman-v18-n1-a1

Müller, J. M., Kiel, D., & Voigt, K. I. (2018). What drives Industry 4.0 implementation? *Sustainability, 10*(1), 247. https://doi.org/10.3390/su10010247

Munawaroh, M., Indarti, N., Ciptono, W. S., & Nastiti, T. (2023). Learning from entrepreneurial failure. *Journal of Small Business and Enterprise Development, 30*(3), 501–522. https://doi.org/10.1108/JSBED-06-2022-0269

Muneer, S., Ahmad, R. A., & Ali, A. (2017). Impact of financial management practices on SMEs profitability. *Information Management and Business Review, 9*(1), 23–30. https://doi.org/10.22610/imbr.v9i1.1593

Nkwabi, J., & Mboya, L. (2019). A review of factors affecting SME growth in Tanzania. *European Journal of Business and Management, 11*(33), 1–8. https://doi.org/10.7176/EJBM/11-33-01

Obaje, A. (2020). *The impact of strategic planning on SME performance in Nigeria* (Doctoral dissertation, Cardiff Metropolitan University). https://doi.org/10.25401/cardiffmet.12017196

Olanrewaju, A. S. T., Hossain, M. A., Whiteside, N., & Mercieca, P. (2020). Social media and entrepreneurship research: A literature review. *International Journal of Information Management, 50*, 90–110. https://doi.org/10.1016/j.ijinfomgt.2019.05.011

Pasternak-Malicka, M., Ostrowska-Dankiewicz, A., & Dankiewicz, R. (2021). Bankruptcy in SMEs: Case of Poland. *Polish Journal of Management Studies, 24*(1), 250–267. https://doi.org/10.17512/pjms.2021.24.1.15

Pedraza, J. M. (2021). SMEs and economic development. *Business and Management Research, 10*(1), 33–44. https://doi.org/10.5430/bmr.v10n1p33

Qalati, S. A., Li, W., Ahmed, N., Ali Mirani, M., & Khan, A. (2020). Factors affecting SME performance: Mediating role of social media adoption. *Sustainability, 13*(1), 1–24.

Rachinger, M., Rauter, R., Müller, C., Vorraber, W., & Schirgi, E. (2019). Digitalization and business model innovation. *Journal of Manufacturing Technology Management, 30*(8), 1143–1160. https://doi.org/10.1108/JMTM-01-2018-0020

Rockart, J. F. (1979). Chief executives define their own data needs. *Harvard Business Review, 57*(2), 81–93. https://europepmc.org/article/med/10297607

Saunders, M., Lewis, P., & Thornhill, A. (2019). *Research methods for business students* (8th ed.). Pearson.

Schwab, K. (2016). *The fourth industrial revolution*. World Economic Forum.
Sony, M., & Naik, S. (2020). Evaluating Industry 4.0 readiness. *Benchmarking: An International Journal, 27*(7), 2213–2232. https://doi.org/10.1108/BIJ-09-2018-0284
Susanto, P., Hoque, M. E., Shah, N. U., Candra, A. H., Hashim, N. M. H. N., & Abdullah, N. L. (2023). Entrepreneurial orientation and SME performance. *Journal of Entrepreneurship in Emerging Economies, 15*(2), 379–403. https://doi.org/10.1108/JEEE-03-2021-0090
Teece, D. J. (2007). Explicating dynamic capabilities. *Strategic Management Journal, 28*(13), 1319–1350. https://doi.org/10.1002/smj.640
Teece, D. J. (2018). Business models and dynamic capabilities. *Long Range Planning, 51*(1), 40–49. https://doi.org/10.1016/j.lrp.2017.06.007
Tornatzky, L. G., & Fleischer, M. (1990). *The processes of technological innovation*. Lexington Books.
Ulewicz, R., Novy, F., & Sethanan, K. (2019). Challenges of Industry 4.0 for SMEs. *Quality Production Improvement, 1*. https://doi.org/10.2478/cqpi-2019-0020
Wade, M., & Hulland, J. (2004). The resource-based view and IS research. *MIS Quarterly, 28*(1), 107–142. https://www.jstor.org/stable/25148626
Warner, K. S., & Wäger, M. (2019). Building dynamic capabilities for digital transformation. *Long Range Planning, 52*(3), 326–349. https://doi.org/10.1016/j.lrp.2018.12.001
Xie, X., Jin, X., Wei, G., & Chang, C. T. (2023). Monitoring SMEs' shutdown risk. *Systems, 11*(5), 260. https://doi.org/10.3390/systems11050260
Xu, M. D., et al. (2018). The fourth industrial revolution: Opportunities and challenges. *International Journal of Financial Research, 9*(2), 90–95. https://doi.org/10.5430/ijfr.v9n2p90
Yu-Wei, L., & Ping-Jian, L. (2013). Strategies for capital chain optimization in SMEs in China. In *Proceedings of the International Conference on Business Computing and Global Informatization*. https://dl.acm.org/doi/abs/10.5555/2545277.2545349
Zhou, D., Kautonen, M., Dai, W., & Zhang, H. (2020). Digital technology and manufacturing innovation. *Journal of Business Research, 119*, 647–657.
Zhu, D., Li, Z., & Mishra, A. R. (2023). Evaluation of critical success factors of dynamic enterprise risk management. *Technological Forecasting and Social Change, 186*, 122137. https://doi.org/10.1016/j.techfore.2022.122137

Appendix – Questionnaire items for each construct.

Critical Success Factors – Entrepreneurial Factors

Use the following scale: 1 = Strongly Disagree | 2 = Disagree | 3 = Neutral | 4 = Agree | 5 = Strongly Agree

CSF-E1: The age of the owner/manager is critical to our firm's survival.
CSF-E2: The education level of the owner/manager is critical to our firm's survival.
CSF-E3: The prior work experience of the owner/manager is critical to our firm's survival.
CSF-E4: The entrepreneurial orientation (innovation, risk-taking, proactiveness) of the owner/manager is critical to our firm's survival.
CSF-E5: The personality traits of the owner/manager are critical to our firm's survival.
CSF-E6: The gender of the owner/manager is critical to our firm's survival.

Critical Success Factors – Enterprise Factors

Use the following scale: 1 = Strongly Disagree | 2 = Disagree | 3 = Neutral | 4 = Agree | 5 = Strongly Agree

CSF-EN1: The age/size of our company is critical to our firm's survival.
CSF-EN2: Access to and management of financial resources is critical to our firm's survival.
CSF-EN3: Strategic planning practices are critical to our firm's survival.
CSF-EN4: Market and product development capabilities are critical to our firm's survival.
CSF-EN5: Marketing capabilities are critical to our firm's survival.
CSF-EN6: Human capital development and management are critical to our firm's survival.
CSF-EN7: Customer relationship management (CRM) is critical to our firm's survival.
CSF-EN8: Business networking and relationships are critical to our firm's survival.
CSF-EN9: Internationalization/export activities are critical to our firm's survival.
CSF-EN10: Record keeping and documentation practices are critical to our firm's survival.

CSF-EN11: Utilization of professional advisors/consultants is critical to our firm's survival.
CSF-EN12: Product/service market timing is critical to our firm's survival.
CSF-EN13: Team selection and composition are critical to our firm's survival.

Critical Success Factors – Environmental Factors
Use the following scale: 1 = Strongly Disagree | 2 = Disagree | 3 = Neutral | 4 = Agree | 5 = Strongly Agree
CSF-EV1: Economic conditions (inflation, exchange rates, interest rates) are critical to our firm's survival.
CSF-EV2: Political stability and government policies are critical to our firm's survival.
CSF-EV3: Legal and regulatory frameworks are critical to our firm's survival.
CSF-EV4: Technological infrastructure and digital access are critical to our firm's survival.
CSF-EV5: Socio-cultural norms and consumer behavior are critical to our firm's survival.
CSF-EV6: Ecological and environmental factors are critical to our firm's survival.

Technology 4.0 Adoption
Use the following scale: 1 = No adoption | 2 = Low adoption (minimal use) | 3 = Moderate adoption (regular use) | 4 = High adoption (extensive use) | 5 = Full integration (fully embedded)
T4.0-1: Mobile technologies (smartphones, mobile apps, SMS services)
T4.0-2: Social media platforms (Facebook, Instagram, LinkedIn, Twitter, WhatsApp Business)
T4.0-3: Cloud computing (Google Drive, Dropbox, Microsoft 365, cloud ERP)
T4.0-4: Digital payment systems (POS, bank transfers, mobile money, PayPal)
T4.0-5: E-commerce platforms (Jumia, Konga, Shopify, company website with online sales)
T4.0-6: Basic automation (spreadsheet formulas, email automation, scheduling tools)
T4.0-7: Data analytics tools (customer analytics, sales tracking, business intelligence)
T4.0-8: Internet of Things (IoT) devices (smart sensors, tracking devices, and connected equipment)
T4.0-9: Artificial Intelligence/Machine Learning (chatbots, predictive analytics, recommendation systems)
T4.0-10: Blockchain technology (secure transactions, smart contracts, and supply chain tracking)

SME Survival Indicators
Use the following scale: 1 = Strongly Disagree | 2 = Disagree | 3 = Neutral | 4 = Agree | 5 = Strongly Agree
SURV-1: Our business has been continuously operating for five years or more.
SURV-2: Our firm has been consistently profitable over the past three years.
SURV-3: Our revenue has shown consistent growth over the past three years.
SURV-4: We have maintained stable employee retention over the past three years.
SURV-5: Our market share has remained stable or increased over the past three years.
SURV-6: We have successfully adapted to major market disruptions (e.g., COVID-19, economic shocks).
SURV-7: Our business has positive cash flow and can meet financial obligations.
SURV-8: We have no immediate risk of business closure.