SSAR Journal of Multidisciplinary Studies (SSARJMS)

Journal home page: https://ssarpublishers.com/ssarjms
Abbreviated Key Title: SSAR J Multidiscip. Stud
ISSN: 3049-2041 (Online)
Volume 3, Issue 1, (Jan-Feb) 2026, Page 65-82 (Total PP.18)
Frequency: Bimonthly
E-mail: ssarpublishers@gmail.com

OPEN ACCESS

ARTICLE HISTORY
Received: 16-01-2026 / Accepted: 07-02-2026 / Published: 09-02-2026

Impact of Software Engineering Practices and Technology Adoption on Business Sustainability

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ABSTRACT: Companies throughout the world are progressively turning to the use of innovative digital technologies and high-quality software engineering processes in order to stay competitive and remain viable. Nonetheless, the organizations in the developing economies, especially in Nigeria, are still facing the problem of successfully applying modern engineering approaches and embracing the novel technologies, which has an adverse impact on sustainable business performance. This is a conceptual paper that explores the role of software engineering practices and adoption of technology on business sustainability based on economic, environmental, and social contexts. The second one is based on the Resource-Based View (RBV) and Technology Acceptance Model (TAM): the research synthesizes a broad range of secondary data based on the scholarly articles and industry reports, as well as the records of technological adoption worldwide. The review demonstrates that Agile carbonates, DevOps, quality assurance, and secure software development contribute to the great increase of the operational efficiency and environmental responsibility, whereas the use of technologies like cloud computing, AI, and automation encourages innovation and product value. Research also points to contextual constraints in the developing countries that are characterized by infrastructural disparity, lack of digital literacy and exorbitant cost of technology investment. The research paper adds a conceptual framework of the connection between internal engineering potentials and technology preparedness and sustainable growth. It ends with a conclusion on the strategic digital transformation policy, the better talent development, and the enhanced integration of engineering best practices in order to facilitate sustainable business performance.

KEYWORDS: Software Engineering Practices, Technology Adoption, Business Sustainability, Digital Transformation, Emerging Economies.

INTRODUCTION

1.1 Background of the Study

In the modern fast changing digital world, organizations all over the world are relying more and more on the performance enhancement, innovation, and even survival through the application of technology-based processes. There are digital technologies, including cloud computing, blockchain, and innovative Information and Communication Technologies (ICT), which have become areas of enabling business growth, competitiveness, and cost efficacy (Gharpure and Ghodke, 2021; Drljevic et al., 2022). Software engineering practices are systematic methods of software development

including Agile methodologies, DevOps, secure coding and quality assurance are important to increase the reliability and efficiency of technology systems that serve a business strategy. Organizations all over the world are struggling to use sustainable technologies in achieving economic, environmental, and social sustainability. Research indicates that sustainable adoption of technologies can play a major role in enhancing the business performance of any business and help achieve the UN Sustainable Development Goals (SDGs) (Maluleke & Mutoko, 2024). As an example, the implementation of digital solutions within industrial ecosystems leads to the improvement of productivity and minimizes the number of unnecessary operations in the organization and negative impacts on the environment. With the development of the Fourth Industrial Revolution (Industry 4.0), companies are more and more opting to incorporate automation, cloud computing, and digital services to enhance competitiveness and guarantee sustainable growth. The Digital transformation is still growing in Africa, but the adoption of technology is not even because of infrastructure and capability limitation. Incorporation of ICT in manufacturing, finance, education, agricultural sector has demonstrated possibilities of increasing productivity, entrepreneurship and enhance sustainability performance. Carvajal-Morales et al. (2024) determined that the efficient implementation of digital technologies in learning institutions affects the satisfaction and performance levels, which supports the notion of the significance of skills and preparedness, a notion also relevant to the issue of business technology adoption in Africa.

The use of innovative technology in West Africa is becoming a vital prerequisite of sustainable economic growth. Yet, there are still gaps in the readiness to implement, availability of IT infrastructure, availability of skilled manpower, and policy support. Researchers point out that companies with positive modern IT practices receive competitive advantages and increase their market reach and performance metrics related to sustainability (Okoye et al., 2023). In Nigeria, in particular, which is the largest economy in the West Africa, ICT and digital transformation investment has increased yet is limited by financial resources, lack of technical skills, and poor infrastructure. Nigerian manufacturing and service companies that have successfully implemented IT solutions have better sustainability performance, boosted productivity, and economic contribution (Okoye et al., 2023). It has been found that cloud computing use in the developing market is less expensive and it benefits the financial performance, and systematic frameworks of the evaluation of the sustainability results are not yet well studied (Gharpure and Ghodke, 2021). Moreover, the activities of Nigerian businesses are becoming more digital, manufacturing smart, developing entrepreneurs, changing HR technology, and digital commerce - all of them are designed to contribute to sustainable growth and improvement in performance (Mohammed and Sundararajan, 2023; Shanmugam et al., 2024). There are however major lapses in software engineering capability, system quality assurance and sustainable technology integration. Thus, it is necessary to conduct a systematic study of the impact of software engineering practices and technological adoption on business sustainability to assist in organizational decision-making, policy choices, and future digital transformation plans in Nigeria and other developing economies.

1.2 Problem Statement

Companies all over the world are slowly transitioning to digital business, in which software engineering activities and software adoption can be central in driving competitiveness, efficiency in operations, and sustainability. Nevertheless, even with these developments, organizations have been facing difficulties in realizing sustainability in the outcomes of technology-based efforts. A considerable number of digital transformations, as a result, cannot bring long-term value because of subpar implementation strategies, lack of proper governance, lack of skills, and the lack of alignment between investments in technology and long-term sustainability objectives (Bakar and Dorasamy, 2023; Drljevic et al., 2022). Technology implementation has been demonstrated to have a positive and significant effect on the growth and financial success of business, which is still underdeveloped in the systematic approaches to measure the sustainability and cost-reduction effect in advanced economies (Gharpure & Ghodke, 2021).

New restrictions are also being encountered by emerging economies, especially in Africa, which include the lack of digital infrastructure, the low level of readiness, and high financial risks related to the implementation of innovative technologies (Maluleke and Mutoko, 2024).

In West Africa, nations are increasingly showing an increasingly digital interest but technology integration issues are still there based on cultural, managerial and regulatory obstacles that negate effective utilization of digital tools to achieve sustainable development. The issues businesses, particularly SMEs and manufacturing companies in Nigeria face in terms of adoption readiness, resource limitations, cybersecurity risks, and uneven IT governance lead to high returns to technology investments and low contribution to sustainability performance (Okoye et al., 2023; Shanmugam et al., 2024). Furthermore, whereas it is shown that contemporary software engineering standards like agile practices and performance-oriented IT capabilities improve the innovation and resilience (Mohammed & Sundararajan, 2023), there is a significant knowledge gap on how the combination of their application with the embracement of technology results in the long-term business sustainability outcomes economically, socially, and environmentally. Thus, the fundamental issue this paper tackles is the following one: even as the number of digital technologies and best practices in software development is growing, the Nigerian businesses still fail to convert these technological endeavors into the sustainable performance results because of contextual issues, strategic ones, and operational ones.

1.3 Significance of the Study

Combining software engineering practices and the adoption of technology is now becoming one of the essential contributors to business sustainability in contemporary digital economy. Software-driven innovation is becoming a necessity as organizations are trying to become more efficient in operations, to save money, and stay competitive (Gharpure and Ghodke, 2021; Godina et al., 2020). The authors believe the study is relevant because it sheds light on the effects of software engineering practices, especially those congruent with agility, quality assurance, and lifecycle optimization, on the long-term business sustainability outcomes, i.e. profitability, environmental responsibility, and social value (Serban et al., 2020; Ch'ng et al., 2021). This is important in the present context of new economies such as Nigeria. The barriers in embracing modern techniques in engineering and sustainable technology are still prevalent in the business with infrastructure and skill shortage and expensive implementation being some of the reasons (Okoye et al., 2023; Abdul-Majid et al., 2024). This paper is relevant in the sense that it establishes the way that organizations can use software engineering maturity and digital transformation efforts to respond to these constraints, and thus achieve long-term growth. Moreover, as the world industries are still depending on cloud computing, machine learning, blockchain, and automation, there is an increasing need to discover for practical frameworks between the implementation of technology and quantifiable sustainability performance (Voorneveld, 2024; Drljevic et al., 2022). The research also bridges the gap on the knowledge needed on the most valuable software engineering practices to sustainability in order to enable firms to allocate resources more efficiently (Serban et al., 2020).

1.4 Research Objectives

The main objective of this study is to examine how software engineering practices and technology adoption contribute to business sustainability in emerging economies, with specific insights applicable to Nigeria. The study seeks to:

1. To evaluate the applicability of software engineering practices to business sustainability from the economic, social, and environmental perspectives.
2. To discuss the effect of the adoption of new technology, such as cloud computing, blockchain and digital transformation, on the resulting business sustainability outcomes.
3. To establish the mediating efficacy of software engineering practices to technological adoption and organizational performance.
4. To study contextual issues for sustainable technology adoption in the Nigerian businesses.
5. To formulate a conceptual model relating software engineering practices, technology appropriation and business sustainability

1.5 Research Questions

In order to attain the above objectives, the following research questions would be asked in the study:

1. How software engineering practices contribute to sustainable business performance?
2. What is the impact of technology adoption on organizational survival in the emerging economies?
3. Does integration of software engineering practices and technology adoption build better business resiliency and competitiveness?
4. What challenges limit sustainable technology adoption in Nigerian business environments?
5. Which conceptual model best explains the relationship between software engineering practices, technology adoption, and business sustainability?

2.0 Literature Review

The literature review provides the conceptual and theoretical basis of this research, which is the role of software engineering practices and technology adoption in business sustainability. Past research has proven that digitalization, innovation, and agile are technology-based management practices that help to enhance organizational resilience, reduce costs, and to be sustainable (Gharpure and Ghodke, 2021; Maluleke and Mutoko, 2024; Drljevic, Aranda and Stantchev, 2022). Likewise, implementation of the efficient process in software engineering leads to the improvement of the business through increased efficiency, reliability of the software, and customer satisfaction. This section is a critical review of literature on software engineering practices, adoption of technology and their combined impact on sustainable business performance. It also reflects the gaps in knowledge that are used as a justification of the present research especially in the circumstances of the emerging economies like in Nigeria where maturity of technology and sustainable management practices is still undergoing (Okoye, Nwokike, and Ezeneme, 2023).

2.1 Conceptual Review

The conceptual review considers the main constructs of the research Software engineering practices, technology adoption, and business sustainability and how they relate to each other. The constructs are individually scrutinized with regard to definition, scope, evolution, and their role to sustainable organizational outcomes.

2.1.1 Software Engineering Practices

Definition and Evolution of Software Engineering Practices

The systematic, disciplined, and quantifiable development, operation and maintenance of software systems is known as software engineering practices (Mohammed, 2023). This has seen the practices change considerably in relation to the traditional waterfall models to the iterative and agile-based models that aim at increasing flexibility and product quality (Sundararajan, Mohammed, and Senthil Kumar, 2023). Application of the concept of software engineering in business operations facilitates better performance, minimization of errors during production, and alignment of software outputs with the organizational objectives. Software engineering was of traditional orientation at maximizing efficiency of the programming process whereas the modern strategy, implies the value delivery, customer satisfaction, and the way to ongoing improvement (Mohammed et al., 2024). The digital economy has also induced the process of contemporary engineering patterns, that is a combination of automation instruments with cloud computing and DevOps architecture that raise the productivity and sustainability of results.

Agile Approaches and Continuous Improvement

Agile software development enhances flexibility, accumulation of knowledge through repetition, and customer responsiveness - the concepts that the sustainable development of business performance revolves around (Aliyu, 2023). Agile models such as Scrum and Kanban promote cross-functional work and timely identification of problems, which result in less waste and better management of resources (Sundararajan, Mohammed, and Lawal, 2023). Mohammed and Sundararajan (2023) argue that the agile performance management system can give an organization the ability to swiftly adjust to technological shocks, promote innovation, and guarantee the consistent delivery of value. The processes of continuous integration and delivery (CI/CD) also promote sustainability through the automation of the testing and deployment cycle, reduction of operational inefficiencies, and software reliability. The practices are compliant with the industry 4.0 aim of the flexibility, quick feedback, and innovation, which should be based on the long-term sustainability (Aliyu, 2023; Mohammed, 2023).

Software Quality Assurance and Testing

Testing and Software Quality Assurance (SQA) are an important part of software engineering activities that provide a means of assuring that a system is delivered according to the functional and non-functional specifications. Quality assurance reduces the cost of maintenance, enhances the dependability and fidelity of products and customers which are essential aspects of business sustainability (Mohammed, Jakada, and Lawal, 2023). As Drljevic et al. (2022) state, the introduction of quality-based models (e.g., ISO/IEC models) and automated testing tools does create coherence and increase transparency and accountability in the development process. Furthermore, SQA practices can help in the sustainable operations by reducing rework and wasting resources which will ultimately result in eco-efficient development in the digital world (Lawal, Abdulsalam, Mohammed, and Sundararajan, 2023). Another element accepting that is associated with successful SQA implementation is the improvement of knowledge dispersion and technology sophistication leading to the improved competitiveness of the economy in question (Okoye et al., 2023).

DevOps and Continuous Integration/Delivery

DevOps is the process of uniting development and operations teams together to enhance the speed, cooperation, and effectiveness of software delivery. Organizations are able to use continuous integration and continuous delivery (CI/CD) to release faster, maintain operational stability, and minimize the risks of deployment, which are major facilitators of sustainable business performance (Mohammed & Sundararajan, 2023). Automating repetitive workflows, DevOps will help to decrease manual workload, reduce defects during an early phase and improve the scalability of technology solutions in volatile markets (Aliyu, 2023). It has also been suggested that DevOps practices have led to agility and traceability improvements, particularly in the application containing machine learning components, which need continuous monitoring and retraining (Serban et al., 2020). These operational capabilities result in sustainability and resiliency.

Requirement Engineering and User-Centric Design

Requirements engineering (RE) ensures that the product specifications have all the information concerning the user expectations, market demands and technological constraints. Using the early inclusion of stakeholder feedback into the software development life cycle, organizations minimize project failures and make digital systems more useful (Sundararajan, Mohammed, and Senthil Kumar, 2023). A usability-cantered and accessibility-driven user-centric design improves customer satisfaction and the retention of software products in the long-term implementation - the key to business sustainability (Mohammed, 2023). With appropriate implementation of RE, software results become more in line with the strategic business goals, which leads to the enhancement of financial performance and competitiveness.

Software Project Management Practices

Software project management (SPM) involves the following: planning, risk management, cost/time estimation, communication and quality control. Achieving the best possible resource distribution and ensuring a timely delivery are two significant factors contributing to a sustainable business operation that is ensured by effective SPM (Mohammed et al., 2024). In developing markets such as Nigeria, delays, cost increases, and wasteful use of technology is a common occurrence due to the absence of sophisticated project management practices (Okoye, Nwokike, and Ezeneme, 2023). According to Gharpure and Ghodke (2021), sustainable project management, in particular, cloud adoption, improves the efficiency of operations and minimizes overall long-term spending.

Role of Secure Coding in System Sustainability

Secure software development ensures that it does not contain vulnerabilities that may cost it the loss of money, disruption of business, and lack of customer confidence. Companies cannot be expected to maintain the work of development of software systems without a good cybersecurity policy throughout the process of development (Drljevic, Aranda, and Stantchev, 2022). The threats of digital transformation in both the private and legal spheres of the African region are significant, as cybersecurity risks, such as data breaches and system failures, endanger the efforts made by the digital transformation (Okoye et al., 2023). Secure coding standards can thus enhance

resilience, confidence of the users, and sustainability of services which are fundamentals of sustainable business success.

Importance of Software Documentation and Lifecycle Management

The maintainability, transfer of knowledge, and operational efficiency are supported by software documentation. Effective documentation will guarantee that the software systems are reusable, upgradeable, and mindful throughout their lifecycle (Mohammed et al., 2023). A lifecycle management process, such as updates, version management, and planned decommissioning, reduce system obsolescence, technical debt, and help maintain environmental sustainability through the reduction of resource waste (Atadoga et al., 2024). Sustainable software lifecycle management also helps organizations to be flexible to new regulation needs and business plans especially in digital economies where there is a high rate of change in technologies (Maluleke and Mutoko, 2024).

2.1.2 Technology Adoption

Concept of Technology Adoption in Business

Technology adoption is the process under which organizations incorporate and make use of emerging technologies in order to enhance efficiency, productivity and competitiveness. It is one of the most critical elements of digital transformation and the primary factor to improve the sustainability of businesses (Gharpure and Ghodke, 2021; Okoye, Nwokike and Ezeneme, 2023). The implementation of new technologies that include cloud computing, blockchain, as well as artificial intelligence have transformed how businesses are conducted to allow them to be more agile, flexible, cost-efficient (Drljevic, Aranda, and Stantchev, 2022).

Technology adoption is currently a determinant of sustainable economic development across the world, particularly in the banking, manufacturing, and education industries (Mishra et al., 2023). Digital tools penetration in Africa has improved financial inclusion and efficiency in operations, but disparities still exist because of infrastructure differences and regulatory inconsistencies (Okoye et al., 2023). In Nigeria, lack of digital literacy, poor funding and policy bottlenecks are some of the challenges that are encountered in the adoption of IT systems and emerging technologies. Nevertheless, successful businesses that have adopted technology have cited high productivity and innovation as well as resilience in the long term (Mohammed & Sundararajan, 2023). Adoption of technology consequently becomes a strong driver to attain sustainable competitive advantage through the application of innovation, optimization of resources, and the use of data in the process of decision-making (Maluleke and Mutoko, 2024).

Digital Transformation and Innovation Adoption

Digital transformation can be defined as the strategic use of digital technologies in every sphere of business activities that essentially transformed the way the organizations create value to customers (Alojail and Khan, 2023). It goes beyond the integration of single technologies to include a change of culture to perpetual innovation, learning and agility (Murugesan, 2008). Implementation of digital transformation is frequently based on the use of such tools as cloud computing, big data analytics, and blockchain to increase transparency, cut operational expenses, and boost customer engagement (Drljevic et al., 2022). As mentioned by Alojail and Khan (2023), aligning the digital transformation strategies with the sustainability goals can result in the long-term environmental and economic payoff and place the businesses in the best position to succeed in the uncertain world. Digital transformation in third world economies like Nigeria presents enormous business opportunities to businesses to overcome structural inefficiencies and grow into new markets. Nevertheless, the effectiveness of such measures is strongly linked to the presence of the leadership commitment, the willingness of the employees, and the presence of facilitating infrastructure (Okoye et al., 2023; Mohammed, 2023). Therefore, the development of an innovative digital culture and the encouragement of capacity-building programs can be taken as the necessary steps to the sustainable, technology-cantered growth.

Determinants of Technology Adoption (TAM and UTAUT Perspectives)

The Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) can serve as a basis of determining the factors that influence technology

adoption. The perceived usefulness (PU) and perceived ease of use (PEOU) are regarded as the critical predictors of technology acceptance according to TAM (Hasani et al., 2023). Companies and individuals would be more inclined to embrace new technologies when they believe that they stand to gain physically and when the systems are easy to use. The utility expectancy, effort expectancy, social influence, and enabling factor related to conditions are however important factors in affecting behavioural intention for adoption of technology as revealed by UTAUT model (Venkatesh et al., 2003). The constructs were tested on SMEs by Hasani et al. (2023), who found that technological readiness, organizational culture, and managerial support have a significant impact on the intention to adopt privacy enhancing technologies (PETs).

These frameworks have the implication that, in terms of sustainable business practices, the adoption of technology does not solely rely on the features of the systems but also on the environmental and organizational preparedness. As an example, Alojail and Khan (2023) found important prerequisite to successful digital transformation as stakeholder engagement and resources distribution. Equally, Okoye et al. (2023) emphasized that organizations that have a high level of managerial commitment and infrastructural support have a propensity to perform better in terms of sustainability through adoption of IT. Thus, the successful application of technologies needs a comprehensive approach consisting of the combination of technological, organizational, and environmental elements with the basis on the preparedness of management and innovation-oriented strategies.

Cloud Computing Adoption in Business Operations

Modern businesses have transformed its operational modes through cloud computing as it provides scalable, cost effective and flexible infrastructure to undertake digital transformation. It allows organizations to store, process, and analyse data in remote servers and therefore minimizes the on-premises infrastructure and maintenance requirements (Gharpure and Ghodke, 2021). Strategically, cloud computing has made it easy to collaborate smoothly, share information, and make real-time decisions, of which all the above enhance business agility and performance (Voorneveld, 2024). Empirical research highlights that the reduction of costs is considered one of the best-known advantages of the cloud computing because companies can turn fixed IT costs into variable costs (Gharpure and Ghodke, 2021). Moreover, with the help of cloud solutions, it is possible to integrate with artificial intelligence (AI) and Internet of Things (IoT) technologies, which facilitate data analytics and predictive modelling, which leads to efficiency. Voorneveld (2024) also indicated that sustainability is also improved by cloud-enabled AI systems in terms of resource utilization and operational waste reduction.

The use of cloud computing is at a developing stage in Nigeria because of the infrastructural issues; however, cloud computing has been embraced more in the banking, telecommunications, and retail sectors as a means to provide scalability, data security, and reliability of the services (Okoye et al., 2023). Cloud computing will also continue to be at the heart of sustainable business practices and operational resilience as the business in the developing economies romance digitalization.

AI, Automation, and Data-Driven Decision Making

Automation technologies and Artificial Intelligence (AI) have become the forces of change to change the business process and strategic management. Such technologies make predictive analysis of data, making the customer more personal, and making it easier to perform the job easier, which eventually makes any operation on the fly and makes the system more operational and sustainable (Voorneveld, 2024; Drljevic, Aranda, and Stantchev, 2022). Intelligence systems using AI help organizations to make decisions that are informed by data to improve efficiency and reduce risks. An example of such is predictive maintenance, which uses machine learning to minimise downtime in manufacturing facilities, and AI-enhanced logistics systems which are more responsive to changes in the supply chain. According to Ch'ng, Cheah, and Amran (2021), technology companies adopting automation and eco-innovation tendencies have better environmental and social performance in the current market orientation framework, particularly

in a dynamic market paradigm. Additionally, AI combined with cloud computing can help to achieve scalable analytics to ensure digital transformation and sustainability (Voorneveld, 2024). Nonetheless, AI and automation can only be successfully implemented with the help of human experience, ethical management, and organization objectives. Mohammed (2023) has also added that the strategic agility, data accuracy, and sustainable competitive advantage of management information systems (MIS) are improved by the utilization of AI in the era of big data.

Factors Hindering Technology Adoption in Developing Nations

Even with the world trend of the digital transformation, there are various obstacles that reduce the use of technology in the developing economies, especially in the Sub-Saharan Africa. They consist of poor digital infrastructure, poor broadband penetration, financial barriers, and technical skills (Okoye et al., 2023). The other key challenges are resistance to change, absence of government incentives, and culture that slows the acceptance of innovative technologies (Obiki-Osafiele et al., 2024). In Nigeria, as an example, a significant part of small and medium-sized business enterprises (SMEs) are not successful in integrating ICT tools because the cost of implementation is high and because of the lack of access to funding (Kurniasari, Hamid, and Lestari, 2025). Also, poor training and awareness of the benefits of technology are a barrier to digital adoption, especially among the traditional business operators (Abdul-Majid et al., 2024). In order to address them, a number of studies submitted that one should consider the collateral that is public-private collaboration, investing in digital literacy training, as well as government policy that is supportive of technology diffusion (Okoye et al., 2023; Maluleke and Mutoko, 2024). As it was emphasized by Obiki-Osafiele et al. (2024), it is needful to create an organizational preparedness by training and infrastructure investments in order to bring to life the full economic potential of technological innovation.

Technology Adoption for Competitive Advantage

Technology adoption is not only a technical improvement but it is strategic asset that improves the competitive edge of an organization. Studies also show that companies that successfully incorporate emerging technologies have stronger competitive advantages in performance, innovation potential, and flexibility towards change in customer markets (Endrodi-Kovacs, Perez Garrido, & Sebrek, 2024). The Resource-Based View (RBV) theory posits that technology resources which are rare, valuable and inimitable are strategic assets which promote sustainability and competitiveness (Obiki-Osafiele et al., 2024). The empirical evidence obtained for European SMEs suggests that technology adoption has a significant positive effect on market performance and sustainability performance, but there is a regional variation (Endrodi-Kovacs et al., 2024). Similarly, eco-innovation and digital adoption were also identified to exert both economic and social dimensions of business performance in the technology sector in Malaysia (Ch'ng et al., 2021). For the Nigerian and other African economies, digital adoption continues to be a key competitive driver that allows firms to leverage their resources optimally, enhance quality and gain access to international markets (Mohammed & Sundararajan, 2023). Furthermore, AI-supported analytics, automation, and ICT integration are enabling organizations to better adapt to changes in the market and build resilience in a long run amidst an increasingly volatile business environment (Alojail & Khan, 2023; Maluleke & Mutoko, 2024).

2.1.3 Business Sustainability (DV)

Concept and Dimensions of Business Sustainability

Business sustainability is the capacity of an organization to exist in such a way that it guarantees its long-term economic prosperity, environment conservation, and social welfare and remains competitive and resilient. It is about value creation that takes into consideration the needs of the present without depleting the future resources or expectations of the stakeholders. The triple bottom line (TBL), economic, environmental, and social performance are the commonly used indicators for business sustainability (Elkington 1998; Ch'ng et al. 2021). In a technologically oriented environment, sustainability means the application of technologies and innovative approaches to optimizing efficiency, effectiveness,

and stakeholder satisfaction (Maluleke & Mutoko, 2024).

Economic Sustainability

Economic sustainability for business includes securing financial stability, increased productivity, cost effectiveness and longevity. In fact, cloud computing has been connected with digital transformation, it has been associated with increased utilization and automation within the organization, which has led to increased efficiency and cost savings as it has allowed for better financial operations (Gharpure & Ghodke, 2021; Voorneveld, 2024). According to Endrodi-Kovacs, Perez Garrido and Sebrek (2024), the adoption of technologies brings a positive impact on the performance of the market and the competitive advantage of the business, especially when combined with entrepreneurial orientation and strategic investments. In Nigeria, the successful marriage of information technology has a positive impact on the productivity, expanding of markets, and economic contribution of manufacturing companies (Okoye et al., 2023), thereby proving that technology enabled sustainability has a transformative influence.

Environmental Sustainability

Environmental sustainability is concerned with maintaining low ecological footprints by reducing consumption of waste, emissions and resources. New technologies such as additive manufacturing (AM) promote the use of less material, sustainable product design, and fewer production cycles, leading to greener operations (Godina et al., 2020). In addition, AI-powered optimisation systems can be used to limit energy consumption and support resource-efficient operations (Voorneveld, 2024). Furthermore, eco-innovation activities including eco-process and eco-product innovations have been known to be important determinants of environmental performance in technology firms (Ch'ng et al., 2021). When companies integrate environmental factors into digital solutions, they target national goals for green industrial transition.

Social Sustainability

Social sustainability is concerned with the well-being of employees, customer satisfaction, the development of the community and fair access to innovation. Technology adoption leads to better quality of jobs, training programs, and services that contribute to better social outcomes (Abdul-Majid et al., 2024). For example, digital platforms based on ICT and cloud enable digital learning, virtual collaboration and more effective human capacity development (Carvajal-Morales et al., 2024). However, automation as well as digital disruptions may also lead to job replacement and digital inequality without proactive workforce reskilling (Mohammed, 2024b). Therefore, social value should be protected by incorporating human development strategies into digital transformation programs.

The Role of Innovation Capability in Sustainable Growth

Innovative capability is the ability to implement new ideas, technologies and processes - is an important driver of sustainability and resilience. Market dynamics and their related factors: Digital innovators and agile practices dynamically respond to change in the market and the investments made by them in the area of digital grow their business in the long run (Mohammed & Sundararajan, 2023). Blockchain-based innovation also adds transparency and trust to sustainable governance and competitive organizational behaviour (Drljevic et al., 2022). Industry 4.0 technologies in combination with business modelling also promote sustainability in terms of economic, social and environmental aspects (Godina et al., 2020). Hence innovation is not only an enabler for change but also a strategic element which sees to improve a sustainable performance.

Sustainability challenges in Technology Driven Businesses

Despite of the known benefits, there are many challenges for achieving the sustainability goals for technology-driven businesses. These include:

- High costs for investment in technology and maintenance of technologies
- Skills deficit and resistance to new systems
- Underdeveloped ICT and digital infrastructure
- Cybersecurity, privacy, and ethical concerns
- Inconsistent regulatory environments

Developing nations like Nigeria face more challenges including poor digital maturity and lack of adequate incentives from their respective governments (Okoye et al., 2023; Obiki-Osafiele et al., 2024). These constraints can potentially postpone complete realization of digital sustainability benefits.

Measurement Indicators of Business Sustainability

Business sustainability is usually assessed in terms of multidimensional indicators that fit the triple bottom line perspective, including:

Sustainability Dimension	Key Indicators
Economic	Profitability, productivity, cost reduction, innovation returns
Environmental	Energy efficiency, waste minimization, carbon footprint reduction, sustainable sourcing
Social	Employee well-being, workforce training, customer satisfaction, stakeholder engagement

Additionally, sustainability performance scorecard and ESG indicators are used for comparison and evaluation of sustainable business performance (Ch'ng et al., 2021; Maluleke & Mutoko, 2024). The use of data analytics and ICT and the resulting visibility and accuracy of reporting helps to better implemented sustainability governance (Seidel et al., 2010).

2.2 Theoretical Framework

The theoretical foundation of this study is based on models of technology adoption behaviour and organizational capability development in terms of sustainable business performance. There are two major theories that are given application, the Technology Acceptance Model (TAM) and Resource Based View (RBV).

2.2.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), which was developed by Davis (1989) is one of the more influential models that is used to explain the behavioural intention of an individual to adopt and use technology. TAM allows that Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) are explanatory of the technology adoption which in turn, influences the actual use of the system. In the context of business sustainability, analysing role of TAM in organization sustainability refers to how organization accept digital technologies like cloud computing, artificial intelligence, blockchain etc which further give a contribution and importance of organizational efficiency and performance of organization sustainability among which Gharpure & Ghodke (2021). Studies in emerging economies also show that user confidence, digital skills and cultural readiness are other elements that strongly shape technology acceptance as well as technology outcome in terms of technology sustainably (Abdul-Majid et al., 2024; Okoye et al., 2023). Thus, TAM provides for the adoption aspect of technology in this research.

2.2.2 Resource Based View Theory (RBV)

The Resource-Based View Theory imply that firms acquire sustainable competitive advantage by the possession of valuable, rare, inimitable and non-substitutable (VRIN) resources (Barney, 1991). Software engineering practices such as DevOps culture, agility capabilities, testing maturity, quality of secure software design and documentation are considered strategic organizational resources.

In cases of their effective use by organizations, these capabilities increase performance of innovation, operational excellence and sustainability results (Mohammed and Sundararajan, 2023; Drljevic et al., 2022). RBV therefore recommits to the concept that digital skills and engineering maturity are important internal enablers of achievable and sustainable business development and resiliency.

2.2.3 Rationale for Theory Selection

Both TAM and RBV are integrated in this study in order to provide an adequate theoretical explanation about organizational transition towards sustainable performance:

Theory	Focus in the Study	Contribution
TAM	Technology Adoption (IV2)	Explains behavior and factors influencing digital transformation initiatives
RBV	Software Engineering Practices (IV1)	Justifies how engineering capabilities lead to sustainable competitive advantage

Combined Lens	Business Sustainability (DV)	Shows how internal capabilities + technology adoption support sustainability excellence

2.3 Linkages Between Theories, IV, and DV

In this section, the theoretical and conceptual interrelationships between the independent variables (Software Engineering Practices and Technology Adoption) and the dependent variable (Business Sustainability) are created. It brings together Resource-Based View (RBV) and Technology Acceptance Model (TAM) in order to explain the role of organizational capabilities and technology acceptance in both understanding performance in relation to sustainability in today's business climate.

2.3.1 How Software Engineering Practices Support Sustainable Competitive Advantage (RBV Perspective)

Resource-Based View (RBV) is a strategic management model that is used to understand the creation and sustainment of competitive advantage in firms based on the exploitation of firm's internal resources (Wernerfelt, 1984; Barney, 1991). Within this context, Software Engineering Practices (SEPs) (such as agile software development, DevOps, secure coding, and documentation) are considered as organisational resources and capabilities that are valuable, rare, inimitable and non-substitutable (VRIN). When successfully implemented, SEPs contribute to the overall quality of the system, the ability to innovate, and the resilience of operations, enabling businesses to react flexibly to changes in the market and the customers (Mohammed et al., 2024; Ch'ng et al., 2021). For instance, Agile and DevOps practices encourage continuous integration, iterative development, and cross-functional collaboration, leading directly to organizational agility and sustainability. Observational research has shown that organizations that are more mature in software engineering (SEM) are more efficient, effective and sustainable (and thus more competitive) if institutionalized into an organizational strategy for long-term digitalization (Drljevic et al. 2022; Okoye et al. 2023). From the RBV point of view, such practices evolve into dynamic capabilities, which contribute to the sustainable organizational performance due to the technological advancements and the appropriate knowledge usage.

2.3.2 How Technology Adoption Influences Sustainability through Technology Acceptance (TAM Perspective)

The Technology Acceptance Model (TAM) proposed by Davis (1989) sheds light on how perceived usefulness (PU) and perceived ease of use (PEOU) shape an individual's and an organization's intention to use new technologies. TAM describes that the integration of digital technologies, including artificial intelligence (AI), cloud computing and additive manufacturing, can improve operational performance and sustainability to improve the long-term viability of business enterprises (Gharpure & Ghodke, 2021; Maluleke and Mutoko, 2024). In cases where businesses see technology as useful and simple to incorporate into their operations, they are more likely to invest in innovation projects to help drive resource efficiency, environmental sustainability, and economic resilience. For instance, cloud-lets can enable scalable operations and cost reduction and AI and automated system controls can increase decision accuracy and energy efficiency (Voorneveld, 2024; Abdul-Majid et al., 2024). However, for the technology to be successfully utilised, organizational readiness, employee capability, and infrastructural support are factors that moderate the technology adoption success as highlighted in TAM and later on TUAUT theory.

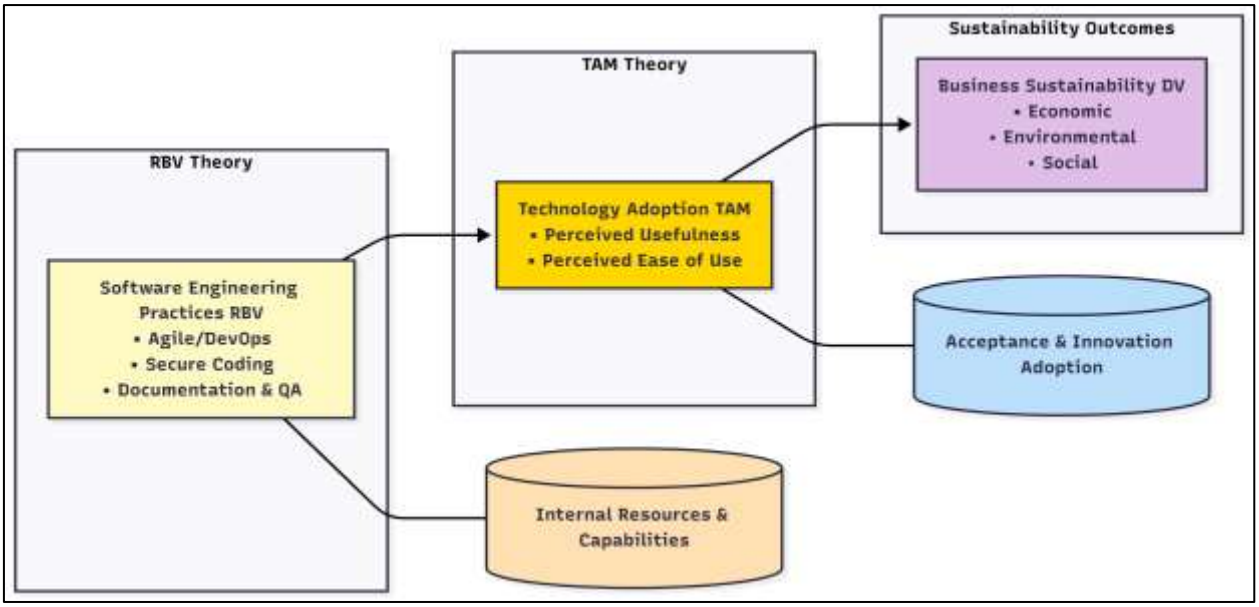

Figure 1: Theoretical Linkage Model

Source: Adapted from RBV (Barney, 1991) and TAM (Davis, 1989), including insights from Mohammed & Sundararajan (2023) and Godina et al. (2020).

Figure 1 explains the context of software engineering practice and the use of technology to facilitate business sustainability. Software engineering practices are valued internal capabilities such as Agile development, DevOps, secure coding, and quality assurance foundational to the Resource-Based View (RBV) which acts as a way of enhancing operational efficiency and innovation potential. When these capabilities are implemented in a technology-enabled environment, if the Technology Acceptance Model (TAM) is followed, technology adoption becomes the mechanism for realizing these internal strengths in its entirety. As technology is becoming accepted and incorporated into business processes, organizations are benefiting with improved productivity, reduced operational risks and greater environmental and social responsibility. Consequently, the role of technology adoption is recognized in the model as mediator that translates the value of engineering capabilities into sustainable results that in turn create opportunities for business entities to be competitive and resilient in face of fast-changing digital ecosystems.

2.4 Empirical Review

Empirical literature, however, indicates that software engineering practices have assumed an increased importance to organisational performance, productivity and value creation. Agile and DevOps integration and continuous quality assurance has been seen to improve the effectiveness of product delivery and flexibility in dynamic business environments (Bakar & Dorasamy, 2023; Sundararajan, Mohammed, & Senthil Kumar, 2023). Furthermore, research shows that user-centred design methodologies and formalised documentation is used to reduce operational risks and assist organisations in maintaining technology-driven operations over longer periods of time (Rahman & Jyoti, 2022). Likewise, application of strategic digital infrastructure like the ERPs, CRM, automated testing system, enhances the efficiency of internal process and accountability that provide a competitive advantage and business continuity (Obiki-Osafiele et al., 2024). Technology implementation is still an important component of the sustainability of businesses in every corner of the world. There is recent evidence supporting that cloud computing, artificial intelligence, and FinTech applications have helped in improving operational agility, reducing the cost structure and accelerating the digital transformation (Voorneveld 2024; Gharpure & Ghodke 2021). Empirical research has also shown that the impacts of technological adoption on market competitiveness, customer satisfaction and broader sustainability outcomes are strong, albeit their strength varies across sectors and for different economies (Endrodi-Kovacs et al., 2024; Maluleke & Mutoko, 2024). Equally, the availability of finance and the preparedness of digital capability have also been pointed out as

enabling elements for business growth in SME ecosystems (Kurniasari et al., 2025).

Experience from developing countries has shown that there are significant differences in the degree of preparedness and adoption of technologies. Nigerian and African businesses still struggle with various infrastructure limitations, high cost of digital tools, low digital literacy, and cultural resistance to change that diminish the business benefits of technology stories (Okoye et al., 2023; Abdul-Majid, Feri, Ise, & Adeniran, 2024). Although the information technology (IT) adoption in sectors like agriculture, finance and telecommunications has shown improvement in production and sustainability, the high cost and lack of policy support are some of the socio-economic factors that impede long-term results (Abdul-Majid et al., 2024; Bakar & Dorasamy, 2023). The empirical studies indicate that organisations need to increase their capabilities in innovation culture, skills development, and system integration to remain technologically driven growth-oriented organisations (Seidel et al., 2010; Ch'ng et al., 2021).

2.5 Research Gap

And although growing areas of scholarship have been generated, various gaps remain to be filled. Theoretically, the combination of software engineering practices and technology adoption as joint explanatory variables of sustainable business outcome is under-researched, as previous studies have dealt more with performance and productivity metrics rather than sustainability outcomes (Gharpure & Ghodke, 2021; Endrodi-Kovacs et al., 2024). Contextually, there has been little empirical focus on emerging markets, especially in Sub-Saharan Africa, where there are specificities in the challenges of adoption and infrastructures (Okoye et al., 2023). Theoretically, most studies use either RBV or technology adoption perspectives separately instead of combining them into one single framework that explains the mechanisms that allow the digital sustainability of internal engineering capabilities. Methodologically, quantitative cross-sectional studies are the predominant approach in the existing literature with a lack of triangulation, mixed-methods and validation across business sectors (Kurniasari et al., 2025; Maluleke & Mutoko, 2024).

This study therefore bridges a critical gap in the literature by postulating a well-worked out conceptual framework relationships of software engineering practices, technology adoption and business sustainability, from RBV and TAM with special reference to technology-based organizations in the developing world - Nigeria in this case.

2.6 Conceptual Framework of the Study

The proposed conceptual model in this research incorporates the inclusion of two mediating variables that are Software Engineering Practices (IV1) and Technology Adoption (IV2) as important predictors of the dependent variable Business Sustainability (DV). It has been constructed based on the Resource-Based View (RBV) on which technological strength within the institution and institutionalization of the software processes can become an origin of competitive advantage and on the Technology Acceptance Model (TAM) where the perceptions of easy usage and usefulness are the elements that define technology adoption. This is evidenced by empirical evidence of the experience of the IT companies. When an organization is successful in utilizing emerging digital technologies, as well as good software engineering practices, it is more likely to become economically viable in the long-term, operationally efficient, socially responsible in the environment and in creating social value.

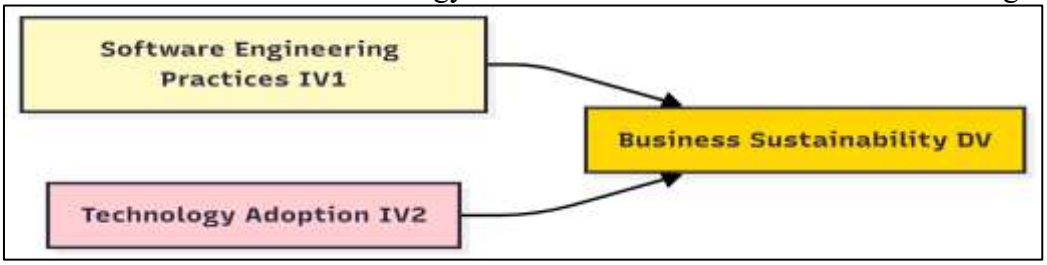

Figure 2.2: Conceptual Model of the Relationship between Software Engineering Practices, Technology Adoption, and Business Sustainability

Source: *Derived based on the Resource-Based View (RBV) (Barney, 1991) and the Technology Acceptance Model (TAM) (Davis, 1989).*

As explained in the conceptual model, Software Engineering Practices and Technology Adoption have an overall and cumulative effect on the Business Sustainability. Effective organization of engineering practices (quality assurance, DevOps, and secure software development) creates high-quality organizational capabilities that are in line with the tenets of the Resource-Based View (RBV). The abilities ensure the sustainability of these competitive advantages by firms through improved efficiency in operations, innovation and flexibility in a dynamic business world that is technologically oriented. Meanwhile, the assumptions of TAM predict that increasing technology adoption is benefiting innovation diffusion and increasing operational efficiency since the perceived usefulness and ease of use are associated with the technology adoption. Combined, these factors create a virtuous cycle: they drive organizations to excellent financial performance, mitigate operational risk, practice responsible environmental stewardship and provide more social value. Therefore, it is not just technology that is privileged when it comes to achieving sustainable performance, but an intelligent engineering capability incorporating digital resilience over the long-term is also necessary.

3.0 Research Methodology

The research in the study is conceptual research, which is research that uses hardly any empirical data collection but focuses on the critical synthesis, theoretical evaluation, and interpretive analysis. The approach has been developed on the basis of incorporating existing theories, literature, and emerging thoughts pertaining to Software Engineering Practices, Technology Adoption, and Business Sustainability. Through this practice, the study has established a theoretical perspective detailing how the technological practice may be applied towards sustainable organizational results. The literature selection was an identification of authoritative and up-to-date publications through peer-reviewed journals, conference proceedings, Scopus-indexed databases, Google Scholar or well-accepted schools of academic publishers. Terms like software engineering practices, technology uptake, sustainable business, RBV and TAM were used to guide the search process. The criterion of inclusion was the year of publication of articles between 2019-2025, and other base theories were pooled irrespective of the year of publication. It has been targeted at research literature and contributing conceptual insights and all the articles in any other economy of the world and also in the developing world like the African and Nigeria. A mental examination was also carried out and included an extensive literature review and codification procedure. The results have been displayed and tabulated by utilizing the constructs Software Engineering Practices (IV1), Technology Adoption (IV2) and Business Sustainability (DV). Hypothetical triangulation and logical deduction were used to draw cause explanations and demonstrate how these variables depend on one another. This method of analysis allows making sure that the conceptual framework that will be created on its basis is theoretically relevant, being context-specific and being able to direct further empirical studies.

4.0 Findings of the Study

Impacts of Software Engineering Practices on Business Sustainability

This study assumes that software engineering practices, including Agile strategies, DevOps, secure software development, and quality assurance, introduce crucial positive changes to the culture of sustainability to the organization. Such practices are helping in minimization of costs, availability of services as well as proper use of technology. More so, they strengthen social responsibility programs based on user-cantered design processes and enhancing employee productivity and attention.

Role of Technology Adoption in Sustainability Indices Improvement

Thanks to the application of modern technologies like cloud computing, automation, and blockchain, utilization and energy saving are improved and delivery speed is accelerated. This in turn results in more sustainable economic and environmental practices and ensures businesses to remain competitive within ever-changing markets.

Technology Adoption as a Mediator of Sustainability and Performance

The study has provided substantial mediating function where the use of technology in practice is an intermediate channel through which top engineering practice is translated into better product innovation and managerial decision

making and contributes towards organizational performance over the long run. Efficiency: Firms that have good engineering organizations can enjoy more digital solutions to ensure better results towards sustainability.

Context Issues in Emerging Economies (Focus on Nigeria)

The challenges that confront the Nigerian businesses are many and limited to inadequate ICT infrastructure, lack of know-how, lack of awareness of sustainability practices, cost of digital investment, etc. These flaws and challenges slow down the pace of sustainable technology transfer and thus engineering best practices implementation in practice.

Building of a Conceptual Sustainability Model

The findings support a conceptual model that integrates SEPs and technology acceptance as the predictors of business sustainability by means of the theories of RBV and TAM. As a result, the model introduces a pathway that links process capability and the digital readiness and that each is critical to sustained growth.

5.0 Recommendations of the Study

Strengthen Software Engineering Capabilities

In order to increase the reliability and reduce operational waste, organizations must institutionalize Agile, DevOps, secure coding, and continuous improvement practices that can be used to enhance sustainability performance.

Promote the Strategic Implementation of Technology

Managers are called upon to adopt cloud-based technologies, intelligent automation and artificial intelligence-based applications for a higher productivity and environmental efficiency to create and preserve value over the long term.

Implant Engineering Practices in Technology Strategy

Organizations must have alignment tools that coordinate software engineering processes to technology adoption goals, and are able to closely coordinate improvement in innovation and sustainability results.

Overcome Local Constraints Through Policy and Capacity Building

There are therefore calls for action: Nigerian Central Bank (NCDA) needs to strengthen digital infrastructure, increase awareness on sustainable technologies, government and regulatory bodies must invest in software engineering education to bridge the gap between the knowledge and resourcing.

Empirical Validation of the Conceptual Model in the Future

Quantitative and sector-specific research is recommended to verify the model relationships across SEPs, technology adoption and sustainability and increase the generalizability to cross-developing economies.

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