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Analyzing the Contribution of Robotics Adoption to Entrepreneurial Firm Growth and Competitiveness

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ABSTRACT: The fast pace of digitalization of business processes has created a growing demand to have a robust cybersecurity strategy in place, and entrepreneurial projects are increasingly exposed to cyber-attacks, breaches of information, and technical malfunctions. The present research is a study of the impact of cybersecurity innovation on the development of entrepreneurship and focuses on the relationship between improved resiliency, integrity, and competitiveness of business through innovative security implementation. The main task will be the correlation analysis of the adoption of cybersecurity and the performance of entrepreneurship, and addressing research questions on the strategic, technological, and organizational aspects of the effective implementation. The study will employ a conceptual research paradigm that relies on the secondary data that will be retrieved from academic journals, books, industry publications, historical literature, and credible news. The analysis of the literature thematically found that novel approaches of cybersecurity, such as the advanced method of encryption, threat detection machines, and secure cloud systems, contribute to restructuring risk, attract investors, and long-term growth of startups and SMEs to a large extent. In addition, it is found that firms with high levels of digital literacy and firms that are active in securing their information are found to have better entrepreneurial performance and in terms of market competitiveness. The study implies that the business model of entrepreneurs should include cybersecurity solutions, and policymakers should facilitate entrepreneurs in their adoption of cybersecurity solutions with the support of regulations and financial aid. Finally, cybersecurity innovation is being used as a strategic facilitator to create entrepreneurship that will establish technological and economic sustainability in an increasingly digital business landscape.

KEYWORDS: Cybersecurity Innovation, Entrepreneurship Development, Digital Security, SMEs, Business Sustainability.

INTRODUCTION

1.1 Background of the Study

The industrial world everywhere is undergoing dramatic change as a consequence of accelerated developments in robotics and automated technologies. Robotics adoption has emerged as an important strategic tool in order to improve productivity, operational efficiency, and competitive positioning in today's enterprise (Graetz & Michaels, 2018). There is empirical evidence showing an important role played by industrial robots in value creation owing to the increment in the labour productivity, reduction of

the cost of production, and improvement in the quality of products (Acemoglu & Restrepo, 2020). These technologies are increasingly seeping into not only large scale manufacturers but also entrepreneurial firms allowing them to be able to scale operations, to innovate and expanse into new markets (Ballestar et al., 2020). As the organizations have moved into Industry 4.0, the role of robotics in preserving the competitive edge only gets more aggressive. In the developed economies, the processes of robotization have influenced the labor markets and remodeled the occupational structure, especially in routine-intensive industries (Bachmann et al., 2024). While some of the studies show displacement of production workers, there is parallel creation of higher skilled roles which reinforces innovation driven growth and performance (Dauth et al., 2017). However, research also warns that firms adopting robotic technology should make sure to invest in complementary aspects of knowledge, R&D, and organizational abilities for these technologies to produce lasting innovation results (Antonioli et al., 2024; Schneider, 2025). The transition to robot-enabled business models, therefore, demands entrepreneurial agility, strategic integration of automation and high absorptive capacity. In developing areas like Africa, the adoption of robotics is still not even, due to constraints in infrastructure, technology and capital. Many economies are still in the process of moving from Industry 2.0 to 4.0 readiness, and the digital transformation process is being frustrated by scarce resources and poor assimilation of advanced technologies (Turkes et al., 2019).

West African countries, including Nigeria, face similar problems, as SMEs are the backbone of industrial activity, but are weak in their capacity to automate, have managerial skills, and cannot invest (Mohammed, Sundararajan & Lawal, 2022). However, there is a growing awareness of the benefits of digital transformation in the entrepreneurial ecosystem of Nigeria, with the potential of automation and technological innovation to drive business growth and market competitiveness (Mohammed 2023). Investments in training, strategic management and ICT adoption have been highlighted to boost productivity and sustainability of entrepreneurial firms in Nigeria (Mohammed et al., 2024). Given these global and regional dynamics, the adoption of robotics is increasingly being known as a catalyst for entrepreneurial competitiveness, as it enables firms to better their operations performance, achieve innovation at a faster rate and keep up with changing market demands. Yet, despite the strategic importance of robots, there is lack of theoretical understanding and empirical diversity with respect to the role of robotics among entrepreneurial companies especially in developing economies such as Nigeria. This raises an interesting need for conceptual enquiry about the impact of integration of robotics on the growth paths and competitive positioning of firms from the resource constrained environment.

1.2 Problem Statement

Although the adoption of robotics has become a cornerstone of industrial transformation in the entire world, the existing gap of understanding concrete contributions to the growth and competitiveness of entrepreneurial firms and even more so in the developing economies. Globally, the evidence would appear to show that industrial and service robots improve productivity, quality and operational precision, and so strengthen firm level performance (Graetz & Michaels, 2018; Dixon, Hong, & Wu, 2021). However, these benefits are not always equally achieved in all contexts. In advanced economies robotics growth is supported by the good innovation ecosystem, finance on hand and a well-supplied human labor. (Dauth et al., 2017; Schneider, 2025) Whereas companies in the developing regions of developing nations have often operated under the constraints of structures, lack of resources, and shortage of technological abilities (Turkes et al., 2019; Ulas, 2019). Empirical research has revealed mixed evidence on the more general taking of robotic effects on the economy and structure. For instance Acemoglu and Restrepo notes (2020) that while the robots are able to make the work within specific sectors more productive, they can also lead to employment suppression, which results in trade-offs on the firm competitiveness. Similarly, Antonioli et al. (2024) concluded that the adoption of robots can lead to diversion of resources from R&D and/or possible poor innovation potential for the product, if not strategically managed. This brings to light the paradox that automation, despite being transformative, can be both the impetus for

entrepreneurial performance and also one of its prohibitive factors based on the contextual expensive setup, absorptive ability, and strategic intent (Ballestar et al., 2020).

In the African context especially in West Africa, adopting robotics is at an embryonic state with little scholarly and policy attention. SMEs and startups -- which form the backbone of regional economies -- still depend on labour-intensive production systems with minimum use of automation (Mohammed et al., 2022). Despite the increasing consciousness about digital technology turn around, the technical necessities to incorporate robotics into the business process are not available among many entrepreneurs firms in Nigeria, which lack appropriate infrastructure, investment capital bases and technical expertise to adopt robotics in their business models (Mohammed, 2023). Consequently, while the developed countries are exploiting the benefits of robotics to gain a competitive edge, the developing economies are in danger of widening the technological and productivity gap. Moreover, most of the existing literature on robotics is focused on industrialized countries and large corporations, which leaves a gap in concepts and empirical knowledge on how small entrepreneurial firms, especially within resource-constrained environments, can leverage on robotics for sustainable growth and competitiveness. Current research is also inclined to focus on productivity and labor implications with little exploration of strategic, organizational and innovation-oriented dimensions of robotics adoption (Dixon et al., 2021; Zong & Guan, 2025). Thus, there is a pressing need for conceptual analysis of the mechanisms through which the adoption of robotics contributes to the growth of entrepreneurial firms especially within the context of developing economies where entrepreneurship functions as one of the key drivers of economic resilience and industrial advancement.

In conclusion, the major problem that has been addressed in this research work is the generalization of theoretical and contextual knowledge on the influence of Nigeria's entrepreneurship robotics adoption on entrepreneurial enhancer and competitor in the developing economies. Bridging this gap is of critical importance for communicating with policy makers, investment strategy and to give entrepreneurs frameworks to apply robotics as a sustainable competitive asset.

1.3 Significance of the Study

Robotic automation (robots) is a transformational force of productivity, innovation, industrial competitiveness in the global economy (Graetz & Michaels, 2018; Acemoglu & Restrepo, 2020). However, the ability of entrepreneurial firms, and particularly in developing countries, to use the power of robotics to develop sustainably has yet to be investigated. Importantly, this study provides for a systematic conceptual contribution on the understanding of the strategic value of robotics adoption in entrepreneurial settings. First, the theoretical implications of the study are discussed by bringing together knowledge from the literature on organizational transformation and technological adoption to conceptually shape the relations that robotics enables to increase firm-level capabilities. Previous research has called for the attention to analyze complementary factors such as knowledge, innovation, and managerial strategy, which interact to determine the productivity response to automation (Ballestar et al., 2020; Dixon, Hong & Wu, 2021). By transforming these discussions into entrepreneurial organizations in the emerging markets, this study advances theoretical understanding on the topic of robotics as a sustainable competitive advantage.

Second, this study has contextual relevance because it takes as its focal point resource constrained environments like that of Nigeria, where SMEs and start-ups are major employment generation and economic growth initiatives (Mohammed, Sundararajan & Lawal, 2022). The low adoption of sophisticated automation in such economies alienates the countries from the competition of developed nations with developing economies (Turkes et al., 2019). This paper therefore provides evidence that may help policymakers, investors and technology stakeholders in framing actions for the promotion of robotics diffusion. Third, the study has practical and managerial merit as it provides evidence informed insights for entrepreneurs wishing to increase driving performance, operational scalability and market growth by automation. Studies have demonstrated how robots, through

strategic deployment, can improve both efficiency and quality of service delivered, and also reduce human error and allow for faster innovation and advancements (Dixon et al., 2021; Zong & Guan, 2025). Addressing these benefits and risks will result in more effective decision making when technology is integrated.

Finally, the paper also suggests the research agenda for the future outlining the emerging gaps on the ground of employment relations, innovation process, and sustainability aspects of transformation through robotics (Schneider, 2025; Antonioli et al., 2024). The results obtained will guide further empirical studies and will advance transdisciplinary collaboration, in particular when it comes to industrial development of African societies.

1.4 Research Objectives

This is a conceptual study based on the following research objectives:

1. To analyse the impact of robotics adoption on improving entrepreneurial firm growth and operation level
2. To analyse the effect of implementation of robotics on the competitiveness of entrepreneurial firms in the emerging economies.
3. The aim is to identify the strategic, presentational and contextual factors that influence effective implementation of robotics in entrepreneurial projects.
4. To postulate a coherent conceptual framework of the link between robotics adoption and sustainable entrepreneurial competitiveness and growth outcomes.
5. To point out important research gaps and research directions on adoption of robotics in entrepreneurial ecosystem, especially in Nigeria.

1.5 Research Questions

Based on the above objectives the study intends to answer the following research questions:

1. How does robotics adoption affect entrepreneurial firms' performance growth?
2. In what ways does the product implementation of robotics improve the competitive advantage of entrepreneurial firms in resource-scarce environments?
3. What are the strategic and contextual conditions of successful assimilation of robotics in entrepreneurial firms?
4. How can be conceptually modelled the relationship among robotics adoption, firm growth and competitiveness?
5. What are the gaps in existing literature on the adoption of robots in the entrepreneurial ecosystem especially in developing countries such as Nigeria?

2.0 Literature Review

When new technology innovation and entrepreneurship meet in the contemporary economy, it has become a factor that brings about competitiveness and sustainability to the contemporary digital economy. Of these new changes, the adoption of robotics and the integration of technologies has become the key enablers of improving the efficiency and productivity of operations and the success of entrepreneurship (Mohammed et al., 2024; Kumar et al., 2024). The current trend of increasing the use of robotics in various industries is not just a manifestation of technological change but the strategic development of capitalizing on the methods of generating, presenting, and actualizing value in a rapidly evolving global market by entrepreneurs.

2.1 Conceptual Review

2.1.1 Robotics Adoption / Technology Integration

Definition and Evolution of Robotics in Industry

Robotics adoption is defined as the organized introduction and application of robotic technologies (from industrial to service robots) that may automate the tasks, increase the production, and optimize the organizations. Modern industrial robots are versatile, flexible, and increasingly autonomous, using advanced sensors, AI and machine learning to execute tasks that were traditionally performed by humans (Graetz and Michaels, 2018; Dauth et al., 2017; Dixon, Hong, & Wu, 2021). In the entrepreneurial organization, robotics adoption is not only an enabler for process automation but also a strategic ability at the service of innovation, operational efficiency and market competitiveness (Ballestar et al., 2020; Antonioli et al., 2024). Historically, robots became specialized manufacturing devices

used in repetitive manufacturing but have developed into general-purpose systems that can carry out decision-making processes, self-adjustment, and are faculty for human workers (Acemoglu & Restrepo, 2020; Schneider, 2025). With this is happening in line with the larger trend of Industry 4.0, where the use of robotics in production, service delivery and operational management has become a key component to firm competitiveness and growth (Zong & Guan, 2025; Turkes et al., 2019).

Types of Robots

Robots can be divided into three categories of great interest to entrepreneurial firms:

1. **Industrial Robots:** Mostly used in the manufacturing sector in assembly, welding, painting and material handling. They help to improve production efficiency, lower costs, and improve quality (Graetz and Michaels, 2018; Ballestar, et al., 2020).
2. **Collaborative Robots (Cobots):** Cobots are manufactured to safely work in coordination with human workers, to assist in complex production processes, augment human abilities, and lessen the significance of repetitive tasks (Dixon, Hong & Wu, 2021).
3. **Service Robots:** Such robots are utilized in such industries as tourism, hospitality, and retail, and serve in terms of deliveries, concierge, and self-service automation (Ivanov, Webster, and Berezina, 2019). Service robots can help in increased customer satisfaction, reduced costs of operation and innovative lines of services.

Determinants of Robotics Adoption

Application of robotics in entrepreneurial companies is subject to a number of factors:

1. **Cost:** High capital investment has been one of the main limitations to SMEs and startups, especially in the emerging economies (Turkes et al., 2019; Dallocchio et al., 2024).
2. **Skills and Human Capital:** The implementation of robotics requires highly literate and digitally literate employees possessing management skills to be able to use the robots (Bachmann et al., 2024; Dixon, Hong, and Wu, 2021).
3. **Infrastructure and Technological Readiness:** Those companies that have an established ICT infrastructure, Industry 4.0 preparedness, and access to complementary technologies including AI, IoT and cloud platforms are better placed to implement robotics (Zong and Guan, 2025; Nagy et al., 2018).
4. **Cultural Compatibility:** Organizations that are designed based on forward-thinking approaches and whose culture is oriented on innovation, efficiency and competitive advantage are more likely to succeed in its implementation of robotics (Raymond, Bergeron, and Blili, 2005; Antonioli et al., 2024).
5. **External Support:** Policies (incentives) by the government, the industry partnership, and access to technical assistance will ensure that deploying robotics in emerging regions (such as Nigeria and West Africa in general) is not very challenging (Chen et al., 2021; Holl and Rama, 2024).

Digital Transformation and Automation

The application of robotics is fundamentally linked to the digital transformation wherein automated systems are applied by organizations in broader organizational processes. Automation with robotics helps entrepreneurial enterprises to improve production activities, to eliminate operational errors and to optimize resources (Zong & Guan, 2025; Nagy et al., 2018). The fusion of robotics and AI, along with IoT and data analytics support the development of real-time monitoring, predictive maintenance, and elastic decisionmaking processes to create both more operationally efficient and business-resilient processes (Dixon, Hong, & Wu, 2021; Varzaru & Bocean, 2024). This transformation is extremely important for startups and SMEs as they can compete against larger companies with such technological efficiency as opposed to relying on scale alone (Raymond, Bergeron, & Blili, 2005; Ulas, 2019).

Barriers and Enablers in Entrepreneurial Settings

Despite the possible gains, robotics adoption creates challenges in entrepreneurial firms:

- **Barriers:** High cost of investments and low availability of technical skills, as well as lack of ICT infrastructure and resistance to organizational change limit the adoption (Turkes et al., 2019; Chen et al., 2021;

Dallocchio et al., 2024). Along with SME's and startup, in Africa and West Africa, Nigeria often faces the problem of resources limitation that hinders the integration of robotics into business processes at a full capacity (Holl & Rama, 2024; Raymond, Bergeron, & Blili, 2005).

- **Enablers:** Public free market and funding schemes, strategic alignment to business strategy, workforce reskilling, and using complementary technologies, such as AI and cloud computing, may promote effective robotics integration (Bachmann et al. 2024; Zong & Guan 2025; Hokmabadi, Rezvani, & de Matos 2024). Collaborative ecosystems, knowledge-sharing networks, and partnerships with research institutions are also considered key enablers for entrepreneurial firms in the process of robotics adoption (Turkes et al., 2019; Dixon, Hong, & Wu, 2021).

Relationship Between Robotics Adoption and Productivity

In line with the theoretical prediction, there is rather nuanced empirical evidence on the link between robotics penetration and productivity. Industrial and collaborative robots have a positive effect on labor productivity, lower operational costs, and raise quality of production (Graetz and Michaels, 2018; Schneider, 2025). However, employment impacts and organizational structure impacts are heterogeneous. While, for example, robots may decrease the need for routine manual jobs, they may also increase employment in skilled and technical jobs, partly transforming the composition of the workforce and partly the nature of jobs (Acemoglu & Restrepo, 2020; Ballestar et al., 2020; Dauth et al., 2017). Furthermore, the diffusion of robots has implications for the firm's capacity for innovation. On the other hand, some papers find that investments in robotics crowd out R&D and product innovation, especially in larger or established firms not having complementary investments (Antonioli et al., 2024). On the other hand, for high absorptive capacity and knowledge endowed startups and SMEs, they achieve increased productivity, process efficiency and competitive advantages (Raymond, Bergeron, & Blili, 2005; Dixon, Hong, & Wu, 2021; Zong & Guan, 2025).

2.1.2 Innovation Capability / Digital Transformation Readiness

Concept of Innovation Capability

Innovation capacity is defined as the ability of the firm to create, implement and commercialize new products, services, processes or business models, which create competitive competitive advantage (Varzaru & Bocean, 2024; Loureiro & Nascimento, 2021). Need and Research Objectives: The development and application of an innovative capacity is a vital element for the long-term competitiveness, growth and market adaptation of entrepreneurial businesses (Mohammed, 2023; Hokmabadi, Rezvani & de Matos, 2024). Empirical research has found that firms with stronger innovation capabilities are more likely to be able to leverage the effective use of robotics and automation technologies, which can translate into higher productivity and higher quality of services and operational efficiency (Dixon, Hong, & Wu, 2021; Zong & Guan, 2025).

Digital Maturity and Absorption Capacity

Enterprise Digital transformation readiness was found to be influenced by the digital maturity and absorptive capacity of entrepreneurial business firms. Digital maturity is an indication of firms' extent of adoption of digital technologies and use in main business processes; absorptive capacity is the capability of the firm to be able to identify, draw, and utilize new technological information (Ballestar et al., 2020; Ulas, 2019). Companies with a higher level of digital maturity and absorptive capacity are more capable of integrating the technologies of robotics, artificial intelligence and Internet of Things into businesses for a more agile response to market dynamics and foster sustainability through innovation-driven growth (Raymond, Bergeron, & Blili, 2005; Dixon, Hong & Wu, 2021). On the other hand, the digital readiness of firms that have a low level of digitally readiness implies that they are not able to realize productivity improvement and/or competitive differentiation from the adoption of robots (Turkes et al., 2019; Holl & Rama, 2024).

Technological Complementarity (AI, the Internet of Things, Big Data)

Technological complementarity is defined as the combined use of digital technologies to improve the performance of the firm. Robotization is best adopted in conjunction with other complementary

technologies like artificial intelligence, the Internet of Things, and big data analytics (Zong & Guan, 2025; Nagy et al., 2018). Among others, big data provides market intelligence and situational decision-making, AI-driven analytics allow predictive maintenance and process optimization, IoT devices provide real-time insights into operations, and connectivity supported by Blockchain allows company-wide data management (Varzaru & Bocean, 2024; Zong & Guan, 2025). The empirical data suggests that a positive effect in terms of the output of innovations, the enhanced efficiency of operations and the competitive advantage is observed in the entrepreneurial firms that strategically combine robotics with other complementary technologies, particularly within the framework of highly-shifting markets (Schneider, 2025; Ivanov, Webster, and Berezyna, 2019).

2.1.2 Entrepreneurial Firm Growth and Competitiveness

Definition and Indicators of Firm Growth

Firm growth is a multidimensional construct with different aspects including firm resource, market, operational capacity, and organizational performance enlargement over time (Graetz & Michaels, 2018; Dauth, Findeisen, Sudekum, & Woessner, 2019). Quantifiable indicators, such as increased revenue, expansion in market share, growth in workforce, and an increase in productivity, are often used to measure growth. In tech-based companies, especially those using robotics, growth does not only relate to financial indicators, but extends to process efficiency, innovation intensity, and the ability to scale business processes (Bachmann et al., 2024, Schneider, 2025). Empirical evidence is mixed on the impacts of robotics adoption on employment - while labour productivity and operational costs can be reduced when introduced. For instance, robots tend to substitute routine manual occupations at the same time that they generate higher skilled jobs leading to a reallocation rather than a loss of employment over the long term (Acemoglu & Restrepo, 2020; Ballestar, Diaz-Chao, Sainz, & Torrent-Sellens, 2020). Moreover, the use of robotics is correlated with the assessment of process standardization, quality control, and the possibility of reacting to the market, which are all indirect proxies for growth.

Competitive Advantage in Entrepreneurial Ecosystems

Competitive advantage in entrepreneurial ecosystems are realized through the use of distinctive resources, technological capabilities and strategic positioning to secure a competitive edge over rivals in terms of market performance, customer satisfaction and effectiveness (Varzaru & Bocean, 2024; Zong & Guan, 2025). Robotics adoption can be a crucial enabler of competitive advantage because it enables firms to:

- **Reduce Operational Costs:** Automation of repetitive tasks helps reduce human error and labor costs (Ivanov, Webster, & Berezina, 2019).
- **Improve Product and Service Quality:** Robots can help to ensure precision, consistency, and reliability in the production process and service delivery (Dixon, Hong, & Wu, 2021).
- **Speed up Time-to-Market:** The automation is used to construct faster production cycles and delivery of goods or services and enhance the responsiveness in the market (Antonioli et al., 2024).
- **Position Differentiation:** By installing robotics and complementary technology (artificial intelligence, internet of things and data analytics), the firms may establish strategic differentiation in products offered imposing exogenous constraints on the competition, and finding niche positions within the entrepreneurship ecosystem (Hokmabadi, Rezvani and de Matos, 2024).

This competitive leverage is especially important for start-ups and SMEs that actually work in an industry mainly characterized by a fast-changing or technology-intensive environment, where early implementation of robots in the short-term may mean the difference between survival and failure as well as between market relevance and irrelevance (Raymond, Bergeron, & Blili, 2005).

Sustainability Dimensions (Economic, Technological, Strategic)

The Sustainability of Entrepreneurial Firms refers to the long-term economic viability (economic sustainability), technological sustainability (resilience), and forward-looking ability (strategic foresight) of an entrepreneurial firm, as it relates

to its growth and competitiveness (Graetz & Michaels, 2018; Schneider, 2025).

- **Economic Sustainability:** The adoption of Robotics can be considered economically sustainable since it causes jobs and increases in labor productivity to be optimized, more efficient use of resources, and increase in profitability. According to the literature, the introduction of robotics will be capable of increasing the value-added production and optimizing the efficient distribution of the factors of production (Schneider, 2025; Zong and Guan, 2025).
- **Technology Sustainability:** The investment in tech robots in companies should be accompanied by the presence of other digital technicalities, such as IOT, AI and data analytics. This technological mutualism enhances the absorptive power of the respective companies that are friendly to everlasting innovation, adaptive dissolving and long-term reaction to the competitive nature of the respective markets (Dallocchio et al., 2024; Nagy et al., 2018).
- **Smart Sustainability:** Robot application would allow strategic agility whereby companies can respond appropriately to market disruption and surface opportunities when it arises. Since an expressed strategy towards robotics companies will be able to install flexible manufacturing frameworks, proper choice generation and could possibly be able to have a flash forward observation of the market dynamics (Ivanov; Webster; Berezina, 2019; Dixon; Hong, Wu, 2021).

Role of Innovation and Technology Leadership

Innovation and technology leadership plays a key role in the commercialization of robotics adoption into tangible growth and competitive advantage. The combination of robotics with other digital technologies shows that firms are more absorbent, create greater innovation and perform better (Varzaru & Bocean, 2024; Dixon, Hong, & Wu, 2021). Technology leaders are leaders in creating new business models, optimizing workflows and setting themselves apart in the market with better product quality, improved customer experiences and operational efficiencies (Antonioli et al., 2024; Ivanov, Webster, & Berezina, 2019). Moreover, as research shows, the benefits of the adoption of robotics are not automatic but rely on complementary investments in employee skills, R&D, and organisational routines. Firms that do not incorporate these complementary factors into their business may experience a boost in productivity, but not in innovation or long-term competitiveness (Ballestar et al., 2020; Schneider, 2025).

2.2 Theoretical Framework

Technology Acceptance Model (TAM)

The original Technology Acceptance Model (TAM) was developed by Davis (1989) and the TAM is a powerful model for understanding organizational and individual behavior toward the acceptance of new technologies, including robotics. TAM assume that two related factors perceive usefulness (PU) and ease of use (PEOU) are the primary factors determining technology adoption. In the case of entrepreneurial firms, the adoption of robotics is impacted by the degree to which managers and employees believe that automation tools provide benefits in terms of operational efficiency, productivity and positioning in the competitive markets (Dixon, Hong, & Wu, 2021; Ivanov, Webster, & Berefina, 2019). According to empirical studies, entrepreneurial firms are inclined to adopt such technologies into their operation workflows, in line with their expectations about the effects of robotics on the outcome (e.g., enhancing quality control units, decreasing the time required to produce, or ensuring ease of innovation) (Bachmann et al., 2024; Schneider, 2025). On the other hand, there may be negative effects of barriers such as lack of technical expertise, high initial costs, and poor infrastructure that may have a negative impact on the adoption intention, particularly in developing economies (Turkes et al., 2019; Ulas, 2019). TAM also enables exploration of behavioural intention at the organizational level, which emphasizes the influence of managerial attitudes, organizational readiness and cultural acceptance in the deployment and scalability of robotics solutions (Zong & Guan, 2025; Hokmabadi, Rezvani, & de Matos, 2024). By using TAM, this study is in a position to identify both drivers and inhibitors of robots adoption in entrepreneurial firms hence linking technology integration with the measurable growth results.

Resource-Based View (RBV)

The Resource-Based View (RBV) is a complement of TAM that offers a strategic perspective to determine the contribution of robotics adoption to sustained competitive advantage. According to RBV, it is a company that possesses the resource that is valuable, rare, inimitable, and non-substitutable (VRIN) that attains long-term competiveness (Barney, 1991). Robotics capabilities, taken together with complementary digital technological, e.g. AI, IoT, and data analytics, are strategic assets that improve innovation, operational efficiency, and organisation learning (Varzaru and Bocean 2024; Ballestar et al 2020). In entrepreneurial firms, the adoption of robotics is not simply automation but it changes the composition of knowledge, skills, and technological capability of the firm. Research shows that companies that have a higher absorptive capacity and complementarity between technology and other available technologies are more likely to turn the robotics investments into innovation-driven growth and competitive differentiation (e.g., Antonioli et al., 2024; Dallocchio, E.; et al., 2024). Moreover, RBV highlights how such capabilities are hard for competitors to replicate especially when combined with organizational routines, human capital development and process innovation (Graetz & Michaels, 2018; Dixon, Hong, & Wu, 2021).

Integration of TAM and RBV

The integration of TAM and RBV creates a solid conceptual base to understand the adoption of robotics in entrepreneurial firms. TAM addresses the behavioural and organizational intention to adopt robotics whereas RBV focuses more on the strategic and competitive outcome of robotics adoption. Together, these theories explain to a great extent not only why firms have adopted robotics, but also how this adoption has translated into measurable growth and competitiveness in entrepreneurial ecosystems in the global, African and Nigerian contexts (Raymond, Bergeron, & Blili, 2005; Turkes et al., 2019; Varzaru & Bocean, 2024).

2.3 Linkages between Theories, IV & DV

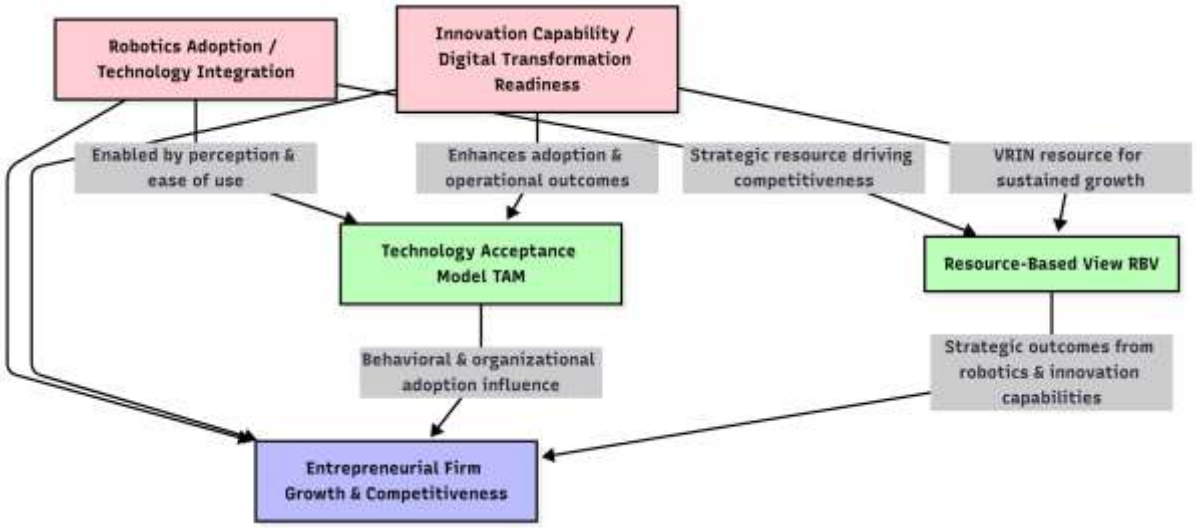

Figure 1. Conceptual Model of Robotics Adoption, Innovation Capability, and Entrepreneurial Firm Growth

Source: Developed by the authors based on Dixon, Hong, & Wu (2021); Ivanov, Webster, & Berezina (2019); Bachmann et al. (2024); Schneider (2025); Graetz & Michaels (2018); Antonioli et al. (2024); Ballestar et al. (2020); Văzaru & Bocean (2024).

Figure 1 shows the conceptual relations among adoption of robots, innovation ability and entrepreneurial firm's growth and competitiveness. The latter factors Robotics adoption (IV1) and innovation capability/Digital transformation readiness (IV2) play a mediating role, through the Technology Acceptance Model (TAM) and the Resource-based view (RBV), directly and indirectly on growth. TAM focuses on robotics behavioral and organizational intention by focusing on perceived usefulness and integration ease, while RBV focuses on strategic value of robotics and innovation capability as VRIN resources that create sustainable competitive advantage. The graph shows that firms with high innovation capability are more able to effectively use robotics, which leads to better operational

efficiency, cost efficiency and innovation-enability, which in turn leads to higher entrepreneurial firm growth and competitiveness (global, Africa, West Africa and Nigerians).

2.4 Empirical Review

The empirical literature results in strong evidence on the role of robotics adoption and innovation capabilities on firm performance, growth and competitiveness in varying regions and contexts. Globally, studies show that use of robotics leads to a massive improvement in overall productivity, efficiency and competitiveness in the market with respect to manufacturing and service sectors. For instance, Graetz and Michaels (2018) found that industrial robots raised labor productivity and value added and decreased prices, albeit with heterogeneous impacts on employment. Similarly, according to Acemoglu and Restrepo (2020), robots replaced manual routine tasks and led to decreased employment in some occupations but new job opportunities in other occupations. Dixon, Hong, and Wu (2021), showed that the adoption of robotics results in improved quality of products and services, better managerial structures, and reformulated organizational hierarchies, especially for the firms that are characterized by high absorptive capacity. However, Bachmann et al. (2024) demonstrated that in the European framework, the influence of robot exposure on job stability, measured in terms of separation concentration, comes positive for the lower labor costs countries and the same influences differently by the occupation intensity for standard routine tasks. Schneider (2025), in a review of more than 1800 estimates, confirmed a positive mean impact of robots on productivity but finds a great heterogeneity determined by firm size, country, sector and presence of complementary investments like skills and R&D.

Within Africa and West Africa, there are unique issues of adoption of advanced technology by SMEs; these challenges range from lack of resources to inadequate digital literacy and infrastructural challenges. Turkes et al. (2019) discovered that Romanian SMEs in transition economies revealed a high level of awareness of Industry 4.0 technologies and a low capacity of adoption given the limitation of the resources to sustain it--a scenario that is often repeated in the Nigerian SMEs (Mohammed, 2024). Nigerian firms in particular, struggle with financial, infrastructural and managerial challenges as well, even though high innovation capability and strategic adoption of digital technologies, including robotics, can improve growth, market reach and competitiveness (Aliyu, 2024; Mohammed & Sundararajan, 2023). Also, research papers find a positive relationship between robotics adoption and digital transformation maturity and innovation readiness. Ballestar et al. (2020) showed that the better a SME understands their environment and absorbs knowledge, the better the benefits are from their robot adoption, leading to better in terms of their productivity, quality of jobs, and innovation. On the other side, Antonioli et al. (2024) found that an adoption of robots without complementary R&D investments can have a negative impact on product innovation, especially in established, non-high-tech firms. Varzaru and Bocean in their study in 2024 highlighted that the convergence of robotics with Artificial intelligence, Internet of Things, and big data improves not only the operational efficiency but also means of dynamic competitiveness, believing the synergy between the technology adoption and innovation capability.

In sum, empirical evidence highlights the fact that robotics adoption and innovation capability are a crucial factor for entrepreneurial firm growth and competitiveness. The results are context-specific with some upper rewards to technologically mature and innovative-ready firms however problems remain in resource constrained environments which characterize developing economies like Nigeria and West Africa in general.

2.5 Research Gap

Despite the very numerous studies carried out on the adoption of robotics, digital transformation, and entrepreneurial performance some critical gaps exist, justifying the choice of the present study. Conceptually, although there has been lots of research on robotics adoption vis-a-vis productivity and operational efficiency (Graetz & Michaels, 2018; Acemoglu & Restrepo, 2020), there is not much research to have added value of robotics adoption integrated with innovation capability and digital transformation readiness to assess the growth and competitiveness of an entrepreneurial firm in a holistic way. Most of the

studies address robotics as a technological intervention to separate its influences on interaction with prices and dimensions, without addressing its interaction with the innovation capacity of the organizations, its absorptive capacity and technological complementarity (Ballestar et al., 2020; Varzaru & Bocean, 2024). Theoretically speaking, current research frequently focuses on a single point of view, e.g. Resource Based View (RBV) or Technology Acceptance Model (TAM) (Dixon, Hong, & Wu, 2021; Bachmann et al., 2024), resulting in a gap in understanding the combination of behavioural intentions to make use of robotics with strategic resource implementation to achieve continuous competitive advantage. An integrated theoretical approach including RBV and TAM is required that explains both the mechanisms of adoption and the strategic results of adoption of robotics in entrepreneurial settings.

Contextually, much of the empirical studies are centered on advanced economies or EU countries (Schneider, 2025; Dauth et al., 2019), with less focus on other developing economies especially Africa, West Africa and Nigeria, for instance, where SMEs are constrained by their infrastructure (including financial), skills-related constraints (Aliyu, 2024; Mohammed, 2024; Turkes et al., 2019). Understanding impact of local market conditions, regulatory frameworks, and resource limitations on adoption of robotics and the role that this plays in its contribution to firm growth is underexplored. Methodologically most studies are based on single country data-sets, sector specific analyses, or (macro) labour market evaluation (Bachmann et al., 2024; Graetz & Michaels, 2018), which limits generalisability. There is a need for multi-level, integrative approaches to the behavioral sciences that connect firm-level technology adoption practices with measurable strategic outcomes, especially in entrepreneurial firms that are operating in resource-constrained environments. Practically, though the adoption of robotics has been linked to productivity gains, operational efficiency and improved competitiveness (Ivanov, Webster, & Berezina, 2019; Dixon, Hong, & Wu, 2021), actionable guidance for entrepreneurial firms, particularly in emerging markets, on the use of robotics in tandem with innovation capability for sustainable growth and competitiveness is limited (Mohammed & Sundararajan, 2023; Zong & Guan, 2025).

In summary, this study bridges these conceptual, theoretical, contextual, methodological, and practical gaps by integrating the capabilities of robotics adoption and innovation into an overall concept, which is rooted in TAM and RBV theories, and focus on entrepreneurial firms on global, African, West African and Nigerian. The research is not only to explain but also to offer recommendations both academically and to managers and policymakers who are trying to improve the growth and competitiveness of entrepreneurial firms through the adoption of robotics.

2.6 Conceptual Framework

The conceptual framework of this study shows the relationships among the robotics adoption, innovation capability and entrepreneurial firm growth and competitiveness. Robotics adoption (IV1) such as industrial, collaborative and service robots are a technological enabler while innovation capacity and digital transformation preparedness (IV2) improve the capability of the firm to integrate and leverage these technologies effectively. The sum of these independent variables (IVs) facilitate the growth and competitiveness of entrepreneurial firms in terms of growth, productivity, market share and sustainable strategic advantage which is reflected in sales growth and reflected in the value of the dependent variable (DV). This framework is based on the Technology Acceptance Model (TAM), explaining managerial intentions to adopt robotics, and the Resource-Based View (RBV), explaining how these resources create a sustained competitive advantage (Bachmann et al., 2024; Dixon, Hong, & Wu, 2021; Varzaru & Bocean, 2024).

Figure 1: Conceptual Framework Linking Robotics Adoption, Innovation Capability, and Entrepreneurial Firm Growth

Source: Developed by the authors based on Bachmann et al. (2024), Dixon, Hong, & Wu (2021), Ivanov, Webster, & Berezina (2019), and Vărzaru & Bocean (2024).

Figure 1 displays the integrated conceptual model which shows that the entrepreneurial firm growth and competitiveness are jointly affected by the adoption of robots and the innovation capability of the firm. Robotics penetration offers technology infrastructure, automation and efficiency gains and innovation capability and digital transformation readiness uphold the absorptive capacity and complementary technology (AI, IoT, big data) exploitation capability of the firm. "Above, the arrows signify a two-step process: TAM describes why firms decide and implement robotics and RBV describes how such within-firm capabilities result in sustained competitive advantage. The combination of robotic ventures adoption and the strong innovation capabilities will be the primary key enabler for productivity, market responsiveness and sustainable growth for firms, particularly in Africa, West Africa and Nigeria where resource scarcity necessitates strategic deployment of technology.

3.0 Research Methodology

A conceptual research study is applied in this study, which is suitable for synthesizing past knowledge, showing theoretical relationships, and creating an integrated framework to understand the effect of robotics adoption and innovation capability on entrepreneurial firm growth and competitiveness. Unlike empirical research, it does not use primary data, but secondary data extracted from the literature, with the right justification of theory building, gap identification, and proposing a direction for future study in the context of global, African, West African, and Nigeria entrepreneurial ecosystems. The literature selection strategy adopted an organized search of leading science databases of Scopus, Web of Science, Google Scholar, ScienceDirect using specific keywords, namely, robotics adoption, digital transformation, innovation capability, entrepreneurial growth, firm competitiveness, SMEs, and technology integration. Inclusion criteria were the peer-reviewed journal articles, conference proceedings and conceptual studies published between 2005 and 2025 relating to the adoption of robotics, innovation capability or entrepreneurial performance outcomes. Exclusion criteria eliminated non-English language publications, opinion articles, anecdotal evidence and studies that did not involve entrepreneurial or technology contexts. This limited the literature used to develop the concept to high quality, relevant and up to date.

To provide a model conceptualization, the selected academic literature was thematically synthesized combining the conceptual contributions about robotics implementation, readiness to digital transformation, innovation competence and firm growth. Key emerging measures identified are cost, skills and infrastructure, digital maturity, technological complementarity (AI, IoT, big data), boost in productivity, gain of competitive advantage and sustainable growth. Through the use of the Technology Acceptance Model (TAM) and Resource-Based View (RBV) as analytical tools, the study looks at both behavioural and strategic dimensions of technology adoption and innovation in entrepreneurial firms. Lastly, this methodology will facilitate establishment of a conceptual framework in comparing robotics adoption with the innovation capability and an entrepreneurial firm performance and competitiveness. It provides a theoretically and integrative model that explains the two ways, by which technological and innovation capabilities influence an organization performance. The method will also give the guidance to policy makers, managers and researchers on the focus of the technology adoption and the entrepreneurial-readiness innovation at the various contexts in terms of success.

4.0 Findings of the Study

1. **The Adoption of Robotics Technologies and their Positive Impact on the Growth of the Entrepreneurial Firm:** The researchers find that the adoption of robotics technologies, including industrial, collaborative, and service robots, has a positive association with the growth of the entrepreneurship (Dixon, Hong, and Wu, 2021; Graetz and Michaels, 2018). According to the results, most of the companies that have successfully utilized robotics have registered improved

performance values (the sales value, employment issues, optimization of business procedures), etc.

2. **Better Competitiveness with the help of robotics:** By applying robotics, entrepreneurial firms will be able to create the competitive advantage because it will allow automation, quality of services, innovations in products, and innovations in services (Ivanov, Webster, and Berezina, 2019; Antonioli et al., 2024). The more technological the firm is, the more receptive it would be to the market changes, the greater the differentiation, and the further the positioning would be in the entrepreneurial ecosystems.
3. **Adoption is influenced by Strategic and Contextual Factor:** The level of organizational capabilities, the perception of manager, digital maturity and contextual factors like infrastructure and availability of skilled labours play a significant role in influencing the success of robotics implementation (Bachmann et al., 2024; Turkes et al., 2019). These aspects identify the extent to which companies can leverage robotics to give them a competitive edge and growth leading advantage.
4. **Coherent Conceptual Framework Provides a Unified Perspective:** The synthesis of the Technology Acceptance Model (TAM) and Resource-Based View (RBV) provides twofold perspective on the perception of how and why firms implement robotics i.e., both the behavioral (why) and strategic (how) of the adaptation process. This framework ties to the adoption of robotics and innovation capability to measurable outcomes in growth and competitiveness (Varzaru & Bocean, 2024; Ballestar et al, 2020).
5. **Research Gaps Identify Areas for Further Study:** In spite of good impact, unaddressed gaps persist with regards to empirical validity especially in African, specifically Nigerian contexts in relation to longitudinal effects, industry-specific implementation and integration with complementary technologies like AI and IoT (Raymond, Bergeron, & Blili, 2005; Zong & Guan, 2025). These are gaps that leave room for future research about the growth and competitiveness of robotics.

5.0 Recommendations

1. **Organizational Level:** In order to gain the most from technology integration firms need to invest in robotics but at the same time invest in people's skills human resource robots give through reskilling and upskilling methods (Aliyu, 2024; Dixon, Hong and Wu, 2021). Firms should also create change management strategies to ensure the smooth adoption.
2. **Policy Level:** Governments and industry watchdogs ought to create rewards, tax incentives, or funding programs that encourage SMEs to utilize robotics and related digital innovations - especially in the resource-constrained zones (Turkes et al. 2019, Varzaru and Bocean 2024). Policies should also include issues related to digital infrastructure, training programs and innovation clusters.
3. **Strategic and Managerial Guidance:** Firms should evaluate their innovation capacity as well as their digital preparedness prior to incorporation of robotics while ensuring that there is an alignment with business objectives, market conditions, and competitive strategies (Ballestar et al., 2020; Antonioli et al., 2024).
4. **Research-Level Recommendations:** Scholars should therefore enhance the empirical validation of the proposed conceptual framework through the use of structural equation modelling, longitudinal studies and cross-industry analyses to test causal linkages of relationship measures between robotics adoption, innovation capability and entrepreneurial outcomes (Zong & Guan, 2025; Raymond, Bergeron, & Blili, 2005).
5. **Context Specific Case-study:** Future Research should be conducted specifically for Nigeria and West Africa on context-based constraints and opportunities in Nigerian SMEs examining how cultural, economic, infrastructural factors determine use of robots and firm competitiveness (Bachmann et al., 2024; Turkes et al., 2019). This will lead to useful inputs for regional decision-makers, management people, and technology suppliers.

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