Adaptability Challenges in Implementing Big Data Analytics in Tanzanian Small and Medium Enterprises

Peter George Ngugulu
Teesside University International Business School
Middlesbrough, United Kingdom
Email: S3378826@tees.ac.uk

Min Prasad Bhandari
Teesside University International Business School
Middlesbrough, United Kingdom
Email: m.bhandari@tees.ac.uk

Abstract — **This study investigates the adaptability challenges faced by Tanzanian Small and Medium Enterprises (SMEs) in adopting Big Data Analytics (BDA) to enhance operational strategies and strategic decision-making. Grounded in the Technology-Organization-Environment (TOE) framework, the study employed a qualitative approach using semi-structured interviews with SME managers across selected regions. Preliminary insights reveal key challenges to BDA adoption, including infrastructural limitations, skills shortages, financial constraints, and regulatory uncertainties. While the data is limited to a small pilot sample, these findings offer an initial foundation for designing a more comprehensive future study.**

Keywords - Big Data Analytics; SMEs; Tanzania; Technology Adoption; TOE Framework.

I. INTRODUCTION

Small and Medium Enterprises (SMEs) in Tanzania account for over 95% of firms and contribute 35% of Gross Domestic Product [1]. Big Data Analytics (BDA), defined as the process of extracting actionable insights from large, complex datasets [2], can enhance SMEs' operational efficiency and decision-making capabilities. Despite these advantages, Tanzanian SMEs lag in adopting BDA due to infrastructural limitations, financial constraints, and skill shortages [3]. Prior studies have focused on developed economies, or large enterprises, leaving a gap in understanding the Tanzanian SME context [4]. This study investigates the challenges faced by Tanzanian SMEs in adopting BDA and proposes strategies to overcome them.

Tanzania has its economic environment defined by its categorization as a lower-middle-income nation, with an inclined agricultural sector that employs the majority of the workforce and contributes a large amount to GDP. Although this is the case, interest in technology advancement and innovation is increasing in urban cities, where tech hubs and startups are starting to develop [5]. Furthermore, the government of Tanzania has endorsed the utilization of technology as an essential factor [6] in fostering economic activities. It is featured in the development agenda, such as Vision 2025, which has aimed at transforming Tanzania into a semi-industrialized country that focuses on technology and human capabilities.

The paper is structured as follows: In Section II, the literature review examines global and regional perspectives on BDA adoption, identifying gaps specific to Tanzanian SMEs. Section and the research objectives and scope, focusing on adaptability challenges in operational and strategic contexts. Section III presents the core findings on adaptability challenges, divided into two subsections: enhancing operational strategies and strategic decision-making. Section IV discusses the theoretical frameworks and methodology —Technology Acceptance Model (TAM), the Diffusion of Innovations Theory (DOI), and TOE that inform the study's analytical lens. The methodology, including the qualitative approach and data collection techniques. Section V reports the results from interviews with SME managers, illustrating key themes and challenges. Finally, Section VI concludes the paper by outlining future research directions, emphasizing the need to expand the sample size, refine the analytical framework, and explore practical interventions to support BDA adoption in Tanzanian SMEs.

II. LITERATURE REVIEW

BDA has been widely utilized in technologically advanced economies, such as the United States and the United Kingdom, where it has transformed operational strategies, management decisions, and market competitiveness [7][8]. Gandomi et al. [2] described how SMEs in these regions leverage data analytics to improve business processes and customer interactions in considerable detail [2]. Similarly, Asian countries, including China and India, have experienced a growing emphasis on BDA usage in commercial industries, particularly among SMEs, which has fostered innovation and enhanced economic performance [10]. Research conducted in these regions has provided valuable insights into the benefits and challenges associated with the adoption of BDA integration in SMEs.

In contrast, studies focusing specifically on the Tanzanian context continue to show significant gaps [11]. While Mwemezi et al. [11] explored the role of BDA in the banking sector using the TOE framework, limited research exists on how Tanzanian SMEs are adopting BDA to improve operational areas, such as supply chain management, inventory control, and cost efficiency [12].

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Although studies like those by Adaga et al. [12] highlight the importance of BDA in decision-making, they do not examine its specific influence on managerial practices within Tanzanian SMEs, particularly considering the unique challenges of the country's economic environment [13].

Even though BDA research has been extensively carried out in different settings worldwide, especially in developed markets, its adoption and effects in emerging markets—particularly among SMEs in Tanzania—remain underexplored. Didas et al. [10], specifically point out a significant gap in the literature on BDA in Tanzania [10]. This is supported by Joubert et al. [13], who emphasize that although BDA is recognized as a potential economic driver, research at the country level in developing nations remains minimal [13].

Additionally, while some studies in Tanzania explore BDA, they do not specifically focus on SMEs. For example, Mwemezi et al. examined BDA in the banking sector [11]. Malero and Seif discussed Hadoop and BDA readiness in Africa generally [14]. Didas et al. explored BDA for managerial large enterprise business-driven decision-making rather than for SMEs [16]. Mkumbo et al. [16], also examined the effect of awareness on BDA adoption readiness in public sector auditing in Tanzania using the TAM [17]. According to Changalima, et al. [17], as cited from Ismail, there is a significant research gap in understanding the technological adoptability capacity in SMEs in Tanzania [18]. In light of this, it becomes evident that while the benefits of BDA are widely discussed, the challenges faced by industries, including SMEs, in adopting BDA—particularly in developing countries—are less frequently covered. Joubert, Murawski, and Bick highlight that there is extensive research on the benefits of BDA, but a significant gap exists in understanding the challenges faced by all African countries in adopting BDA [14]. Similarly, Alalawneh et al. discussed BDA adoption challenges in developing economies and note that, while the advantages are well documented, the challenges are often overlooked [19].

The literature presents a research void on how Tanzanian SMEs are utilizing these technologies to address their unique challenges, including restricted resources, limited infrastructure, and lack of qualified human resources [20]. This exploration addresses this gap by contributing new qualitative data on the acceptance landscape of BDA in Tanzania, extending the work of Ismail et al., who examined low levels of technology absorption among Tanzanian SMEs [12]. Also, according to Ishengoma et al., Tanzanian SMEs—particularly in the manufacturing sector—play a crucial economic role but often lack an appropriate framework for technology adoption tailored to their specific needs [21]. In response to this gap, this study aims to develop a framework that better supports the BDA technology adoption of Tanzanian SMEs, ensuring it aligns with the local conditions and requirements.

Adaptability challenges in the context of BDA refer to the challenges that impede the effective adoption and utilization of BDA technologies [22][23]. The following sections highlight the most prominent adaptability challenges faced by Tanzanian SMEs, categorized by their impact on operational strategies, and strategic decision-making [24]-[27]. The objectives of this work are as follows:

- To identify the adaptability challenges Tanzanian SMEs face in enhancing operational strategies through BDA.
- To explore the adaptability challenges in leveraging BDA for strategic decision-making among Tanzanian SME managers.

III. Adaptability Challenges in BDA

A. Adaptability Challenges in Enhancing Operational Strategies

BDA has the potential to revolutionize operational strategies by providing real-time insights into supply chain optimization, resource allocation, and cost efficiency. However, Tanzanian SMEs face significant challenges in leveraging BDA for these purposes. Key among these is the lack of affordable and scalable technological solutions, which hinders SMEs from utilizing predictive analytics to optimize their operations [28]. The high costs associated with these technologies and the limited availability of scalable solutions further exacerbate these challenges [29]. Operational inefficiencies often arise from the inability to integrate data from various sources due to fragmented digital infrastructure [25]. For instance, SMEs in Tanzania struggle to adopt tools like predictive maintenance and real-time analytics, which could reduce operational costs and improve efficiency. This gap is compounded by financial constraints, as many SMEs lack the capital to invest in advanced BDA tools and systems [30]. The financial burden of acquiring and maintaining these technologies often leads to underutilization of BDA capabilities, limiting the potential benefits for operational strategies [31].

B. Adaptability Challenges in Strategic Decision-Making

BDA facilitates data-driven decision-making by uncovering patterns, trends, and insights critical for formulating effective strategies [32]. However, Tanzanian SMEs often lack the internal expertise required to analyze and interpret complex datasets. This skills gap significantly limits their ability to make informed decisions based on data insights [33]. Additionally, the lack of a data-driven culture and insufficient training further exacerbate these challenges [22]. SMEs face challenges in aligning BDA initiatives with their strategic objectives. Many decision-makers in Tanzanian SMEs remain skeptical about the value of BDA due to limited awareness and understanding of its potential benefits [18]. This skepticism, coupled with the absence of a robust decision-making framework, often leads to underutilization of available data, thereby hindering the

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effectiveness of strategic planning [17]. The lack of a clear strategy for integrating BDA into business processes further complicates the adoption and utilization of BDA in strategic decision-making [34].

IV. Theoretical Framework and Methodology

There are several key theories used to understand technology adoption; however, the TAM, DOI, and the TOE framework are more commonly used [35][36].

A. TAM

Developed by Fred Davis in 1989 [36]. TAM focuses on the determinants of technology adoption, emphasizing Perceived Usefulness (PU) and Perceived Ease Of Use (PEOU) as primary factors influencing whether individuals or organizations accept and use new technologies. In the context of Tanzanian SMEs adopting BDA, TAM provides a useful lens to understand how SMEs perceive the benefits of BDA and their apprehension toward complex technology adoption. For example, SMEs in resource-constrained environments, such as Tanzania, may prioritize technologies perceived as easy to use and with visible benefits due to limited budgets, infrastructure, and technical expertise [37]. TAM has been widely utilized in various research contexts to explain user behavior and technology adoption. For instance, Venkatesh and Davis expanded TAM to include external factors such as social influence and facilitating conditions, making it applicable across diverse cultural and organizational settings [38]. Mishrif et al. identified the need for a more nuanced perspective to account for cultural tendencies and infrastructural disparities [39]. Despite its simplicity and wide applicability, TAM's limitations include its narrow focus on individual perceptions and its inability to consider organizational readiness and socio-cultural factors [40].

B. DOI

DOI, introduced by Everett Rogers in 1962 [36], provides a macroscopic view of technology adoption by categorizing adopters into groups: innovators, early adopters, early majority, late majority, and laggards. This segmentation is particularly useful for strategizing the introduction and diffusion of BDA technologies in SMEs. In Tanzanian SMEs, DOI helps identify patterns of adoption behavior, allowing policymakers and technology providers to design targeted interventions for different adopter categories. DOI has been applied in various studies to analyze technology adoption dynamics. For example, during the COVID-19 pandemic, Mishrif et al. highlighted how SMEs rapidly adopted digital technologies to sustain operations, demonstrating the utility of DOI in categorizing adoption behaviors during crises [39].

C. TOE

The TOE framework, introduced by Tornatzky and Fleischer in 1990 [41], offers a comprehensive view of technology adoption by examining three dimensions. The Technological Context includes factors such as compatibility, complexity, and perceived benefits of the technology. The Organizational Context encompasses internal factors like organizational readiness, management support, and employee skills. The Environmental Context involves external factors such as competitive pressure, regulatory environment, and market trends [42]. The TOE framework has been widely utilized in research on technology adoption in SMEs. For instance, Oliveira et al. used the TOE framework to study cloud computing adoption in SMEs, highlighting the significance of external factors like vendor support and industry standards [43].

A qualitative abductive approach was employed, suitable for exploring emerging phenomena [40]. Semi-structured interviews were conducted with five SME managers across cities in Tanzania, namely Dar es Salaam, Arusha, and Dodoma between September and December 2024. Purposive sampling targeted firms in manufacturing, retail, and services. The interviews focused on experiences with data use, perceptions of BDA, and adoption challenges. Data were analyzed thematically using NVivo software to identify recurring patterns aligned with the TOE framework.

V. Results

Theme 1: Operational Efficiency and Data Infrastructure

The ability of BDA to enhance operational efficiency emerged as a dominant theme among the respondents. However, challenges to adopting these capabilities were emphasized. For instance, Respondent 1 highlighted, “We don’t fully understand the benefits and limitations of BDA,” underscoring the lack of awareness and technical knowledge as a key challenge to BDA adoption. This aligns with Babalghaith et al. [34], who found that technical aspects such as complexity and compatibility are significant challenges to BDA adoption in SMEs. Similarly, Willetts et al. [44] identified the lack of expertise and resources as major barriers to effective BDA implementation in SMEs. Respondent 5 echoed similar concerns: “The book used for recording health issues and livestock births got lost, causing a significant loss of information,” which illustrates the absence of proper digital systems for operational data management. This is consistent with findings by Infopulse [29], which discuss how inadequate digital infrastructure can impede the effective implementation of BDA.

Theme 2: Supply Chain and Inventory Management

Overstocking and supply chain challenges were also highlighted. Respondent 2 noted, “When relying on analytics tools, overstocking or, vice versa, stockouts can be avoided due to the ability to forecast demand fluctuations.” This highlights how BDA can mitigate supply chain

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inefficiencies by enabling better inventory management and demand forecasting. McKinsey [45] emphasizes that BDA can significantly enhance supply chain decision-making by expanding the dataset for analysis and applying powerful statistical methods to improve inventory management and demand forecasting. Similarly, Cohen [46] discusses how real-time data and machine learning algorithms can revolutionize inventory management, reducing both overstocking and stockouts.

Theme 3: Strategic Decision-Making and Data Collection

Strategic decision-making through market insights was recognized as a key benefit of BDA, but adaptability challenges remain. Respondent 2 observed, "The lack of technical expertise and inadequate data collection from different sources are the main challenges," highlighting the difficulties in generating actionable insights. Respondent 3 stated, "We lack the tools to collect data, such as sensors, to transfer information to computers for recording," which underscores the infrastructural deficits in gathering and utilizing customer data. Additionally, Respondent 4 noted, "Most of our records are done on paper, and we currently only track credit customers, not cash buyers," illustrating the limitations in data collection for creating personalized marketing strategies. Maroufkhani et al. [47] emphasize the importance of top management support and organizational readiness for BDA adoption. This is supported by Babalghaith et al. [34], who found that organizational aspects such as top management support, organizational readiness, and a data-driven culture are crucial for encouraging BDA adoption in SMEs.

Respondent 4 also stressed, "Without proper sales records, we lack performance metrics to rely on," which reflects the limitations in data collection and analysis for effective decision-making. This aligns with the findings of Pingax [48], which discuss the challenges of data collection, including issues of data quality, completeness, and accuracy, that can significantly impact the reliability of insights derived from BDA. Additionally, Willetts et al. [44] highlight that SMEs often struggle with data quality issues, including incomplete, inaccurate, or inconsistent data, which can hinder effective decision-making. The importance of handling missing or incomplete data is emphasized by Cohen [46], who discusses strategies such as data imputation to address gaps in datasets, thereby improving the quality of insights and decision-making processes. The study by McKinsey [45] also underscores the significance of robust data collection and management practices in leveraging BDA for strategic decision-making, noting that reliable data is essential for accurate market insights and effective decision-making.

Theme 4: Organizational Readiness – Resistance from Senior Management

Resistance from leadership was identified as a challenge to BDA adoption. Respondent 5 observed, "The owner, who lacks formal education, is wary of new technologies, fearing that educated employees might take advantage of him." This remark highlights a common challenge in SMEs, where decision-making is often centralized, and leaders may lack the technical literacy to appreciate the potential benefits of advanced technologies. Similarly, Respondent 1 noted, "Our senior managers are hesitant to invest in unfamiliar technologies due to perceived risks." This resistance often stems from a lack of understanding or confidence in the ability of BDA to deliver measurable returns on investment [49]. Leaders who are accustomed to traditional operational practices may view data analytics as an unnecessary complication, further slowing the pace of adoption. To address this resistance, organizations must prioritize leadership engagement and education. Providing senior managers with clear demonstrations of BDA's potential benefits, such as case studies from similar industries, can help alleviate concerns. Additionally, involving leadership in pilot projects and decision-making processes ensures that they feel invested in the technology's success.

VI. Conclusion and Future Work

This pilot study highlights that Tanzanian SMEs face challenges to BDA adoption across the TOE framework. Technologically, inadequate Information Technology infrastructure and limited digital systems hinder readiness; organizationally, weak leadership support and low technical skills remain constraints; and environmentally, unclear policies and limited institutional backing create further challenges. These findings confirm that adoption depends on multiple interrelated factors rather than a single determinant. The research journey offered several lessons. Recruiting SMEs proved difficult due to time pressures and limited awareness of BDA, while language preferences required adaptation of technical concepts. Although participants recognized the value of analytics, financial and expertise gaps restricted engagement. These challenges underline the importance of piloting instruments, building trust, and ensuring cultural sensitivity before scaling up. Future research will expand the sample size across diverse sectors and regions, supported by analysis to prioritize challenges and identify solutions. The next phase will also strengthen the scientific contribution by incorporating tables, graphs, and comparative results to visualize patterns and validate findings. Technical directions include testing low-cost digital tools, targeted training programs, and collaboration with technology providers and industry associations. These steps will refine the TOE framework and generate actionable insights for policymakers and SME leaders.

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