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A Multi-Theory Framework for Assessing IoT Adoption in Botswana SMEs

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Abstract

The rapid surge of technological innovation is reshaping industries, and Small and Medium Enterprises (SMEs) are key players in this digital transformation. However, despite their prominence, SMEs often struggle to adopt cutting-edge technologies like the Internet of Things (IoT). While IoT offers the potential to revolutionise SME operations, integrating these interconnected devices presents significant hurdles. Thus, to bridge this research gap, a robust conceptual framework is necessary to understand the factors influencing IoT adoption in SMEs. This study addresses a critical gap by proposing a novel multi-theoretical framework, integrating established technology adoption theories and models like, Diffusion of Innovation (DOI), Technology-Organisation-Environment (TOE) framework, Technology Acceptance Model (TAM), and Unified Theory of Acceptance and Use of Technology (UTAUT). This framework will assist researchers, policymakers, and practitioners in crafting strategies to improve SMEs IoT adoption in Botswana and other developing economies. Future studies will validate this framework through survey research.

Keywords: Internet of Things, IoT, Multi-theory, Small and Medium-sized Enterprises, SMEs, Botswana

1. INTRODUCTION

The rapid surge of technological innovation is reshaping industries, technologies has emerged, holding immense potential to reshape our societies and economies. Within this realm of ground breaking technologies, the Internet of Things (IoT) has emerged as a potent catalyst, instigating transformative shifts across a variety of economic sectors [1]. In broadest sense, IoT refers to a revolutionary paradigm where ordinary objects possess the ability to be read, identified, discovered, addressed through information sensing devices, and/or remotely controlled via the internet, irrespective of the communication method employed [2]. This concept embodies the merging of the physical and digital domains through a complex network of sensors and actuators [3]. This intricate network

interlinks not only objects but also individuals, as they gather and exchange data related to their usage patterns and surrounding environment [4].

The increasing integration and utilisation of IoT technology, along with the widespread adoption of smart devices, are expected to have a positive impact on the market [5]. Thus, research has demonstrated that IoT empowers companies to implement solutions aligned with the Fourth Industrial Revolution, including applications such as inventory tracking, digital instructions, and machine vision inspection, among others [6]. Thus, with the IoT, automation becomes ubiquitous, weaving itself into the very fabric of our environment [7]. The Small and Medium-sized Enterprises (SMEs) renowned for their pivotal role in job creation and overall economic growth [8] are not immune to this trend. In fact, Rejeb et al. [9] assert that IoT presents SMEs with a plethora of opportunities such as; development of innovative applications and services, improved facility management, production flow monitoring, plant safety and security, energy management, enhanced asset management, quality control, improved logistics operations, and supply chains. Thus in general, it has been observed that embracing new technologies and fostering a culture of innovation among SMEs, serve as catalysts for their sustainable growth [10].

Despite SMEs significant role in promoting economic diversity, studies have shown that there are significant concerns about their performance and growth [11]. According to Mitake et al. [12], one of the primary challenges faced by SMEs is the lack of technology integration into their business operations. This constraint has also been linked to their low success rates [13]. In this sense, these stagnant rates concerning IoT adoption within the SME sector should function as a wake-up call for policymakers, as they indicate that SMEs are hardly prepared to embrace advanced technologies like the IoT into their business processes [11]. Nonetheless, without implementation of advanced technologies like IoT, countries run the risk of intensifying economic inequality, hindering opportunities for social mobility, and dragging down global industrial productivity [14]. Despite these challenges, equipping SMEs with relevant technologies can still significantly boost their development and ensure they stay competitive in the market [15].

While existing literature into IoT adoption in SMEs discuss diverse perspectives, trends and issues on its adoption, diffusion, and innovation within organisation [16], [17], most empirical studies employ a single theoretical model [18], [19], or in some instances, no theoretical framework is employed to explain IoT adoption factors in SMEs [20]. Consequently, such studies underestimate the potential benefits of integrating multiple theories to comprehensively address the same subject matter [21]. This knowledge gap limits our understanding of nuisance factors at play in breakthrough technology integration like IoT in SMEs context [21]. Moreover, recognising the limitations of single models, several

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studies have highlighted the difficulty of conclusively proving one model's superiority over others [22]. Therefore, research suggests the integration of the multiple theoretical models for explaining innovation adoption, as it offers enhanced explanatory power [23].

This study proposes a new framework combining established technology adoption theories (i.e. Diffusion of Innovation (DOI), Technology-Organisation-Environment (TOE) framework, Technology Acceptance Model (TAM), and Unified Theory of Acceptance and Use of Technology (UTAUT)) to understand how SMEs in developing nations adopt IoT. Moreover, it aims to identify key drivers and barriers, informing researchers, policymakers, and practitioners on strategies for successful IoT implementation in SMEs. Subsequently future studies will validate this framework through surveys research.

2. METHODS

2.1. Technology Adoption Theories

Several theoretical models and frameworks have been established to explain the adoption of innovations within firms. These theories are categorised into two main levels: individual-level and firm-level. At the individual level, there are several theoretical models such as the TPB [24], TAM [25], TRA [26], and UTAUT [27]. On the other hand, at the organisational level, there are theories like the DOI [28] and the TOE framework [29]. The study will examine technology adoption at both individual and organisational levels, focusing on internal and external factors within SMEs. Consequently, to explain the factors influencing IoT adoption in SMEs, the study has considered only four prominent technology adoption models, namely; DOI, TOE framework, TAM, and UTAUT. Specifically, TOE and DOI frameworks are found relevant for evaluating IoT adoption at the organisational level, while the TAM and UTAUT are deemed appropriate for evaluating user adoption factors for IoT in SMEs.

2.1.1. TOE framework

The TOE framework, developed by DePietro et al. [30], is a generic framework widely accepted and multi-perspective approach for studying the organisational adoption of new technology innovation [31]. This theory posits that the firm's context, encompassing three key dimensions: technological, organisational, and environmental, significantly influences the adoption and implementation of innovations [32]. The technological context considers factors like the complexity of the innovation and compatibility with existing infrastructure, while the organisational context focuses on resources, leadership support, and culture. Correspondingly, the environmental context examines external factors like

competition, regulations, and market trends [29]. In SMEs context, Thong [33] utilised the TOE and identified three key factors influencing Information Systems (IS) adoption. Similarly, Zhang and Xiao [34] adapted the TOE framework to study social media adoption in local government agencies. Rahayu and Day [35] investigation of e-commerce adoption in SMEs, highlight the applicability of the TOE framework across various contexts and technologies.

2.1.2. DOI

Everett Rogers' DOI theory, established in 1962 and refined in 2003, has its roots in the well-established framework of institutional theory [36]. DOI explains the core dynamics that influence adoption rates, enabling predictions about an innovation's success and its integration within a social system [36]. It identifies four key elements driving technology adoption process, namely the innovation, the communication channels, the time it takes for adoption, and the social system within which it occurs. There are five key attributes that influence the adoption rate of innovations in the DOI theory [36], namely; (a) Relative Advantage, refers to the perceived benefits of the innovation compared to existing solutions. b) Compatibility considers how well the innovation fits with existing practices, values, and workflows. (c) Complexity emphasises the perceived difficulty of understanding and using the innovation. (d) Observability highlights the visibility and clarity of the innovation's results. (e)Trialability refers to the ease of testing and experiencing the innovation at first-hand.

Empirical research has validated the applicability of DOI theory, demonstrating how specific factors within its framework influence adoption decisions across various contexts such as adoption in university faculty [37], internet adoption [38], and the Unified Payment Interface adoption in India [39].

2.1.3. TAM

TAM, developed by Davis [25], builds upon the foundation of the TRA [40]. In contrast to the TRA, which relies on attitude beliefs, TAM specifically examines user acceptance of IS through two key constructs, namely; perceived usefulness (PU) and perceived ease of use (PEOU) [25]. In Davis [25] model, PU describes a person's belief that using a particular system will improve their job performance, while PEOU captures the extent to which they believe using the system will be effortless. Due to its simplicity TAM has been particularly well-suited for predicting user adoption and usage within organisations [41]. In this regards researchers have thoroughly scrutinised the validity of the TAM model by investigating the connections among its components across a wide range of IS application domains [42].

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2.1.4. UTAUT

The existence of several technology models prompted Venkatesh et al. [27] to unite multiple theories into one overarching model to explain technology adoption and usage. In this regards, UTAUT was established aiming to overcome limitations of previous technology adoption models by providing a more comprehensive depiction of the acceptance process [27]. UTAUT model integrates insights from eight previously validated models rooted from psychology, sociology, and communications. These models comprise of TRA, the Motivational Model, the TAM or TAM2, TPB, the Model of Personal Computer Utilisation, DOI, and Social Cognitive Theory [43]. UTAUT focuses on both user intentions to use an IS and their actual usage behaviour [44].

The core of UTAUT lies in four key predictors influencing technology adoption [27]. These key predictors include; (a) Performance Expectancy (PE) - the degree to which using the system will enhance job performance. (b) Effort Expectancy (EE) describes perceived ease or difficulty of using the system. (c) Social Influence (SI) considers perceived pressure from important others to use or not use the system. (d) Facilitating Conditions (FC) considers availability of organisational and technical resources supporting system adoption. The UTAUT predictors shape two key outcomes, namely (a) Behavioural Intention - the likelihood of users intending to use the system. (b) Use Behaviour - the actual frequency and duration of system use. While UTAUT's core lies in its four key predictors, the model also acknowledges the influence of individual factors on technology adoption such as; gender, age, experience, and voluntariness [27].

The UTAUT has been extensively scrutinised in research related to understanding IS adoption [45] such as in online banking [46], mobile learning [47], and mobile internet [48].

2.2. Literature Review Strategy

To ensure transparency and minimise potential bias in our literature analysis process, we followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol [49]. By adopting this systematic approach, we focused on relevant titles and abstracts from peer-reviewed academic journals and conference proceedings in fields like Business Information Systems, Knowledge Management, Information Systems, Information Technology, and Computer Science. This process involved establishing clear inclusion or exclusion criteria, identifying relevant databases and sources, formulating search strategies, and screening retrieved studies for eligibility. Our initial search yielded 2780 potentially relevant studies. Table 1 provides a summary of the literature review process.

Table 1. The literature review process for the study

Stage	Description
Inclusion criteria	1) Only peer-reviewed journals and conference proceedings. 2) Studies published between January 2015 and January 2024 were reviewed. 3) Only English-language publications were reviewed. 4) Only studies focusing on IoT adoption within organisations.
Exclusion criteria	1) Studies not published in full-text in academic journals or conference proceedings, or if they only consisted of abstracts without complete findings. 2) Studies not directly exploring IoT adoption in organisations were excluded. 3) Studies published before January 2015, were excluded.
Identifying Sources and Databases	We searched various digital databases (e.g. Emerald Insight, Science direct, Springer link, MDPI, Scopus, Web of Science, IEEE Xplore, EBSCOHost, ProQuest, the University of Botswana Library catalogue, University of Botswana Research, Innovation and Scholarship Archive, Google Scholar, and Google).
Formulating Search Strategies	We focused on capturing articles that addressed IoT adoption using search terms and keywords like "Internet of Things AND adoption" and "IoT AND adoption." Additionally, we narrowed the focus of our search by combining with the key terms like "factors," "effects" and "impact ".
Performing Classification Analysis	1) Our initial search across various databases yielded 2,780 potential studies. 2) We utilised Zotero software to eliminate duplicate entries. 3) Subsequently, two independent reviewers were engaged to screen the remaining studies based on the pre-defined selection criteria. 4) Disagreements between reviewers were resolved through collaborative discussion for final consensus.

Figure 1 illustrates the PRISMA flow diagram we employed to guide the selection process of the study.

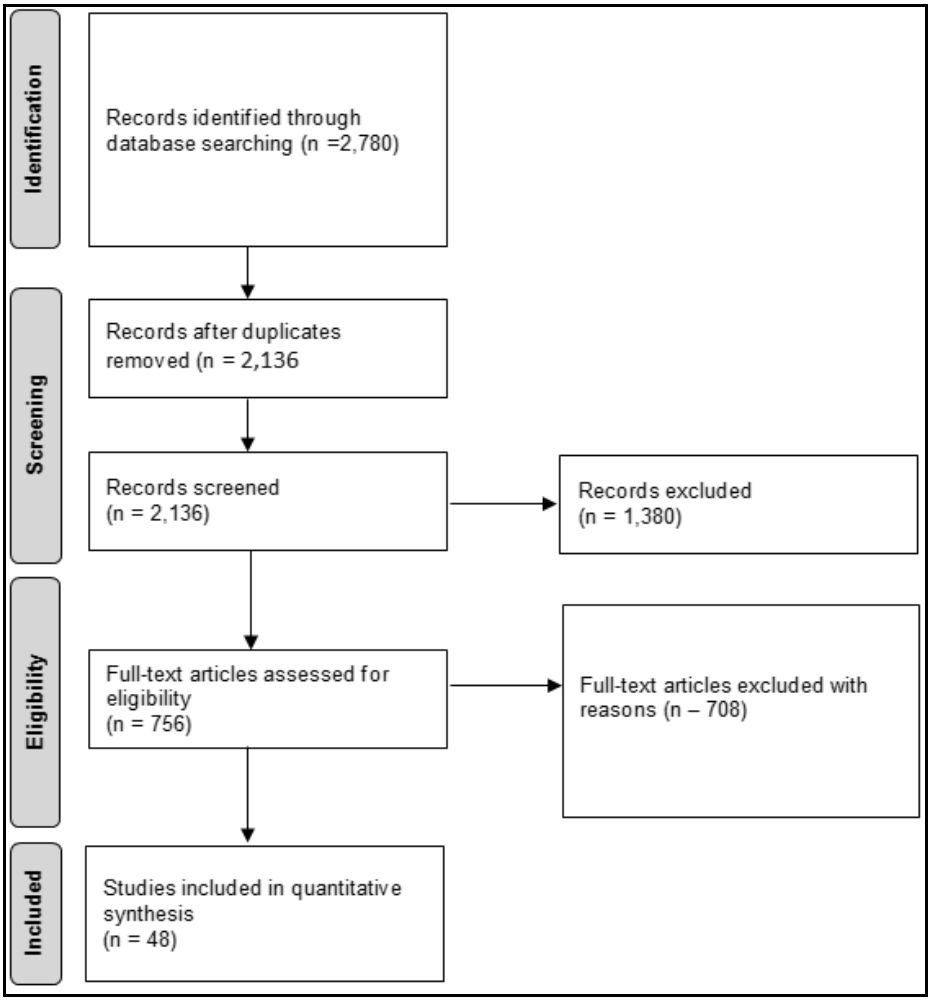

Figure 1. PRISMA flow diagram adopted by the study

Following a rigorous literature selection process, 48 studies emerged as highly relevant considered for further analysis. We used a stringent quality evaluation procedure to ensure the reliability and correctness of the selected studies. The Database of Abstracts of Reviews of Effects (DARE), and York University all provided established criteria that were used in this process [50]. A consistent grading method with three options—Yes (scored 1), No (scored 0), or Partially Meets Criteria (scored 0.5)—was used to evaluate each study. To ensure consistency in selecting relevant studies, two reviewers independently assessed them against predetermined criteria. Each reviewer's evaluation was documented. Any disagreements were resolved through cordial discussions until both reviewers reached a consensus.

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3. RESULTS AND DISCUSSION

In recent years there a substantial body of research has been conducted to discern the characteristics of SMEs and their strategies for adopting technology [11]. Traditionally, SMEs are regarded as being comparable to larger companies, except for their size [51]. Nonetheless, in practise SMEs' characteristics and adoption of IS differs significantly from large firms' with respect to their exhibiting problems and limitations [52]. Blanchier et al. [53] highlight numerous factors that discourage SMEs from IoT adoption and harnessing the benefits of IoT technologies such as the complex and fragmented nature of the IoT ecosystem, SME's lack of financial, time, and human resources to implement IoT, complexity of online hindering SMEs utilise the necessary information, and the IoT compliance requirements imposed by larger companies on their partners can discourage SMEs from engaging in collaborations, potentially limiting their growth opportunities.

Other studies have highlighted IoT adoption factors that influence SMEs decision makers to adopt IoT technologies. Madakam et al. [54] emphasise that IoT empowers objects to make automated decisions by sharing information without human intervention. This capability significantly strengthens SMEs' competitive positions across various sectors and facilitates their expansion into global markets [11]. In line with these perspective, Jung et al. [55] accentuate the need for SMEs to embrace smart IoT technologies to stay competitive. To facilitate this adoption, they have devised a smart factory concept tailored to guide SMEs in implementing IoT solutions. While studies suggest that adopting smart technologies like IoT can lead to cost savings and improved efficiency for businesses [9], the findings remain inconclusive. Therefore, a strong conceptual framework is needed to explore the factors influencing IoT adoption in SMEs and provide a more definitive understanding.

A number of researchers discuss diverse perspectives, trends and issues on IoT adoption in SMEs [17], [56], however, majority of such studies employ a single theoretical model [18], [19], or in some instances, no theoretical framework is employed to explain IoT adoption factors in SMEs [20], [57]. Subsequently, such studies overlook the potential benefits of integrating multiple theories to comprehensively address the same subject matter [21]. While implementing IoT in organisations seems promising, Wungcharoen [58] highlights that it's a complex process influenced by various factors and specific contexts. Therefore, a multi-theory approach is necessary to explore the factors affecting IoT adoption in SMEs, as Jaafreh [21] suggests. This means combining different theories to gain a more comprehensive and definitive understanding of how SMEs in developing economies decide to adopt IoT. Such a framework could shed light on the multifaceted aspects that directly impact these decisions.

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3.1. Analysis of Factors Influencing IoT Adoption

Our analysis of the reviewed studies revealed thirty-three (33) distinct factors influencing organisational adoption of IoT. These factors span a broad spectrum, incorporating aspects like trust, security, privacy, technical complexity, compatibility with existing systems, potential benefits, ease of monitoring, system reliability, perceived risks, user convenience, ease of trial implementation, organisational size, top management support, existing technology infrastructure, financial resources available, organisational culture, external pressures to adopt, vendor and external support, government incentives, word-of-mouth recommendations, enabling conditions, change management strategies, user demographics (gender, age, education level, computer experience), perceived ease of use and usefulness of the technology, required user effort, social influence, and user training and motivation[58]–[69]. Figure 2 illustrates the distribution of these identified IoT adoption factors across the number of reviewed studies.

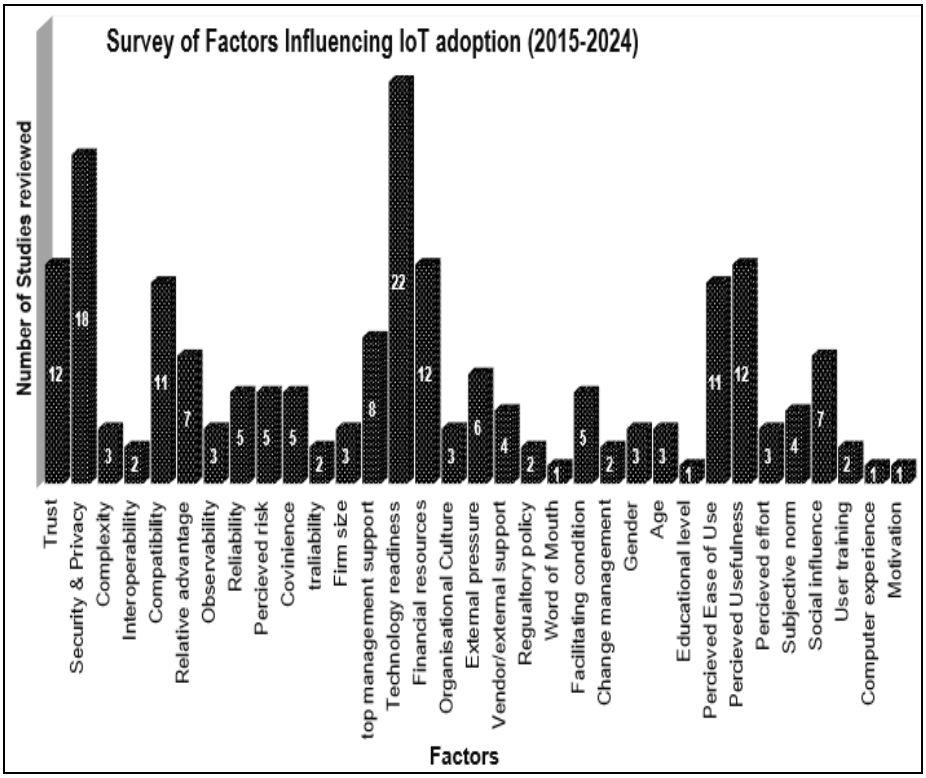

Figure 2. Analysis of factors influencing IoT adoption: Source- author

Figure 2 illustrates the primary determinants IoT adoption garnered from the extent literature analysis. To this end, five most predominant critical factors

emerge that SMEs should consider in IoT adoption. These factors include; technology readiness, security and privacy concerns, financial resources, perceived usefulness, and trust. Technology readiness takes precedence as a significant factor for IoT adoption by creating a fertile ground for these innovations to flourish. In other words, when organisations possess the necessary Information and Communication Technology (ICT) infrastructure, skills, and knowledge, this makes individuals more receptive to the transformative potential of IoT. Subsequently, concerns about security and privacy remain a significant factor to broader adoption of IoT technologies. This highlights the crucial need for robust data protection and privacy measures within the interconnected world of IoT. Moreover, financial resources also play a critical role, as the costs associated with implementation and maintenance can pose significant challenges for potential IoT adopters. Perceived usefulness also acts as a key factor, indicating that individuals and organisations are more inclined to embrace IoT solutions when tangible benefits and value are evident. Successively, embracing new technology often requires a leap of faith, and trust becomes crucial in this context. In other words, trust in IoT technology comprises confidence in the technology, the data it handles, and the entities overseeing its implementation and operation. Therefore, when individuals trust the IoT devices, platforms, and providers managing their data, they can overcome anxieties and confidently embrace the IoT ecosystem.

3.2. Theoretical Distribution of the Studies on Factors Influencing IoT Adoption

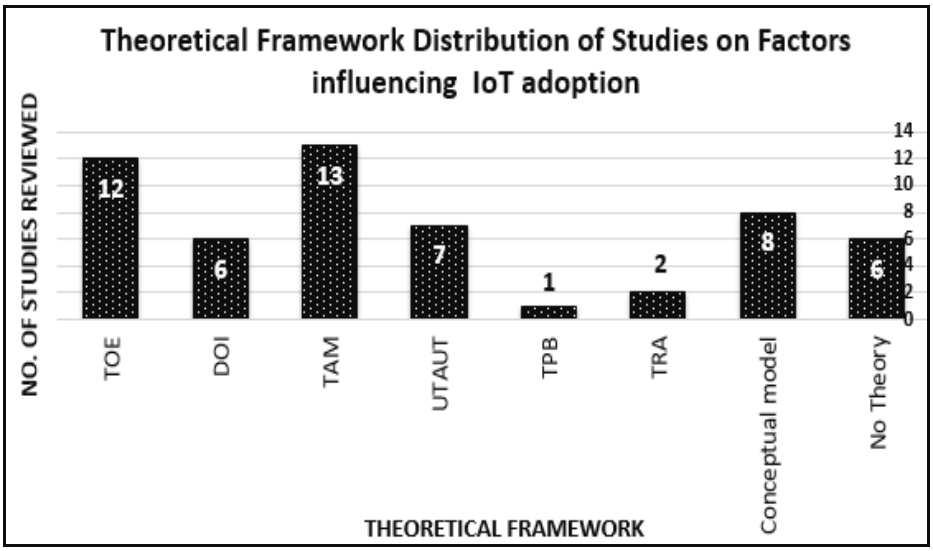

Figure 3. Theoretical distribution of studies on factors influencing IoT adoption: Source- author

Figure 3 summarises the theoretical frameworks adopted in studies on IoT adoption. The figure shows the most popular models are TAM, TOE, UTAUT, and DOI, with TAM being the most studied and DOI the least. Interestingly, due to the complexity of IoT adoption, many studies also used a conceptual model approach, while a few employed no theory at all. This clearly suggests that most research has focused on individual-level analysis of IoT adoption, compared to organisational-level analyses. However, it is important to note that while individual-level analysis are valuable, organisational-level factors also play a significant role in explaining IoT adoption factors. Therefore, this study will not only examine individual-level factors, but also consider organisational-level factors. Therefore, by taking a holistic approach that considers both individual and organisational factors, this study aims to provide a more nuanced understanding of the factors that influence IoT adoption in SMEs.

3.3. Justification of a Multi-theory Perspective Framework

Research indicates that the adoption of innovation is complex, forming a multifaceted tapestry where no single theoretical model comprehensively explains every aspect of technology behaviour [70]. Consequently, the robustness and versatility of theoretical models like TOE, DOI, TAM, and UTAUT make them popular choices for explaining IS adoption in research. This widespread application solidifies their position as leading frameworks in this field [71]. Nonetheless, driven by the research problem, objectives, and questions, this study supports a multi-theory perspective to analyses IoT adoption in SMEs. This approach integrates four widely recognised models: the TOE framework, DOI model, TAM, and UTAUT. By combining these models, we aim to unveil the intricate nature of IoT adoption at both individual and organisational levels. This aligns with research suggesting that combined models offer deeper insights and are therefore preferred [56]. Moreover, recognising the limitations of single models, several studies have highlighted the difficulty of conclusively proving one model's superiority over others [22]. In addition, literature supports a multi-theoretical perspective for explaining innovation adoption in organisations, highlighting its improved explanatory power and effectiveness [72].

3.4. Conceptual Model Development

The proposed conceptual model for this study is illustrated in Figure 4. This illustrates the integration of the core constructs from the integrated models (TOE, DOI, TAM, and UTAUT) and moderating factors (age, gender, computer experience, and educational level). The integration of these theories enhances the explanatory power of the proposed conceptual model. Furthermore, this approach also addresses limitations highlighted by Sun and Zhang [73], who observed that incorporating moderating factors like age, gender, and experience, can improve the low explanatory power of technology acceptance models. On

top of that, Venkatesh et al. [27] formerly observed that such factors (i.e. age, gender, education level and experience) can moderate the relationship between independent constructs and intention to use behaviour.

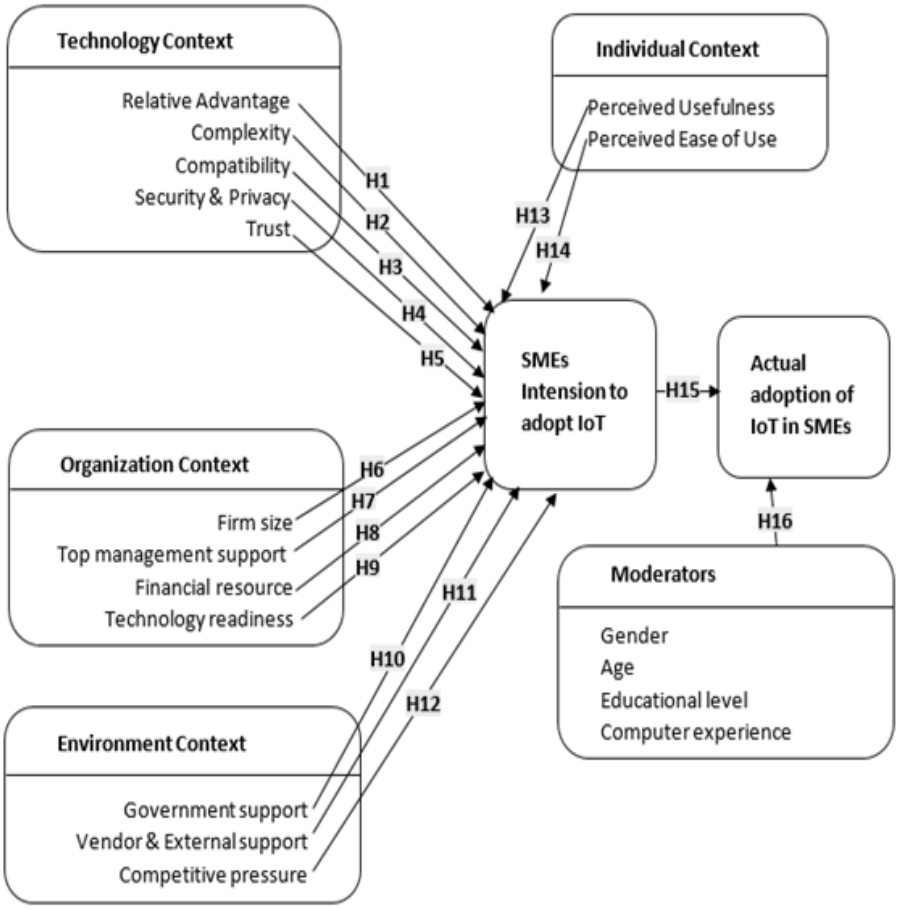

Figure 4. The proposed conceptual model of the study

The conceptual model proposed in Figure 4 has considered 20 constructs: 14 core constructs drawn from established technology adoption models (TOE, DOI, TAM, and UTAUT), 2 additional constructs identified through literature analysis (Security and privacy, Trust) and 4 moderating variables (age, gender, computer experience, and educational level). These components form the underpinning for formulating the study's hypotheses, which will subsequently guide the data analysis. This study hopes to improve the understanding of how the different dimensions (technological, organisational, environment and individual) affect IoT adoption by SMEs in developing economies.

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3.5. Research Hypothesis

3.5.1 Technology context

1) Relative advantage

Rahimi et al. [74] conceptualise relative advantage as the notion of replacing an idea or technology with a superior one. Within the SMEs context, relative advantage denotes the perceived benefits of adopting IoT in comparison to other ICT solutions. The adoption of IoT by SMEs can yield numerous advantages, such as optimised resource allocation, reduced waste, and decreased operational costs [9]. Similarly, embracing IoT can streamline processes, enhance operational efficiency, and afford SMEs a competitive edge [11], [59]. Thus, in light of this, we propose the following hypothesis:

> H1: The perceived relative advantage (e.g., economic benefits and operational benefits) of IoT will positively influence SMEs intensions to adopt it.

2) Complexity

Rogers [36] defines complexity as the perceived difficulty in comprehending and using an innovation. This concept plays a crucial role in technology adoption, as Mapande et al. [75] argue that complex innovations, requiring significant effort to understand, are less likely to be integrated into everyday workflows. Parra and Guerrero [60] identify the complexity of implementation, coupled with significant investment costs, as one of the major obstacles for SMEs venturing into the world of IoT. Hence.

> H2: The complexity of integrating and managing IoT devices will negatively influence the intention of SMEs to adopt IoT.

3) Compatibility

Rogers [36] underscores compatibility as a key factor in his DOI theory, defining it as the perceived ease of integrating an innovation with existing practices and systems. Compatibility plays a dual role in SME IoT adoption. This is because it ensures that the new technology aligns with existing organisational values [76]. On the other hand, compatibility also concerns the technical integration of various components. For instance, Wungcharoen[58], highlights that compatibility between sensors, networks, and applications from different vendors become critical for successful IoT integration in SMEs. Hence we hypothesis that:

H3: Compatibility of IoT with existing practices and systems will positively influence the intention of SMEs to adopt it.

4) Security and privacy concerns

Research has repeatedly identified security and privacy concerns as a major obstacle to IoT adoption in SMEs [77]. The very nature of IoT devices, characterised by their heterogeneity, widespread deployment, lack of standardisation, and limited resources, creates a unique landscape of security and privacy challenges [53], [78]. There we hypothesise that:

H4: Security and privacy concerns in IoT will negatively influence the intention of SMEs to it.

5) Trust

According to Nazron [79] research has firmly established a direct and positive correlation between trust and the adoption of IoT technologies. Corbitt [80] demonstrates that consumer trust in online shopping platforms enhances their confidence in making purchases. Mthembu [81] also observe that trust in e-commerce vendors significantly influences managers' decisions regarding adoption. These trust-related variables act as determinants for SMEs decisions for integrating IoT into their business operations [53]. There we hypothesise that:

H5: Trust in IoT will positively influence the intention of SMEs to adopt it.

3.5.2 Organisational context

1) Top management support

Top management stands as a crucial force in shaping the technology adoption decisions of SMEs [82]. Their endorsement and active involvement are essential for ensuring adequate resource allocation and fostering successful technology implementation [83]. Top management's optimism and enthusiasm for IoT can significantly boost employee confidence and provide vital encouragement for navigating the change process [84]. Hence, recognising this critical role of top managers, we propose the following hypothesis:

H6: Top management support will positively influence the intention of SMEs to adopt IoT.

2) Firm size

Firm size, measured by various metrics like employee count, revenue, or operational capacity, affects IoT adoption decisions for SMEs [85], [86]. Larger firms, fuelled by their greater resources and risk tolerance, seem poised for technological innovation [87]. However, SMEs, despite their agility, often lack the resources and knowledge readily to embrace such technologies [87]. Their smaller scale can also introduce bureaucratic hurdles and hinder adaptation processes [88]. Based on these considerations, we hypothesis that:

H7: Firm size will positively influence intensions of SMEs to adopt IoT.

3) Financial resource

Financial resources serve as a critical barrier or enabler for SMEs' adoption of IoT technologies [53]. Unlike larger enterprises, SMEs typically face stringent financial constraints [89], making the higher costs of IoT implementation a significant hurdle [12]. Therefore the following hypothesis is predicted as follows:

H8: Greater availability of financial resources will positively influence the intention of SMEs to adopt IoT technologies.

4) Technology readiness

Technological readiness describes an organisation's infrastructure, employee knowledge, and skills, plays a crucial role in IoT adoption [85]. Therefore, organisations with robust technological infrastructure and employees possessing updated IT skills and knowledge tend to be more technologically ready and thus more likely to adopt IoT [85]. Nugroho et al. [90] underscore that well-prepared SMEs can easily integrate IoT enabling them to leverage data-driven insights for growth and market expansion. Hence, we hypothesise that:

H9: Higher levels of technology readiness among SMEs will positively influence their intention to adopt IoT technologies.

3.5.3 Environment context

1) Government support

Government support can serve as a powerful catalyst and propelling SME's innovation adoption [91]. This support can manifest in diverse ways, ranging from establishing clear regulatory frameworks and guidance [92], to providing financial incentives and infrastructure assistance [93]. Government initiatives

providing infrastructure and IT support can bridge the gap for SMEs, paving the way for wider adoption of ICTs [94]. Therefore, hypothesise that:

> H10: Government support will positively influence the intention of SMEs to adopt IoT technologies.

2) Vendor/External support

Vendor support the assistance provided by IT/IS vendors in implementing and utilising the technology [95]. Bhattacharya and Wamba [96] echo this point, noting that SMEs often require customised solutions tailored to their specific needs and growth. Therefore, the availability of such tailor-made support, along with comprehensive guidance, can incentivise SMEs to invest in technology even with limited internal expertise. Therefore the following hypothesis is proposed:

> H11: Vendor/External support in IoT will positively influence the intention of SMEs to adopt IoT technologies.

3) Competitive pressure

Competitive pressure arises from a firm's rivals, creating a sense of anxiety about falling behind or experiencing financial losses compared to their peers [51]. Bhattacharya and Wamba [96] demonstrate how competitive pressure can lead to increased Radio Frequency Identification (RFID) adoption in firms, as witnessing the competitive advantages gained by rivals using RFID creates a sense of urgency to follow suit. Therefore, we predict the following hypothesis:

> H12: Competition pressure will positively influence the intention of SMEs to adopt IoT.

3.5.4 Individual context

4) PEOU

Suhartanto and Leo [97] suggest that PEOU can predict personal rejection of technology, meaning users are more likely to adopt IoT solutions they find easy to use. This is particularly relevant for SMEs, which often have limited resources and technical expertise [98]. Ali et al. [99] suggest users are motivated to adopt innovations that require minimal training and are easy to manage. Therefore, we propose the following hypothesis:

> H13: Perceived Ease of use will positively influence IoT adoption intentions in SMEs.

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5) PU

PU specifically focuses on the tangible benefits and return on investment that SMEs expect from adopting IoT technologies [59]. Research consistently shows that PU plays a crucial role in influencing the intention to adopt IoT technology [100]. Parab [11], deposit that specific applications of IoT, like using sensors for predictive maintenance, can significantly reduce downtime and maintenance costs for machinery, providing SMEs with a competitive edge. These tangible benefits further solidify the perceived usefulness of IoT adoption in SMEs. Hence, we hypothesise that:

> H14: Perceived Usefulness will positively influence IoT adoption intentions in SMEs.

6) Behavioural intentions (BI)

BI reflects users' positive or negative inclinations towards using a new technology [24]. More precisely Yass [101] describes BI as the motivation and purpose that drives individuals to utilise IT systems and applications. BI specifically focuses on the likelihood of SMEs adopting and using IoT systems and services. This intention serves as a crucial bridge between attitudes towards IoT and actual usage behaviour [102]. Research has consistently demonstrated the strong influence of BI on technology adoption [103]. Therefore we predict the following hypothesis:

> H15: Behavioural intention to use IoT services has a positive influence on actual IoT adoption behaviour among SMEs.

3.5.5 Moderator variables

1) Age

Venkatesh et al. [27] found that younger individuals prioritise perceived benefits when forming their adoption intentions, while older individuals place greater emphasis on ease of use and social influence from peers and colleagues. In this context, age is considered an important factor moderating innovation intentions adoption and will moderate factors influencing IoT adoption intensions in SMEs.

2) Gender

Gender has emerged as a key factor influencing technology adoption in the workplace Venkatesh and Davis [104]. Mandari and Chong [105] found that men and women demonstrate distinct patterns in adopting and utilising digital

innovations. Formerly, Venkatesh et al. [27] have shown that, performance expectancy's influence on the construct on intention to use is stronger for men, meanwhile Effort expectancy and social influence have a significant impact on women's intentions to adopt technology. In this perspective, gender is considered an important factor, and will moderate factors influencing IoT adoption intensions in SMEs.

3) Education level

Individuals' educational level significantly impacts their openness to adopting new technologies like the IoT. Higher education often translates to a stronger understanding of technology and its potential, leading to greater awareness and adoption [27], [28]. Inversely, limited educational background can breed anxiety towards technical complexities, perceived risks, and uncertainty about the return on investment, resulting in hesitation and lower adoption rates [106]. In this context, education level is considered an important factor and will moderate factors influencing IoT adoption intensions in SMEs.

4) Computer experience

To better align with the conceptual model and enhance its explanatory power, the variable "Experience" in the original UTAUT model was renamed to "Computer Experience" and introduced as an additional moderating factor. Coffman [107] asserted that individuals are more likely to adopt new technologies if they possess prior experience with similar or comparable technologies. In this manner, extensive prior knowledge fosters advanced ICT literacy and enhances system understanding [108]. Computer experience is considered an important factor and will moderate factors influencing IoT adoption intensions in SMEs.

Based on the prior mentioned considerations regarding the moderator variables, we propose the following moderator hypothesis:

> H16: The identified moderators (age, gender, education level, and computer experience) will have a positive moderating effect on the actual IoT adoption in SMEs.

4. CONCLUSION

Despite playing a crucial role in driving national economies, SMEs often face challenges when it comes to adopting cutting-edge technologies like the IoT. This study identifies five prominent factors, drawn from existing literature including technology readiness, security and privacy concerns, financial resources, perceived usefulness, and trust. These factors should be considered by

SMEs including the ones in Botswana about IoT adoption decisions in their organisations. To predict patterns of IoT use in the SMEs, these factors are integrated into a multi-theory framework that integrates well-established technology adoption theories such as the TOE, DOI, TAM and the UTAUT model. Several studies advocate for combination of relevant constructs from multiple theories to thoroughly investigate technology adoption in SMEs. Findings will assist researchers, policymakers, and practitioners in developing strategies to improve SME adoption of IoT in Botswana and other developing economies. The proposed framework serves as a foundational starting point for future empirical studies. Consequently, future research can explore this model further through case studies, refining it through application and testing in surveys. Ultimately, the findings suggest that the government or Ministry of Trade and Entrepreneurship in Botswana should consider guidelines across individual, technological, organisational, and environmental aspects to encourage SMEs to embrace emerging technologies like IoT.

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