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Original Article

Blockchain-Enabled Cloud Services for Secure and Transparent Data Management in SMEs

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Abstract *- This research investigates the key factors affecting the intention of Small and Medium Enterprises (SMEs) to adopt blockchain-based cloud services. The aim is to design sustainable and effective business ecosystems. The study refines the Unified Theory of Acceptance and Use of Technology (UTAUT) model to develop a theoretical framework. This framework evaluates how various factors, such as Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), Facilitating Conditions (FC), Trust (TR), and Security Concerns (SC), influence the Behavioral Intention (BI) to adopt blockchain-enabled cloud services. To achieve the research objectives, data were collected via an online questionnaire. A total of 273 valid responses from small enterprises in Somalia were collected and analyzed using Structural Equation Modeling (SEM). Empirical evidence indicates that the independent constructs PE, FC, SI, TR, SC, and BI are positively associated. The integration of Security Concerns (SC) and Trust (TR) concepts adds a significant contribution to the existing body of knowledge. The study's outcomes are particularly important for SMEs, offering valuable insights into encouraging technology adoption for sustainable and successful innovation.*

Keywords *- Blockchain, Cloud services, Data security, SMEs, UTAUT.*

1. Introduction

Blockchain Technology (BT) initially emerged as a Financial Technology (FinTech) primarily associated with the creation of distributed ledgers for Bitcoin. BT is gaining independent recognition while evolving into a foundational technology within the FinTech family [1]. Numerous specialists and scholars have recognized that blockchain's influence extends far beyond Bitcoin and transcends the financial sector, ushering in transformative shifts across various industries [2].

Within FinTech, blockchain stands out as one of the most auspicious cutting-edge technologies [1]. Blockchain can revolutionize numerous business processes within the financial sector and other commercial areas [3]. A blockchain may be expressed as a chain of data blocks, each meticulously designed to document transactions. Each block comprises a cryptographic hash of the preceding block, a timestamp, and transactional information [1]. Therefore, BT is vital in advancing financial innovations and is the core technology behind the Fintech revolution. However, its primary application has largely been focused on payment systems. The evolution of payment instruments and systems has been driven by advancements in technology, including business processes, alongside the ever-growing expectations of consumers. Moreover, the central goal of any payment system remains the facilitation of secure and intelligent transactions [4]. Besides, the emergence of cryptocurrencies or digital currencies, facilitated by BT, represents the most recent breakthrough in money transfer. Here, cryptocurrencies employ decentralized networks, cryptographic techniques, encryption methodologies, and Public Key Infrastructure (PKI), where sets of private and public keys ensure the secure exchange of information [5]. The need for reliable governments, intermediaries, private entities, and counterparties is eliminated, with trust being placed in the protocols and the supporting infrastructure instead [6].

Cloud Computing (CC) involves providing IT services, such as hardware, software, data, and shared resources, to clients on-demand rather than delivering them as separate products, enabling organizations to establish and maintain their position in the global markets [7] while reducing the expenditure associated with investments and maintenance of

IT infrastructure [8]. CC has five key characteristics that set it apart from traditional IT: resource pooling, fast elasticity, measurable services, on-demand self-service, and broad network access [9]. These characteristics facilitate the implementation of cost-efficient and adaptable IT solutions. With these solutions, businesses can improve operations and communications more quickly than traditional techniques and lower the cost of administering and maintaining IT systems [10]. Research on blockchain-enabled cloud services in SMEs is still in its early phases of development. However, it offers only qualitative explanations and arguments or fails to clarify the implementation of blockchain-enabled CC in SMEs with appropriate data substantiation.

This study examines the factors affecting SMEs' intentions to adopt blockchain-enabled cloud services, contributing to the body of knowledge on blockchain-based cloud computing. Furthermore, the research utilizes the UTAUT model to incorporate various perspectives into the analysis. The article is structured as follows: Section 2 provides an overview of blockchain technology and related literature, Section 3 details the theoretical framework, Section 4 describes the research methodology, Section 5 presents the results and findings along with the discussion, and Section VI concludes the study.

2. Literature Review

The digitalization of asset ownership is recognized as a significant advancement, with blockchain technologies playing a crucial role by enhancing transparency, security, and efficiency in managing assets. In addition to providing a secure and immutable audit trail, blockchain is recognized as a versatile platform that enables efficient management of ownership and contracts, enhancing trust and transparency [11]. Blockchain is a form of distributed ledger technology that guarantees the integrity of stored data, such as certificates, protecting it from accidental or intentional modifications [12]. BT offers two significant benefits: it establishes an immutable transaction record structured in distinct blocks that cannot be modified. It also replaces manual monitoring systems that are traditionally part of conventional business processes [13].

BT is commonly categorized into two types: private and public systems. Public blockchains typically allow participants to engage in transactions openly, whether they are aware of the parties' identities. Private blockchain systems require participants to have prior knowledge of each other's identities when conducting transactions. In terms of business decisions, there is a distinction between private and public blockchains. Additionally, public blockchains may potentially help organizations save money and time. In contrast, private blockchains can potentially eliminate traditional intermediaries in business transactions [14]. Blockchain has applications in numerous fields, serving as a decentralized infrastructure in commercial services, economic transactions, and prediction markets [15]. Blockchain has the potential to advance digital payments, financial auditing, and standard banking services, streamline the settlement of financial assets, improve existing banking systems, enhance central finance reporting, facilitate prediction markets, and optimize centralized operations. Furthermore, blockchain substantially shifts derivative transactions [16]. The potential of BT to transform markets and societies has led to significant investments from both private and public sectors in developing blockchain-driven applications [17]. The BT market is projected to reach approximately $7.59 billion by 2024, growing at a Compound Annual Growth Rate (CAGR) of 37.4%, driven by demand in finance, consumer goods, telecommunications, healthcare, and transportation [18].

Cloud Computing (CC) is gaining significant interest from researchers because of its ability to (I) foster inter-organizational relationships, (II) facilitate collaboration with customers, (III) enable responsiveness to environmental changes, and (IV) provide value for enterprises [9]. Three primary services are available to small businesses: Infrastructure as a Service (IaaS), which gives small and medium-sized enterprises virtualized hardware resources like CPU and storage so they can scale server services according to their needs; and changing developer application deployment methods [19], Software as a Service (SaaS) provides businesses with on-demand software hosted by service providers, allowing them to access software remotely over the internet and doing away with the need to purchase individual programs [20]. Platform as a Service (PaaS) provides developers with an integrated environment and tools to create applications without the necessity of maintaining the underlying infrastructure, supporting web services, APIs, and application development platforms [21].

Sharma et al. [22] studied IT professionals' adoption of cloud computing services and created a model that includes external dimensions of the Technology Acceptance Model (TAM), such as employment opportunities, trust, and self-efficacy. The findings show that perceived usefulness, ease of use, self-efficacy, trust, and employment prospects are critical drivers of adoption. Lian et al. [23] conducted a study to investigate the factors influencing cloud computing adoption in hospitals in Taiwan. They proposed a novel model by using the TOE theory. The findings showed that adoption is significantly influenced by several criteria, including perceived technical competency, data security, cost, and support from senior management.

3. Theoretical Framework

The Technology Acceptance Model (TAM) predicts user acceptance of ICT by analyzing the influence of perceived ease of use, perceived usefulness, and behaviors [24]. TAM suggests that these perceptions shape users' attitudes and intentions. Many empirical studies have applied this model to identify factors influencing the adoption of modern technologies and information systems [25]. Previous studies have highlighted the factors that influence the adoption of new technologies [26]. TAM is the most cited theory on technology acceptance and has gained increasing prominence over time [27]. Venkatesh et al. [25] provided in-depth explanations of advanced theories that detail the factors affecting IT acceptance, developing an integrated user acceptance theory by examining and analyzing established

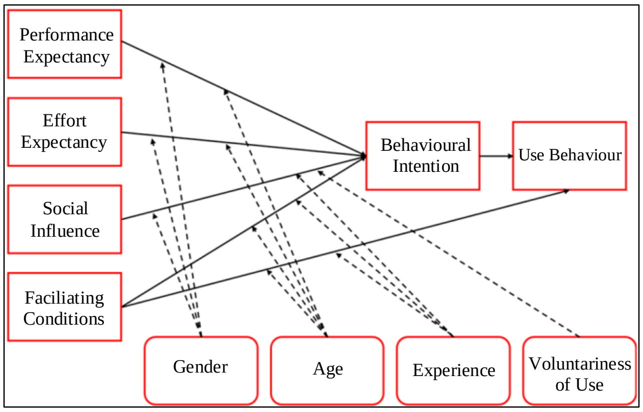

Fig. 1 The UTAUT theory

Figure 1 illustrates the UTAUT research model, which serves as the theoretical framework for this study. Existing theories suggest that the intention to use IT is influenced by four key factors: PE, EE, SI, and FC, alongside moderating variables such as gender, age, experience, and voluntary usage [25]. The four determinants primarily influence intention and behavior, while the behavior is directly influenced by facilitating conditions. PE refers to how new information technologies are perceived to enhance job performance, while EE relates to the perceived ease of using a system. SI refers to how individuals' important peers perceive the use of new technology. The FC determines how people feel the organization's technology and infrastructure benefit them when using the system. The influence relationship between moderating variables is explained by arrows pointing to the lines.

The social impact of blockchain adoption has been studied in Brazilian supply chains using the UTAUT model, while individual factors like age, experience, and income have been included in the IoT utilization model for intelligent farming [28]. The security factor is an essential metric for every Information System (IS) people use [29]. Previous researchers have provided a security image to guarantee transaction convenience, transaction accuracy, and an application that cannot be hijacked. Therefore, security is critical in users' decision-making process when employing the payment system.

Sadhya and Sadhya [30] identified security and vulnerability as crucial obstacles to technology adoption, underscoring the importance of balancing security with performance. The trust variable indicates a strong correlation between the level of trust and an individual's inclination to utilize BT [31]. Security and trust are essential factors to consider when using emerging technologies. The planned framework supporting trust is assumed to include security control [32]. Results from recent studies also demonstrate how trust and transparency affect people's intentions to accept blockchain applications.

4. Research Methodology

4.1. Conceptual Framework

To achieve the objective of the study, hypotheses were formulated to identify and empirically validate the factors influencing the acceptance of BT as a determining factor in addressing research issues. Figure 2 displays the proposed research model. The following are the research hypotheses of this study:

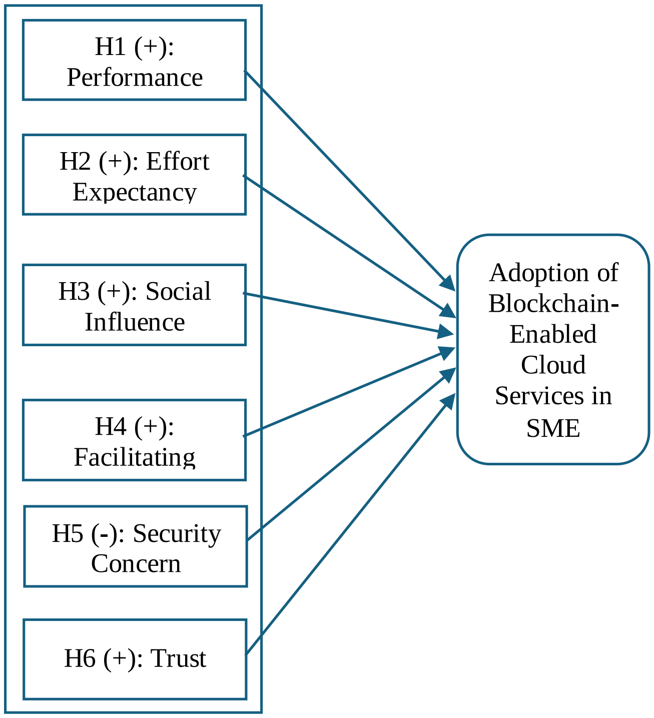

Fig. 2 Proposed research model

H1 : Performance Expectancy is a significant influence on the adoption of Blockchain-Enabled CC in SME
H2 : Effort Expectancy significantly influences the adoption of Blockchain-Enabled CC in SMEs.
H3 : Social Influence (SI) significantly influences the adoption of Blockchain-Enabled CC in SMEs.
H4 : Facilitating Conditions (FC) significantly influences the adoption of Blockchain-Enabled CC in SMEs.
H5 : Security Concerns (SC) significantly influence the adoption of Blockchain-Enabled CC in SMEs.
H6 : Trust (TR) significantly influences the adoption of Blockchain-Enabled CC in SMEs.

4.2. Participants and Data Collection

This research explores the factors that influence the adoption of blockchain-enabled cloud services within the SME sector in Somalia. The online questionnaire was conducted through Google Forms and distributed via email for easy access. It adhered to ethical research standards, guaranteeing informed consent and confidentiality. The study examined SMEs in Mogadishu, Somalia, which were chosen to reflect the target audience. SEM was the statistical analysis approach employed in the study, which gathered 273 valid participant responses. The researchers created an English-language questionnaire to collect data on the constructs of a conceptual model. The survey consists of two sections: respondent details and factors relevant to the research model, with 25 items in total, including four items for the PE variable, four items for EE, four for FE, three for SI, four for SC, three for TR, and three for BI. The Likert scale was used to measure attitudes. The researchers used SPSS software to conduct inferential and descriptive statistical analyses on the study participants' demographics and screen data for quality and missing values. The SmartPLS validated the research model, using the criteria in Figure 3 to assess the measurement model.

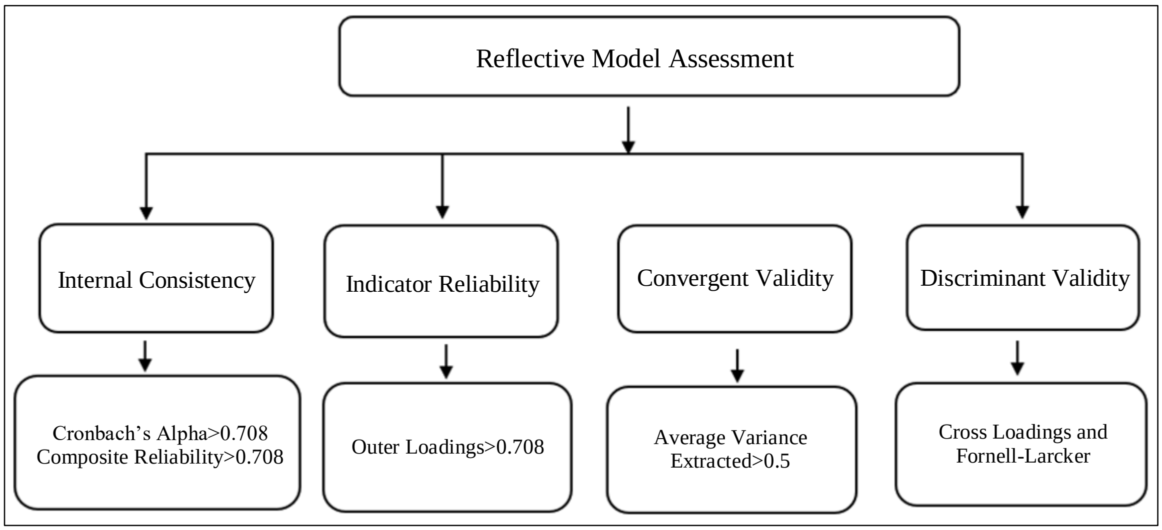

Fig. 3 Measurement model criterion

5. Results and Findings

5.1. Demographic Characteristics

The demographic profile showed 80% male and 20% female participation. 55% employ less than 20 people, whereas 12% employ more than 100. Regarding IT workers, 75% have 3 to 5, and 15% have more than 6. The result found that 88% of respondents had broadband (Internet) access, while 11% did not. Around 47.69% of respondents utilize SaaS, and 30.25% use PaaS for CC. Around 39.5% of respondents can pay for a single-user license, and 23.6% can afford an annual or monthly membership fee.

5.2. Measurement Model

The measurement model evaluates construct quality through validity and reliability analysis, including factor loadings, Cronbach's alpha, Composite Reliability (CR), Average Variance Extracted (AVE), and Variance Inflation Factor (VIF) for multicollinearity assessment. The measurement model was evaluated to determine its reliability and accuracy. Factor loadings between 0.50 and 0.70 were considered suitable [33]. Sarstedt et al. [34] Proposed removing indicators with factor loadings between.40 and. 70 to increase internal consistency. The factor loadings for these indicators ranged from 0.659 to 0.932, falling within the acceptable range, as indicated in Table 1. Sarstedt et al. [34] proposed that convergent validity required an AVE value greater than 0.50. Additionally, Chua [35] and Ringle et al. [36] recommend that an acceptable value of AVE be greater than or equal to 0.50. All values were found to be higher than the lowest acceptable threshold. Composite reliability was used for reliability testing because it provides a more accurate estimate [34]. All the items had CR values that were higher than the minimum requirement of.70, with acceptable values ranging from 0.836 to 0.942.

Convergent validity is evaluated through factor loading and AVE, which measure how well the latent construct accounts for the observed variability in an indicator [34]. Table 1 shows the results of determining convergent validity using AVE and factor loading. Discriminant validity is a construct's capacity to differentiate itself from others based on empirical data [37]. Chin [38] and Fornell and Larcker [39] developed two approaches for assessing discriminant validity in Partial Least Squares (PLS) studies, using HeterotraitMonotrait Ratios and the Fornell-Larcker Criterion. According to Chua [35], The Fornell-Larcker criteria assess a discriminant validity by calculating the square root of the AVE for all variables. This suggests that the variables are more strongly correlated with one another. The findings indicate significant discriminant validity.

Table 1. Measurement model

Variables	Item	Loading	CRONBACH'S ALPHA	rho_A	CR	AVE	VIF
Performance Expectancy	PE01	0.914	0.907	0.915	0.934	0.781	3.235
	PE02	0.861					2.459
	PE03	0.886					2.682
	PE04	0.873					2.680
Effort Expectancy	EE01	0.734	0.746	0.788	0.836	0.563	1.604
	EE02	0.818					1.389
	EE03	0.659					1.248
	EE04	0.780					1.765
Social Influence	SI01	0.893	0.907	0.914	0.942	0.844	2.547
	SI02	0.931					3.480
	SI03	0.932					3.304
Facilitating Conditions	FC01	0.900	0.893	0.908	0.925	0.755	3.117
	FC02	0.852					2.075
	FC03	0.832					2.272
	FC04	0.890					2.810
Security Concern	SC01	0.899	0.869	0.884	0.911	0.718	2.877
	SC02	0.820					1.954
	SC03	0.785					1.748
	SC04	0.882					2.760
Trust	TR01	0.834	0.816	0.819	0.891	0.732	1.740
	TR02	0.850					1.761
	TR03	0.881					2.010
Behavioral Intention	BI01	0.871	0.829	0.835	0.898	0.745	1.930
	BI02	0.825					1.735
	BI03	0.893					2.224

The HTMT was employed in the study to evaluate the discriminant validity. HTMT criteria are established by comparing the average correlation between indicators across various constructions to the average correlation across indicators that measure the same construct [34]. According to Chua [35], The results of the HTMT correlation ratio test should be less than 0.90, which might be interpreted as suggesting discriminant validity.

The study applied the Goodness of Fit method to evaluate the model's fit, as shown in Table 2. It assessed model fit using SRMR, d ULS, and NFI, utilizing the PLS-SEM for goodness of fit to prevent model misspecification [34]. The study employed d_LS and d_G to calculate differences, with statistical significance p >0.05. Both d_LS and d_G meet the criteria, which suggests they are acceptable. The study evaluated the model's overall fit using the Normed Fit Index (NFI), which is considered good when it exceeds 90. The model shows an acceptable degree of fit, as shown by the study in Table 2.

Table 2. Model fit

Fit indices	SRMR	D-ULS	DG	NFI
Suggest Value	<0.10	>0.05	>0.05	>0.9
Recommended Values	0.07	1.46	0.88	0.94

5.3. Structural Model

Structural model assessment is essential for determining the significance and relevance of proposed relationships, employing various metrics to evaluate their effectiveness [40]. The metrics used in this research included assessing construct collinearity and calculating coefficients of determination (R2), Predictive Relevance (Q2), and F Square (F2) Value by examining the importance and relevance of route coefficients.

5.3.1. Collinearity Value

The study assessed the model for the possibility of collinearity, which could result in biased route coefficients. Because the data was acquired from a single source using the same instrument, a diagnostic test was performed to identify common technique bias.

According to the findings, all variables had Variance Inflation Factor (VIF) values below 5, as proposed in [41]. The results did not reveal any problems with common procedure bias. The results of the collinearity are shown in Table 1.

5.3.2. The Coefficients of Determination (R2), Predictive Relevance (Q2), And F Square (F2) Value

The Coefficient of Determination (R^2) was used to evaluate the structural model's predictive accuracy, examining its capacity to reliably predict outcomes with the dependent variable, as the results are shown in Table 3 [34]. Falk and Miller [42] proposed that R2 values of .10 or above are necessary for the variance explanation of a particular endogenous concept to be regarded as appropriate.

According to Cohen [33], The R2 values of endogenous latent variables should be evaluated on a scale of .26 (substantial), .13 (moderate), and .02 (weak). The value of R2 on the intention to implement blockchain-enabled cloud services in SMEs is 54.8%, as shown in Table 5. Q^2 is a statistical measure that evaluates a model's predictive significance, with values greater than zero suggesting that the values have been well-reconstructed. According to Sarstedt et al. [34], the effect levels for each impact are as follows: weak (.02), moderate (.15), and high (.35).

Table 3 shows the study's Q^2 findings, which show Q^2 values of 0.481 for intention to use blockchain-enabled cloud services in SMEs. This supports the model's predictive validity since the predicted Q2 values are above zero.

Table 3. The coefficients of determination (R2), predictive relevance (Q2)

Variable	R2	Adjusted R2	Q2
Behavioural Intentions	0.548	0.519	0.481

The F2 is a statistical technique used to examine the influence of removing elements from a model on the R2 value. This evaluation determines whether these modifications significantly impact the endogenous structure. The value of f-square is .02 (small), .15 (medium), and .35 (large) [33, 34]. The results in Table 4 indicate that the F2 analysis values significantly affect SMEs' intention to adopt blockchain-enabled cloud services.

5.3.3. The Significance of Path Coefficients

Sarstedt et al. [34] suggest that 5000 resamples are needed to investigate conventional beta, R2, and t-values. Table 4 and Figure 4 evaluated each parameter and matrices mentioned above. The findings of the study revealed a significant relationship among FC, PE, TR, and SI with the intention to adopt blockchain-enabled cloud services.

As a result, the following hypotheses are supported: (H2 β=0.186, p<0.031, f2=0.050, H3 β=0.228, p<0.012, f2=0.057, H4 β=0.225, p<0.007, f2=0.066, H6 β=0.191, p<0.022, f2=0.045). The study found that Effort Expectancy and Security Concern had no impact on the intention to adopt blockchain-enabled cloud services (H1 β=0.017, p>0.434, f2=0.000, H5 β=0.121, p>0.085, f2=0.017). Therefore, H1 and H5 were not supported.

Table 4. Structural model hypothesis testing

Hs	Path	Std. Beta	SE	t-Value	F2	p-Values	Supported
H1	Effort Expectancy -> Behavioral Intentions	0.017	0.099	0.166	0.000	0.434	No
H2	Facilitating Conditions -> Behavioral Intentions	0.186	0.099	1.872	0.050	0.031***	Yes
H3	Performance Expectancy -> Behavioral Intentions	0.228	0.101	2.267	0.057	0.012***	Yes
H4	Trust -> Behavioral Intentions	0.225	0.092	2.452	0.066	0.007***	Yes
H5	Security Concern -> Behavioral Intentions	0.121	0.088	1.373	0.017	0.085	No
H6	Social Influence -> Behavioral Intentions	0.191	0.094	2.023	0.045	0.022***	Yes

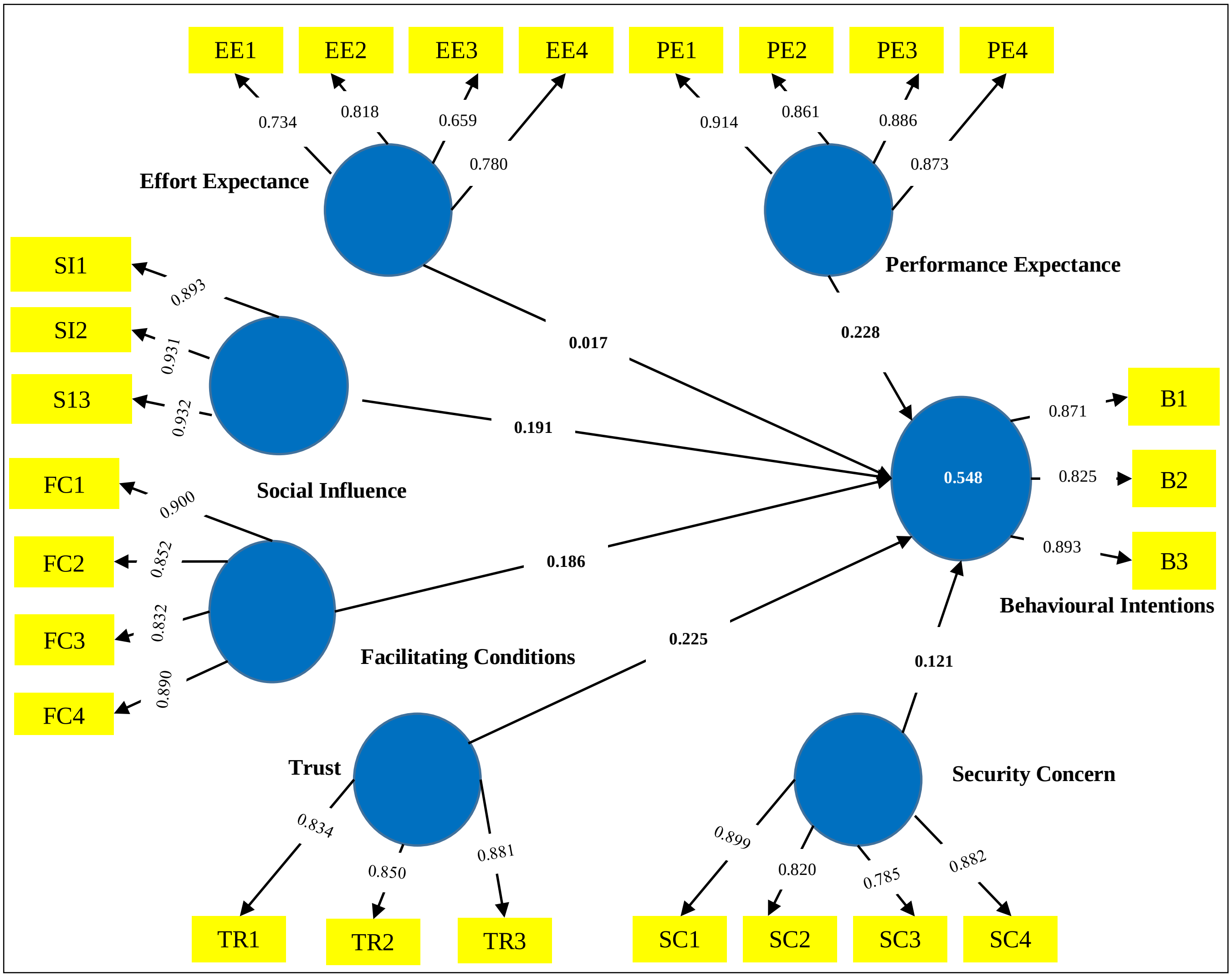

Fig. 4 Structural model

6. Discussion

This research study examines the factors influencing SMEs to adopt blockchain-enabled cloud services to create sustainable and profitable business ecosystems. This study proposed a research framework that extends and modifies the UTAUT model by incorporating TR and SC constructs while removing BU variables, as shown in Figure 2. The empirical study has supported the hypotheses, highlighting each construct's impact on the behavioral intention to adopt blockchain-enabled cloud services in SMEs.

Firstly, the findings show a positive correlation between PE and BI. SMEs are more likely to adopt blockchain-enabled cloud services when they perceive the technology as valuable and effective in achieving desired outcomes. It is essential to align the primary features of blockchain-enabled cloud services with the specific requirements of SMEs to increase platform adoption effectively. The platform will become more exciting and valuable to them, so they are more likely to use it if customized to solve their specific difficulties and requirements.

Additionally, the findings support the H6 hypothesis, which proposes a positive correlation between SI and BI. The findings suggest that social factors, such as input from trustworthy individuals within their social networks, play a role in SMEs' decisions regarding whether to embrace the platform. Promoting a feeling of community and social engagement among small businesses could be an effective technique for capitalizing on this discovery and further enhancing the adoption of blockchain-enabled cloud services. The study shows that the FC (H2 hypothesis) strongly impacts SMEs' behavioral intention to embrace blockchain-enabled cloud services. This finding was made in relation to the actual utilization of blockchain-enabled cloud services. The study also confirmed a negative relationship between EE and BI (H1 hypothesis). SMEs are more likely to adopt blockchain-enabled cloud services when they perceive them as easy to use. Enhancing the platform's usability and accessibility for small businesses can promote adoption by reducing perceived barriers and increasing acceptance rates.

The study shows that the TR (H4 hypothesis) had an insignificant impact on BI. Blockchain-enabled cloud services allow SMEs to quickly establish trust in the platform, ensuring transparency in their business transactions. Traditional methods are error-prone due to the large volumes of data handled by similar businesses. The study showed a positive connection between SC and BI (H5 hypothesis). Security issues play a crucial role in relationship quality, influencing the desire to adopt blockchain-enabled cloud services. Ensuring users' perception of data and financial security is essential. While security is shaped by individual viewpoints, providing information and guarantees about data safety can enhance users' perception of blockchain security.

6.1. Theoretical Implications

This paper contributes to several important theoretical advancements. First, to the best of our knowledge, this is the first attempt to conduct a comprehensive analysis of blockchain-enabled cloud services in SMEs. Extending the UTAUT model by including trust and security concern factors is the strength of this study, even though very few previous studies have addressed blockchain adoption using the UTAUT model. Our research model has a strong explanatory power (0.54), which supports this.

Second, it is essential to emphasize that PE, TR, SI, FC, and SC variables are relevant to blockchain-enabled cloud services in SMEs. This requires modifying the UTAUT framework to include contextual elements to explain the adoption of blockchain-enabled cloud services in SMEs. The findings could be useful for future research on technology adoption and give an integrative model that may be used to evaluate the impact of behavioral factors on adopting new technologies.

6.2. Limitation of the Study

This study has some limitations that should be addressed. First, the authors only focused on SMEs in Somalia; other developing countries may reveal different conclusions. Second, this study did not investigate the moderating effects of demographic characteristics of users, such as age, gender, voluntariness, and experience. Finally, future research could investigate alternative methodologies, such as a qualitative study incorporating interviews, to facilitate a more comprehensive assessment of blockchain-facilitated cloud services. Overall, this study has made significant progress in understanding blockchain-enabled cloud services in SMEs, and future research should consider these constraints and broader settings to produce more robust results.

7. Conclusion

This study aims to identify the factors that influence the willingness of small businesses to implement blockchain-enabled cloud services in SMEs. The ultimate objective is to establish sustainable and successful business ecosystems within the SME domain. To achieve this goal, the authors integrated the TR and SC constructs into the UTAUT model, representing an extension and customization of the model. The empirical research has demonstrated that there are positive connections between several different variables, including PE, FC, and SI, as well as the TR of blockchain-enabled cloud services. The results have both theoretical and practical implications.

Theoretically, the study contributes to the literature by providing insights into adopting innovative technology platforms and filling gaps in previous studies. This study contributes to a better understanding of new innovative technology in SMEs by highlighting the importance of considering TR and SC in decision-making. This study provides valuable information for small business stakeholders, including policymakers. Policymakers can promote SMEs' adoption of blockchain-enabled cloud services by providing targeted support and incentives based on understanding the critical factors influencing adoption decisions. Future research should investigate different industries to validate the findings across other sectors. Furthermore, this study did not take individual aspects like gender, age, and experience into account, which presents a chance for additional research to examine their possible impact on platform adoption.

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