



Digital Ecosystem Barriers and E-Commerce Adoption among SMEs in Least Developed Countries: An Empirical Study from Sudan

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Abstract

Purpose: This study examines how barriers in the digital ecosystem influence e-commerce adoption among SMEs in Sudan, offering insights from a least-developed-country context

Design/methodology: A qualitative methodology was utilised, involving semi-structured interviews with SME owners and managers, followed by thematic analysis of the collected data.

Findings: The results demonstrate that e-commerce adoption is hindered by several interconnected barriers, including inadequate digital infrastructure, cybersecurity risks, inefficient logistics and supply chain systems, weak regulatory and legal frameworks, limited digital literacy, geopolitical instability, and challenges with online payments. Together, these factors discourage investment in e-commerce technologies. The study also finds that addressing these ecosystem-level barriers requires coordinated action from governments, financial institutions, technology providers, and SME support organisations.

Originality/value: This research offers practical recommendations for policymakers and stakeholders seeking to enhance the digital ecosystem and promote SME participation in the digital economy. It also contributes to the literature on digital transformation and technology adoption in least developed countries by providing qualitative evidence on the ecosystem conditions that influence e-commerce adoption in Sudan.

Keywords: Digital Ecosystem, E-Commerce Adoption, Small And Medium-Sized Enterprises (Smes); Sudan, Least Developed Countries

Introduction

The rapid expansion of the digital economy has fundamentally reshaped how businesses operate, compete, and create value across global markets (Judijanto, 2024). E-commerce, a core component of this transformation, has become a strategic channel for firms to reach wider markets, reduce operational costs, and enhance customer engagement (Azeez, 2026). Small and medium-sized enterprises (SMEs), which account for a significant share of businesses and employment worldwide, are increasingly encouraged to adopt digital technologies to sustain competitiveness in a digitalised global economy (Kumar & Sharma,

2023). Despite this global trend, e-commerce adoption among SMEs remains uneven, particularly in developing and least developed countries, where structural and institutional constraints continue to limit digital transformation (Abdullah et al., 2026).

In developed economies, robust digital infrastructure, effective regulatory frameworks, secure payment systems, and high levels of digital literacy support e-commerce (Khan & Hassan, 2023). These conditions have fostered integrated digital ecosystems that enable seamless online transactions and business operations (Kim & Lee, 2024). By contrast, many developing countries face persistent challenges that hinder e-commerce implementation. These include poor internet connectivity, limited access to digital payment platforms, weak logistics networks, inadequate cybersecurity, and a lack of supportive regulatory environments (Alzahrani, 2023). As a result, small and medium-sized enterprises (SMEs) in these areas often struggle to fully benefit from digital commerce, despite its potential to boost productivity and expand market access (Ahmed & Rahman, 2024).

In the least developed countries, these challenges are compounded by economic weaknesses and unstable institutions (Muhammad et al., 2026). The absence of a mature digital ecosystem limits SMEs' ability to engage effectively in digital markets (Zheng et al., 2025). Barriers within the digital ecosystem, including technological, organisational, and environmental constraints, significantly shape firms' decisions to adopt or reject e-commerce technologies (Rahman & Islam, 2023). While previous research has examined individual factors that affect e-commerce adoption, such as perceived usefulness, technological readiness, and organisational capability, fewer studies have taken a comprehensive view of how digital ecosystem barriers interact, particularly in fragile and low-income economies.

Sudan is a critical yet under-researched context for understanding e-commerce adoption in least developed countries. The country faces multiple structural challenges, including unreliable internet infrastructure, limited broadband coverage, underdeveloped digital payment systems, and weak logistics and delivery networks (Abdalla et al., 2025). In addition, regulatory uncertainty, limited institutional support for digital entrepreneurship, and broader geopolitical and economic instability further constrain the development of digital business models (Sleiman et al., 2022). These conditions create a complex operating environment for SMEs, making e-commerce adoption difficult and risky. Consequently, many SMEs in Sudan remain reliant on traditional business models, limiting their growth potential and competitiveness in regional and global markets.

Although research has examined technology adoption and digital transformation in developing countries, a significant research gap remains regarding the impact of digital ecosystem barriers on e-commerce adoption among small and medium-sized enterprises (SMEs) in least developed countries such as Sudan. Quantitative approaches and the isolation of factors in most prior research do not fully capture the contextual and experiential realities of SME owners and managers. Additionally, qualitative evidence that provides comprehensive insight into how SMEs perceive and respond to these interrelated barriers in fragile economies is scarce.

To address this gap, this study explores the barriers within the digital ecosystem that influence e-commerce adoption among SMEs in Sudan, using a qualitative approach. It seeks to provide

a comprehensive understanding of the technological, organisational, and environmental constraints that shape adoption decisions. By focusing on the lived experiences of SME owners and managers, this research contributes to a more nuanced understanding of digital transformation challenges in least-developed countries.

The main objectives of this study are: (1) to identify the key barriers within the digital ecosystem that affect e-commerce adoption among SMEs in Sudan; (2) to explore how these barriers interact and influence adoption decisions.

The study is guided by the following research questions: What are the key barriers within the digital ecosystem that affect e-commerce adoption among SMEs in Sudan? How do these barriers influence SMEs' decisions to adopt e-commerce?

This study makes several contributions to the literature. Theoretically, it extends research on digital transformation and technology adoption by integrating a digital ecosystem perspective that captures the multidimensional barriers faced by least developed countries. Empirically, it provides qualitative evidence from Sudan, a context that remains underrepresented in e-commerce adoption research. In practical terms, the findings offer insights for policymakers, financial institutions, and digital service providers seeking to strengthen the digital ecosystem and support SME participation in the digital economy.

Literature Review

E-commerce

Electronic commerce (e-commerce) is the buying, selling, marketing, and exchange of products, services, and information via electronic networks, particularly the Internet (Indiani et al., 2025). It enables businesses and consumers to conduct commercial transactions without the constraints of physical location or time (Alaskar et al., 2023). Rapid advances in information and communication technologies, mobile technologies, and digital payment systems have significantly accelerated e-commerce development worldwide, transforming traditional business operations into digital business models (Laudon & Traver, 2024).

Over the past two decades, e-commerce has grown rapidly worldwide, driven by rising internet penetration, smartphone adoption, innovations in digital payments, and improvements in logistics infrastructure (Ben Youssef & Dahmani, 2023). The COVID-19 pandemic further accelerated digital transformation, prompting businesses and consumers to shift towards online transactions (Yuwono et al., 2024). Both developed and developing economies have seen significant growth in online retail, digital marketplaces, and cross-border e-commerce (Kumar & Sharma, 2023). However, e-commerce growth remains uneven across countries. While developed economies benefit from advanced digital infrastructure and supportive regulatory environments, least developed countries continue to face substantial challenges, including limited ICT infrastructure, inadequate digital payment systems, weak logistics networks, and regulatory barriers that constrain the adoption of digital technologies (Hendricks & Mwapwele, 2024).

Importance of E-commerce for SMEs

E-commerce offers significant opportunities for small and medium-sized enterprises (SMEs) by providing access to national and international markets at relatively low investment costs

(Yuwono et al., 2024). By using online platforms, SMEs can improve customer engagement, increase sales, enhance operational efficiency, and compete more effectively with larger firms (Hossain et al., 2025). E-commerce also fosters innovation, business resilience, and economic growth by reducing geographic barriers and enabling continuous operations (Shahadat et al., 2023). Despite these benefits, SMEs in many least developed countries struggle to adopt e-commerce due to limited digital skills, inadequate infrastructure, financial constraints, and institutional barriers (Masran & Azaze, 2022). Understanding these challenges is therefore important for developing policies and strategies that advance digital transformation and sustainable SME development, particularly in countries such as Sudan.

Least Developed Countries (LDCs) Context

In 1971, the United Nations (UN) introduced the term "Least Developed Countries" (LDCs) to describe low-income countries facing severe structural barriers to sustainable development. The classification was intended to provide these nations with targeted international support, such as preferential trade access, development aid, or technical cooperation (Judijanto, 2024). LDCs are defined by three main criteria: gross national income (GNI) per capita, human assets, and economic and environmental vulnerability (United Nations Committee for Development Policy, 2024). These criteria are crucial for determining a country's LDC status. As outlined in UN Security Council resolutions, Sudan has been categorised as one of the Least Developed Countries for an extended period due to severe economic difficulties, inadequate institutional capacity, infrastructure shortcomings, and susceptibility to political and environmental shocks (Sleiman et al., 2022). Given these characteristics, it is reasonable to focus on the challenges of establishing digital ecosystems and promoting e-commerce among small and medium-sized enterprises (SMEs).

The United Nations has classified these countries as having low per capita incomes, poor human capital, low levels of economic and social development, and high susceptibility to environmental degradation. Despite rapid progress in digital technologies and e-commerce, the challenge of effectively digitalising businesses remains prevalent in LDCs. Despite its potential advantages, e-commerce is still hindered by insufficient digital infrastructure and logistics systems, a lack of regulatory frameworks, inadequate digital skills (Masran & Azaze, 2022), cybersecurity risks, and limited access to finance.

Sudan's inclusion in the group of Least Developed Countries makes these issues particularly worthy of discussion. A range of economic and institutional factors shape the country's digital transformation and online business practices (Abdalla et al., 2025). Sudanese SMEs must identify barriers to e-commerce adoption within the digital ecosystem and develop policies and strategies to accelerate digitisation and promote sustainable development (Sleiman & Reider, 2022). Sudan's findings may also serve as a valuable resource for other least-developed nations facing comparable structural and technological challenges.

E-commerce Adoption by SMEs in Least Developed Countries

E-commerce has enabled SMEs to expand their market reach, reduce transaction costs, improve operational efficiency, and compete in international markets (Hossain et al., 2025). By utilising digital channels, SMEs can attract new customers, streamline supply chains, and become increasingly integrated into the global virtual economy (Shahadat et al., 2023).

Despite many opportunities, SMEs in LDCs are less likely to participate than those in developed or emerging economies (Mustafa et al., 2022). Structural challenges in LDCs include inadequate digital infrastructure, limited internet access, weak logistics systems, a lack of digital payment methods, cybersecurity concerns, regulatory uncertainties, and low levels of digital proficiency (Abdullah et al., 2026). In Sudan, the growth of online business is evidently hindered by long-standing economic challenges, unclear political circumstances, poor internet and technology infrastructure, and insufficient support from organisations (Sleiman et al., 2022). While the internet and mobile phones have become more prevalent in Sudan, many small businesses remain reliant on traditional practices and are slow to adopt online sales (Mosbah, 2017). Why is this so? We need to understand the challenges that prevent these businesses from moving online so we can develop better policies and plans to help them grow competitively, not only in Sudan but also in other low-income countries.

By examining the impact of digital ecosystem barriers on SME adoption in Sudan, this study seeks to provide policymakers, practitioners, and researchers with evidence to promote a more inclusive digital economy in Least Developed Countries.

Digital Ecosystem Concept

The term Digital Ecosystem was coined in Europe in March 2002 at an international meeting of the European Union in Lisbon, Portugal (Francesco et al., 2002). The concept was widely regarded as innovative and was seen as strong support for ICT adoption. Through the Lisbon Agenda, the Digital Business Ecosystem was adopted as a pilot project in Europe to actively incorporate ICT research priorities into business information systems (Hossain et al., 2025).

As digital technologies have reshaped business environments and economic activity, the concept of a virtual digital ecosystem has gained prominence (Shahadat et al., 2023). A digital ecosystem is a network of organisations, individuals, technologies, institutions, and digital platforms that interact to create, share, or capture value through digital technology. As in a biological ecosystem, the system's sustainability and performance depend on multiple stakeholders who interact with one another (Mustafa et al., 2022).

Autio and Thomas (2020) describe digital ecosystems as socio-technical systems that integrate digital technologies, business actors, and institutional arrangements to foster innovation and value creation. Similarly, Senyo et al. (2019) define digital ecosystems as networks of information and communication among organisations that enable collaboration, knowledge exchange, and the delivery of products and services via digital platforms. The effectiveness of a digital ecosystem depends on the quality of its technological infrastructure, governance structures, institutional backing, and stakeholder engagement (Muhammad et al., 2026). E-commerce relies on digital ecosystems as the foundation for efficient online business activities (Hossain et al., 2025). Digital platforms, payment systems, logistics providers, regulatory institutions, telecommunications networks, and technology service providers enable online business transactions to occur more quickly (Mustafa et al., 2022).

The Role of Digital Ecosystems in Digital Transformation and E-commerce Adoption

Digital ecosystems are critical to accelerating digital transformation, enabling organisations to integrate digital technologies into their business processes and value-creation activities (Mustafa et al., 2022). By collaborating with technology providers, financial institutions,

logistics companies, governments, and digital platforms, businesses can access the resources required to achieve successful digital transformation (Shahadat et al., 2023).

For SMEs, a well-developed digital ecosystem lowers barriers to e-commerce adoption by providing affordable internet access, secure payment solutions, reliable logistics services, digital skills development, and supportive government regulations (Masran & Azaze, 2022). These ecosystem elements reduce operational uncertainty and increase the perceived benefits of adopting e-commerce technologies (Hossain et al., 2025). Conversely, weaknesses in the digital ecosystem, including poor ICT infrastructure, limited availability of digital payment methods, inadequate logistics systems, weak regulatory support, and low digital literacy, can significantly hinder SMEs' e-commerce adoption (Alzahrani, 2023). These challenges are particularly evident in least developed countries such as Sudan, where institutional and technological constraints continue to slow digital transformation.

Therefore, understanding barriers within digital ecosystems is essential for explaining variations in SMEs' e-commerce adoption and for developing effective policies that support digital economic development in least-developed countries.

Digital Ecosystem Barriers

Barriers within digital ecosystems include technological, institutional, economic, and social challenges that impede business participation in digital economic activities (Shahadat et al., 2023). These barriers hinder e-commerce adoption by limiting firms' access to digital tools, online transactions, and digital markets (Hossain et al., 2025). In least developed countries (LDCs), small and medium-sized enterprises (SMEs) frequently encounter these obstacles, which constrain their digital transformation and engagement with e-commerce (Mustafa et al., 2022).

ICT Infrastructure

Information and Communication Technology (ICT) infrastructure underpins digital commerce by providing internet access, telecommunications, cloud services, and data management (Masran & Azaze, 2022). When ICT infrastructure is reliable, businesses can communicate with customers, process online transactions, and manage digital operations effectively. Many small and medium-sized businesses in the least developed countries face ICT infrastructure challenges, including weak broadband, unreliable electricity, slow internet speeds, and limited access to digital tools (Shahadat et al., 2023). These issues reduce the effectiveness of online business and often prevent companies from adopting e-commerce (Muhammad et al., 2026).

Affordable and accessible Internet services are essential for digital inclusion and participation in e-commerce (Mustafa et al., 2022). High Internet costs and limited network coverage hinder SMEs from operating online (Sleiman et al., 2022). The International Telecommunication Union (ITU, 2023) reports that in many least developed countries, high data costs, poor rural connectivity, and unreliable Internet infrastructure constrain the growth of digital business. Lowering Internet costs can enable more SMEs to participate in e-commerce and the digital economy.

ICT infrastructure in Sudan is severely affected by conflict, ongoing political unrest, corruption, unreliable electricity, limited internet connectivity across several regions, high costs, and inadequate investment (Sleiman et al., 2022). A significant digital divide between urban and rural areas persists due to limited connectivity (Mosbah, 2017). The country also faces insufficient broadband infrastructure and a lack of ICT skills (Abdalla et al., 2025). These problems impede education, healthcare, business development, and digital government services. Improving the situation requires investment in telecommunications, power infrastructure, digital skills, and supportive policies.

Digital Payment Systems

Digital payment systems enable electronic financial transactions through platforms such as online banking, mobile money, digital wallets, payment gateways, and credit cards (Kim & Lee, 2024). Reliable and secure payment systems are essential for e-commerce, facilitating transactions and enhancing customer confidence (Azeez, 2026). However, digital payment services remain underdeveloped in many least developed countries due to weak financial infrastructure, low banking penetration, regulatory restrictions, and limited interoperability among payment providers (UNCTAD, 2024). As a result, small and medium-sized enterprises (SMEs) struggle to accept electronic payments, limiting their participation in online markets.

Logistics and Supply Chain

In e-commerce, logistics and supply chain systems ensure that products are stored, transported, and delivered to customers on time (Shahadat et al., 2023). Mustafa et al. (2022) found that efficient logistics can improve customer satisfaction and support sustainable online business. Many developing countries struggle with e-commerce because of weak transport systems, unreliable postal services, customs delays, and poor delivery networks (Abdalla et al., 2025). Small and medium-sized businesses also struggle to compete in digital markets because of high delivery costs and slow shipping.

The ongoing conflict, infrastructure damage, fuel shortages, and economic instability have severely disrupted logistics and supply chains in Sudan (Osman, 2022). Many transport routes are at risk or obstructed, and other infrastructure is often congested and damaged (Ali & Saeed, 2023). In addition to disruptions, high inflation, power outages, and communication issues hinder the movement of goods. These problems cause shortages of food, medicine, and other supplies; drive up prices; and make it difficult to deliver humanitarian aid.

Regulatory and Legal Framework

A robust legal and regulatory framework supports e-commerce development by incorporating established guidelines for electronic transactions, digital signatures, consumer protection, privacy, taxation, and cybersecurity (Masran & Azaze, 2022). Weak or outdated legal systems can create uncertainty for businesses and consumers, eroding trust in online transactions (Mustafa et al., 2022). The absence or inadequacy of e-commerce laws hinders the growth of digital businesses in several underdeveloped nations (Zheng et al., 2025).

Sudan's limited and incomplete legal framework for electronic commerce has slowed the growth and adoption of digital business. Small and medium-sized businesses need clear, reliable laws to operate online, protect consumers, and build legitimate businesses. However, several regulatory challenges continue to hold back e-commerce in Sudan. A major challenge

is the lack of comprehensive e-commerce laws. E-commerce businesses depend on rules governing electronic transactions, digital signatures, online contracts, consumer protection, and cybersecurity. Because Sudan's digital economy laws are enforced inconsistently, the legality and enforceability of online transactions remain uncertain (Osman, 2022). Consequently, many small and medium-sized enterprises are reluctant to invest in e-commerce platforms, citing concerns about potential legal disputes and inadequate legal protection.

Digital Skills and Human Capital

Digital skills encompass the knowledge and abilities required to use digital technologies effectively (Rahman & Islam, 2023). Human capital is crucial for small and medium-sized businesses to adopt and manage e-commerce technologies. In many of the least developed countries, SME owners and employees often have limited digital literacy and lack the technical skills needed to set up online business solutions (World Bank, 2021). This skills gap reduces confidence in digital technologies and slows digital transformation.

The country's human capital development has been hindered by economic instability, low investment in education, and a lack of vocational and technical training programmes (Ali & Saeed, 2023). As a result, there are insufficiently qualified ICT professionals to support e-commerce infrastructure, and businesses often struggle to adopt digital solutions and keep pace with new technologies. Digital skills strongly shape consumers' readiness to engage in online shopping. Individuals unfamiliar with online platforms may hesitate to make purchases because of concerns about security, privacy, or the transaction process. A lack of confidence in these areas reduces the likelihood of using e-commerce services, potentially hindering the expansion of digital markets.

Trust and Cybersecurity

Trust is fundamental to online commerce, as buyers and sellers rarely meet in person. According to Judijanto (2024), consumers must trust online platforms to safeguard personal information and process transactions securely. Cybersecurity threats, including fraud, identity theft, hacking, and data breaches, undermine consumer confidence and deter small and medium-sized enterprises (SMEs) from adopting e-commerce technologies (Azeez, 2026). Consequently, creating secure digital environments is critical to fostering online business activity.

Digital trust and cybersecurity are major obstacles to e-commerce growth in Sudan. Many consumers lack confidence in online platforms, fearing fraud, identity theft, data breaches, and insecure payment systems (Indiani et al., 2025). These concerns are compounded by weak digital infrastructure, inadequate cybersecurity measures, and a lack of robust legal protections for online transactions. Low levels of digital literacy in Sudan heighten users' vulnerability to cyber threats and erode trust in e-commerce services (Sleiman et al., 2022). As a result, businesses, especially small and medium-sized enterprises (SMEs), often lack the resources to implement robust cybersecurity measures, further eroding customer confidence. Consequently, security concerns and insufficient trust deter both consumers and businesses from engaging in e-commerce. Strengthening cybersecurity, refining regulatory frameworks, and enhancing digital literacy are critical to promoting e-commerce adoption in Sudan.

Geopolitical Factors

Geopolitical factors such as political instability, armed conflict, sanctions, trade restrictions, economic crises, and diplomatic tensions can shape business environments and influence technology adoption (Kumar & Sharma, 2023). These challenges may disrupt supply chains, financial systems, telecom infrastructure, and international trade (Hossain et al., 2025). Economic conditions play a major role in e-commerce adoption (Abdalla et al., 2025). Kumar & Sharma (2023) also argued that many developing countries have technological infrastructure that exceeds their capacity to manage it. As a result, e-commerce growth in countries with poor economic conditions is relatively slow (Sleiman et al., 2022). Unstable economic conditions in some countries limit their participation in ICT development (Mustafa et al., 2022).

In countries such as Sudan, the UNCTAD Digital Economy Report (2024) shows that geopolitical instability has weakened internet infrastructure, banking systems, investment, and business confidence. These challenges make it much harder for small businesses to adopt digital tools and e-commerce. To understand the barriers within digital ecosystems in the least developed countries, it is important to consider the geopolitical context.

Previous Studies on E-commerce Adoption in Sudan & Existing Challenges and Opportunities

Research on e-commerce adoption in Sudan is limited but growing. Most studies indicate that SMEs face multiple barriers, including inadequate ICT infrastructure, low digital literacy, financial constraints, and weak institutional support (Mohamed, 2014; Sleiman et al., 2022; Abdalla et al., 2025; Mustafa et al., 2022). For example, Ali (2020) found that perceived usefulness, ease of use, and infrastructure quality significantly influence e-commerce adoption among Sudanese SMEs. Sleiman (2022) also highlights that trust, security concerns, and limited payment systems are major determinants of adoption behaviour. Overall, existing studies suggest that although awareness of e-commerce is increasing, actual adoption remains low due to systemic barriers within the digital ecosystem.

Despite the challenges, Sudan offers several opportunities for e-commerce development. The growing use of smartphones, the rise of social media platforms, and the increasing number of young entrepreneurs are creating new pathways for digital business models (Mustafa et al., 2022). However, key challenges remain, including weak ICT infrastructure, limited financial inclusion, regulatory uncertainty, logistics inefficiencies, and political and economic instability (Hendricks & Mwapwele, 2024). These factors collectively hinder e-commerce adoption. Meanwhile, opportunities exist to expand e-commerce, improve digital payment integration, invest in ICT infrastructure, and develop supportive government policies (Indiani et al., 2025). Strengthening these areas could significantly enhance SME participation in e-commerce and contribute to economic growth.

Theoretical Foundation

This study examines the dynamics and implications of digital ecosystems for business transformation using a range of theoretical frameworks. It draws on the TOE Framework and Institutional Theory to shed light on the barriers to e-commerce adoption among small and medium-sized enterprises (SMEs) in Sudan.

Tornatzky and Fleischer (1990) suggest that technology adoption in organisations is shaped by three interdependent contexts: technological, organisational, and environmental. The technological context concerns the availability and characteristics of technologies, including internet infrastructure, digital payment systems, and cybersecurity capabilities (Mustafa et al., 2022). The organisational context encompasses internal attributes such as management backing and support, budgetary resources, digital expertise, and organisational proficiency. The environmental context comprises external factors such as government policy, legal systems and markets, transport infrastructure (logistics), and trade relations. The TOE Framework has gained widespread acceptance in research on technology and e-commerce for its ability to capture both internal and external factors that influence innovation within organisations. According to Institutional Theory, organisations operate within an institutional framework comprising formal rules, regulations, norms, and social expectations. These institutional influences shape organisational decisions by promoting conformity with legal, industrial, and societal standards (Mustafa et al., 2022). Institutional factors such as regulatory quality, government support for enterprises, financial regulations, political instability, and the legal environment may influence the adoption of digital commerce technologies in Sudan and affect SMEs' willingness and ability to adopt them.

This study draws on a robust theoretical framework that integrates the TOE Framework and Institutional Theory. The TOE Framework identifies technological, organisational, and environmental barriers to e-commerce adoption, while Institutional Theory offers a more detailed account of how regulatory conditions and institutions shape SME behaviour. Together, these theories provide a comprehensive understanding of the barriers within the digital ecosystem that hinder e-commerce adoption among SMEs in Sudan and help interpret qualitative evidence from interviews with business owners and managers.

Research Gap

Despite the growing body of research on e-commerce adoption among SMEs, significant gaps remain. Most prior studies have focused on developed or emerging economies, with little attention to the least developed countries, such as Sudan. Existing research has mainly examined technological and organisational factors, while overlooking the broader digital ecosystem. This ecosystem includes digital infrastructure, payment systems, logistics, regulatory frameworks, and institutional challenges. Additionally, most studies have used quantitative methods, leaving a lack of qualitative evidence reflecting the experiences of SME owners and managers. This study aims to address these gaps by exploring barriers within the digital ecosystem that affect e-commerce adoption among Sudanese SMEs. It will use a qualitative approach grounded in the Technology-Organization-Environment (TOE) Framework and Institutional Theory.

Research Methodology

This study adopted a qualitative approach to examine how digital ecosystem readiness influences e-commerce adoption among SMEs. A qualitative design was chosen to provide an in-depth understanding of participants' experiences, perceptions, and challenges related to digital transformation and e-commerce practices. The study followed an interpretivist philosophy, focusing on participants' subjective experiences and meanings. The target population comprised SME owners and managers engaged in digital business operations. Purposive sampling was used to select participants with experience of e-commerce adoption.

Semi-structured interviews were conducted to elicit detailed insights into SMEs' digital readiness and experiences of e-commerce adoption. Interview questions were developed from the literature on digital ecosystem readiness, the TOE framework, Institutional Theory, and e-commerce adoption studies. A pilot interview was conducted with two SME representatives to assess the clarity and relevance of the questions prior to data collection. Participants were informed of the study's purpose and provided consent before the interviews. Confidentiality and anonymity were maintained throughout the research process.

Data Analysis

Interview data from 15 participants were analysed using Braun and Clarke's (2006) six-step thematic analysis (Fig 1). The interview questions were validated through expert review and pilot testing. Three experts in the field examined the interview guide for clarity, relevance, and alignment with the research objectives. A pilot interview was conducted to assess the clarity and sequencing of the questions. All telephone interviews were audio-recorded, transcribed verbatim, and verified for accuracy. During the interviews, the interviewer took manual field notes, prepared document summaries, kept diary notes, and wrote scripts to highlight participants' responses. The research team repeatedly read the transcripts to ensure familiarity with the data. The team generated initial codes manually and then organised them into potential themes. The team reviewed, refined, defined, and named themes to ensure coherence and alignment with the dataset. The final themes were reported alongside representative quotations from participants to illustrate key findings. Manual coding and reflexive memo-writing were employed throughout the analysis to enhance analytical rigour and transparency.



Figure 1: Braun and Clarke's (2006) Six-Phase Thematic Analysis Process. Adapted from Braun and Clarke (2006).

Participants' Characteristics

Judijanto (2024) supported purposive, or judgemental, sampling. This method involves identifying and selecting cases that yield substantial, useful information. The primary aim is to select individuals who can provide the most relevant information for the study. Purposive

sampling was based on two factors: the number of employees in an SME (1-250) and employees' basic experience in e-commerce, ICT infrastructure units, and related areas. Sudan's Ministry of Industry and Trade provided a register of small and medium-sized enterprises (SMEs). Initially, we randomly selected firms based on these criteria. The researchers then confirmed the final selection of firms by telephone and assessed their willingness to participate.

Table 1

Participants Profile

Participant Code	Business type	Industry	Description
P1	Electronics shop	Retail	Retail consumer electronics, gadgets, accessories, and related technical products to individuals and businesses.
P2	Convenience store	Retail	Provides everyday essentials such as groceries, snacks, beverages, and household items for quick customer use.
P3	Auto repair shop	Automotive services	Diagnoses, repairs, and maintains vehicles to ensure safe and reliable operation.
P4	Soap manufacturing	Manufacturing & Crafts	Produces handmade or commercial soaps and personal care products for retail distribution.
P5	Custom furniture maker	Manufacturing & Crafts	Designs and produces made-to-order furniture tailored to customer specifications and preferences.
P6	Event planning service		Organizes and manages weddings, corporate events, parties, and other special occasions for clients.
P7	Language school	Education & Training	Teaches foreign languages through structured courses, workshops, and learning programs.
P8	IT support company		Assists businesses with computer systems, networks, software troubleshooting, cybersecurity, and technical maintenance.
P9	Marketing agency	Professional Services	Helps businesses promote their products and services through advertising, branding, digital marketing, and market research.
P10	Restaurant	Food & Beverage	Offers dine-in, takeaway, or delivery meals, with a focus on a specific cuisine or dining experience.
P11	Coffee shop	Food & Beverage	Serves coffee, tea, beverages, and light meals in a comfortable environment for customers to socialise or work.
P12	Gift shop	Retail	Offers a variety of gift items, souvenirs, greeting cards, and speciality products for personal and corporate gifting.
P13	Handyman Service	Home Services	Offers general repair, maintenance, and improvement services for homes and small businesses.
P14	Interior Design Firm	Creative Industries	Plans and designs functional and aesthetically appealing interior spaces for clients.
P15	Clothing Boutique	Retail	Sells fashionable clothing, footwear, and accessories targeted at specific customer segments through physical or online stores.

Findings and Results

This section presents findings from 15 semi-structured interviews with owners and managers of small and medium-sized enterprises (SMEs) in Sudan. The data were analysed using thematic analysis, combining deductive and inductive approaches. The deductive component followed the digital ecosystem framework, while the inductive component allowed new insights to emerge from participants' experiences.

The analysis identified seven key themes representing barriers within the digital ecosystem that affect e-commerce adoption among SMEs in Sudan. These themes are: (1) digital infrastructure barriers, (2) cybersecurity and trust issues, (3) logistics and supply chain constraints, (4) regulatory and legal barriers, (5) digital literacy challenges, (6) geopolitical and economic instability, and (7) online payment systems. Additionally, cross-theme patterns were identified, showing how these barriers are interconnected.

Table 2
Coding Framework

Main Theme (Barrier)	Sub-Themes	Description / Meaning
1. Infrastructure barriers	Internet connectivity, bandwidth quality, ICT availability, system reliability and Power Outages.	Refers to the availability, affordability, and stability of digital infrastructure required for e-commerce operations.
2. Cybersecurity and trust issues	Data protection, online fraud, trust in digital platforms, payment security	Concerns related to security risks, lack of trust, and vulnerability to cyber threats affecting online transactions.
3. Logistics & Supply Chain limitations	Delivery systems, transportation challenges, last-mile delivery, warehousing	Operational constraints in delivering products efficiently to customers in online business models.
4. Regulatory & Legal Framework	E-commerce laws, taxation policies, government support, legal protection	Institutional and policy-related barriers that affect the legality and governance of e-commerce activities.
5. Digital Literacy challenges	ICT skills, training availability, awareness of e-commerce tools, managerial competence	Level of knowledge and skills among SME owners and employees to effectively use digital technologies.
6. Geopolitical & Economic instability	Political instability, economic uncertainty, sanctions, currency instability	External environmental factors that create uncertainty and reduce confidence in digital investment and e-commerce adoption.
7. Online payment system	Limited banking infrastructure, low digital literacy, customer trust and acceptance, limited access to international payment services.	Banks rely on traditional banking methods and lack the technical expertise to use online banking and digital payment applications.

Table 2: Source: created by author.

Theme 1: Digital Infrastructure Barriers

Digital infrastructure was the most frequently cited barrier to SMEs' e-commerce adoption. Participants repeatedly highlighted issues with unreliable internet, high data costs, and poor ICT infrastructure.

Many respondents noted that unreliable internet connections severely disrupt online business. One participant said, "Sometimes the internet disconnects in the middle of customer communication, which makes online selling very difficult." (P2). Another SME owner highlighted financial constraints: "The cost of internet data is very high compared to our business income, so maintaining online platforms is not always possible." (P9). These findings indicate that weak digital infrastructure hinders SMEs' ability to sustain continuous online operations, limiting their participation in e-commerce.

Electricity shortages are another obstacle to adopting e-commerce. Power outages are a major concern for participants and one of Sudan's most serious problems, affecting many sectors of the economy. One participant said, "Sometimes when the electricity stopped working, all the information and communication technology infrastructure also stopped, affecting the e-commerce ordering process and customer service" (P3). "In our firm, power outages are a significant issue for the finance and marketing departments. When an outage interrupts the e-commerce process, the finance department cannot send payment confirmation emails to customers. Additionally, the delivery department cannot process orders for customer delivery." (P6).

Theme 2: Cybersecurity and Trust Issues

Cybersecurity concerns and a lack of trust in digital transactions were significant barriers to e-commerce adoption. SMEs were concerned about fraud, payment security, and customer hesitancy to make online purchases. One participant said, "Customers are afraid of paying online because they think they might lose their money or get scammed." (P4). Another respondent said, "We do not fully trust digital payment systems because there is no strong protection if something goes wrong." (P11). These insights suggest that low trust in digital systems limits both customer engagement and SMEs' willingness to invest in e-commerce platforms.

Theme 3: Logistics and Supply Chain Constraints

Logistics and delivery systems were identified as a major operational challenge. SMEs reported difficulty delivering products efficiently because of poor transport networks and unreliable logistics providers. One participant stated, "Even if we receive online orders, delivering products outside the city is very complicated and expensive." (P8). Another noted, "There is no proper delivery system that supports small online businesses." (P3). These issues constrain e-commerce growth and reduce customer satisfaction.

Theme 4: Regulatory and Legal Barriers

Participants reported that unclear regulations and weak institutional frameworks hinder e-commerce growth. They often cited the lack of specific e-commerce laws and inconsistent tax policies. One SME manager explained, "We are not sure about the legal rules for online business, so we prefer traditional selling methods." (P1). Another participant stated, "Government regulations for online trade are not clear, especially regarding taxes and

business registration.” (P13). These findings suggest that regulatory uncertainty reduces confidence in adopting digital business models.

Theme 5: Digital Literacy Challenges

Digital literacy has become a major challenge for organisations. Many SME owners and employees lack the ICT skills to manage online platforms effectively. One participant said, “We do not have enough training on how to manage online stores or digital marketing tools.” (P5). Another participant noted, “Most of us learned business traditionally, so using e-commerce platforms is challenging.” (P12). These findings indicate that skill gaps significantly constrain SMEs' ability to adopt and use e-commerce technologies.

Theme 6: Geopolitical and Economic Instability

External environmental conditions, particularly economic instability and political uncertainty, were identified as significant barriers. Participants cited currency fluctuations and unstable business environments as major concerns. One respondent said, “With the unstable economy, investing in online systems feels risky.” (P8). Another stated, “Political and economic instability makes long-term digital investment difficult.” (P15). These conditions reduce SMEs' willingness to allocate resources to digital transformation.

Theme 7: Online payment system

Customers need sufficient knowledge to use digital payments for e-commerce transactions, but most are not well trained in the technology or are unfamiliar with debit or credit cards, or with ordering through e-commerce channels. “New technology should be easy to use, and users should stay informed about the latest advances in computing. We have had problems when users are not kept up to date on new technologies” (P13). Supporting this claim, two owners believed that e-commerce remained overlooked because secure electronic payment methods were unavailable. They noted that most consumers lack full access to credit or debit cards, or even bank accounts, to shop online securely. This situation can complicate online shopping.

Cross-Theme Analysis

The findings indicate that barriers within the digital ecosystem are highly interconnected rather than isolated. For instance, inadequate digital infrastructure intensifies cybersecurity concerns by limiting access to secure platforms. Regulatory uncertainty also exacerbates logistics inefficiencies and diminishes trust in digital transactions. Additionally, economic instability reduces small and medium-sized enterprises' (SMEs) willingness to invest in digital infrastructure and training, thereby reinforcing digital literacy gaps. These interdependencies suggest that e-commerce adoption in Sudan is shaped by a fragmented digital ecosystem rather than by single-factor constraints.

Summary of Findings

Overall, the study shows that small and medium-sized businesses in Sudan face several interconnected challenges in the digital environment, making it difficult for them to adopt e-commerce. The biggest issues are poor digital infrastructure, concerns about online security, slow and inefficient logistics, unclear rules and regulations, insufficient knowledge of how to use digital tools, online payment system issues, and broader political and regional instability. Together, these problems shape how SMEs think about, prepare for, and decide to use e-

commerce. The study also suggests that solving these problems requires a comprehensive approach that accounts for the entire digital environment, rather than merely fixing individual issues.

Discussion

Overview of Key Findings

This study investigated barriers within the digital ecosystem that hinder e-commerce adoption among small and medium-sized enterprises (SMEs) through a qualitative approach comprising 15 semi-structured interviews. The analysis identified seven interrelated barriers: digital infrastructure, cybersecurity and trust, logistics and supply chain constraints, regulatory and legal barriers, digital literacy challenges, geopolitical and economic instability, and online payment issues. These findings indicate that e-commerce adoption in Sudan is shaped by a complex, interconnected digital ecosystem rather than by a single factor.

Theoretical Contributions (TOE Framework Extension)

The findings strongly support and extend the Technology–Organisation–Environment (TOE) framework. Consistent with prior research, technological (e.g., infrastructure limitations), organisational (e.g., digital literacy), and environmental (e.g., regulation and instability) factors significantly influence adoption decisions. However, this study advances TOE theory by integrating a digital ecosystem perspective, showing that barriers do not operate in isolation but interact dynamically. For example, weak infrastructure intensifies cybersecurity concerns, while regulatory uncertainty exacerbates logistics inefficiencies. This interaction effect is rarely captured in traditional TOE-based studies, which often treat the dimensions separately.

Digital Infrastructure as a Foundational Barrier

The results indicate that inadequate digital infrastructure is the primary obstacle to e-commerce adoption. This aligns with recent findings (Kim & Lee, 2024) that suggest technological readiness is a crucial driver of digital transformation in SMEs. Sudan's SMEs face significant challenges in maintaining online operations due to unreliable internet connectivity and high data costs. This observation aligns with earlier evidence from developing economies, which shows that effective e-commerce requires digital readiness. When infrastructure is unreliable, other factors that contribute to adoption, such as marketing proficiency and platform use, become insignificant.

Cybersecurity and Trust

Cybersecurity concerns pose a significant barrier, particularly regarding online payment security and customer mistrust. This observation aligns with existing research, which identifies cybersecurity and data privacy as persistent obstacles to e-commerce adoption among small and medium-sized enterprises (SMEs) (Zheng et al., 2025).

In fragile economies such as Sudan, the lack of formal protection mechanisms heightens perceived risk for SMEs and customers alike. Consequently, trust is a critical determinant of adoption behaviour. This finding aligns with innovation resistance theory, which identifies perceived risk as a primary inhibitor of technological adoption.

Logistics and Supply Chain Constraints

Logistical constraints have been identified as a structural barrier to the comprehensive implementation of e-commerce. Small and medium-sized enterprises (SMEs) reported challenges including delivery difficulties, a limited number of logistics providers, and elevated transport costs. These findings align with broader research in emerging markets (Hendricks & Mwapwele, 2024; Hossain et al., 2025), where last-mile delivery remains a significant constraint on the growth of digital commerce.

The results indicate that, despite the availability of digital platforms, physical delivery systems remain a bottleneck. This reinforces the argument that e-commerce success depends on effectively integrating digital and physical infrastructure.

Regulatory and Legal Framework

The study identifies ambiguous regulations and inadequate institutional frameworks as major obstacles. Small and medium-sized enterprises (SMEs) face uncertainty regarding taxation, business registration, and legal protections for online transactions.

This finding aligns with recent literature highlighting regulatory support as a critical environmental factor shaping SMEs' adoption decisions in digital contexts (Díaz et al., 2024). In Sudan, weak governance structures undermine confidence in digital investment and constrain e-commerce formalisation.

Digital Literacy challenges

Digital literacy is a significant organisational barrier. Many small and medium-sized enterprise (SME) owners lack the information and communication technology (ICT) skills needed to manage digital platforms effectively. This observation aligns with previous research (Alaskar et al., 2023), which shows that organisational readiness and managerial capability are essential determinants of e-commerce adoption.

The results suggest that, even when infrastructure is in place, insufficient human capability significantly reduces the likelihood of technology adoption. This finding underscores the importance of the organisational dimension within the Technology-Organization-Environment (TOE) framework as a key determinant of technology adoption outcomes.

Geopolitical and Economic Instability

This study's principal contribution is identifying geopolitical and economic instability as a primary environmental barrier. Factors such as currency volatility, political uncertainty, and economic instability constrain long-term investment in digital systems.

This finding extends the existing Technology-Organization-Environment (TOE) literature by emphasising macro-level instability as a critical constraint in least-developed countries. In these contexts, institutional fragility directly impedes digital transformation.

Cross-Barrier Interaction and Digital Ecosystem Perspective

A key finding of this study is the deep interconnection among barriers. For instance:

- Weak infrastructure increases cybersecurity vulnerability.
- Regulatory uncertainty undermines trust in online payments
- Economic instability discourages investment in digital skills.

These observations indicate that e-commerce adoption in Sudan is shaped by a fragmented digital ecosystem rather than by isolated factors. This finding aligns with recent integrative studies, which suggest that digital transformation in small and medium-sized enterprises requires concurrent advances across technological, organisational, and environmental domains.

Summary of Discussion

This study advances both theoretical understanding and practical application by demonstrating that SME e-commerce adoption in Sudan is constrained by a complex, interdependent digital ecosystem. The research extends the Technology-Organization-Environment (TOE) framework by integrating ecosystem-level interactions and emphasising the need to address structural and institutional barriers concurrently rather than in isolation.

Conclusion

This study examined barriers within the digital ecosystem that influence e-commerce adoption among small and medium-sized enterprises (SMEs) in Sudan, using a qualitative approach. Drawing on 15 semi-structured interviews with SME owners and managers, the study identified and analysed the lived experiences of firms operating in a constrained and fragile digital environment. Thematic analysis revealed that e-commerce adoption is shaped by a complex set of interrelated barriers rather than by isolated factors.

Summary of Key Findings

The findings indicate that SMEs in Sudan face six major barriers in the digital ecosystem: (1) weak digital infrastructure, (2) cybersecurity and trust issues, (3) logistics and supply chain constraints, (4) regulatory and legal uncertainty, (5) limited digital literacy, and (6) geopolitical and economic instability. Together, these barriers constrain SMEs' ability to adopt and use e-commerce platforms effectively.

A key insight from this study is that these barriers are not independent but deeply interconnected. For example, weak digital infrastructure exacerbates cybersecurity concerns, while regulatory uncertainty and economic instability reduce firms' willingness to invest in digital technologies. This underscores that e-commerce adoption in Sudan is fundamentally an ecosystem-level challenge rather than a single-factor issue.

Theoretical Contributions

This study advances the literature on technology adoption and digital transformation in several key ways. Firstly, it extends the Technology–Organisation–Environment (TOE) framework by incorporating a digital ecosystem perspective that highlights interactions among technological, organisational, and environmental factors. Secondly, the study advances the e-commerce adoption literature by showing that barriers operate within a complex, interconnected system, particularly in least developed countries. Unlike earlier research that examines factors in isolation, this work emphasises the need to understand how constraints mutually reinforce one another in shaping adoption decisions. Thirdly, by focusing on Sudan—a context that remains under-researched—the study enhances the empirical literature on digital transformation in fragile and low-income economies.

Practical Implications

This study's findings have several important implications for policymakers, industry stakeholders, and SME owners.

For government and policymakers, the results underscore the urgent need to improve digital infrastructure, establish clear and enforceable e-commerce regulations, and strengthen institutional support for digital entrepreneurship. Policy interventions should focus on building an integrated digital ecosystem rather than addressing individual barriers in isolation. For ICT and telecommunications providers, improving internet reliability and affordability is essential to enable SME participation in digital markets. Similarly, fintech providers can play a critical role in enhancing trust through secure, user-friendly digital payment systems. For SMEs, the findings emphasise the importance of improving digital literacy and investing in basic digital skills to enhance readiness for e-commerce adoption. Capacity-building programmes and training initiatives can significantly improve SMEs' ability to engage in digital business activities.

Limitations of the Study

Although this study offers valuable insights, it has some limitations. Firstly, it is based on a small sample of 15 SMEs, which is suitable for qualitative analysis but limits the generalisability of the results. Secondly, the research is conducted solely in Sudan, which may limit the applicability of the findings to other regions. Thirdly, because the study is qualitative, it provides a detailed understanding but does not permit statistical testing of relationships among variables.

Future Research Directions

Future research could extend this study in several directions. Quantitative research could test and validate the proposed digital ecosystem barrier framework using a larger sample of SMEs. Comparative analyses of Sudan with other least developed or developing countries could yield deeper insights into the contextual differences in e-commerce adoption. Further research could investigate sector-specific dynamics, including differences among SMEs in retail, services, and manufacturing. Longitudinal studies would also be valuable for examining how barriers within digital ecosystems evolve over time, particularly in response to technological and policy developments.

Final Remarks

Overall, this study highlights that SMEs in Sudan face significant challenges in adopting e-commerce due to a fragmented and underdeveloped digital ecosystem. Overcoming these obstacles requires coordinated action across technological, institutional, and organisational levels. Adopting a comprehensive ecosystem approach enables stakeholders to identify and address the structural barriers that hinder digital transformation in least-developed countries more effectively.

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