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A Typology of Blockchain Technology Applications and Adoption Among Small and Medium-Sized Enterprises

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Abstract - The article aims to provide a comprehensive examination of how small and medium-sized enterprises (SMEs) apply and adopt blockchain technology. Although blockchain has gained widespread attention for its transformative potential in ensuring transparency, security, and immutability across industries such as finance, healthcare, and supply chain management, its implementation within SMEs remains underexplored. Using a narrative and critical literature review, the study identifies key application areas, as well as the main drivers and barriers influencing blockchain adoption among SMEs. It finds that supply chain and finance are the most prominent sectors adopting blockchain due to their complex, multi-stakeholder environments and issues of information asymmetry. However, challenges such as technological complexity, regulatory uncertainty, and limited digital capabilities hinder broader adoption. The study emphasizes the need for tailored blockchain solutions, particularly through Blockchain-as-a-Service (BaaS), and highlights the role of governments, regulators, and SME associations in improving technological literacy. By presenting a structured classification of blockchain applications, along with an analysis of adoption drivers, barriers, and future research directions, this research contributes valuable insights to advancing the understanding and strategic integration of blockchain technology in SMEs.

1.INTRODUCTION

The global landscape of business operations and financial transactions has undergone a significant evolution in recent years, largely driven by the integration of cutting-edge technologies. Among these, blockchain technology stands out as a particularly transformative force. Characterized by its decentralized, transparent, and secure ledger system, blockchain has the potential to redefine practices across various industries. Small and medium-sized enterprises (SMEs) are positioned to gain substantial advantages from this technology, which promises to innovate all facets of their operations. However, the novelty of blockchain, combined with the typical constraints of technical expertise and resources within SMEs, has resulted in an unclear application and adoption pathway for these businesses.

Widely regarded as the lifeblood of most economies, SMEs hold a crucial role in the global business ecosystem. They function as engines of economic growth, hubs of innovation, and primary sources of employment generation[61]. Their notable agility and resilience highlight their importance not just as economic entities, but also as agents of social and technological progress. In the current era of rapid digital transformation, the adoption of advanced technologies has become a key determinant of competitiveness and sustainability for SMEs [49]. Blockchain has emerged as one such groundbreaking innovation with the capacity to fundamentally alter the foundations of business operations.

The unique structure of blockchain—defined by its decentralized and tamper-resistant design—holds the potential to reshape the financial landscape for SMEs. By reducing the need for intermediaries, lowering transactional friction, and building trust through transparent and auditable records, blockchain offers a compelling solution to many persistent challenges faced by SMEs [2]. Furthermore, the technology's programmable smart contracts create opportunities for automation and the development of new financial instruments, potentially enabling innovative and tailored models for lending and investment.

This article undertakes an exploratory investigation into the application and adoption of blockchain technology within SMEs. The primary objectives are to establish a taxonomy for its application and adoption and to conduct an in-depth analysis of the associated drivers, barriers, opportunities, and challenges. We examine how blockchain technology can be leveraged to help SMEs achieve greater financial inclusivity, improve operational efficiency, and gain access to new funding mechanisms. Identifying these opportunities can guide the creation of blockchain solutions specifically designed for SMEs. Similarly,

analyzing the risks related to blockchain integration—such as regulatory uncertainties and technical complexities-can inform strategies to mitigate them and help design clear implementation roadmaps. Understanding the drivers and barriers to adoption is crucial for accelerating the technology's diffusion among SMEs.

In the sections that follow, we will first establish foundational definitions and key concepts related to blockchain technology. We will then provide a detailed overview of the materials and methodologies used in this study. The subsequent discussion section will present our findings, focusing on the proposed taxonomy for blockchain application and adoption in SMEs and introducing a framework of associated opportunities and risks. Finally, we will summarize the article's contributions, discuss the implications derived from our research, and suggest potential directions for future study.

2.LITERATURE REVIEW

Blockchain technology is a decentralized, distributed ledger system that securely records and verifies transactions across a network of multiple computers, known as nodes [9]. In this system, individual transactions are grouped into blocks. Each new block is then cryptographically linked to the preceding one, forming a continuous, chronological, and tamper-resistant chain of records [13].

Operating on a peer-to-peer network, blockchain eliminates the necessity for a central governing authority. Instead, the system relies on a collaborative process where the multiple nodes collectively maintain, access, and validate the same data. This decentralized architecture ensures that no single participant has control over the entire network. The transaction process within this system is illustrated in Figure 1.

To maintain the ledger's integrity and security, blockchain employs consensus mechanisms. These protocols enable all nodes in the network to agree on the validity of transactions and the current state of the ledger. Prominent consensus mechanisms include Proof of Work (PoW), Proof of Stake (PoS), and Delegated Proof of Stake (DPoS), each contributing to the system's robustness and efficiency through its distinct method of transaction validation.

A central innovation within blockchain technology is the smart contract. These are self executing contracts with the terms of the agreement between parties written directly into code [50]. Smart contracts automatically enforce terms and execute predefined actions once specific conditions are met. Their applications are diverse, ranging from facilitating automated payments to managing intricate business processes, thereby enabling a trust less, multi-party ecosystem for tamper-proof transactions.

Another notable innovation within blockchain technology is the concept of blockchain tokens—digital assets or units of value that are created and managed on a blockchain network. These tokens can embody different types of value, such as cryptocurrencies, utility tokens, or security tokens. They play a vital role in blockchain ecosystems by enabling a wide range of applications, including facilitating transactions, granting access to specific services, and supporting participation in decentralized applications (Dapps). Moreover, tokens can be traded, exchanged, and utilized both within and outside blockchain networks, serving as mechanisms for incentivizing engagement and governing activities within the blockchain community

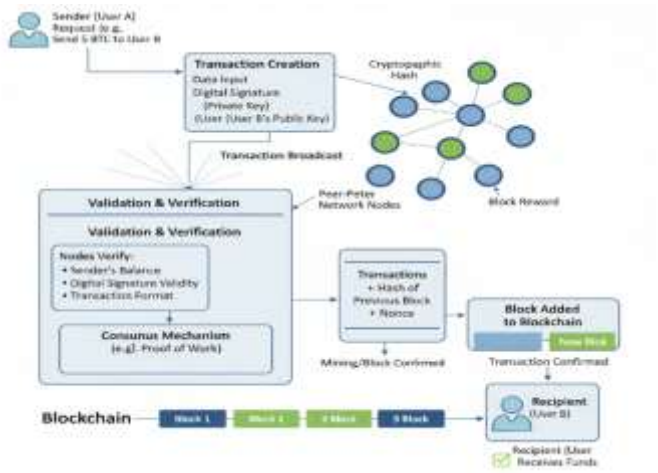

Fig -1: Blockchain Transaction Process

Blockchain technology comprises several distinct types—public, private, and hybrid blockchains—each designed to meet specific functional and organizational needs within the broader blockchain ecosystem [13]. Public blockchains operate on an open, permissionless model that allows unrestricted participation and promotes transparency. Well-known examples such as Bitcoin and Ethereum demonstrate their effectiveness in use cases that require trust among participants who may not know one another. In contrast, private blockchains function as closed, permissioned networks, typically implemented in controlled environments. Participation in these systems is

restricted through invitations or predefined authorization processes, making them particularly suitable for applications like internal recordkeeping, supply chain management, and collaboration among selected partners.

Hybrid blockchains combine elements of both public and private systems, offering a balanced approach between transparency and confidentiality [17]. In such architectures, certain aspects of the blockchain are accessible to the public, while others remain private and limited to specific participants. This model is ideal for scenarios that require flexible levels of data visibility, enabling organizations to benefit from the openness of public blockchains while maintaining control over sensitive information. Ultimately, the choice among these blockchain types depends on an entity's specific goals, operational needs, and governance structures, making a thoughtful selection essential for the effective and strategic implementation of blockchain technology.

A defining characteristic of blockchain technology is its ability to create transparent and auditable transaction records. Through tamper-resistant ledgers that record every transaction, blockchain fosters a high level of trust and accountability among users. This transparency is particularly valuable in contexts where multiple stakeholders must access and verify shared information, such as in supply chain management or financial transactions. Serving as a single, shared source of truth, blockchain helps minimize disputes, streamline collaboration, and promote mutual confidence [50]. Its strong cryptographic foundation further protects against data tampering and fraud, ensuring the integrity and immutability of recorded information. By employing digital signatures and encryption, blockchain guarantees the authenticity and security of data—an essential attribute in sensitive industries such as healthcare and finance, where privacy and data protection are critical.

Another major advantage of blockchain is its ability to enhance operational efficiency. By removing intermediaries and reducing the need for manual reconciliation, blockchain simplifies transactions, leading to faster processing, lower costs, and fewer errors compared to traditional systems [20]. This improved efficiency translates into more streamlined, cost-effective operations that boost productivity and competitiveness across sectors ranging from cross-border payments to logistics. Furthermore, blockchain's decentralized architecture which operates without a central governing authority empowers participants while eliminating single points of failure. Such networks are inherently more resilient, as no individual entity can compromise the system as a whole. This decentralization is particularly valuable in critical applications such as voting systems and digital identity management, where maintaining trust without centralized control is essential. Figure 2 illustrates the key features of blockchain technology and the corresponding benefits derived from them.

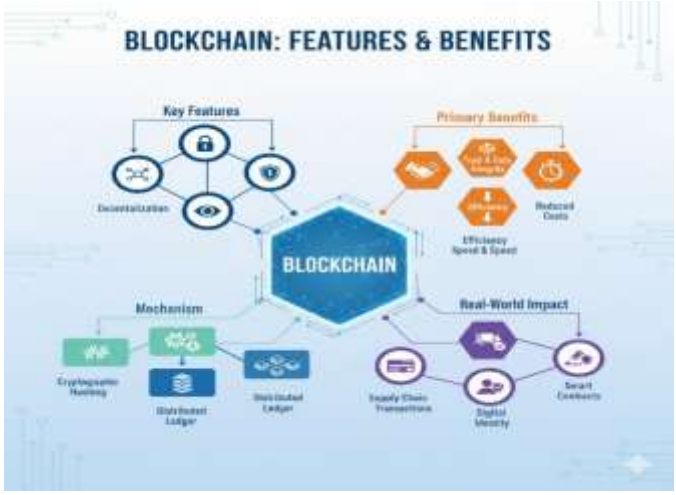

Fig-2: Blockchain features and resulting benefits

Blockchain leverages consensus mechanisms and cryptographic techniques to verify and validate transactions, reducing the need for intermediaries to establish trust. This capability is particularly impactful in sectors where intermediaries have traditionally been central, such as real estate and legal services. By simplifying complex processes, minimizing third-party involvement, and accelerating transaction times, blockchain enhances efficiency [20]. For SMEs, these efficiencies translate into significant cost savings.

Optimizing operations through blockchain reduces redundancy and administrative overhead, improves resource allocation, and strengthens competitive positioning. By streamlining workflows and lowering reliance on intermediaries, blockchain offers cost-effective solutions that enable SMEs to thrive in today's competitive business environment. Collectively, these features highlight blockchain's transformative potential across industries, reshaping how businesses operate, collaborate, and manage data. Effectively understanding and leveraging these capabilities can drive more secure, efficient, and resilient processes, benefiting organizations of all sizes.

RESEARCH METHODOLOGY

In this study, we conducted a comprehensive examination of the application and adoption of blockchain technology in SMEs using a narrative and critical literature review, following the approach outlined by Ratten (2023). Building on existing research, we explored the academic discourse surrounding blockchain adoption in SMEs. The initial literature search employed the keywords "SME" and "Blockchain," followed by a systematic screening process that included title and abstract evaluation, as well as full-text analysis. The gathered literature was then organized into thematic categories of blockchain application in SMEs, forming a structured taxonomy, which was further analyzed to identify trends and insights within each theme.

Drawing on methodological insights from Korzynski et al. (2023), we developed the taxonomy as an organizational tool to distill key themes and foster a deeper understanding of blockchain adoption in SMEs. Throughout the process, we maintained reflexivity to address limitations and ensure transparency and credibility. The synthesis of findings contributes to the evolving knowledge base, providing valuable insights into the challenges, nuances, and future directions of blockchain adoption within the SME sector.

This article makes a conceptual contribution by producing a detailed taxonomy of blockchain technology applications and adoption in SMEs, derived from an exhaustive review of the literature. Our analysis spans multiple dimensions of blockchain usage, resulting in a nuanced thematic classification. Additionally, we examined various adoption theories and frameworks to analyze how SMEs adopt blockchain, culminating in conceptual models that highlight the key enablers and barriers to adoption. The study also identifies the associated opportunities and challenges of implementing blockchain in SMEs. The conceptual frameworks presented serve as practical and scholarly guidance for SMEs, blockchain solution providers, and researchers, offering direction for designing tailored blockchain-based solutions for the SME context.

RESULTS AND DISCUSSION

Blockchain Technology Applications in SMEs

Blockchain technology presents a wide range of applications for SMEs across multiple sectors, including finance, supply chain finance (SCF), supply chain management (SCM), manufacturing, IT infrastructure, collaboration, energy, human resource management (HRM), and marketing. It has the potential to address inefficiencies caused by numerous intermediaries and traditional processes. In SCM, blockchain enhances transparency, traceability, and product quality [9]. Beyond supply chains, it can streamline manufacturing processes, facilitate collaboration, optimize energy trading, and improve HRM practices.

Within the supply chain finance sector, blockchain serves as a transformative tool by improving coordination among participants, building trust, reducing credit risk, and providing enhanced transparency and traceability [71]. These benefits are especially impactful in industries such as food production, where they can lead to significant improvements in product quality. Figure 3 presents a taxonomy of blockchain applications in SMEs, derived from an extensive review of the literature.

In the financial sector, blockchain's impact is equally profound, fostering a new financing model based on distributed ledger and cryptographic technologies. This model enhances transparency, security, and trust, reduces information asymmetry, and enables the development of blockchain-based credit systems capable of more accurately differentiating between risk profiles [5].

Fig -3. Taxonomy blockchain applications for small firms

Blockchain's benefits also extend to payment systems, taxation, and auditing, where it enhances efficiency and accuracy. By automating financial processes and utilizing smart contracts, blockchain reduces administrative workloads and facilitates quicker access to capital for

SMEs. This innovation not only drives significant cost savings but also improves access to vital financial resources, enabling SMEs to strengthen their competitiveness in the global market. The following section explores the applications of blockchain technology in SMEs across the various domains illustrated in Figure 3.

Finance

The financial system faces long-standing inefficiencies caused by outdated practices, centralization, and exclusivity. Blockchain technology offers a transformative solution by improving transparency, accessibility, and efficiency in financial operations [39]. This innovation is particularly beneficial for small and medium-sized enterprises (SMEs), which often struggle to access timely and affordable financing due to cash shortages and lack of collateral [30].

Blockchain addresses these issues by enhancing data sharing and information availability. Through distributed ledgers, it records and verifies transactions transparently, reducing information asymmetry between lenders and borrowers [66]. As a result, creditworthy SMEs can demonstrate financial reliability and obtain loans even without traditional collateral.

Moreover, blockchain can modernize credit systems by promoting transparency and equal access to transaction records. Smart contracts automate loan processes and share default information instantly across institutions, increasing the cost of default and helping lenders distinguish between risk classes [69]. For instance, in blockchain-based ecommerce platforms, verified trading and logistics data allow banks to evaluate SME loan applicants more accurately [73].

Blockchain also mitigates the agency problem by minimizing information gaps between financial intermediaries and users, enhancing transparency, and reducing transaction costs [11]. When combined with big data analytics, blockchain supports comprehensive credit evaluation systems [64]. Smart contracts further improve the efficiency and integrity of microfinance institutions, as each entrepreneur can have a unique digital identity for loan applications, promoting accountability and reducing defaults [5].

Beyond credit systems, blockchain has broader applications in banking, payments, taxation, and auditing. It enhances transparency in deposit markets, accelerates payment processes, and can simplify tax settlements, particularly benefiting SMEs by reducing administrative burdens [15]. Overall, blockchain strengthens the financial ecosystem by reducing transaction costs and processing times, building trust, and ensuring more accessible financing for SMEs.

Supply Chain Finance

Supply Chain Finance (SCF) aims to optimize the flow of funds within supply chains, but traditional models—such as prepayment, accounts receivable, and inventory financing—often fail to meet SMEs' needs due to inefficiencies. Blockchain technology addresses these challenges through its decentralized, transparent, and secure ledger system, reducing costs and eliminating information asymmetry [19].

Blockchain enhances coordination among financial institutions, core firms, and other supply chain participants by fostering mutual trust and preventing private collusion seen in traditional SCF systems [73]. Using smart contracts, blockchain automates transactions and pledge management processes, minimizing errors and third-party dependency while improving reliability [71].

Additionally, blockchain resolves the issue of information islands, where core companies control data access. By ensuring that all records are verified and shared across the network, SMEs at the lower tiers of the supply chain can access affordable financing [73]. In Kenya, for instance, a Hyperledger Fabric-based platform enables SMEs to obtain financial products through a transparent three-party model involving buyers, sellers, and intermediaries [28].

Blockchain also strengthens risk management in SCF by improving information transparency and reducing credit, operational, and collateral risks. Integrating blockchain with the Internet of Things (IoT) enhances real-time tracking and monitoring [6]. Furthermore, it supports the creation of sustainable SCF models by addressing regulatory challenges and promoting ecosystem stability [44].

Notable platforms such as we. Trade and Link Logis exemplify blockchain's real-world success. These systems

enhance visibility and trust across supply chains, making bank financing more accessible and reliable for SMEs. Overall, blockchain technology is revolutionizing SCF by improving efficiency, transparency, and sustainability in global trade.

Supply Chain Management

In Supply Chain Management (SCM), blockchain technology is primarily applied in two key areas: streamlining operations and ensuring product authenticity and provenance. It has been used for various purposes, including automation, enhanced integration across supply chain stages, improved traceability, real-time tracking, and the restructuring of agricultural commodity trading systems. Blockchain also plays a vital role in developing smart rural supply chains, promoting transparency and efficiency across all participants [21].

By enabling secure data sharing among geographically dispersed entities, blockchain significantly reduces administrative complexities, transaction times, and overhead costs. This seamless exchange of information enhances trust among stakeholders while ensuring that every transaction is accurately recorded and verifiable, ultimately improving the overall performance of supply chain networks.

Manufacturing

In the manufacturing sector, blockchain technology offers substantial benefits for small and medium-sized enterprises (SMEs). It helps improve demand and supply forecasting, lowers production costs, and fosters collaborative manufacturing partnerships. As a key enabler of Industry 4.0, blockchain empowers SMEs to digitize and optimize their production systems, facilitating automation, real-time monitoring, and data-driven decision-making [57].

Blockchain also supports secure data sharing, access control, and remote equipment maintenance among manufacturers. Within the Industry 4.0 framework, smart contracts introduce self-executing processes that enhance cloud-based and distributed manufacturing. These mechanisms improve production planning, minimize overproduction, and reduce operational costs [6]. Furthermore, blockchain serves as a crucial enabler of the shared economy, particularly for SMEs engaged in social manufacturing, by fostering trust, transparency, and collaboration across networks [36].

Collaboration and Sharing

Small and medium-sized enterprises (SMEs) are increasingly embracing cloud and ubiquitous manufacturing to encourage trustworthy collaboration and efficient information sharing in rapidly changing markets [6]. By automating data exchange and facilitating stronger connections between participants, blockchain technology supports the growth of decentralized business ecosystems [5].

Despite its advantages, concerns remain regarding public data sharing, particularly among SMEs in sensitive industries like the food supply chain, where firms are hesitant to disclose proprietary information [3]. Nevertheless, blockchain and smart contracts improve cross-organizational collaboration by reducing entry barriers and limiting corporate dominance, enabling smaller firms and entrepreneurs to participate more freely [60].

The rise of Decentralized Autonomous Organizations (DAOs) further illustrates blockchain's potential in promoting collective entrepreneurship and organizational innovation [51]. Within DAOs, members self-organize and engage in entrepreneurial activities that drive growth. Distributed ledger technology (DLT) ensures secure intellectual property protection, reliable smart contract execution, and data privacy, fostering cooperation and regulatory compliance in manufacturing and service networks. Moreover, industry–university collaboration offers SMEs a path to enhance their technological capabilities, where careful partner selection is crucial to success [5].

IT Infrastructure

Blockchain strengthens IT infrastructure by providing secure, decentralized data storage that lowers operational costs while improving data integrity. It supports decentralized applications (DApps), which enhance scalability and flexibility, making it particularly valuable in the era of digital transformation. Many SMEs struggle with fragmented data systems that limit efficient data utilization.

To address this, Liu et al. (2020) proposed a blockchain-based platform integrating decentralized identification to

verify data sources and ensure secure user data storage. This system uses smart contracts and federated learning models to extract insights from distributed data securely.

Cybersecurity remains a major concern for small firms. Lopez et al. (2020) developed an intelligent cybersecurity platform that combines machine learning and blockchain to detect, prevent, and recover from cyberattacks. Similarly, Sadeq et al. (2021) emphasize blockchain's potential for data protection, leveraging its hash replication and mining algorithms to identify and prevent unauthorized alterations, thereby enhancing overall data security.

Energy

In the energy sector, blockchain enables SMEs to participate actively in energy generation, trading, and management. Markakis et al. (2021) introduced a blockchain-based energy brokerage system that allows small producers, such as solar grid owners, to sell surplus energy through peer-to-peer transactions. Similarly, Leelasantitham (2020) proposed a decentralized electricity trading model in Thailand, where consumers and SME prosumers can exchange energy to reduce costs.

Expanding on this idea, Li et al. (2021) developed a blockchain-enabled peer-to-peer energy trading network for electric vehicles. Using smart contracts and superconducting energy storage, the system helps avoid network congestion and ensures more reliable energy exchanges. This model improves transaction success rates and optimizes energy consumption across the mobility sector.

Human Resource Management (HRM):

SMEs often face challenges in recruiting and retaining qualified personnel due to limited resources and competition with larger firms [30]. Blockchain offers an innovative solution by providing a secure and transparent method to verify the authenticity of candidates' educational and professional records. This improves the efficiency and accuracy of the hiring process.

Rhemananda et al. (2021) introduced a blockchain-based framework for human resource management that enables secure validation of applicant credentials. This system streamlines recruitment, ensures trust in employee data, and aligns candidate skills with organizational needs—ultimately enhancing productivity and workforce quality for SMEs.

Blockchain Technology Adoption in SMEs

Investment in blockchain-based business solutions has been growing rapidly in recent years. However, the overall adoption of this technology among businesses—particularly small and medium-sized enterprises (SMEs)—remains limited [43]. Several factors contribute to this cautious uptake. The complexity and novelty of blockchain pose challenges for smaller firms that often lack the necessary technical expertise. Moreover, many projects struggle to move beyond the proof-of-concept stage, resulting in fragmented and partial implementation.

Financial constraints also play a major role. SMEs frequently face budget limitations that prevent them from investing in advanced technologies like blockchain. Considering these barriers, this section examines existing research on blockchain adoption by SMEs to identify the drivers, barriers, opportunities, and challenges associated with its implementation.

A Brief Overview of Technology Adoption Frameworks and Perspectives

Understanding how organizations adopt new technologies requires insight into the theories and frameworks that explain the process of technological acceptance, diffusion, and integration. Researchers have developed several models to capture the multifaceted nature of technology adoption, encompassing technical, social, organizational, and contextual factors.

These frameworks help explain how individual perceptions, organizational structures, and environmental conditions interact to influence technology uptake. Table 1 provides a concise summary of the major technology adoption frameworks and perspectives that help clarify blockchain adoption dynamics within SMEs.

Frameworks Used to Study Blockchain Adoption in SMEs:

The decision-making process behind adopting new technologies is highly complex. It involves the interaction of multiple dimensions—technical, social, environmental, cultural, and behavioral. For SMEs, this process is particularly challenging due to limited resources, expertise, and infrastructure.

Researchers have analyzed blockchain adoption using various conceptual and theoretical frameworks, as illustrated in Figure 4. Each framework offers a unique perspective on the factors that influence an SME's decision to adopt blockchain. Together, these perspectives highlight the diverse challenges, motivations, and contextual influences that shape the adoption journey for smaller enterprises in the blockchain landscape.

Factors Influencing Blockchain Technology Adoption in SMEs:

Although blockchain holds tremendous promise, its adoption among SMEs is still at an early stage. Based on the studies summarized in Figure 4, the factors influencing blockchain adoption can be categorized into enablers, barriers, moderators, and insignificant factors.

- Enablers act as drivers, accelerating the acceptance and use of blockchain technology.
- Barriers hinder or delay adoption due to limitations such as cost, knowledge, or infrastructure.
- Moderators affect the strength and direction of these enablers and barriers, amplifying or mitigating their impact depending on the firm's context.
- Insignificant factors are those that exert minimal influence on the adoption process.

Figure 5 summarizes these key determinants, showing how they interact to shape the pathway of blockchain integration in SMEs. As these factors evolve, they define the strategic, operational, and technological considerations that guide small businesses toward—or away from—blockchain adoption.

Table 1.1 Technology adoption frameworks and perspectives summary

Framework / Theory	Description
Technology Acceptance Model (TAM)	Proposed by Davis (1986), TAM explains technology adoption based on individual perceptions. It identifies perceived usefulness and perceived ease of use as key determinants influencing users' acceptance and continued use of technology.
Unified Theory of Acceptance and Use of Technology (UTAUT)	Developed by Venkatesh et al. (2003), UTAUT combines several earlier models and identifies four primary factors affecting technology adoption: performance expectancy, effort expectancy, social influence, and facilitating conditions.
Technology–Organization–Environment (TOE) Framework	The TOE framework highlights how technological, organizational, and environmental contexts interact to shape technology adoption. Key variables include organizational size, top management support, external pressures, and technological complexity.
Post-Acceptance Model (PAM)	An extension of TAM, PAM focuses on post-adoption behaviours, including user satisfaction, continued system usage, and word-of-mouth influence.
Diffusion of Innovations (DOI) Theory	Introduced by Rogers (1962), DOI explains how innovations spread across social systems. It classifies adopters into groups and highlights the roles of communication channels, social networks, and innovation attributes in influencing adoption.
Innovation Diffusion in Networks (IDN) Model	The IDN model examines the social network structure and its influence on innovation diffusion. It considers node characteristics and types of relationships (ties) to understand how innovations spread through interconnected communities.
Social Cognitive Theory (SCT)	Developed by Bandura, SCT suggests that personal cognition, environmental conditions, and behavioural factors collectively shape adoption behaviour. It emphasizes self-efficacy, observational learning, and expected outcomes.

Innovation Theory Perspective (ITP)	ITP focuses on innovation attributes such as novelty, complexity, and compatibility, examining how these characteristics affect adoption. It also stresses the role of innovation management strategies in fostering acceptance.
Socio-Technical Perspective (STP)	The STP highlights the need for alignment between social systems and technical systems. Successful adoption occurs when both technological and human aspects are integrated effectively.
Knowledge Management Perspective (KMP)	The KMP views adoption through the lens of organizational learning and knowledge sharing. It emphasizes how knowledge creation, dissemination, and transfer facilitate successful technology implementation.
Extended Complexity Theory (ECT)	ECT applies complexity theory to technology adoption, recognizing it as a nonlinear, dynamic process influenced by interconnected factors, feedback loops, and emergent behaviours.

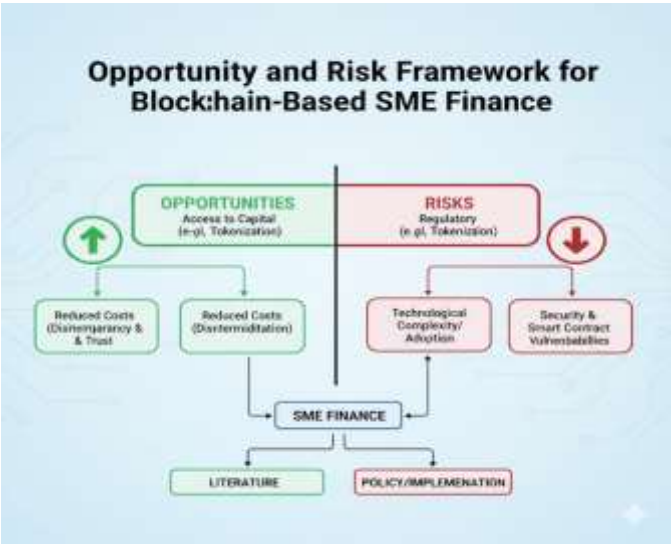

Fig -4: Opportunity and risk framework for blockchain-based SME finance literature

Conclusions
Paving the Way for Future Exploration

Blockchain technology is widely regarded as a transformative force in the digital era, with the potential to reshape industries and redefine business ecosystems. Small and medium-sized enterprises (SMEs), often constrained by limited resources and scale, stand to gain significantly from adopting this technology, leveraging it to enhance operational efficiency and competitive advantage [45]. This study examined the application and adoption of blockchain in SMEs, highlighting key areas of implementation as well as the factors influencing its uptake. While blockchain presents substantial opportunities for SMEs such as increased transparency, improved trust, access to capital, and operational efficiency [5] its adoption is not without challenges. SMEs must navigate technical complexities, scalability issues, evolving regulatory frameworks, and limited awareness as they integrate blockchain solutions [11].

This research contributes to the broader discourse by focusing specifically on SMEs, a sector often overshadowed by large corporations and financial institutions in blockchain studies. Through a narrative and critical literature review, this study provides a comprehensive understanding of blockchain's transformative potential in SMEs, offering both theoretical and practical insights. The proposed framework outlining opportunities and challenges serves as a valuable guide for SMEs seeking to implement tailored blockchain solutions while advancing academic understanding of adoption dynamics.

Furthermore, by identifying gaps in current research, this study highlights avenues for future exploration and innovation. These gaps present opportunities for scholars to investigate underexplored aspects of blockchain adoption and for practitioners to develop strategies that address the unique needs of SMEs.

The dual emphasis on theoretical contributions and practical applicability underscores the broader relevance of this research and encourages sustained engagement with the evolving intersection of blockchain technology and SMEs.

It is important to acknowledge the limitations of this review. Given the fast-paced nature of blockchain development and the variability across industries, regions, and individual SMEs, implementation outcomes may differ [10]. Therefore, the findings presented should be

viewed as a foundational guide rather than prescriptive solutions.

Looking ahead, a multifaceted approach is required to maximize blockchain's potential in SMEs. Collaboration between SMEs, technology providers, and policymakers is critical to fostering supportive ecosystems. Educational initiatives can empower SMEs to navigate technical and regulatory challenges, while proactive policy frameworks can balance innovation with security and compliance.

Future research should explore in-depth case studies across various industries and regions to uncover context-specific strategies for blockchain adoption. Comparative analyses can illuminate the impact of regulatory environments, while longitudinal studies can track the long-term benefits and challenges faced by SMEs. Additionally, investigations into socio-economic implications, ethical considerations, and the integration of emerging technologies can further enrich our understanding of blockchain adoption. Employing mixed-methods research can provide a holistic perspective, combining qualitative insights with quantitative analyses to identify patterns, trends, and correlations.

Ultimately, this review lays the groundwork for a future where blockchain technology becomes an integral part of SME operations. By developing a comprehensive understanding of opportunities, risks, and strategic considerations, SMEs can navigate challenges effectively and harness blockchain's transformative potential. With collaborative efforts, strategic foresight, and a commitment to innovation, SMEs can position themselves at the forefront of a business landscape increasingly shaped by blockchain technology.

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