

Blockchain Technology and SMEs: A Bibliometric Analysis and Future Directions

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Abstract: The growing use of digital tools provides opportunities for small and medium-sized enterprises (SMEs) to embrace digital transformation. However, SMEs may face significant challenges in adopting emerging technological innovations, particularly blockchain technology. Therefore, this study aims to examine the research trends in blockchain technology and identify the factors associated with blockchain adoption, with a particular emphasis on SMEs. To analyze research trends in blockchain technology, bibliometric data were collected from Scopus-indexed publications. A search of the Scopus database using the keywords “blockchain” and “SMEs” yielded 489 publications. Applying the inclusion criterion of original articles published in English and excluding book chapters, conference proceedings, and white papers resulted in a final sample of 76 articles published between 2020 and 2026. The extracted Scopus-indexed dataset was subsequently analyzed using bibliometric tools, namely Biblioshiny (R-Studio) and VOSviewer. The findings showed that China contributed the largest number of publications in this field, while Italy and the United Kingdom demonstrated stronger international research collaborations. Additionally, the literature review suggests that the adoption of blockchain technology by SMEs is closely associated with the deployment of smart contract innovations and supportive organizational capabilities. The literature highlights several critical factors that influence blockchain adoption among SMEs, including scalability and interoperability issues, trust and stakeholder acceptance, limitations in connectivity and infrastructure, and concerns regarding security and data privacy. Collectively, these factors significantly affect the successful implementation of blockchain technology among SMEs.

Keywords: Blockchain, Small-medium enterprises, Supply chain management, Bibliometric, Resilience, Sustainable Business, Interoperability, Scalability.

1. Introduction

Blockchain technology refers to a decentralized and distributed digital ledger that chronologically records and validates transactions, ensuring transparency, traceability, security, and resistance to data tampering [1], [2]. Blockchain technology offers significant potential to enhance the trading performance and supply chain management (SCM) capabilities of SMEs by increasing transparency, traceability, digitalization, and data security through automated transactions and smart contracts. Globally, blockchain-based initiatives have expanded rapidly as organizations increasingly recognize the technology's ability to improve operational efficiency, reduce

transaction costs, and strengthen trust among supply chain stakeholders. For instance, “Trade-lens” IBM and Maersk jointly developed a global blockchain-based trade platform to facilitate information exchange and document management in maritime supply chains [3]. IBM and Maersk ceased this platform due to inadequate commercial viability [4]. Yet, “Trade-lens” remains a significant case study to understand the possible benefits and challenges concerning the implementation of blockchain-based supply chain management platforms.

Blockchain technology enables organizations to manage its product returns, identify the waste flow and closed-loop aspects concerning the supply chains, which can support to enhance trust, traceability, and transparency [1]. Studies have shown that blockchain technology support reduces paperwork and centralizes the trade activities and corresponding, as it facilitates the streamline transactions and sharing of information [5]. The applications and implementation of blockchain technology is not restricted to specific sectors or supply chains. The sectors like agri-food, industrial production and distribution, logistics, maritime transport, and healthcare sectors have adopted blockchain technology [2]. But the key challenges in blockchain adoption are associated with inter-organizational system, business environment (internal and external) and technological factors [6]. Factors like limited knowledge of blockchain applications and difficulties are major challenges that can have significant issues in integrating blockchain aspects. Studies [6], [7] have discussed that the blockchain technology adoption and success depends on interconnected factors, such as organizational factors (organizational culture, top-management support, governance, and technological readiness), business environmental factors (legislation, regulation, competitive pressure, and external support) and technological and operational factors (compatibility, complexity, cost, information exchange, transaction security, and interoperability).

The structure of the market, the willingness of supply-chain partners to participate, and the compatibility of blockchain systems with existing business processes and contractual arrangements may also influence adoption decisions. Sheel and Nath [8] found that blockchain adoption can improve supply chain adaptability, flexibility, alignment, and performance, the conditions under which SMEs can realize these benefits require

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further investigation. Nevertheless, the development of blockchain-based business models in small and medium-sized enterprises (SMEs) is still in its early stages, as many SMEs possess limited financial resources, technological expertise, and infrastructure, and lack sufficient knowledge regarding how blockchain-based business models can support their competitiveness and sustainability [9], [10]. This implies that research needs to examine the factors influencing the development of these models and to determine how blockchain technology can enhance adaptability, flexibility, resilience, competitive advantage, and performance of SMEs.

The present study pursues two objectives in this context. First, it examines the development and intellectual foundations of research in the field of blockchain systems. Second, it analyzes the key factors for blockchain adoption, particularly in small and medium-sized enterprises (SMEs). Accordingly, the study examines research questions developed through bibliometric and scholarly mapping. The bibliometric analysis uses the R package Bibliometrix and the Biblioshiny interface to examine the current state of research and identify publication trends in Scopus-indexed articles [11]. VOSviewer was used to create and visualize bibliometric networks [12]. Together, these tools support to identify key research trends, intellectual foundations, research gaps, and potential opportunities for integrating blockchain technology into SME business models.

This article is structured as follows: Section 2 discusses literature review, which covers discussion on the importance of SMEs and the significance of blockchain technology, particularly in the context of Omani SMEs. Section 3 describes the data, research design, and analytical methods. Section 4 presents the bibliometric results and discusses the main trends in blockchain technology for SMEs research. Section 5 discusses the findings of the study, presents its conclusions and implications, identifies its limitations and research gaps, and suggests directions for future research.

2. Literature Review

Blockchain technology enables the recording and exchange of validated transactions within a network of authorized participants and characterized by decentralization, immutability, traceability, transparency, security, and peer-to-peer information exchange [13], [14]. Through the blockchain protocol, participants can access and verify agreed-upon datasets without relying on a central intermediary. A network may assign public, pseudonymous, or authorized identities to participants. Modifying a transaction is difficult once it has been validated and recorded in the ledger, as any change requires consensus within the distributed network. Cryptocurrency transactions were initially recorded and validated using blockchain technology, pioneered by Bitcoin. As researchers and practitioners realized that distributed ledgers could support far more than just cryptocurrencies [14], [15], their scope of application expanded to other sectors (including inter-organizational collaboration, supply chain management, finance, accounting, logistics, and healthcare). Beyond their existing functions, programmable smart contracts enable the automatic execution of predefined contractual clauses once

specific conditions are met.

A blockchain network can employ various consensus mechanisms, such as Proof of Work (PoW) and Proof of Stake (PoS), to validate transactions. Unlike PoW, PoS selects validators based on the assets they contribute to the network. Recent blockchain developments have improved scalability, interoperability, transaction speed, energy efficiency, privacy, and governance. However, these improvements entail trade-offs between decentralization, security, performance, and implementation costs. To successfully implement blockchain technology, organizations, technology providers, regulators, financial institutions, and supply chain partners must coordinate far more than just technical decisions. Blockchain offers several potential benefits to small and medium-sized enterprises (SMEs). These include improved data security, operational transparency, transaction traceability, supply-chain visibility, information sharing, process automation, and reduced information asymmetry. Blockchain may also help SMEs improve their access to finance by providing lenders and supply-chain partners with more reliable and verifiable transactional information. In supply-chain contexts, its adoption has been associated with greater efficiency and stronger export performance, although its direct effect on financial performance is not always consistent across studies [16]. This indicates that blockchain does not automatically generate financial returns; its benefits depend on how effectively the technology is integrated with existing organizational resources, business processes, and strategic objectives.

Despite its potential benefits, blockchain technology remains largely underutilized by SMEs. Although blockchain is widely known among Italian SMEs, respondents possess limited technical knowledge, and actual usage is low. Consequently, future intentions to use technology are primarily driven by knowledge, perceive usefulness, and perceive ease of use [17]. In a similar study, Hamdan, et al. [18] identified perceived usefulness and ease of use as key drivers of blockchain adoption. The researchers demonstrated that mere awareness is insufficient; executives must also understand how blockchain can be applied to solve problems within their organizations and processes. A Technology-Organization-Environment (TOE) model illustrates how technological, organizational, and environmental factors influence blockchain adoption. Various technological factors play a role, including relative advantage, compatibility, complexity, security, cost, and technological maturity. Several factors are essential for business success, such as management support, financial resources, employee skills, organizational maturity, and strategic alignment. Supply chain collaboration is influenced by factors including competitive pressure, market dynamics, legislation, regulatory support, supplier support, and supply chain regulations [10], [14]. The significance of these factors can vary depending on the national and sectoral context. A study by Bag, et al. [10] found that relative advantage, compatibility, management support, organizational readiness, competitive pressure, external support, and regulatory requirements significantly influenced blockchain adoption among South African SMEs. Complexity,

on the other hand, had a negative impact. Furthermore, the authors identified management support as a reliable predictor of blockchain adoption, followed by organizational readiness and competition. For Indian SMEs, perceived investment costs and technological complexity posed significant hurdles, whereas relative advantage, management support, competitive pressure, and market dynamics facilitated adoption [14].

The adoption of blockchain technology is also influenced by relationships within the supply chain. Small and medium-sized enterprises (SMEs) in the Malaysian halal food sector have adopted blockchain solutions. This process was facilitated by management support, opportunities for experimentation, external assistance, and competitive pressure, with supply chain integration moderating the adoption process [19]. Other studies indicate that a lack of vision at the management level, cultural differences, collaboration challenges, and employee resistance can hinder implementation [10]. Consequently, blockchain projects require stakeholder engagement, shared standards, and a clear governance structure. Even a technically sophisticated system can fail if supply chain partners are not involved. SMEs are particularly vulnerable to resource constraints regarding their organizational readiness. Financial resources, digital infrastructure, technical expertise, management commitment, and skilled IT professionals are essential for project success. Studies involving Saudi SMEs show that organizational readiness strengthens the link between supply chain agility and the intention to adopt blockchain technologies [20]. SME decisions regarding digital transformation are influenced by various factors, including IT infrastructure, digital tools, innovation capabilities, employee skills, and financial resources [20]. Therefore, management must align investments in blockchain technologies with business strategies, the development of employee skills, and goals for enhancing resilience [21].

Thus, it can be implied that economic, legal, and administrative systems rely heavily on contracts, transactions, and institutional records, where the SMEs/companies, government agencies, supply chain partners, and individuals base their actions on these documents. Traditional data recording and management systems often involve intermediaries and central authorities, which increases transaction costs, creates information asymmetries, and limits transparency. Given the evolving digital landscape, SMEs must therefore rethink their traditional administrative and transactional processes and develop technology-enabled operating models to operate with greater responsiveness, transparency, and flexibility.

3. Materials and Methods

The scientific articles included in this review were examined using bibliometric analysis. This method utilizes aggregated bibliographic data from academic databases such as Scopus. In recent years, quantitative bibliometric methods have been increasingly employed to evaluate scientific research and map the evolution of a field of study [22]. Articles from peer-reviewed journals indexed in academic databases are often regarded as "certified knowledge" because they have undergone

formal evaluation, thereby enhancing the credibility of bibliometric findings [23]. Data for this study were extracted from Scopus in August 2026. Scopus, an abstract and citation database developed by Elsevier, indexes scientific literature from recognized peer-reviewed journals and other scholarly sources. It provides author profiles containing information on publications, citations, collaborations, and bibliographic references. Scopus also offers citation alerts and tools for calculating authors' h-indices, enabling registered users to track changes in author profiles and citation performance over time.

The PRISMA flow diagram (Fig. 1) illustrates the systematic selection of studies on blockchain technology and SMEs. Initially, 489 records were retrieved from Scopus. The results were refined using Boolean operators to identify relevant articles. After applying the publication-period filter (2020–2026), 27 records were excluded, leaving 462 articles. No studies were removed based on document type or language because all remaining records were English-language journal articles. The Business and Management subject-area filter reduced the dataset to 99 articles, excluding 363 records. Following a relevance assessment, a further 23 unrelated articles were removed. Consequently, 76 studies met the eligibility criteria and were included in the final bibliometric analysis. The final query ((TITLE-ABS-KEY (blockchain AND technology) AND TITLE-ABS-KEY (SMEs)) AND PUBYEAR > 2020 AND PUBYEAR < 2027 AND (LIMIT-TO (SUBJAREA, "BUSI")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English"))). It can be observed that only research articles were considered; book chapters, conference papers, and white papers were excluded. For the sake of comparability, only English-language publications were used for the data analysis.

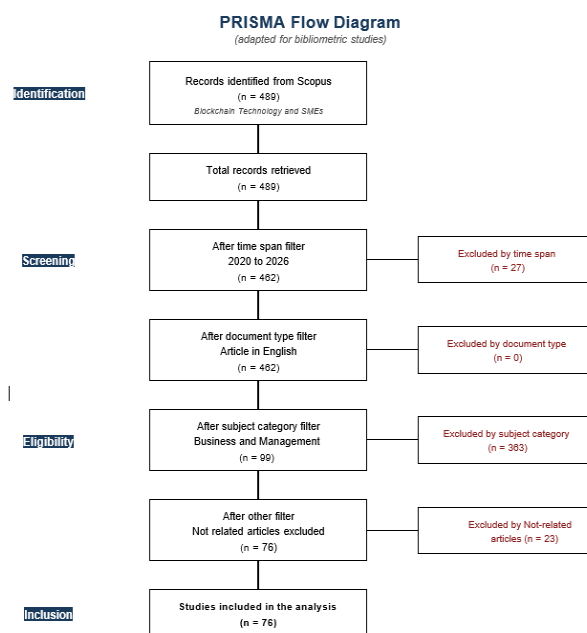


Fig. 1. PRISMA flow diagram

Source: Own-development via Biblioshiny

Data analysis and visualization were carried out using various tools, including Biblioshiny and VOSviewer. The extracted data were analyzed using Biblioshiny via R-Studio. Citation and co-occurrence analyses were conducted. Citation analysis is based on the value researchers assign to publications when citing sources. Bibliometric analysis makes it possible to identify key success factors for blockchain adoption and to understand how this technology can facilitate trade and help SMEs identify revenue-generating business opportunities. Blockchain can only succeed if its unique financial ecosystem is successfully deployed on a non-digital infrastructure, with the support of stakeholders.

4. Findings and Discussions

The dataset extracted for this study comprises 76 documents from 62 sources, published between 2020 and 2026. Academic interest in blockchain technology and SMEs is growing rapidly, as evidenced by an annual publication growth rate of 57.04%. Research in this field is relatively recent and constantly evolving, indicated by the average document age of 1.78 years. Literature has gained considerable academic influence, with an average of 28.04 citations per publication. The documents cite a total of 5,490 references, drawing upon a wide range of existing knowledge. Furthermore, the dataset includes 216 "Keywords Plus" and 285 author keywords, covering a broad spectrum of concepts and research topics associated with blockchain technology adoption among SMEs. Among the 254 authors who have contributed to the literature, there is an average of 3.45 co-authors per document. Six documents are single-authored, while 39.47% of the publications are co-authored by international researchers. These results obtained through Biblioshiny software suggest that blockchain research is primarily collaborative and internationally oriented. The descriptive findings indicate rapidly expanding, multidisciplinary, and highly collaborative research field.

A. Annual Scientific Production

Research on blockchain technology and SMEs saw significant growth between 2020 and 2026 (see Fig 2). In 2020, only one article was published, followed by five in 2021 and four in 2022. The number of publications reached 9 in 2023, 19 in 2024, and 23 in 2025. Although 15 articles were recorded for 2026, these figures should be interpreted with caution, as they were collected before the end of the year. In total, 57 of the 76 articles (75%) were published between 2024 and 2026. Blockchain adoption in small and medium-sized enterprises (SMEs) emerges as a relatively recent yet rapidly expanding field of research. The publication trend reflects growing academic interest in the factors, barriers, applications, and impact of blockchain technology on SME performance.

The number of publications rose from one in 2020 to five in 2021, this may be due to the COVID-19 pandemic. International supply chains were affected by health restrictions, and digital transactions gained prominence. This prompted researchers and practitioners to explore decentralized, technology-driven methods for coordinating business operations. However, annual publication figures alone do not

prove that the pandemic directly caused this increase. COVID-19 can be viewed as a significant contextual factor that highlighted weaknesses in conventional financial systems and supply chains, while boosting interest in blockchain-enabled transparency, traceability, resilience, and information sharing. For instance, Ali, et al. [19] demonstrated that blockchain can enhance transparency and integrity in halal food supply chains, although successful implementation also relies on strategic supply chain integration and regulatory support.

In 2022, the number of articles dropped from five to four, but this trend does not appear to be persisting. In 2023, nine publications addressed the determinants of blockchain adoption and its impact on businesses, moving beyond initial conceptual discussions. Bag, et al. [10] examined blockchain adoption among South African SMEs using the Technology-Organization-Environment (TOE) framework. The study results indicated that blockchain technology adoption had positively influenced by relative advantages, compatibility, management support, organizational readiness, competitive pressure, external support, and regulation, whereas technological complexity has a negative impact. Moreover, it discussed that SME financial and business performance positively affected by blockchain adoption.

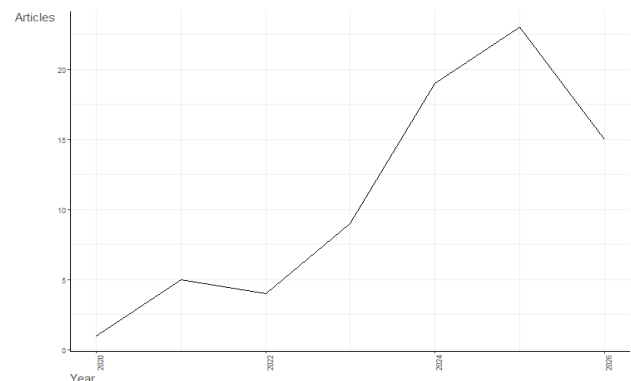


Fig. 2. Annual scientific production
Source: Developed by the Researcher via Biblioshiny

Research activity experienced rapid growth after 2023. The number of publications increased from nine in 2023 to 19 in 2024. Driven by this rapid expansion, blockchain research has emerged as a recognized field of empirical study. During this period, researchers examined the impact of blockchain adoption on the productivity, export performance, financing, resilience, and business development of SMEs. For instance, Purwaningsih, et al. [16] found that blockchain adoption enhances supply chain efficiency and export performance. However, it did not significantly impact the financial performance of SMEs. This finding is significant because it challenges the common assumption that blockchain investments automatically yield financial returns. It can be implied that economic value may stem indirectly from improvements in operational efficiency, market access, information quality, and supply chain coordination.

The number of published articles peaked at 23 in 2025. Approximately 55.3% of the 76 documents published between

2024 and 2025 appeared during those two years alone. When the 15 publications from 2026 are included, 75% of the data originates from the 2024–2026 period. The concentration of this research indicates a relatively recent and rapid rise in studies regarding blockchain adoption in SMEs. Furthermore, it suggests focusing on implementation barriers, organizational readiness, leadership, security, costs, compatibility, supply chain integration, and measurable performance indicators, rather than simply outlining the general potential of blockchain.

The annual scientific publication trends, it appears that publications from 2026 will continue placing greater emphasis on context and performance related to blockchain technology adoption by SMEs. For instances, Bhat, et al. [24] examined blockchain technology adoption among 282 SME owners, managers, and employees in Oman. This study revealed that factors such as costs, management support, competitive advantage, technological compatibility, security concerns, and the level of technological readiness significantly impact adoption, and it had a positive effect on SME performance. But the model did not show statistical significance regarding government frameworks and vendor support. Based on these results it can be implied that favorable policy frameworks may not be enough to encourage SMEs to adopt new technologies if they lack the necessary managerial support, financial resources, technical infrastructure, and relevant employee skills.

Additionally, the publication trends between 2020 and 2026 showed that there is also a rise in publications regarding blockchain-based supply chain finance. SMEs, banks, major corporations, and other supply chain participants can benefit from this technology, as it creates verifiable transaction records, reduces information asymmetry, and improves coordination. A study by Zhan, et al. [25] demonstrated that blockchain-based financing can lower regulatory and audit costs for banks and provide SMEs with more reliable credit information. However, the participation of financial institutions, data credibility, and the implementation of appropriate guaranteed mechanisms are essential.

The trend in publications reflects the growing maturity of research into blockchain and SMEs. While the early years were primarily exploring, empirical studies on adoption factors and organizational impacts expanded rapidly after 2023. However, this rise in publications should not be interpreted as a sign of widespread blockchain adoption among SMEs [10, 14]. The literature continues to identify obstacles such as investment costs, technological complexity, limited management understanding, insufficient organizational readiness, employee resistance, and a lack of collaboration among supply chain partners. Consequently, the surge in research reflects both the perceived value of blockchain and the uncertainty surrounding its implementation in resource-constrained SMEs.

B. Corresponding Author's Countries and International Collaboration

A country-level analysis of corresponding authors reveals that, while blockchain adoption and research within the SME sector are geographically widespread, they are concentrated in a few countries. The Biblioshiny results of first 15 countries is

shown in Fig. 3 and it shows that China was the leading contributor, with 10 articles (13.16% of the total Scopus dataset extracted for this study). India follows with seven articles (9.51%), and Italy with six (7.59%). Indonesia and the United Kingdom each contributed five articles (6.58%), while France contributed four (5.26%). In total, 37 articles originated from these six countries, accounting for 48.7% of the classified documents. Research in the field of blockchain technology and SMEs is concentrated in a few active national research hubs rather than being evenly distributed across the globe. This suggests that the field has developed around a small number of dynamic national research centers.

The research studies associated with China indicated that it's keen interest in blockchain-based supply chain finance, digital transactions, and information exchange has propelled it to the forefront. For example, Zhan, et al. [25] examined how blockchain can improve the financial environment for SMEs and reduce information asymmetries. China's dominant position can thus be attributed to the rapid development of its digital economy, the scale of its supply chain networks, and growing interest both policy-related and academic in blockchain-based financial systems. The rate of collaboration with international partners across the ten Chinese publications is 20%, comprising eight domestic publications and two international ones. Thus, despite high research productivity, China exhibits relatively low levels of international collaboration within this dataset.

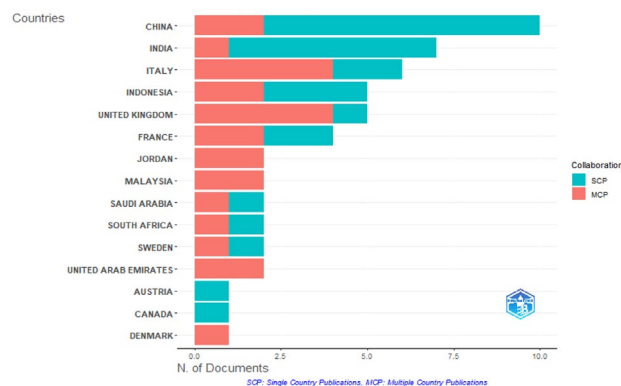


Fig. 3. Corresponding author's countries and international collaboration
Source: Developed by the Researcher via Biblioshiny

Moreover, publications from India showed a similar trend. Six of the seven articles are single-authored publications, and one is an international co-publication, representing a rate of 14.29%. Research conducted in India focused primarily on the determinants of blockchain adoption, implementation barriers, supply chain applications, and the performance of small and medium-sized enterprises (SMEs). For instance, Kumar, et al. [14] concluded that blockchain adoption is influenced by technological, organizational, and environmental factors and can enhance SME performance when supported by appropriate managerial and organizational capabilities. While Chakraborty, et al. [21] highlighted the importance of digital transformation, organizational resilience, and leadership support. The high proportion of domestic publications suggests that Indian

researchers have developed a substantial body of knowledge tailored to their specific context. Furthermore, increased international collaboration may enable researchers to compare adoption conditions across different institutions, regulatory frameworks, and economic environments.

The situation in Italy is different. Although it ranks third in terms of publication volume, four articles stem from international collaborations (MCP). Italian studies have examined knowledge dissemination, firm size, and the practical implementation of blockchain in small and medium-sized enterprises (SMEs). For instance, Bracci, et al. [17] discussed that SMEs possess limited technical knowledge, which hinders the effective adoption of blockchain technology. While Hameed, et al. [26] analyzed blockchain adoption among small Italian businesses. The study results indicated that transparency is universally critical and features like cryptography are aspects of non-negotiable factor for digital product passports. Moreover, Fig. 3, shows that United Kingdom demonstrated the strongest orientation toward collaboration among countries with high publication activity, four articles resulting from international collaborations (MCP). The higher proportion of publications resulting from international collaborations reflects the strong ties of researchers with international scientific networks, facilitating the exchange of experiences and comparative analysis. Thus, it can be implied that international collaboration provides a better understanding of how organizational capabilities and the institutional environment influence blockchain adoption.

Fig. 3 also indicated that 5 articles originate from Indonesia and two of which are co-authored with international researchers (accounting for 40% of international contributions). Indonesian research focuses on SME internationalization, halal supply chains, and export performance. A study by Purwaningsih, et al. [16] indicates that blockchain technology enhances supply chain efficiency and export performance, though it does not directly improve SME financial performance. This finding highlights the importance of research within emerging economies of challenging the conventional wisdom that technology adoption yields immediate economic benefits. Additionally, 4 articles originate from France, with a balanced distribution between local and international supply chains. Although the volume of publications from France is lower than that of China, India, and Italy, the country combines local research with international knowledge exchange. Consequently, blockchain adoption is influenced by both national regulatory frameworks and cross-border technological developments.

The corresponding authors data reveals that, blockchain and SMEs research is widespread internationally, but it is concentrated in a few countries in terms of publications. For example, China leads with 10 publications, followed by India (7), Italy (6), Indonesia and the UK each with 5. India and China publish more single-country studies, while Italy and the UK collaborate internationally. Around 46.7% of publications involve co-authors from multiple countries, showing a moderate level of international collaboration. The publications from African, Middle Eastern, and Latin American research are

limited. Moreover, collaboration with underrepresented regions would enable a comparison of factors such as costs, technological maturity, management support, regulation, and security that influence blockchain adoption.

C. Text Network Data Analysis

VOSviewer (software for creating maps using network data, which allows visualization and analysis of such maps) was used to analysis text network data and co-occurrence of author's keywords. Based on Scopus database files, VOSviewer text network data map is presented in Figure 4. An overlay network of often used terms in the literature on small and medium-sized businesses' (SMEs) use of blockchain technology is shown in Figure 4. The text term's relative frequency is indicated by the size of each node, and its co-occurrence with other terms is indicated by the connecting lines. The average publishing year is shown by the color scale, which goes from earlier subjects in blue and purple to more recent subjects in yellow. The dense network shown in figure 4 suggests that blockchain adoption is a multidisciplinary field of study where supply-chain, organizational, technological, and policy factors are closely related.

Fig. 4 shows that SMEs occupy a central place in literature, serving as the primary unit of analysis. Their use of terms such as "factor," "effect," "implementation," "benefit," "barrier," "innovation," and "supply chain" indicates that researchers are primarily interested in the factors influencing adoption, as well as the organizational consequences of implementation. This pattern aligns with the technology-organization-environment (TOE) framework. For instance, a study by Bag, et al. [10] found that relative advantages, compatibility, management support, organizational readiness, competitive pressure, external support, and regulation contribute to blockchain adoption by SMEs. Kumar, et al. [14] identified SME adoption and subsequent performance as being contingent upon cost, technological complexity, management support, and market conditions.

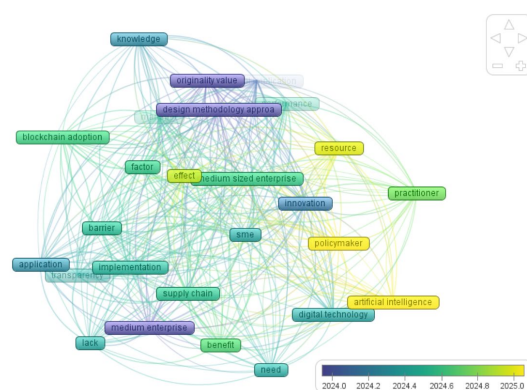


Fig. 4. Text network data analysis

Source: Developed by the Researcher via VOSviewer

Fig. 4 indicates that the literature reveals a strong correlation between "blockchain adoption," "implementation," "obstacles," and "shortages," indicating that blockchain is not viewed merely as a simple technological solution. Emphasis is placed

on the practical challenges faced by SMEs, such as limited financial resources, insufficient technical knowledge, uncertain returns on investment, system incompatibility, and a lack of management preparedness. Bracci, et al. [17] discussed that many SMEs lack the in-depth technical knowledge and implementation capabilities required to adopt blockchain. Similarly, Bag, et al. [10] highlighted that the adoption of blockchain technology in supply chain operations is hindered by managerial, organizational, technological, and inter-organizational obstacles. Given these findings, the gap between expressed interest and actual implementation remains a major challenge.

In recent years the importance of blockchain applications in supply chain research has emerged. Figure 4 indicates that supply chains are also associated with concepts such as "benefits," "transparency," "implementation," and "digital technology." Blockchain technology enables supply chain partners to exchange information, verify transactions, and ensure a transparent process more easily. However, for blockchain to fully realize its benefits, the involvement of multiple organizations and the integration of the technology into existing processes are required. Ali, et al. [19] study showed that the SMEs in the halal food sector are willing to adopt blockchain technology, and it is strongly influenced by its integration into the supply chain. Purwaningsih, et al. [16] discussed that blockchain has improved supply chain efficiency and export performance without significantly increasing financial performance. Blockchain can generate value indirectly rather than through immediate financial gains by enhancing operational efficiency, coordination, and market access. The colors in the overlay indicate gradual evolution in research themes (see Fig 4). Blue and purple represent earlier terms such as "application," "knowledge," "SME," "innovation," "originality value," and "design methodology." Previous studies presented blockchain applications, developed conceptual or methodological approaches, and assessed organizational knowledge and innovation capacity. Knowledge term is closely linked to blockchain emerging early on but remains essential to its adoption, as it forms the foundation. Researchers found that perceived usefulness, ease of use, and blockchain knowledge influenced SMEs' interest in adopting the technology [17].

The recent terms are associated with "resources," "policymakers," "practitioners," and "artificial intelligence," highlighted in green and yellow. It can be implied that literature focuses less on the general potential of blockchain and more on the resources and stakeholder support for its practical implementation. This suggests that adoption increasingly depends on financial resources, digital infrastructure, skilled personnel, and management commitment. For instance, Bhat, et al. [24] discussed that there is a significant correlation between cost concerns, technological compatibility, security, top management support, competitive advantage, and technological readiness factors influence blockchain adoption among Omani SMEs. Moreover, the terms "policymakers" and "practitioners" have gained prominence, highlighting the increased emphasis placed on implementation and policy. SMEs, technology

providers, and public institutions are increasingly seeking practical, science-based guidance. However, it is important to note that policy support alone does not necessarily lead to adoption. The model developed by Bhat, et al. [24] revealed that government measures and provider support were not statistically significant predictors, unlike internal technological and organizational capabilities. Thus, public measures must be complemented by affordability.

Moreover, the term "artificial intelligence" (AI) is closely linked to the concepts of "digital technology," "policy," and "resources." Blockchain is increasingly viewed as an integral part of a broader digital transformation ecosystem rather than an isolated technology as evidenced by its current standing. AI can optimize data analysis, forecasting, anomaly detection, and decision-making, while blockchain can enhance data integrity, traceability, and information exchange. Nevertheless, AI still plays a relatively minor role in research concerning blockchain and SMEs, suggesting that this field is still in its infancy. The text network data illustrates the transition from exploratory discussions regarding blockchain applications to practical considerations concerning adoption barriers, organizational resources, stakeholder responsibilities, and complementary digital technologies. However, the close association of these terms suggests that no single factor can explain the success of blockchain adoption. Numerous factors contribute to it, including technological readiness, organizational capabilities, management support, supply chain integration, institutional frameworks, and anticipated business benefits. Future research should therefore examine how these factors interact and whether blockchain can generate sustainable outcomes for SMEs in terms of operations, market share, and financial performance. It is essential that the network reveals patterns of co-occurrence rather than causal relationships between the terms. The frequency of a term indicates its relative prominence or influence on adoption within the dataset, but it is not necessarily an indicator of its theoretical importance. Consequently, the figure should be interpreted in conjunction with the empirical findings of the studies reviewed. To validate the proposed mechanisms, assess their transferability to other sectors, and identify practical guidance for SMEs seeking sustainable competitiveness and blockchain-driven operational improvements, future work must combine qualitative analyses with quantitative models.

5. Conclusions, Limitations and Future Directions

A bibliometric analysis shows that, despite rapid growth in blockchain adoption among small and medium-sized enterprises (SMEs), the field is still relatively nascent. An annual growth rate of 57.04% represented by 76 documents published between 2020 and 2026 and 57 publications appeared between 2024 and 2026, making up 75% of the dataset. A growing number of academic and practical interests have resulted in this recent concentration, including blockchain adoption, supply chain management, digital transformation, sustainability, financial performance, and artificial intelligence. It appears, however, that knowledge is dispersed rather than concentrated within a core group of established journals, as

evidenced by the distribution of seventy-six documents across sixty-two sources of publication.

The bibliometric analysis indicated that distributed ledger technology falls under the umbrella of information technology, and blockchain is a distributed ledger technology. Moreover, blockchain technology initially attracted to the opportunities presented by Bitcoin, and more than one entity involved in a single transaction in a blockchain. A transaction's content can be encoded using transaction hashes provided by blockchain technology. Blocks are linked in a chain, and altering or eliminating transactions is challenging, particularly for SMEs, since the blockchain mechanism does not allow data to alter [27]. However, blockchain enables transparency as all participants can access the same data [28]. This implies that blockchain adoption may support improving security and reliability as changes are recorded and visible to all participants.

Based on these findings, blockchain adoption cannot be viewed solely as a technological investment. There is a strong interplay between technology, organizational factors, and the environment that determines the success of a project. There are many factors that influence adoption [10], [14], [24] including relative advantages, compatibility, cost, security, technological maturity, management support, competitive pressure, external support, and regulatory frameworks. Therefore, SMEs should first identify a specific operational issue (for example, lack of supply chain transparency, unreliable data, delays in trade finance, or information asymmetry) before considering blockchain.

SMEs have limited financial, technological, and human resources. Consequently, organizational readiness is of particular importance. Understanding blockchain does not automatically lead to its adoption; leaders must also grasp its benefits, implementation requirements, and compatibility with existing business processes [17]. It is crucial that they conduct a readiness analysis covering infrastructure, employee skills, cybersecurity, investment capacity, data quality, partner engagement, and expected returns on investment. Beyond the initial decision to adopt blockchain, successful implementation requires organizational learning, process reorganization, and coordination with external stakeholders [21]. Furthermore, the literature indicates that the benefits of blockchain are not always immediate or purely financial. While blockchain enhances supply chain efficiency and export performance, Purwaningsih, et al. [16] note that its direct impact on financial performance remains limited. However, Bag, et al. [10] and Bhat, et al. [24] found a positive correlation between blockchain adoption and SME performance. Outcomes can be influenced by sectoral conditions, the level of implementation maturity, complementary resources, and measurement methods. SMEs should employ a combination of indicators to measure value, including traceability, transaction times, error reduction, supply chain responsiveness, customer trust, export capacity, market performance, and financial returns.

The benefits of blockchain technology depend on the willingness and capabilities of suppliers, customers, financial institutions, and logistic companies. Ali, et al. [19] discussed SMEs in the Halal food production sector are more likely to

adopt blockchain if supply chain are integrated. Therefore, SMEs should first conduct small-scale pilot projects with trusted partners before undertaking large-scale implementation.

This study dataset shows that blockchain is linked to artificial intelligence, digital transformation, and sustainability. These technologies should view as complementary tools rather than isolated ones. Blockchain enhances data integrity, enables data traceability, and allows for the controlled exchange of information. AI can support forecasting, anomaly detection, and decision-making. Wu, et al. [29] demonstrate that blockchain, AI, and big data analytics supported by data-driven lean practices and green technologies, these can contribute to green technological innovations. However, SMEs should avoid implementing multiple technologies without a clear integration strategy, as this can increase costs and complexity without generating proportional benefits. For instance, Bhat et al. (2026) discussed that the situation of Omani SMEs and discussed that it is influenced by factors such as cost concerns, top management support, relative advantages, technological compatibility, security concerns, and technological readiness. In contrast, neither government measures nor vendor support appear as significant predictors in the model. Companies may not be able to pursue policy messages on their own if they do not have the necessary resources and skills. SMEs performance can enhance by the adoption of blockchain technology, but internal preparedness is crucial. For examples, the Omani insurance sector showed that aligning new technologies with internal processes, financing, training, and external partnerships, as well as long-term institutional support, are important for adoption of advanced technology [30].

The findings of this study suggest that SMEs should conduct a comprehensive blockchain readiness analysis to evaluate their preparedness for blockchain adoption. This process can facilitate strategic investment decisions related to technology infrastructure, financial resources, workforce capabilities, cybersecurity measures, data quality, and integration needs. A structured problem-solving approach is also critical, as it allows organizations to recognize and capitalize on the advantages of blockchain technology, particularly its capacity to enable shared verification, transparency, and immutable record-keeping. The advancement of blockchain functionalities, particularly traceability and programmability, is essential given their potential advantages over conventional database systems. Nevertheless, organizations should adopt a phased implementation approach by conducting pilot projects before committing them to large-scale blockchain deployment. Pilot applications in areas such as product traceability, supplier authentication, invoice management, trade documentation, and supply chain financing can help evaluate feasibility and identify potential challenges. The findings from these initiatives can inform investment strategies, policy development, and implementation frameworks. Additionally, policymakers should complement general digital transformation strategies with sector-specific technical assistance and regulatory support to accelerate blockchain adoption among SMEs. The performance must be measured should evaluate not only short-term financial returns but also operational, financial,

commercial, social, and environmental impacts. For example, blockchain improves transparency in the supply chain and enables access to an asset's "story"[31]. In addition to blockchains, financial firms actively embrace blockchain technology to address payment problems [32].

Additionally, SMEs can enhance the collaboration between international and regional organizations. For example, by collaborating with other underrepresented economies and other less developed nations, it can enhance their comparative understanding of blockchain adoption. This will facilitate developing shared industry collaboration platforms. Often studies have discussed that a lack of resources can make it difficult for SMEs to implement standalone blockchain systems. It also allows stakeholders to instantly access accounting data, improving governance and transparency [33]. Thus, to support SMEs the trade association, technology providers, financial institutions, and government agencies can develop shared platforms or Blockchain-as-a-Service platforms. This will facilitate the joined blockchain network.

The ability to operationalize new technology applications must be developed by gaining and combining resources [34]. SMEs can benefit from theoretically grounded insights on resource readiness to facilitate the successful adoption of blockchain technology, particularly given that its applications and implications are still evolving. Existing literature suggests that technological, organizational, and environmental factors play a significant role in influencing SMEs' adoption of blockchain technology and its application in trade finance. Therefore, the successful implementation of blockchain requires the availability of both technological capabilities and organizational resources. Furthermore, SMEs and government agencies should collaborate to establish common data standards, clearly defined participant roles, access rights, dispute resolution mechanisms, and cybersecurity requirements. Such measures can help mitigate the challenges and barriers associated with blockchain adoption while promoting greater interoperability, trust, and effective implementation.

Blockchain technology can offer substantial benefits, particularly in enhancing organizational operational performance. However, its successful implementation and outcomes depend not only on the technology itself but also on the development of a shared organizational culture and mutual trust among business leaders and policymakers [35]. Accordingly, strengthening the skills and knowledge of managers and employees is essential for facilitating effective blockchain adoption. In addition to technical blockchain concepts, training programs should address strategic objectives, legal considerations, cybersecurity challenges, data management and governance practices, as well as the expected business value and competitive advantages for SMEs. This holistic approach can improve organizational readiness and contribute to the successful implementation of blockchain technology.

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