

Leveraging Blockchain Technology to Combat Counterfeiting: Expert Perspectives and Practical Solutions

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ABSTRACT

Counterfeiting has become a significant global issue, raising concerns among stakeholders in supply chains. Counterfeit products often contain substandard or hazardous components, posing significant health risks, particularly in sectors such as pharmaceuticals, cosmetics, and food. They may lead to consumer illness or even death, while also causing substantial revenue losses for businesses, disrupting legitimate supply chains, damaging brand reputation, and weakening consumer confidence. Counterfeit goods are often manufactured in unregulated settings that disregard environmental standards, resulting in the use of toxic materials, improper waste disposal, and increased pollution. Therefore, preventing counterfeit goods is crucial to ensuring the economic benefits of all stakeholders and promoting the sustainable development of the supply chain. Blockchain Technology (BT) is a revolutionary technology that offers several unique characteristics for combating counterfeiting. Nevertheless, BT deployment currently remains in the experimental stage, especially for anti-counterfeiting purposes. This study examines the barriers that hinder the adoption of BT-based solutions. This is the first study to conduct interviews with academic and industry experts to look into the key barriers to deploying BT-based anti-counterfeiting solutions. This study utilized key barriers identified in previous studies, including technological, organizational, and environmental barriers, to establish a foundation for interview questions. Semi-structured questions will be selected to obtain expert opinions and viewpoints on the significant challenges in Vietnam. As a result, this study indicated that deployment cost is the most significant technological barrier. A lack of competence and skills is a significant organizational barrier, whereas the absence of a defined legal framework is the most significant environmental barrier. In addition to the most significant barriers, several other barriers are identified, such as limited customer awareness, a lack of reliable service providers, and inadequate national infrastructure. As a result, practical solutions have been proposed to address those barriers and encourage stakeholders to adopt blockchain-based solutions.

Keywords: *Blockchain Technology, Counterfeiting, E-commerce, Supply chains.*

1. INTRODUCTION

Counterfeiting has existed for centuries and is becoming increasingly prevalent worldwide, particularly as e-commerce continues to grow. Shopping online has emerged as a global trend. E-commerce has been rapidly expanding throughout the years. The global e-commerce market is expected to reach \$6.09 trillion in 2024, representing an 8.4% increase from the previous year (Shopify, 2025). A multinational survey conducted by Michigan State University researchers (Alhabash *et al.*, 2023) explored customer purchasing behavior across 17 countries, ranging from leading industrialized nations such as the United States and the United Kingdom to emerging countries like Kenya and Nigeria. They discovered that over 70% (74%) of the 13,053 respondents had purchased counterfeit products. They frequently purchased counterfeits via e-commerce platforms and social media, with Facebook accounting for 68% of the total. E-commerce has increased the complexity of the supply chain while also increasing the presence of counterfeit items. Online shoppers can only view product images and descriptions, and cannot inspect the product's quality. They did not deal with merchants directly. This enables the spread of counterfeit products.

According to the International AntiCounterfeiting Coalition Inc. (2024), counterfeiting is a criminal activity caused by replicating another's brand. A counterfeit product utilizes the owner's trademark without their approval. There are two main types of counterfeiting. Non-deceptive means that buyers recognize the difference between the genuine product and the counterfeit product, yet still purchase the counterfeit product. In contrast, deceptive counterfeit refers to buyers who cannot distinguish between genuine and counterfeit goods before making a purchase (Pun *et al.*, 2021). Customers who purchase counterfeit goods suffer economic, legal, health, and safety risks (U.S. Customs and Border Protection, 2023). Besides, authentic companies will lose revenues to counterfeiters, potentially leading to bankruptcy. Additionally, consumers may be concerned about the brand, which can lead to customer dissatisfaction and a negative reputation (Gayialis *et al.*, 2022). Furthermore, the government may lose tax revenue due to the bankruptcy of genuine enterprises. Consequently, counterfeit items hurt supply chain stakeholders, particularly customers, corporations, and governments.

Counterfeiting is becoming increasingly prevalent, particularly in developing nations. According to the Global Organized Crime Index (2025), China has the highest counterfeit products trade index (9.5 out of 10), followed by Paraguay (9), Peru (9), Afghanistan (8.5), Cambodia (8), and



Figure 1 Some examples of anti-counterfeiting solutions (VietNamNet ICom, 2022)

Ethiopia (8). It's worth noting that the top countries with the highest indexes are all emerging markets with low incomes and inadequate technology infrastructures. Additionally, most of them come from Asia, such as China, Afghanistan, India, Cambodia, Thailand, and Vietnam. Additionally, the prior survey highlighted that India, Kenya, Egypt, and Nigeria had the highest rates of counterfeit purchases (Alhabash *et al.*, 2023). With the increasing growth of e-commerce, the issue of counterfeit goods in emerging economies has become a more serious concern. As a result, addressing the counterfeiting issue is becoming increasingly urgent in those countries.

Many technological techniques have been developed and implemented to prevent counterfeit goods. Radiofrequency identification (RFID) and near-field communication (NFC), barcodes, holograms, and DNA coding are some of the most frequently utilized anti-counterfeiting technologies (Chen *et al.*, 2022; European Union Intellectual Property Office, 2021). Figure 1 depicts examples of holograms and QR codes. They are applied to the goods to help customers identify genuine products. However, they have several drawbacks, including being easily copied, counterfeited, and not electronically authenticated (e.g., holograms). Additionally, these solutions, such as QR codes, often rely on centralized databases that are susceptible to tampering. Moreover, they could not offer online tracking of product history or authentication, which are crucial features in today's increasingly complex and digital supply chains. Hence, there is a growing need for innovative technologies that can effectively address these challenges.

Blockchain technology (BT) emerges as a promising solution, offering a decentralized, highly secure, and tamper-resistant system. BT ensures data integrity through immutability, preventing unauthorized or tampered alterations. It enables authorized participants to verify product authenticity at every stage independently. Many popular solutions rely on centralized databases, which are vulnerable to tampering, manipulation, or single points of failure. In contrast, BT offers a decentralized system that enhances security and resilience. Its use of proven consensus mechanisms ensures the reliability and integrity of the network. Furthermore, BT provides smart contract integration, enabling automatic and transparent rule enforcement, as well as reliable digital tracking throughout the supply chain.

BT has emerged as an effective anti-counterfeiting technology. It offers numerous distinctive properties, including security, privacy, decentralization, transparency, flexibility, tamper-proofness, traceability, immutability, non-repudiation, and anonymity (Chen *et al.*, 2022; Islam *et al.*, 2022; Ma *et al.*, 2020; Zhu *et al.*, 2020). BT features a decentralized architecture that eliminates the reliance on a central authority. All parties must verify all transactions. Additionally, BT provides a powerful way to monitor all activities across a supply chain, from manufacturing to retail (European Union Intellectual Property Office, 2021). BT prevents counterfeiters from manipulating product information, ensuring that buyers receive only original products (Mohammed *et al.*, 2024). Therefore, several researchers have employed BT to develop anti-counterfeiting systems. For example, Chen *et al.* (2022) developed a BT-based anti-counterfeiting management system to track high-end products. BT is used to safely store supply chain data on raw material procurement, manufacturing, consumer distribution, product transportation, and logistics. Mohammed *et al.*, (2024) created TrustChain, which integrates BT and barcode technologies to identify the past and origins of products.

However, most BT-based anti-counterfeiting solutions are still in the research phase. Only a few applications have been implemented in real-world scenarios, such as Aura Blockchain Consortium (<https://auraconsortium.com/>), Everledger (<https://everledger.io/>), and VeChain (<https://vechain.org/>). For example, the Aura Blockchain Consortium, created by LVMH, Prada, and Cartier, offers BT-based authentication that allows consumers to confirm the authenticity of expensive items. They are targeted at high-end products and are used by large enterprises such as LVMH, Walmart, and Nestlé. It is evident that the majority of blockchain-based solutions have been adopted in developed countries and by luxury brands, which typically possess the financial resources and technological infrastructure to support implementation. However, counterfeiting remains an ongoing concern in prosperous nations such as the European Union and the United States (OECD & EUIPO, 2025). Although these developed countries have effectively deployed BT in several fields such as finance and logistics, its adoption for anti-counterfeiting purposes is still limited. Many firms in those nations, especially small and medium-sized enterprises, have yet to adopt blockchain-based solutions. Consequently, adoption is becoming increasingly challenging in developing nations

due to obstacles such as insufficient financial resources, a scarcity of skilled professionals, and low levels of digital literacy among consumers. Therefore, it is essential to conduct further research to explore the challenges to the adoption of BT for anti-counterfeiting purposes.

Additionally, few studies have investigated the challenges of employing BT against counterfeits. However, they primarily employed a systematic literature review. For example, Yiu (2021) examined relevant publications to investigate potential difficulties with developing decentralized solutions for anti-counterfeiting. Pesqueira *et al.* (2024) conducted a systematic literature review to examine the challenges and prospects of BT for anti-counterfeiting in the healthcare sector. As a result, this study contributes to the existing literature review by conducting in-depth interviews with specialists. Discussions with professionals can help us better understand the challenges and opportunities of using BT to prevent counterfeiting.

This study will interview specialists who possess a thorough understanding of BT and extensive experience in implementing its solutions. Participants will come from both academia and industry, ensuring a balanced perspective. The chosen organizations are actively involved in developing and implementing BT-based solutions. Their opinions will be critical in identifying significant impediments and developing effective ways to encourage the adoption and integration of BT into existing corporate processes. As a result, the study will propose practical recommendations to promote the use of BT in anti-counterfeiting activities, particularly in developing countries.

The remainder of the research is divided into six sections. Section 2 provides an overview of the literature on BT and related studies. Section 3 presents the research methodology. Section 4 explains the findings. Section 5 proposes solutions. Section 6 presents future work. Section 7 concludes the study.

2. LITERATURE REVIEW

Section 2 reviews the literature on blockchain technology (BT) and its relevance to anti-counterfeiting. Section 2.1 describes the fundamental characteristics of BT, while Section 2.2 examines its applications in various industries. Section 2.3 focuses on the use of BT for anti-counterfeiting, whereas Section 2.4 identifies impediments to its adoption. These subsections provide a foundation for understanding BT’s potential and challenges in this area.

2.1 Blockchain Technology

Blockchain technology (BT) is a decentralized ledger that records the information of each transaction in its corresponding blocks (Lu *et al.*, 2022; Mohapatra *et al.*, 2023). BT is a distributed ledger technology that records and verifies transactions (Chen *et al.*, 2023). Figure 2 depicts how BT performs. First, the user initiates a transaction. Then, it broadcasts to node-based networks. These nodes validate the request based on predefined rules to ensure its authenticity. After validation, this transaction will be combined with other transactions to create a new block. This block is then permanently added to the blockchain network, ensuring its immutability. Finally, the transaction is completed. The modified blockchain has been distributed throughout the network’s nodes, allowing all parties to see the final confirmation.

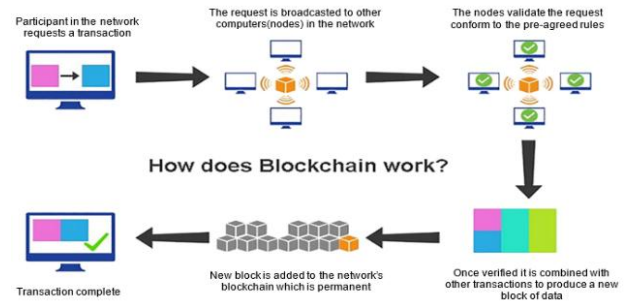


Figure 2 Main stages of Blockchain (Mohapatra *et al.*, 2023)

BT has evolved into four phases: Blockchain 1.0, Blockchain 2.0, Blockchain 3.0, and Blockchain 4.0 (Bodkhe *et al.*, 2020; Sunny *et al.*, 2022). Blockchain 1.0 refers to the initial generation of BT, which was mainly involved with cryptocurrency. This generation launched in 2009. Bitcoin is an example of a 1.0 blockchain. Blockchain 2.0 expands beyond cryptocurrency to include financial and business applications. Ethereum is the most notable platform for Blockchain 2.0, featuring smart contracts. Blockchain 3.0 enables decentralized applications across various domains, including healthcare, governance, IoT, supply chain management, business, and smart cities. Blockchain 4.0 represents the most recent generation of BT. It integrates with cutting-edge technologies, including artificial intelligence, the Internet of Things, and big data. It prioritizes applications such as decentralized digital records and real-time, distributed databases.

BT can be classified into several types. Some authors classified it as public, consortium, and private (Ghosh *et al.*, 2023; Jiang & Chen, 2021; Mohammed *et al.*, 2024). The public blockchain is open to all users. In contrast, only authorized participants are permitted to join the private blockchain. However, it is managed by a single organization. Meanwhile, the consortium blockchain is managed by a group of selected businesses. Others categorized BT into four types: private, public, consortium, and hybrid (Zoughalian *et al.*, 2022). Hybrid blockchains have been introduced, which include both public and private characteristics. A hybrid blockchain in which everybody can access it, but only a few authorized nodes can make updates.

Table 1 shows comparisons between BT types. Private, consortium, and public blockchains differ significantly in terms of efficiency, consensus mechanisms, data integrity, centralization, access rights, and consensus processes. In terms of efficiency, private and consortium blockchains perform well due to their limited participation and streamlined validation. In contrast, public blockchains tend to have lower efficiency due to their open and resource-intensive consensus protocols. In terms of consensus determination, private blockchains rely on a single organization, consortium blockchains use a subset of nodes, and public blockchains demand consensus from all miners. In terms of constancy, or resistance to tampering, public blockchains are nearly immutable due to their decentralized structure. In comparison, private and consortium blockchains may be vulnerable to manipulation by authorized parties. Public blockchains are fully decentralized, with no central control, while private blockchains are centralized, and consortium blockchains are

Table 1 Blockchain types and their properties (Ghosh *et al.*, 2023)

Blockchain Type	Private	Consortium	Public
Efficiency	High	High	Low
Determination of consensus	An organization	Chosen node set	All miners
Constancy	Could be tampered with	Could be tampered with	Almost impossible
Centralized	Yes	Partial	No
Reading authorization	Public or restricted	Public or restricted	Public
Process of Consensus	Approved	Approved	Permissionless

partially decentralized. For reading authorization, both private and consortium blockchains may restrict access, whereas public blockchains are open to everyone. Finally, consensus processes in private and consortium blockchains are approved by designated participants. In contrast, public blockchains rely on permissionless mechanisms, such as Proof of Work (PoW) or Proof of Stake (PoS), which allow anyone to participate in the validation process.

BT offers various essential attributes, many of which contribute to its potential as a promising solution for preventing counterfeiting. These include decentralization, security, transparency, immutability, and traceability (Chen *et al.*, 2023; Duan *et al.*, 2023; Jiang & Chen, 2021; Lu *et al.*, 2022; Mohapatra *et al.*, 2023; Sun *et al.*, 2023; Tsai & Shen, 2024; Wang *et al.*, 2024). This study employs a circular diagram format to highlight the interrelated nature of blockchain's key characteristics, as illustrated in Figure 3. The circular layout illustrates how core attributes work together to enhance the effectiveness of BT in combating counterfeiting. The equal placement of each element signifies that these characteristics are interdependent and collectively reinforce the integrity and reliability of the BT-based system. Decentralization eliminates the need for a central authority, allowing all participants to access and verify data equally (Chen *et al.*, 2023; Lu *et al.*, 2022; Mohapatra *et al.*, 2023; Tsai & Shen, 2024). This reinforces immutability, ensuring that once data is recorded, it cannot be altered (Ghosh *et al.*, 2023; Mohapatra *et al.*, 2023), thereby preventing counterfeiters from tampering with or inserting false information.

Moreover, BT provides strong security through cryptographic techniques and consensus mechanisms, which protect data from unauthorized access and ensure its integrity (Duan *et al.*, 2023; Z. Li *et al.*, 2021), effectively preventing counterfeiters from manipulating the system. Additionally, it promotes transparency by making information openly available across the network, allowing stakeholders to view transaction histories and track a product's origin and movement throughout the supply chain. BT facilitates traceability by offering a complete, tamper-proof record of transactions at all stages of the supply chain (Duan *et al.*, 2023). It enables shoppers to track items across the entire supply chain, from raw material selection and manufacturing to transit and final sale, by providing access to verified data stored within the system (Sun *et al.*, 2023).

2.2 Blockchain Technology Implementation

BT has been applied in various domains. Sunny *et al.* (2022) reviewed BT applications published from 2015 to late 2021. They found that BT is widely used in various fields, including transportation, commerce and industry, privacy and security, the financial sector, government, education, healthcare, and the Internet of Things (IoT). Most BT applications are in financial management. BT has been

increasingly implemented in several sectors, including education, healthcare, IoT, and transportation. Besides, numerous studies have focused on implementing BT in supply chains (Lu *et al.*, 2022; Yiu, 2021; Zhang *et al.*, 2022).

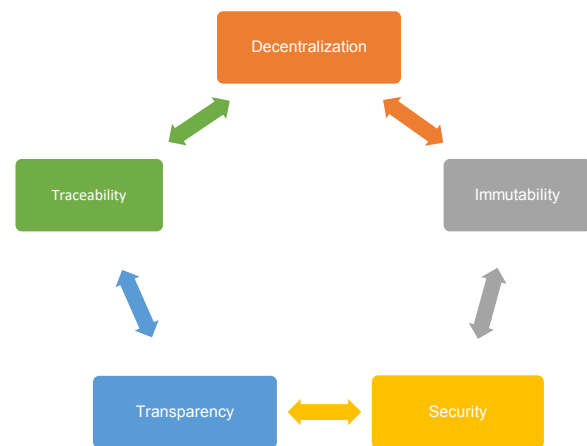


Figure 3 Blockchain's key attributes in preventing counterfeits

For example, Chen *et al.*(2023) proposed a framework integrating BT into the tea supply chain. BT offers data tracking throughout the tea supply chain by reliably recording the stage of the supply chain, from growing to retail, as shown in Figure 4. This framework includes three main components: application, data storage, and BT network. As a result, it enhances transparency and prevents the production of counterfeit tea. Moreover, BT has applied to e-commerce (Jiang & Chen, 2021; Liu *et al.*, 2023). They emphasized the critical role of blockchain-powered e-commerce platforms in eliminating counterfeit products. Legitimate companies generate more significant revenue by employing BT when production costs are high (Jiang & Chen, 2021).

2.3 Adoption of Blockchain Technology for Anti-counterfeiting

BT has been increasingly used in anti-counterfeiting initiatives. Multiple authors have proposed BT-powered anti-counterfeiting methods (Chen *et al.*, 2020, 2022; Ma *et al.*, 2020; Zhu *et al.*, 2020; Zoughalian *et al.*, 2022). For example, Ma *et al.* (2020) proposed a BT-based anti-counterfeiting system for manufacturers, sellers, and consumers. The authors utilized Remix, an online Solidity IDE, to simulate and evaluate gas usage, estimating that deploying their blockchain-based anti-counterfeiting system would cost approximately \$1.29 for a one-time contract setup per product and \$0.17 for each transaction in the sales process.

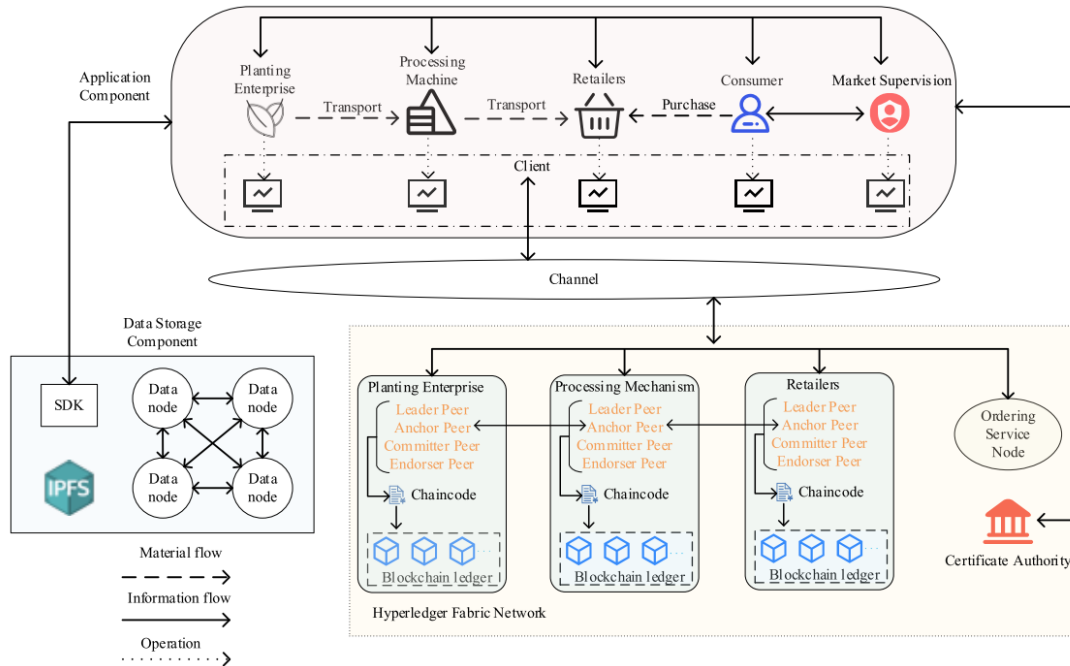


Figure 4 Integrating Blockchain Technology into the tea supply chain (Chen *et al.*, 2023)

They suggested that the system was cost-efficient, making it more accessible for low-budget firms while helping boost consumer trust in product authenticity. Similarly, Zhu *et al.* (2020) offered a blockchain-based system of medicine anti-counterfeiting and traceability. They executed 300 medicine tracking operations in Python to imitate blockchain operations and verify the suggested technique. All simulations and testing were performed on a single PC, with no deployment on an actual blockchain network. Chen *et al.* (2022) developed a BT and smart contract-based anti-counterfeiting management system for traceable luxury goods: BT stores raw material source, manufacture, demand, and product transportation data. The proposed system offers decentralized data storage, removing reliance on external regulators or hardware to preserve blockchain records. They evaluated the performance of their proposed blockchain systems through experimental simulations using Hyperledger Caliper, a performance benchmarking framework designed for evaluating blockchain systems. Thus, the majority of the proposed anti-counterfeiting systems based on BT have been examined in simulation environments, hence their result could change in real-world implementations. This is because simulation environments sometimes streamline or ignore critical factors such as system scalability, network latency, hardware constraints, customer behavior, and integration into current enterprise systems. As a result, they could disregard key technical and operational challenges in real-life deployment.

Moreover, several studies have investigated whether corporations should employ BT to combat counterfeiting (Jiang & Chen, 2021; Z. Li *et al.*, 2021; Lu *et al.*, 2022). For example, Jiang & Chen (2021) used Stackelberg equilibrium theory to develop enterprise profit-driven analytical models. They claimed BT does not always benefit businesses, retailers, and buyers. Legitimate companies should employ BT when production costs are high. Z. Li *et al.* (2021) investigated how BT adoption affects the decision of legal

enterprises to select the most effective distribution channel. They typically use a dual sales channel in the absence of BT. With the adoption of BT, they should switch to a single channel. The entire supply chain system can perform better through the platform's blockchain adoption if the quality of imitation products and the platform's credibility level are low (Lu *et al.*, 2022). BT adoption enhances supply chain performance, especially when fake products are of low quality and the platform lacks strong credibility (Lu *et al.*, 2022). Moreover, previous studies have demonstrated that BT adoption improves consumer surplus and social welfare (Z. Li *et al.*, 2021). BT platforms improve consumer rights (He *et al.*, 2023).

As a result, the majority of past research has employed simulations and game theory to evaluate the effectiveness of BT in anti-counterfeiting. Those papers prioritize computational simulation rather than real-world execution. Choi *et al.* (2020) stated that the acceptance rate of BT is considerably low. Thus, researchers are increasingly paying attention to identifying and assessing the difficulties associated with blockchain implementation (Mohapatra *et al.*, 2023). After reviewing Google Scholar, we found that there has been limited research on the implementation of BT for anti-counterfeiting purposes. As a result, this study will address this gap.

While previous research focused primarily on general barriers to blockchain adoption, such as scalability, interoperability, and regulatory concerns, there remains an urgent need to comprehend the particular challenges related to using BT to combat counterfeiting. Blockchain-based anti-counterfeiting applications differ from other blockchain use cases in that they require product-specific materials, item-level traceability, real-time verification, and the integration of physical identifiers, such as RFID and QR codes. These solutions, in particular, must enable end users or stakeholders to easily verify the validity of a product using cellphones, barcode scanners, or specialized mobile applications. This

level of accessibility is critical for fostering trust and promoting widespread adoption. These systems must function effectively within complex supply chains, where stakeholders may be hesitant to provide data due to competitive or cultural reasons. As a result, the design and implementation of blockchain for anti-counterfeiting purposes need to consider not only technical barriers to adoption, but also organizational and environmental factors.

2.4 Barriers To The Adoption Of Blockchain Technology For Anti-Counterfeiting

The Technology-Organization-Environment (TOE) concept has been frequently utilized to clarify the challenges of adopting many IT advances (Choi *et al.*, 2020). Several researchers have employed the TOE framework to investigate the challenges of BT adoption (Choi *et al.*, 2020; Clohessy & Acton, 2019; Kouhizadeh *et al.*, 2021; Rani *et al.*, 2024). The TOE framework refers to the technological, organizational, and environmental dimensions. According to Kouhizadeh *et al.* (2021), technological barriers are the underlying technical limitations of BT systems that limit their usability. Organizational barriers include internal operating challenges as well as coordination issues among supply chain partners. Environmental barriers are external constraints imposed by governments, businesses, institutions, and communities. As a result, this study will categorize barriers utilizing TOE frameworks.

BT has been widely adopted across various industries and sectors for a diverse range of purposes. Table 2 summarizes recent research on the challenges and impediments to the adoption of BT. These studies demonstrate the growing academic interest in understanding the barriers that hinder the application of BT in various scenarios. Most recent research has focused on general BT implementation difficulties, particularly in supply chains (Esmailian *et al.*, 2020; Kouhizadeh *et al.*, 2021), healthcare (Pesqueira *et al.*, 2024), food industry (K. Li *et al.*, 2023), agriculture (Mohapatra *et al.*, 2023), and fashion (Moretto & Macchion, 2022). For example, K. Li *et al.* (2023) identified the primary barriers to BT adoption in the food industry as technology, governance, regulations, cost, and awareness and education. Moretto & Macchion (2022) identified two key barriers to BT adoption in fashion supply chains: technological and industry-specific. Technological barriers include cost and complexity. Industry-specific refers to a shared technological standard, technical culture, and collaboration among several SC partners. Pesqueira *et al.* (2024) discovered obstacles to BC adoption in the healthcare sector, including cost, technical knowledge required, scalability, and the requirement to integrate BC-based solutions with existing technology.

Nevertheless, limited attention has been paid to the challenges associated with using BT to combat counterfeiting. Yiu (2021) performed a literature analysis and examined the shortcomings of current supply chain anti-counterfeiting solutions. They recommended leveraging BT to develop decentralized systems that improve security and transparency in product verification and traceability. However, this study solely highlighted the technological limitations of BT implementation. Recently, Pesqueira *et al.* (2024) highlighted concerns about counterfeiting in the healthcare sector. They conducted a systematic review of the

literature published in 2023, focusing on blockchain applications for enhancing traceability, combating counterfeiting, and detecting fraud in the healthcare sector. While they identified several opportunities and general challenges, they did not explicitly categorize the barriers using the TOE framework. One relevant study by (Kouhizadeh *et al.*, 2021) used a qualitative method to investigate the barriers to blockchain implementation in sustainable supply chains, gathering insights from both academics and industry experts. However, the study did not cover blockchain applications for anti-counterfeiting. As a result, this study addresses those gaps by conducting in-depth interviews to investigate barriers in blockchain adoption for anti-counterfeiting objectives.

Numerous challenges have been explored. Based on Table 2, some significant technological challenges include scalability, security, privacy, immaturity, and integration with existing technology (Duan *et al.*, 2023; Kouhizadeh *et al.*, 2021; K. Li *et al.*, 2023; Mohapatra *et al.*, 2023; Pesqueira *et al.*, 2024). In terms of organizational barriers, financial limits, lack of knowledge and skills, lack of management commitment and support, and lack of organizational policies are key barriers (Choi *et al.*, 2020; Clohessy & Acton, 2019; Duan *et al.*, 2023; Esmailian *et al.*, 2020; Moretto & Macchion, 2022; Rani *et al.*, 2024). Some prevalent environmental challenges include a lack of stakeholder trust, resistance to blockchain culture, and inadequate customer knowledge. Governmental Policies, Unstable internet infrastructure (Kouhizadeh *et al.*, 2021; K. Li *et al.*, 2023; Mohapatra *et al.*, 2023).

Furthermore, most previous studies used systematic literature reviews to investigate the barriers. Few studies have used surveys. However, they have mainly concentrated on surveys with business executives in charge of deciding whether to implement or reject technology. For example, Choi *et al.* (2020) surveyed 83 businesses to identify the obstacles preventing organizations from integrating blockchain into their supply chains. They discovered that complexity, security, and privacy issues, as well as implementation costs, all have a positive correlation with organizational resistance. Clohessy & Acton (2019) evaluated the impact of organizational characteristics on blockchain adoption in Irish businesses. Top management support and organizational readiness are key enablers of blockchain adoption, and large corporations are more likely to adopt it than small and medium-sized businesses. However, this approach has limitations because enterprises often provide only practical or context-specific viewpoints, rather than a comprehensive and strategic analysis. Additionally, a study by Kouhizadeh *et al.* (2021) examined the perspectives of academics and practitioners knowledgeable about BT and sustainable supply chains to help analyze the barriers. However, they did not focus on anti-counterfeiting efforts. As a result, this study will interview specialists with expertise in researching, consulting, and implementing BT to gain a better understanding of the main barriers, current situations, and long-term growth potential. Additionally, specialists may offer insights that enhance the research's academic rigor and relevance. They can also make helpful recommendations to encourage the use of BT as a tool to combat counterfeiting.

Table 2 Some papers explore the main challenges of adopting blockchain technology

Authors	Technological barriers	Organizational barriers	Environment barriers	Method	Purpose
(Clohessy & Acton, 2019)	Complexity	Top management support Lack of skills and competencies Financial resources	Lack of government incentives	Qualitative content analysis and Multiple-case study (20 companies in Ireland)	impact of organizational factors on the adoption of blockchain
(Esmaeilian <i>et al.</i> , 2020)	Scalability Security Energy consumption	N/A	Regulatory	Literature review	Explore blockchain's role in enabling sustainable supply chain management
(Choi <i>et al.</i> , 2020)	Maturity Scalability Security and privacy	Expertise and technical knowledge	Perceived collaboration efforts	Qualitative method (SEM, survey 83 companies)	Factors affecting organizations' resistance to the adoption of blockchain technology
(Yiu, 2021)	Cost Scalability Security Privacy Integration	N/A	N/A	Systematic literature review	Anti-counterfeiting
(Kouhizadeh <i>et al.</i> , 2021)	Security Access to technology Immaturity	Financial constraints Lack of management commitment and support Lack of organizational policies Lack of knowledge and expertise	Lack of customers' awareness Governmental policies Market competition and uncertainty Lack of external stakeholders' involvement.	Qualitative method (academics and industry experts opinions)	Explore blockchain adoption barriers in sustainable supply chains
(Batwa & Norrman, 2021)	N/A	Lack of Trust in BT	Lack of trust in supply chain partners	Systematic literature review	Examine the impact of blockchain on trust in supply chain management.
(Moretto & Macchion, 2022)	Complexity Cost	N/A	Shared technological standard Technical culture Collaboration among several SC partners	Qualitative method (Interviews with five blockchain providers and seven fashion focal companies)	Explore how blockchain enables traceability in fashion supply chains.
(Sunny <i>et al.</i> , 2022)	Transaction time Cost	N/A	Lack of policy	Systematic literature review	Provide an overview of blockchain applications in numerous domains.

Authors	Technological barriers	Organizational barriers	Environment barriers	Method	Purpose
(Mohapatra <i>et al.</i> , 2023)	Data privacy Costs	Limited knowledge	Unstable internet infrastructure Regulatory issues	Bibliometric study	Explore blockchain applications in agri-food systems
(Duan <i>et al.</i> , 2023)	Privacy Security Availability of BCT tools	Lack of budget Lack of expertise and knowledge Lack of leadership commitment Infrastructure facility	Lack of government support Cultural concerns Regulations Lack of industrial involvement	Systematic literature review	Investigate blockchain adoption in Supply chain management
(K. Li <i>et al.</i> , 2023)	Scalability Cost	Lack of knowledge and skills Data ownership	Lack of trust among stakeholders, lack of stakeholder awareness Ease of use Resistance to blockchain culture	Systematic literature review	Investigate blockchain adoption in food supply chains
(Ghosh <i>et al.</i> , 2023)	Scalability Privacy Security Computing power limitations Interoperability Standardization	N/A	N/A	Systematic literature review	Investigate blockchain adoption in healthcare Systems
(Pesqueira <i>et al.</i> , 2024)	Storage Requirement Scalability Integrating with existing technology Cost	Technical expertise	N/A	Systematic literature review	Explore how blockchain fights fraud and counterfeiting in healthcare packaging and labeling.
(Rani <i>et al.</i> , 2024)	Immutability and flexibility Scalability and usability Privacy Data unavailability Standardization Integration challenges	Lack of skills Management commitment and support Monetary issues	Sustainability concerns Laws and regulations Market and ecosystem readiness	Systematic literature review	Investigate blockchain adoption in education sector
<i>This study</i>	<i>Cost Integration into existing systems Standardization Security Privacy Scalability Transaction speed</i>	<i>Lack of expertise and skills Lack of established guidelines Lack of infrastructure and technical support Financial constraints Lack of management commitment and support</i>	<i>Lack of clear legal framework Lack of trustworthy service providers Inadequate Infrastructure Lack of customer awareness Lack of stakeholder involvement</i>	<i>Qualitative methods (In-depth interviews with industry and academia experts)</i>	<i>Anti-counterfeiting</i>

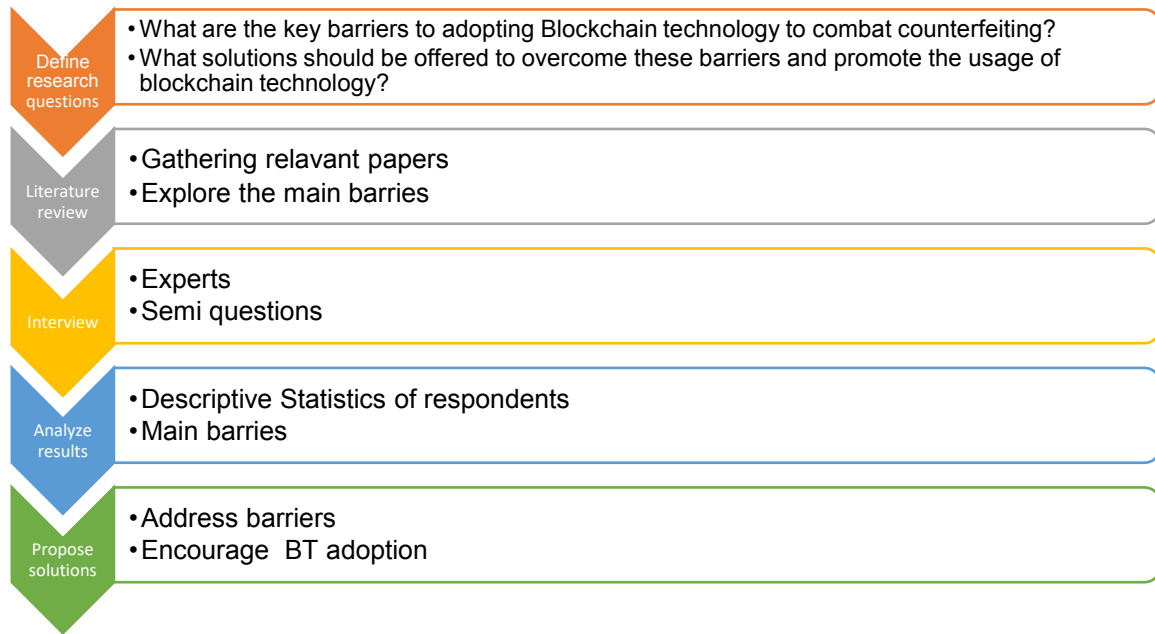


Figure 5 Research stages

3. METHODOLOGY

This study uses a qualitative approach to analyze the primary barriers to implementing BT to prevent counterfeiting. Figure 5 illustrates the various research steps, which include identifying research questions, conducting a literature review, conducting interviews, analyzing results, and proposing solutions. Each stage will be detailed below.

3.1 Stage 1. Defining Research Questions

This study will address two significant questions as follows:

RQ1: What are the key barriers to adopting Blockchain technology to combat counterfeiting?

RQ2: What solutions should be offered to overcome these barriers and promote the usage of blockchain technology?

3.2 Stage 2. Conducting A Literature Review

This phase will analyze relevant papers focusing on the barriers or challenges to employing BT for anti-counterfeiting purposes. The purpose is to identify research gaps and significant challenges, which will be the foundation for the survey's subsequent stages. The main challenges identified in prior investigations are summarized in Table 2. The literature review directs the development of interview questions, ensuring they are relevant and consistent with past studies.

3.3 Stage 3. Performing Interviews

The study conducted in-depth interviews with experts. They included both academics and practitioners. They were picked using nonprobability sampling. This project will choose participants with relevant experience in research and deployment of BC applications, particularly for anti-counterfeiting goals. This study was carried out in Vietnam, a developing country experiencing rapid growth in e-commerce. Vietnam is facing a growing counterfeit goods crisis (BT, 2025). In 2024, officials processed over 47,000 infractions, seizing products worth VND 425 billion, a 23% increase from the previous year (Trang, 2025). A significant case comprised a phony milk network with over 600 goods

worth VND 6,700 billion, including counterfeit HIUP milk (My, 2025). These include not only consumer and luxury goods, but also potentially harmful things such as counterfeit medications and foods. Counterfeiting poses substantial health risks to consumers, particularly to young people and older adults.

This survey chooses experts from both academia and industry. Fifty percent of the experts are professors at Vietnam National University, one of the country's leading universities. The remaining expertise comes from businesses developing BT-based solutions, particularly in the area of anti-counterfeiting advances. This study aims to interview top executives who possess technical expertise and have worked directly with various organizations to implement BT solutions.

Semi-structured interviews were employed to obtain experts' in-depth perspectives. The barriers in Table 2 served as a starting point for constructing interview questions, ensuring that the content was aligned with the difficulties highlighted in earlier literature. At the same time, the semi-structured interview allowed participants to discuss their personal experiences and practical ideas freely. The study also employed open-ended questions to solicit expert opinions on overcoming challenges associated with using BT in anti-counterfeiting.

3.4 Stage 4. Analyzing And Discussing The Findings

The collected responses were then thematically analyzed to identify the primary challenges associated with using blockchain in the supply chain. This step addresses the first research question by identifying the key technological, organizational, and environmental barriers.

3.5 Stage 5. Proposing Practical Solutions

This stage addresses the second research question by proposing practical solutions to overcome the previously identified barriers. Additionally, the proposed solutions will facilitate the broader adoption of BT, particularly in underdeveloped countries.

4. RESULTS AND DISCUSSION

Section 4 provides the study's findings and discussion. Section 4.1 presents the respondents' profiles, including their roles, industries, and levels of blockchain familiarity, which are used to explain the qualitative data collected. Section 4.2 examines the primary challenges to utilizing blockchain technology for anti-counterfeiting, drawing on expert responses gathered through interviews. These findings provide a foundation for the practical solutions proposed in the following section.

4.1 Respondent Profile

This study gathered responses from 16 experts with substantial experience working and researching BC in Vietnam. Although the sample consists of only 16 interviews, this size is appropriate for qualitative research using in-depth interviews, especially when targeting a highly specialized and hard-to-reach population. This study's participants include corporate experts and academic researchers with substantial expertise in blockchain deployment and education. Their findings are particularly significant considering the limited use of blockchain for anti-counterfeiting in Vietnam, where such knowledge is scarce.

The study followed the principle of data saturation, as key themes consistently emerged across interviews, and no significant new insights were identified in subsequent interviews. The sample was therefore considered adequate for in-depth analysis. Moreover, the participants had previously conducted related research, enabling them to provide informed perspectives on the challenges of implementing blockchain for anti-counterfeiting. Furthermore, as illustrated in Table 2, the majority of previous studies used a systematic literature review approach (Esmaeilian *et al.*, 2020; Ghosh *et al.*, 2023; Pesqueira *et al.*, 2024; Rani *et al.*, 2024). Few prior studies have used primary data collection methods, particularly interviews (Choi *et al.*, 2020; Moretto & Macchion, 2022). For example, Clohessy & Acton, (2019) gathered information from twenty companies in Ireland to explore the organizational factors that influence blockchain adoption. Moretto & Macchion (2022) conducted semi-structured interviews with five blockchain solution providers and seven fashion companies to explore the drivers, barriers, and supply chain-related factors influencing blockchain adoption. Hence, our sample is considered sufficient and comparable to earlier studies employing qualitative methods.

Counterfeiting is a serious global issue that affects both developing and developed countries. In 2021, counterfeit products accounted for around USD 467 billion, or 2.3% of global imports, up from USD 464 billion in 2019 (OECD & EUIPO, 2025). While China and Hong Kong continue to be key sources, Southeast Asia, the Gulf, and Latin America all contribute. Counterfeit imports totaled USD 117 billion in the EU, accounting for 4.7% of overall imports (OECD & EUIPO, 2025). Moreover, consumers in India, Kenya, and Nigeria reported high rates of unintentionally purchasing counterfeit goods, particularly through e-retail platforms. Similarly, respondents in Australia, Brazil, Canada, China, and the United Kingdom identified online marketplaces as

the most common source of counterfeit products (Alhabash *et al.*, 2023). The findings reveal that digital advancements are driving the growth of the global counterfeit trade. As a result, the use of emerging technologies such as blockchain is crucial for preventing the prevalence of counterfeit items.

However, the implementation of blockchain-based anti-counterfeiting systems for real-life scenarios remains limited. Existing implementations are primarily limited to high-value goods and specific sectors such as fashion. This study, based on expert interviews conducted in Vietnam, a developing country severely impacted by counterfeiting, offers valuable insights into the practical challenges of blockchain adoption. Although the sample is context-specific, the findings may provide a valuable reference for other countries, both developing and developed, that face similar threats and are exploring technology-based solutions to combat counterfeiting.

Table 3 displays the respondents' information. Most respondents hold advanced academic credentials, with 56% possessing a master's degree and 38% holding a PhD, indicating a high level of expertise on this topic. Additionally, 50% of the participants are CEOs or top executives from enterprises that develop and offer blockchain-based applications and systems, including Wischain, SeedSoft (Australia), Veron, Ernst & Young (EY), and VIB. Furthermore, nearly 70% of responders had at least three years of experience researching and implementing BT. Some interviewed have over 5 years of experience, accounting for 44%. As a result, this sample has a potent combination of academic qualifications and real-world industry experience. As a result, their responses are a valuable source of information for understanding the obstacles and opportunities of utilizing BT to combat counterfeiting in Vietnam.

Table 3 Demographic and Professional Background of Interviewees (Interview results).

	Frequency	Percentage
Education level		
Master	9	56%
PhD	6	38%
Professors	1	6%
Working place		
University	8	50%
Companies	8	50%
Experiences (years) in research and adoption of Blockchain Technology		
from 1 to below 3	5	31%
from 3 to below 5	4	25%
from 5 to below 11	7	44%

All respondents confirmed the potential of BC to prevent counterfeiting. They stated its superior ability to verify product authenticity and traceability. One interviewee commented, "Once a transaction (product information, place of manufacture, shipping time...) is recorded on the blockchain, it cannot be modified or deleted". Several

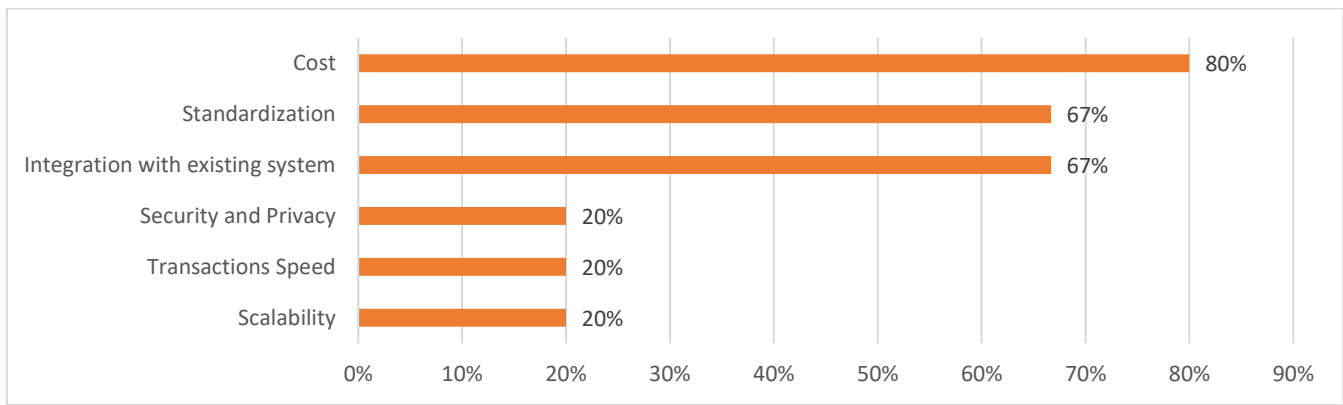


Figure 6 Some significant technological challenges

respondents stated that adopting blockchain for anti-counterfeiting is a promising and feasible way to standardize product codes among all chain participants. They emphasized that blockchain-based systems are the only feasible solution to preventing supply chain counterfeiting. The product code should be registered with entities responsible for managing and verifying product codes. Every product's manufacturing process must be recorded and approved by network members. Customers merely need to scan the product code with code scanning software to learn about its origin and manufacturing date.

Despite the growing global interest in BT, its practical applications in Vietnam remain limited. Although there is growing awareness of its potential, adoption among Vietnamese firms, particularly BT-based anti-counterfeiting solutions, is still in its early stages. There are several causes for this. However, a paucity of research has been conducted to better comprehend these concerns. Thus, this study fills the literature gap and addresses urgent practical difficulties.

The following parts will detail the primary barriers, which are divided into three categories: technological, organizational, and environmental.

4.2 Main Barriers To Adopting Blockchain Technology For Anti-Counterfeiting Measures

4.2.1 Technological barriers

Table 2 states a variety of technological challenges. This study highlights the primary barriers that received the highest level of acceptability from respondents. Figure 6 illustrates the primary technological challenges associated with utilizing blockchain to prevent counterfeiting, including cost, integration into existing systems, standardization, security, privacy, scalability, and transaction speed. The data indicates that BT solutions have significant implementation costs, with 80% of respondents agreeing with this. Cost is the most significant technological hurdle that firms confront. Mohapatra *et al.*, (2023) stated that only low-cost technologies can effectively reach and assist communities in developing nations. The BT may need a significant upfront expenditure, hindering its general adoption. Thus, lowering the cost of developing and adopting BT-based solutions is crucial for stimulating their use.

Besides, 67% of participants identified integration with existing systems and a lack of standards as the significant technological hurdles to blockchain implementation. These

findings are similar to the previous review (Pesqueira *et al.*, 2024; Rani *et al.*, 2024). These issues demonstrate that businesses are concerned about integrating BT with current infrastructure and a lack of unified technical standards.

Most experts stated that many organizations' existing IT systems are unsuitable for integrating blockchain's distributed architecture. Management systems, such as ERP, CRM, and SCM, were frequently designed years ago and often lack open interfaces (APIs), a uniform consensus standard, and compatibility with how data is handled on the blockchain. Additionally, many organizations rely on manual processes, which can hinder cross-chain integration. Thus, Vietnamese businesses must re-standardize data, redesign business processes, or even invest completely to integrate effectively. As a result, firms can modernize their systems, restructure their operations, and transition to a more transparent, secure, and optimal supply chain via BT applications.

Besides, security, privacy, scalability, and transaction speed are the main challenges limiting BT deployment. Although BT is renowned for its excellent security due to its encryption mechanism and distributed architecture, many risks and security holes can still be exploited, particularly during the implementation process into anti-counterfeiting systems. One of the most significant risks is programming faults in smart contracts, such as logic problems or re-entrancy vulnerabilities, which attackers can use to carry out invalid transactions or misappropriate funds. Additionally, using open-source libraries increases the potential for exploitation if third-party components have previously unknown security flaws. Moreover, another concern is errors in consensus techniques, such as Proof of Stake, which can be manipulated if one organization controls a significant portion of the network's assets or nodes. In blockchain ecosystems, users often need to manage their own wallets and private keys, which increases the risk of asset loss due to human error or phishing attempts. The interconnection of network members (endpoints) can be a vulnerability if not effectively safeguarded.

Moreover, there are certain practical risks in using BT to combat counterfeiting. First, input data, whether entered by humans or technology, can be manipulated, resulting in blockchain information that does not correctly reflect reality. Second, QR or NFC codes on products can be copied or counterfeited, leading consumers to scan non-genuine products. Third, public blockchains can be exceedingly

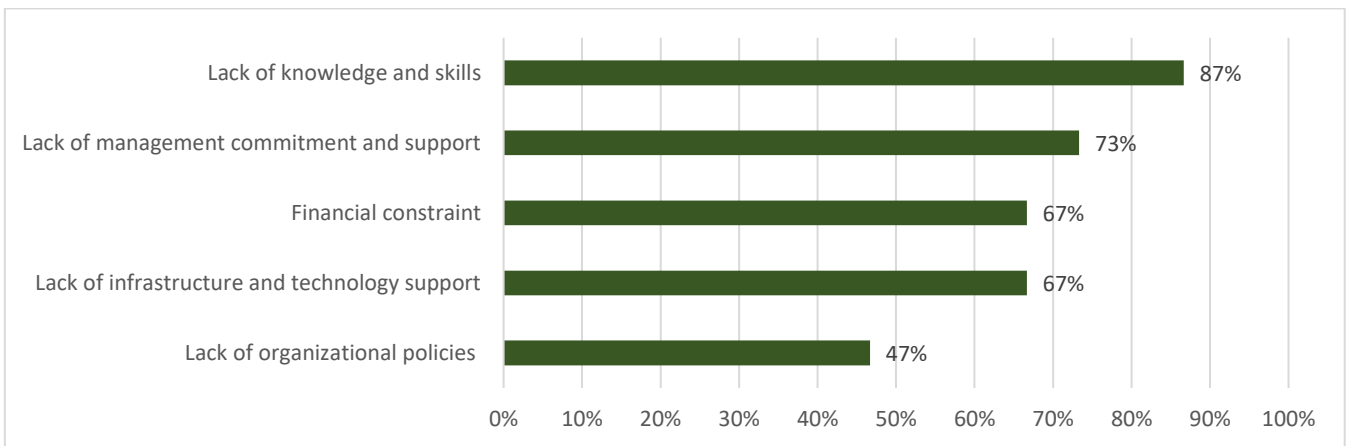


Figure 7 Some significant organizational challenges

expensive to create and operate, whereas private blockchains are potentially subject to manipulation by network-controlling parties. Finally, fake QR codes can still trick consumers into visiting non-authentication websites that are difficult to discern. These issues demonstrate that further organizational measures and user education are necessary to effectively prevent counterfeiting.

4.2.2 Organizational barriers

Several significant barriers prevent firms from employing blockchain-based anti-counterfeiting solutions. Figure 7 illustrates the significant organizational barriers that received high agreement from the interviewees. They include a lack of expertise and skills, a lack of established guidelines within the company, inadequate infrastructure and technical support, financial constraints, and a lack of management commitment and support. Those barriers are consistent with previous studies (Duan *et al.*, 2023; Pesqueira *et al.*, 2024). Lack of expertise and skills is a significant barrier, according to 87% of respondents. Before implementing a new technology, firms should analyze their requirements and the technology's impacts and downsides on their business operations (Sunny *et al.*, 2022). Thus, without sufficient knowledge and skills, firms may struggle to identify the critical components for effectively implementing BT.

The second main challenge is the lack of management commitment and assistance, which was evaluated by more than 70% of respondents. In Vietnam, the adoption of blockchain-based anti-counterfeiting solutions remains limited, with most initiatives in the pilot or experimental stages. Thus, many organizations remain uncertain about their effectiveness. Leadership commitment and strategic support from decision-makers are critical for implementation.

Moreover, financial constraints, lack of infrastructure, and technical assistance are the third essential issues, according to 67% of respondents. One of the most significant barriers preventing many small and medium-sized enterprises from implementing BT-powered solutions is a lack of financial resources. Implementing innovative technology requires a considerable initial investment and, if necessary, modification to existing systems (Rani *et al.*, 2024). Thus, the respondent emphasized that organizations typically conduct a cost-benefit analysis before embracing those solutions. Additionally, due to budgetary limitations, many businesses prioritize different innovations that directly

impact their manufacturing operations. Their inadequate infrastructure and a lack of technical support, both within and externally, hinder the deployment of innovative ideas. Many organizational processes still rely on human workflows or obsolete systems. This current system reduces productivity and poses significant barriers to integrating with advanced technology.

Furthermore, a lack of specific organizational policies frequently results in managerial confusion and employee dissatisfaction. Managers may feel hesitant about deciding whether to implement BT-based solutions. Employees may not fully understand the system's benefits, resulting in inconsistent communication, low morale, and inefficient performance. This type of ambiguity may reduce trust in a company over time, making it more challenging to implement new changes successfully. This demonstrates that the success of BT adoption is dependent on an organization's readiness in multiple areas, including policies, financing, human resources, leadership, and technical systems.

4.2.3 Environmental barriers

Numerous external obstacles have been identified that hinder organizations from adopting anti-counterfeiting systems. These obstacles are frequently caused by government agencies, partners, and customers, including a lack of a clear legal framework, unreliable service providers, inadequate infrastructure, insufficient customer awareness, and inadequate stakeholder involvement, as illustrated in Figure 8.

The most significant barrier is a lack of a clear legal framework, as 80% of respondents stated. Although there is growing interest and potential in BT, the legal environment for BT applications remains limited. There are no official legal documents in Vietnam governing BT, particularly in anti-counterfeiting measures. Additionally, there are no government regulations mandating the use of anti-counterfeiting technologies or requiring businesses to authenticate genuine products. Many products, including those sold online, did not require proof of authenticity. Some businesses employ stamps or QR codes to verify genuine ones. However, those without them are still being marketed. As a result, respondents stated that without legislative orders, corporations have no incentives or obligation to implement blockchain-based anti-counterfeiting solutions. Implementing such technologies will increase expenses, a significant problem in underdeveloped countries. This

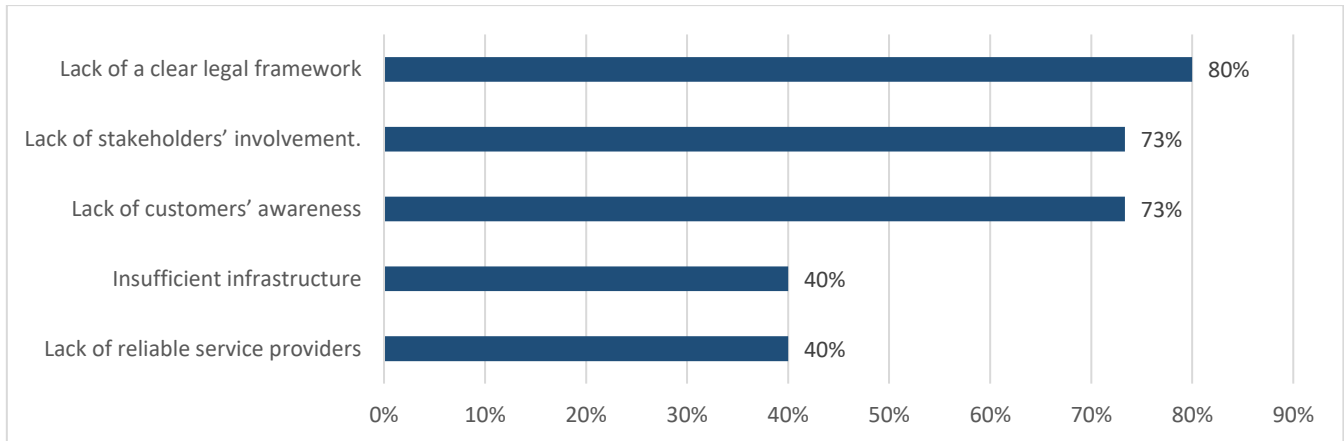


Figure 8 Some significant environmental challenges

challenge aligns with findings from earlier research (Mohapatra *et al.*, 2023; Rani *et al.*, 2024).

Furthermore, insufficient infrastructure is a barrier to the implementation of BT. Many developing nations face constraints in internet access, data storage systems, and digital security frameworks, making it challenging to support BT-based solutions properly. Without a reliable technology infrastructure, businesses may struggle to maintain the stability, scalability, and efficiency required for such systems. Mohapatra *et al.* (2023) stated that developing nations face obstacles in adopting BT, including regulations, unreliable internet connectivity, data privacy, and costs.

Besides, 73% of respondents identified a lack of stakeholder involvement and consumer awareness as key environmental constraints. Most respondents stated that various firms are still extremely hesitant to share data due to concerns about safety risks and a lack of trust between parties. Batwa & Norrman (2021) underlined that a significant barrier to establishing BT solutions is a lack of confidence in the technology and among business partners. This poses a significant challenge for building BT-based solutions, which rely on transparency and data exchange among participants to ensure system consensus and confidence. Moreover, a significant hurdle arises from the buyer's perspective. In reality, numerous customers still ignore the origin of items. Many Vietnamese buyers continue to buy products despite being unable to verify their origin, indicating that awareness of authentic products and information transparency remains low. As a result, customers have not been the driving force behind firms implementing blockchain-based anti-counterfeiting solutions. When market demand is insufficient, businesses have no motive to invest in such innovative and costly solutions.

Furthermore, 40% of interviewees stated that a lack of trusted service providers is a significant difficulty. While some companies provide blockchain-based solutions, such as anti-counterfeiting tools, their popularity has been limited. For example, the CEO of Wischain, one of the firms in Vietnam that provides BT-based solutions, was interviewed for this study. He explained that WaLAuth, a recent solution that provides product traceability, has encountered problems acquiring customers due to low demand from enterprises in Vietnam. As previously stated, many businesses struggle to

afford blockchain-based systems due to their high implementation cost. Thus, organizations must carefully weigh the benefits and costs of investing in anti-counterfeiting systems.

Additionally, some blockchain-based solutions, such as traceability stamps, are quite low-cost, and many businesses are unwilling to implement them. The primary cause is a lack of laws and regulations, which makes these solutions seem optional rather than obligatory. Without legislative pressure or incentives, businesses may fail to recognize the importance or urgency of investing in such technologies. As a result, only a few companies offer blockchain-based anti-counterfeiting solutions, which limits their availability and accessibility in Vietnam.

4.3 Unique Challenges in Blockchain-Based Anti-Counterfeiting

The results of this study highlight numerous significant hurdles in implementing blockchain technology (BT) for anti-counterfeiting objectives. Table 2 compares the findings of this study with those of prior research to underscore the unique contributions of our work to the existing literature.

The major technological impediments include cost, integration with existing systems, standardization, security, privacy, scalability, transaction speed, and input data quality. Costs are one of the most challenging, particularly for small and medium-sized enterprises. This finding aligns with prior studies in other blockchain adoption contexts, such as supply chains (Choi *et al.*, 2020); fashion (Moretto & Macchion, 2022); transportation, commerce and industry, financial sector, government, education, healthcare (Sunny *et al.*, 2022); agriculture (Mohapatra *et al.*, 2023); healthcare (Pesqueira *et al.*, 2024).

Besides, this study highlights standardization and system integration as significant barriers to implementing blockchain for anti-counterfeiting objectives. While these challenges have been identified in a few recent studies, such as healthcare (Ghosh *et al.*, 2023; Pesqueira *et al.*, 2024) and education (Rani *et al.*, 2024), they are not widely recognized in the broader context of blockchain adoption. However, our findings underscore their importance in making a significant contribution to the literature. Integration facilitates the transfer of data from existing corporate systems onto blockchain platforms, improving traceability. Standardization guarantees that this data is consistently

understood, disseminated, and confirmed by all supply chain actors. Because anti-counterfeiting systems span multiple organizations and technologies, standardization and integration become essential requirements.

Moreover, the findings revealed an updated key technical challenge relating to the use of blockchain in anti-counterfeiting: transaction speed. Real-time validation can be challenging if transactions are processed slowly, especially in supply chain settings where products must be validated rapidly at multiple stages. As a consequence, counterfeit goods may go unreported or reach clients before verification is complete. Additionally, businesses and individuals will be hesitant to use.

Furthermore, security, privacy, and scalability have also emerged as critical technical concerns in the adoption of blockchain for anti-counterfeiting purposes. This finding is consistent with previous studies across multiple sectors, including food (K. Li *et al.*, 2023), healthcare (Ghosh *et al.*, 2023), and supply chain management (Duan *et al.*, 2023). Security is crucial to ensuring the integrity and validity of product information, especially since counterfeiters may attempt to tamper with digital records or exploit system weaknesses. When sensitive data about product origin, supply chain partners, or consumer transactions is stored on decentralized networks, privacy concerns arise. Scalability is a major challenge; as e-commerce grows, an increasing number of consumers will utilize blockchain to verify product authenticity. Blockchain-based anti-counterfeiting applications must be easily scalable to offer real-time verification and a consistent user experience.

Regarding organizational barriers, several have been identified, including a lack of expertise, the absence of internal guidelines, insufficient infrastructure, limited financial resources, and weak managerial support. The biggest challenge is a lack of knowledge and skills. This finding is consistent with previous studies on blockchain adoption in other fields, such as supply chains (Duan *et al.*, 2023), healthcare (Pesqueira *et al.*, 2024), education (Rani *et al.*, 2024), and agriculture (Mohapatra *et al.*, 2023). While issues such as a lack of internal guidelines, poor infrastructure, limited financial resources, and inadequate managerial assistance were all mentioned, they were not as prominently stressed.

In terms of environmental impediments, several primary challenges have been identified, including the absence of a clear legislative framework, unreliable service providers, inadequate national infrastructure, low customer awareness, and a lack of stakeholder engagement. The lack of clear regulatory frameworks is widely pointed out as a significant barrier, similar to other blockchain adoption scenarios, such as education (Rani *et al.*, 2024), agriculture (Mohapatra *et al.*, 2023), and supply chain management (Duan *et al.*, 2023; Kouhizadeh *et al.*, 2021). This suggests that regulatory challenges are not exclusive to anti-counterfeiting applications but rather represent a broader concern across multiple sectors.

Besides, a lack of stakeholder involvement has been highlighted as a major obstacle, comparable with previous research in other blockchain applications, including supply chains (Choi *et al.*, 2020; Duan *et al.*, 2023; Kouhizadeh *et al.*, 2021); food (K. Li *et al.*, 2023); fashion (Moretto & Macchion, 2022). This issue arises from the blockchain's

decentralized structure, which relies on the participation of various stakeholders in data sharing and verification.

Furthermore, this study identified a lack of customer awareness as an emerging challenge, which has not been previously highlighted. This makes a significant contribution to the literature on the use of blockchain for anti-counterfeiting. In contrast with previous studies on other blockchain applications, the anti-counterfeiting context focuses on client knowledge. Anti-counterfeiting solutions are designed not only to help businesses but also to enable end users to distinguish between genuine and counterfeit products, thereby enhancing consumer trust.

Moreover, the results identified a shortage of trustworthy service providers and insufficient national infrastructure as major challenges. These challenges are not widely reported across the blockchain adoption literature, with only a few mentions in contexts such as agriculture (K. Li *et al.*, 2023; Mohapatra *et al.*, 2023). Anti-counterfeiting solutions require reliable internet access and an efficient digital infrastructure that enables end users to verify products in real-time.

To address these barriers, this study proposes practical solutions to promote the adoption of blockchain technology (BT) in combating counterfeiting. The following section outlines those measures that require the engagement and coordination of all supply chain stakeholders.

5. PROPOSED PRACTICAL SOLUTIONS

This paper proposes practical solutions to address the technological, organizational, and environmental challenges associated with utilizing BT for anti-counterfeiting purposes. The proposed solutions are designed for key stakeholders, including governments, businesses, consumers, service providers, and experts. The next parts not only detail these solutions but also discuss their feasibility and potential for implementation.

5.1 Government-Level Solutions

The government plays a significant role in regulating and promoting the adoption of BT-based anti-counterfeiting technologies by issuing legislation, launching educational programs and campaigns against counterfeit goods, and providing infrastructure investment and financial assistance. Firstly, a well-structured legal and regulatory framework is required to facilitate the legal adoption of BT in businesses and its applications, particularly in anti-counterfeiting. It will determine the legal responsibilities of all parties involved, monitor the authentication process, and maintain transaction transparency. In addition, this legal framework must be updated regularly to reflect evolving BT and other technologies to protect the parties' rights, drive corporate growth, and safeguard national security. Furthermore, the government should enact legislation requiring product traceability and advanced technology to monitor the origin of products, ensuring consumer safety. Companies that fail to provide product traceability will face penalties and are prohibited from selling their products. Secondly, authorities could increase public awareness about the dangers of counterfeit goods through educational programs and campaigns, including hosting conferences, workshops, news broadcasts, contests, and collaborating with influencers and

educational campaigns. By increasing community awareness, such efforts can help combat counterfeit markets and promote more responsible purchasing behavior. Finally, governments should invest in technological infrastructure, such as internet connectivity, cloud platforms, and data management.

5.2 Firm-Level Solutions

Businesses can help accelerate the use of BT against counterfeiting by establishing corporate strategy, upskilling their workers, and integrating blockchain technologies into their systems. Firstly, they must develop corporate strategies incorporating BT-based anti-counterfeiting technologies and brand protection objectives. Corporate strategies should include both short-term and long-term objectives. They should explicitly describe the risks of counterfeiting, emphasize the necessity of traceability, and commit to investing in technologies that ensure supply chain transparency. They should clarify the action plan, responsibilities, and financial allocation. A detailed roadmap will help employees understand the importance of BT, change their thinking and attitude toward data sharing, and lay the groundwork for transforming the company culture. Secondly, companies may organize internal training sessions or send workers to conferences, workshops, and programs at local and international universities and research institutions to gain knowledge of BT and its applications in preventing counterfeiting. This training is not only for staff but also for top executives. Besides, learning and referencing successful Blockchain implementation practices from other firms is a practical step toward effective deployment in practice. Thirdly, businesses should invest in and utilize blockchain-based anti-counterfeiting technologies to protect their trademarks and ensure the authenticity of their goods. There are various factors to consider before implementing. They should understand the corporation's goals. They must analyze the current company's processes, data security, finances, workforce, and counterfeiting problems. Many experts have emphasized that firms should select reliable and specialized service providers to implement BT-based solutions, allowing them to focus on their core operations without worrying about technical expertise and infrastructure.

5.3 Customer-Level Solutions

Consumers play a crucial role in the development and adoption of BT solutions. Customers should be aware of the counterfeiting issues. Counterfeit products have significant financial, health, and social consequences. They can be life-threatening, particularly in food, pharmaceuticals, and cosmetics. Besides, they may go underutilized and end up as waste, endangering the environment and the planet. Therefore, customers should be wise and proactive in protecting themselves by requesting product traceability. Product traceability enables customers to track the origin, transportation, and handling of items, from raw materials to the point of sale. As a result, customers can avoid buying counterfeit goods.

Moreover, buyers should understand the roles and significance of BT-based anti-counterfeiting solutions, which are critical to accurate product traceability. These solutions help prevent fraud, promote transparency, and ensure the accuracy and tamper-proofing of data related to a

product's origin, manufacture, and distribution. Customers should research and learn how to use them to verify the authenticity of products. Furthermore, they should be the driving force that influences companies to implement those solutions. Customers should avoid items and firms that do not offer traceability or any BT-based applications. Businesses must implement these solutions to remain competitive and satisfy customers' requirements. As a result, they can boost customer confidence, protect the brand, and ensure sustainable growth.

5.4 Service Provider-Level And Researcher-Level Solutions

Service providers and researchers play a crucial role in developing and implementing BT-based solutions. Researchers and service providers should collaborate to study, develop, and evaluate BT-based anti-counterfeiting solutions. Service providers have financial resources and equipment, whereas researchers possess extensive knowledge. The collaboration will bridge theoretical insights to actual implementation, thereby increasing the practicality of the suggested solution system. Thus, they should take full responsibility for researching and developing BT-based solutions that are cost-effective, user-friendly, have better transaction speed, and are easy to integrate with existing business systems and e-commerce platforms. Additionally, BT-based solutions can be accessed quickly using QR codes or mobile applications, making them more accessible to users. Besides, service providers should provide training to both enterprises and customers. Moreover, businesses can offer a free version to users to educate them on how to assess product authenticity and the benefits of traceability. Furthermore, they can provide technical assistance to ensure the successful deployment of BT-powered anti-counterfeiting applications. Those apps are still in their early phases; thus, they may meet various unexpected challenges.

5.5 Proposed Collaboration Framework Among Key Stakeholders

Figure 9 depicts a proposed collaboration framework among key stakeholders to generate blockchain-based anti-counterfeiting solutions. It demonstrates how government agencies, corporations, consumers, service providers, and experts may work together to address adoption difficulties. At the center of Figure 9 is a pilot project that aims to apply BT in combating counterfeiting. Its implementation requires active support and coordination among multiple stakeholders, as counterfeiting is a systemic issue that goes beyond the responsibility of any single entity. It involves different key participants, including consumers, technology suppliers, regulatory agencies, and users. The participation of researchers and experts is also crucial for providing technical guidance, suggesting appropriate adjustments, and ensuring the project's relevance and effectiveness. Thus, the pilot serves not only as a platform for technical experimentation but also as empirical evidence of blockchain's potential in real-world anti-counterfeiting efforts.

The process begins with the government taking the lead by establishing proper legal frameworks and investing in blockchain infrastructure. These efforts, however, should be supported by empirical data, the findings of successful pilot initiatives, and extensive cost-benefit evaluations. Such

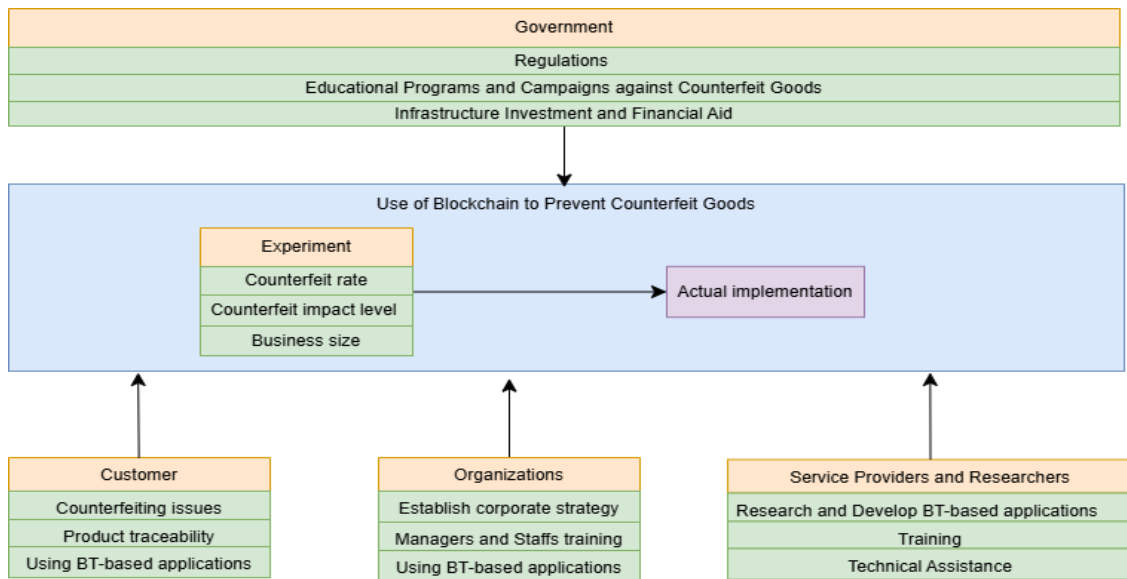


Figure 9 Practical solutions to address barriers and support the adoption of Blockchain technology to combat counterfeiting

evidence serves as a foundation for the government to develop well-informed and contextually relevant regulations that not only encourage innovation but also ensure feasibility and accountability when implementing anti-counterfeiting measures.

Businesses are more willing to invest when pilot projects provide credible evidence of the system’s technical feasibility, economic viability, and potential return on investment. Besides, businesses may adopt and invest in BT more rapidly when enabled by measures such as tax reductions, simplified regulatory procedures, and access to government-backed or co-funded pilot ventures. Additionally, cross-sector collaboration and public-private partnerships play a crucial role in minimizing risks and dispersing implementation costs, thereby encouraging broader experimentation, especially among small and medium-sized enterprises. Customer participation in the pilot project can also function as an effective marketing strategy. By engaging directly, customers gain a clearer understanding of their role in the anti-counterfeiting process. In today’s digitally connected environment, consumers actively share their experiences and knowledge through social media and online platforms. As a result, involving customers not only raises awareness but also amplifies the project’s reach through social influence and peer-to-peer communication. Following experiments, service providers and researchers will identify shortcomings and modify the BT-based solutions to make them suitable for business.

6. FUTURE WORKS

Although this study provides valuable insights into the implementation of blockchain-based anti-counterfeiting systems, several directions for future research should be investigated. Due to time and resource constraints, the research primarily focuses on identifying challenges through expert interviews with a small sample size. Future studies should expand the sample size to enhance the robustness and generalizability of the findings.

Besides, this study focuses on Vietnam. Cross-country comparative research would be beneficial in determining

how internal organizational factors (such as resources, leadership, and structure) and external factors (including the regulatory environment and cultural norms) influence blockchain adoption. Such comparative findings could help policymakers and practitioners develop more context-sensitive and scalable blockchain solutions to prevent counterfeiting.

Furthermore, this study focuses on adoption barriers; future research should develop adaptive blockchain models customized to anti-counterfeiting initiatives. These models must be capable of adapting to different organizational situations and national cultural traits.

7. CONCLUSION

Counterfeiting has become a global issue, raising fears among supply chain stakeholders. Counterfeiting has caused several severe consequences for businesses, customers, governments, and societies. Hence, combating counterfeit goods is vital to protect benefits for all stakeholders and foster sustainability. This is the first study to undertake interviews with academic and industry specialists to investigate the significant barriers to the adoption of BT-based anti-counterfeiting technologies. This study utilized the key barriers identified in earlier studies, such as technological, organizational, and environmental factors, as the foundations for interview questions. Semi-structured questions will be selected to explore expert opinions and viewpoints on the significant challenges in Vietnam.

The findings indicated that the primary technological challenges of using blockchain to prevent counterfeiting are cost, integration into existing systems, lack of standards, security, privacy, scalability, and transaction speed. The significant organizational barriers include a lack of expertise and skills, the absence of established guidelines within the company, inadequate infrastructure and technical support, financial constraints, and a lack of management commitment and support. These environmental barriers include a lack of a clear legal framework, trustworthy service providers, inadequate national infrastructure, limited customer awareness, and insufficient stakeholder involvement. This

study proposes practical solutions to solve these barriers and promote the usage of BT-based anti-counterfeiting. This study can serve as a valuable reference for other countries facing counterfeiting challenges.

Furthermore, whereas previous research mainly focused on secondary data, this study contributes to the current literature by combining practical and academic perspectives. It not only highlights essential challenges to the use of blockchain in anti-counterfeiting, but it also offers context-driven insights based on real-world implementation. This study builds upon prior research, particularly systematic reviews of blockchain adoption challenges, including those conducted in industrialized countries. As a result, the findings are not limited to the Vietnamese context, but may also apply to other countries facing similar counterfeiting issues.

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DISCLOSURE STATEMENT

The authors declare no competing interests.

DATA AVAILABILITY STATEMENTS

The data supporting this study's findings are available from the corresponding author upon reasonable request.

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