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Barriers to Adopting Blockchain Technology for Combating Supply Chain Counterfeits

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ABSTRACT

E-commerce has expanded tremendously globally. It brings numerous benefits to customers, organizations, and governments but raises many issues, especially counterfeit threats. Counterfeiting has a wide range of effects on shoppers, companies, and supply chain stakeholders, such as economic losses and human health risks. Blockchain (BC) technology has the potential for anti-counterfeiting solutions. However, it is still in its early phases, with slow and restricted acceptance, particularly in anti-counterfeiting. This study conducts a systematic literature review on the use of BC against counterfeiting. This analysis compiled relevant research from reputable databases, including ScienceDirect, Springer, Taylor & Francis, Emerald, Wiley, and MDPI. The findings highlighted the primary barriers that businesses encounter when implementing BC-based anti-counterfeiting solutions. They encompass technological, organizational, and environmental barriers. As a result, this study provides practical recommendations to foster BC adoption to combat counterfeit goods in e-commerce and supply chains, including government regulations and assistance, investigations into BC-based anti-counterfeiting systems, improving customer awareness, and encouraging trust among stakeholders.

Keywords: *blockchain technology, counterfeiting, e-commerce, supply chain management.*

1. INTRODUCTION

E-commerce is now recognized as a vital sector in national economics. Its revenue is predicted to rise at a 9.49% CAGR and reach $6,478.00 billion by 2029 (Statista, 2024). Thanks to E-commerce, customers can shop at any time and from anywhere. Businesses can easily reach out to global customers, personalize marketing campaigns, assess customer preferences, and tailor their offerings to meet these needs. However, as e-commerce grows, counterfeit items become increasingly widespread (Aniello *et al.*, 2021; Naoum-Sawaya *et al.*, 2023; Wang *et al.*, 2023). The causes of this issue are invisible participants, indirect engagement, global merchants, and digital images of things. Consequently, the company's reputation, customers' money, and social trust will suffer (H. Lee & Yeon, 2021; Mani *et al.*, 2022). This issue worsens in developing nations when information technology infrastructure is insufficient.

According to the International Trademark Association (2020), "counterfeits are imitations of real products manufactured without approval from the brand's owner's approval." Products ranging from luxury goods to necessities can be found as counterfeit items (Gayialis *et al.*, 2019). The U.S. Customs and Border Protection (2023) reported that numerous counterfeit goods, including consumer electronics, clothing, sports goods, computers, cars, and medications, have been seized. Specifically, Drugs are the most common counterfeit goods found (as shown in Figure 1).

Counterfeit products hurt various stakeholders, including customers, businesses, and governments. They result in financial losses for buyers and legitimate producers, as well as tax losses for governments. Furthermore, some counterfeit products, such as drugs, food, and beverages, can threaten users. Furthermore, they may harm the environment because counterfeit products cannot be used or reused due to their low quality. Furthermore, counterfeit items have numerous adverse consequences for stakeholders, including reputational damage and harm to individuals' health (Gayialis *et al.*, 2022; Mhatre *et al.*, 2023). Counterfeit trading also hurts the economy, public health, safety, and security (Gayialis *et al.*, 2022; Yiu, 2021a). As a result, minimizing counterfeiting is a key priority for preserving our world.

The use of technological applications is critical in addressing counterfeiting challenges. The European Union Intellectual Property Office (2021) has identified five key technologies used to detect counterfeit items: electronic, marking, chemical, physical, mechanical, and digital media. Especially, BC offers enormous potential as an anti-counterfeiting technology (Klöckner *et al.*, 2023; Li *et al.*, 2021; Naoum-Sawaya *et al.*, 2023).

The majority of prior publications have focused on proposed new BC-based anti-counterfeiting technologies (Chauhan *et al.*, 2021; Chen, Fang, *et al.*, 2022; Chen, Guo, *et al.*, 2022; Crossland *et al.*, 2023; Pun *et al.*, 2021). Furthermore, several publications have explored the benefits of incorporating BC into e-commerce platforms (Jiang & Chen, 2021; P. Liu, 2022). However, a lack of study provides an in-depth understanding of the barriers to adopting BC to combat counterfeiting. This research will fill such gaps. This study aims to identify the significant barriers that businesses encounter when implementing BC-based anti-counterfeiting solutions. These barriers will be constructed using a Technological, Organizational, and Environmental (TOE) approach. As a result, this study proposes practical recommendations for overcoming challenges and promoting the adoption of BC.

This study will address the following research questions:

- RQ1. What is the state of the art in applying BC to prevent counterfeits?
- RQ2. What are the key barriers to using BC in the supply chain to combat counterfeiting?
- RQ3. What practical solutions should be proposed to encourage BC usage in the supply chain?

Figure 1 Top health and safety products seized in 2022.

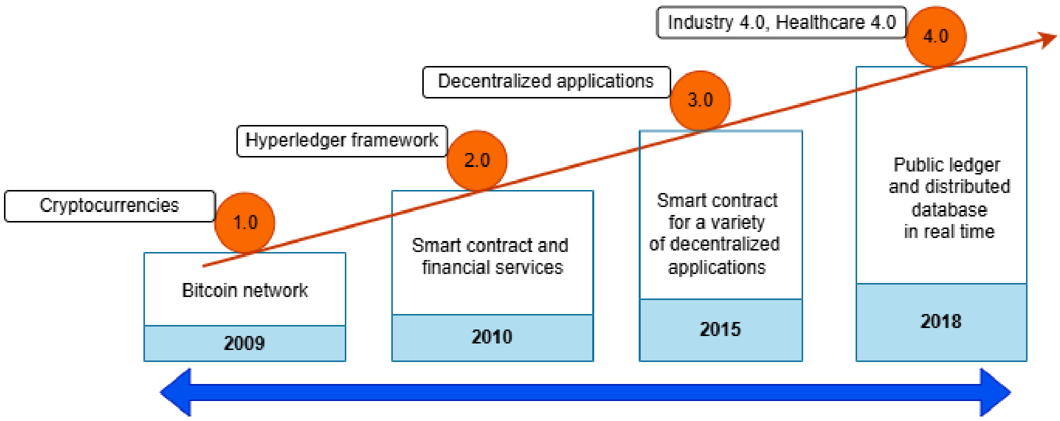

Figure 2 Generations of blockchain technology adapted from (Bodkhe *et al.*, 2020).

The structure of this research proposal is organized as follows. Section 2 presents the methodology. Section 3 discusses the findings and conceptual framework. The final section presents the conclusion and future directions.

2. RELATED WORKS

2.1 Blockchain Technology

BC is a distributed ledger that comprises chain blocks, which are composed of numerous transactions (Gayialis *et al.*, 2019). Figure 2 illustrates the BC revolution, which spans four generations from BC 1.0 to BC 4.0.

Initially, BC was utilized to construct the cryptocurrency Bitcoin. It is now often utilized in a wide range of fields. BC is implemented into Industry 4.0 applications.

Most previous researchers divided BC into public, private, and consortium types. According to the participants, BC can be classified into three groups: public chain, private chain, and consortium chain (Chen, Fang, *et al.*, 2022; Jiang & Chen, 2021; Preetha & Kumar, 2023; Tan *et al.*, 2023). Similarly, regarding the degree of centralization, BC can be characterized as public, private, or consortium (Chen, Fang, *et al.*, 2022). Moreover, some authors have proposed a fourth type of BC, known as hybrid BC, which combines public and private features (H. Lee & Yeon, 2021; Zoughalian *et al.*, 2022).

The public chain is an open BC network; anyone can participate (Chen, Fang, *et al.*, 2022), and does not require permission (H. Lee & Yeon, 2021), such as Bitcoin, Litecoin, and Ethereum. The private chain is a BC held by an organization (Chen, Fang, *et al.*, 2022) and a closed, restrictive, and permissioned system (H. Lee & Yeon, 2021), such as Ripple. The consortium chain is a BC network that prioritizes privacy, security, and decentralization, allowing organizations and individuals to participate (Chen, Fang, *et al.*, 2022). The consortium chain is similar to a private BC but is managed by a group of organizations rather than a single entity (Zoughalian *et al.*, 2022). Some typical examples are Hyperledger Fabric, Hyperledger Sawtooth, Corda, and Quorum (H. Lee & Yeon, 2021). As a result, selecting a suitable BC type is determined based on the various information confidentiality and transparency standards under various application circumstances.

BC has numerous unique characteristics that make it increasingly widely studied and used in diverse fields such as supply chain management, healthcare, banking, and finance. BC has four key attributes: a decentralized structure, a cryptography system, a consensus mechanism, and smart contracts (Batwa & Norrman, 2021). In addition, BC provides the immutability characteristic, which ensures that data recorded cannot be altered or tampered with, resulting in a reliable and immutable record of transactions. This feature enables BC to combat counterfeits and establish a traceability system (Ding & Bai, 2022). Additionally, BC provides robust security features, including encryption, to safeguard data against unauthorized access and modification (Ma *et al.*, 2020). Furthermore, BC guarantees anonymity, allowing users to keep secrecy while ensuring the system's integrity (Duan *et al.*, 2023; He *et al.*, 2023; Ma *et al.*, 2020; Xie *et al.*, 2020).

BC is adaptable to a variety of processes. Dutta *et al.* (2020) stated that BC can improve data management, transparency, response speed, contract management, and intellectual property management. BC can be used to track and trace drugs, provide proof of validity for anti-counterfeiting measures, and help prevent the transportation and sale of counterfeit products (Attaran, 2022). As a result, BC offers numerous advantages, including enhanced traceability and visibility, improved transparency, cost reduction, fraud prevention, quality management, and sustainability (Duan *et al.*, 2023).

2.2 Counterfeits

Counterfeiting can be categorized into various types, including adulteration, tampering, overrunning, theft, diversion, simulation, and counterfeiting (as shown in Table 1). Furthermore, counterfeiting can be separated into deceptive and non-deceptive counterfeits (Pun *et al.*, 2021; Spink *et al.*, 2013). The distinction between these counterfeits is that customers are aware of whether they are counterfeits or not.

Table 1 Counterfeiting types.

Term	Definition
Adulterate	A component of the legitimate finished product is fraudulent
Tamper	Legitimate products and packages are used fraudulently.
Over-run	Legitimate products are made through production agreements.
Theft	A legitimate product is stolen and passed off as if it were legitimately procured.
Diversion	Legitimate products are made through production agreements.
Simulation	An illegitimate product is designed to resemble, but not exactly replicate, the legitimate product.
Counterfeit	All aspects of the fraudulent product and package are fully replicated.

2.3 Blockchain Technology and Counterfeiting Issues

Previous researchers have proposed new anti-counterfeiting systems based on BC. For example, Bapatla *et al.* (2023) developed the PharmaChain architecture, which leverages BC technology combined with the IoT to address counterfeiting issues in the traditional pharmaceutical supply chain. Also, researchers Sharma & Rohilla (2023) proposed a novel BC-based multilevel security and authentication application to address the problem of counterfeiting in the pharmaceutical supply chain.

Existing literature reviews typically cover overall BC applications or their application to specific products, such as medicines. They did not address counterfeiting issues (Kordestani *et al.*, 2023; Sarkar, 2023; Tripathi *et al.*, 2023). For instance, Kordestani *et al.*(2023) recently examined how smart contracts and BC platforms are used in the pharmaceutical supply chain. They ignored the connection between BC and counterfeiting. Besides, the authors (Sarkar, 2023) reviewed the BC platform for drug traceability. Tripathi *et al.* (2023) recently examined articles published between 2015 and 2023 to provide an overview of various aspects of BC technology. They were primarily concerned with the historical context, underlying principles, and BC's unexpected rise in popularity. However, they did not mention the issue of counterfeiting.

Moreover, some reviewers have addressed counterfeiting issues but have not focused on BC. For instance, Islam & Islam (2022) investigated how digital interventions prevent counterfeit medicine. Similarly, Gayialis *et al.*(2022) reviewed traceability approaches for combating supply chain counterfeiting. It is interesting to note that prior reviewers indicated that the BC would be an effective tool for preventing counterfeiting. As a result, we aim to address these gaps in the literature by providing an in-depth analysis of the use of BC in combating counterfeiting.

3. METHODOLOGY

This work conducted a systematic literature review to identify key barriers to the use of BC in preventing counterfeiting. A systematic literature review is a practical approach to analyzing previous studies. It supports the development of evidence-based research and the identification of vital scientific contributions to a subject (Tranfield *et al.*, 2003). According to Thomé *et al.* (2016), a systematic literature review employs clear and strict rules to determine, evaluate, and synthesize the literature in response to specific research questions and hypotheses or to construct novel concepts while minimizing systematic errors. Figure 3 displays the main steps.

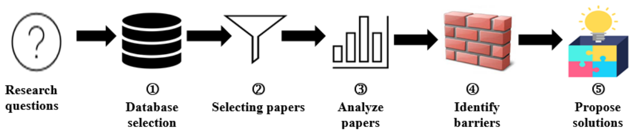

Figure 3 Research stages adapted from (Nguyen, 2023).

All steps will be discussed in detail as follows:
Step 1: Database selection

Following previous research, system reviews consist of many main phases, including identifying research questions, selecting databases, searching for terms, and analyzing the findings.

Based on the research questions, this study collected articles from various databases to provide a comprehensive overview of all BC studies related to counterfeiting. This study gathered all publications from well-known databases, including ScienceDirect, Springer, Taylor & Francis, Emerald, Wiley, and MDPI. There are several reasons why we chose them. First, we were unable to collect all the papers due to the large number of publishers. Reading and analyzing all of them will take a significant amount of time and effort. There is a need for research that provides a comprehensive understanding of the applications of BC in combating counterfeiting, one of the world's most severe problems and urgent tasks. Second, we followed the previous reviewers in choosing some specific, famous publishers. Many researchers have chosen databases to review, for example, Scopus (Gayialis *et al.*, 2022; Naz *et al.*, 2022); Science Direct, Scopus, Emerald Insight and IEEE Xplore®(Lima-Junior & Carpinetti, 2017), ScienceDirect, Emerald, Taylor & Francis, Wiley, and Springer (Nguyen, 2023). Third, to determine the most appropriate publishers, we conducted a trial search of articles in Google Scholar and discovered that these databases comprise the most relevant papers. Furthermore, Springer, Elsevier, Taylor & Francis, and Wiley were ranked first among 100 scientific publishers based on the number of journals (Nishikawa-Pacher, 2022). Additionally, we compiled articles published by other organizations, including SAGE, IEEE, and OSCM, to support the discussion and recommendations. They would contribute to the significance and robustness of our proposal framework.

Figure 4 Word cloud for the keywords of the selected articles.

Figure 5 Word cloud for the title of the articles.

Step 2: Selecting Papers

The first step is to determine the search criteria, including keywords, article types, and duration. The keywords used in this research are straightforward, such as "Blockchain technology" and "Counterfeiting." All databases offered an Advanced search engine with various search parameters, such as "Find articles with these terms: "Authors," "Year," and "Title," etc. We created various combinations to identify the most suitable papers on BC and counterfeit.

Following previous research by Beltrami *et al.* (2021), we excluded conference papers, conference reviews, editorials, and book chapters from our analysis. Only peer-reviewed articles and reviews will be considered. Only papers written in English were selected. This study compiled articles from January 2020 to November 2023. We conducted a trial search and found various publications published since 2020. According to Shiksha Online (2022), BC has been widely used in supply chain processes, such as production, since 2020.

Table 2 Number of papers selected.

Database	Number of papers
ScienceDirect	11
Springer	6
Taylor& Francis	4
Emerald	3
Wiley	4
MDPI	11
Total	39

Initially, we identified 398 papers published by ScienceDirect, Springer, Taylor & Francis, Emerald, Wiley, and MDPI. Some publishers, such as Emerald and Springer, initially discovered many papers. However, the majority of publications didn't match our research topic. As a result, they will be excluded. After removing irrelevant articles, we were left with 39 papers for further examination (as stated in Table 2).

Figure 4 and Figure 5 display Wordcloud for the keywords and titles, respectively. It can be seen that "BC" and "Counterfeit" are the most commonly used terms. In addition, the term "Supply chain" was widely used. As a result, using BC to prevent supply chain counterfeiting has a significant impact on supply chain efficiency. Furthermore, the terms "pharmaceutical" and "drug" are often used interchangeably.

Step 3: Contents Analysis

In this step, descriptive statistics will be conducted for all selected papers, including the document type, number of publications per country, and number of publications per year (Mohsen, 2023). In addition, the contribution and methodology used will be discussed.

Step 4: Define the main barriers

At this stage, this study will define the main barriers in terms of Technological, Organizational, and Environmental factors.

Step 5. Recommendations

This step will provide ways to encourage the use of BC to minimize supply chain counterfeiting. As a result, this work will substantially contribute to the widespread implementation of this unique technology in practice and research.

The research findings will be illustrated and discussed in the next section.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics of Publications

This section provides a detailed summary of selected papers for content analysis. All publications will be evaluated based on article type, the number of publications per country, the number of publications per year, and the number of publications per sector.

Article type

Publication types are classified into research and review. Most publications are research papers, accounting for 97% of the total. It indicated a lack of review papers on BC technology for counterfeiting. Only one review paper was found by Kordestani *et al.* (2023). However, they focused on utilizing smart contracts and BC to combat counterfeiting in the pharmaceutical supply chain. As a result, our research is critical in filling gaps in literature.

Country of authors

Figure 6 illustrates that the majority of published papers originate from China and India. These countries have the world's largest populations and economies. However, counterfeit goods are one of the most serious issues they have encountered and must be addressed to prevent market loss, tax loss, and customer protection issues. In China, for instance, a quarter of the goods traded in online stores were low-quality counterfeit products (Lu *et al.*, 2022).

Furthermore, authors from various countries have expressed interest in using BC to prevent counterfeiting, particularly in developed countries such as the United Kingdom and the United States. Counterfeiting is a global issue that can occur anywhere, including in countries with advanced technologies and solid governance systems. In the United States, the total value of seized products in 2022 exceeded $ 165 million, with drugs accounting for 67% of the counterfeit products (U.S. Customs and Border Protection, 2023). As a result, addressing and preventing counterfeiting issues is essential and meaningful.

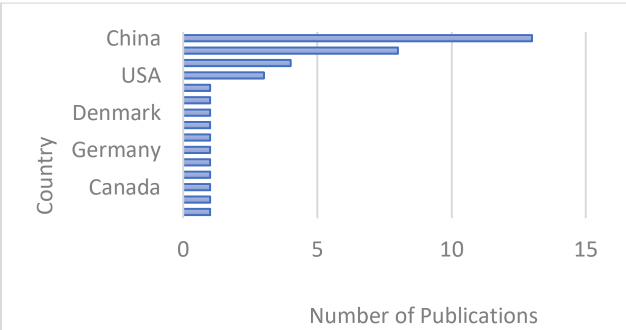

Figure 6 First author's countries

Number of documents distributed per year.

Figure 7 depicts the number of publications per year. Due to its advantages, BC has been widely used to combat counterfeiting in recent years. The total number of articles has increased significantly from 2020 to the present, reaching its highest in 2023. In 2023, the number of articles accounted for more than 41% of total publications during the research period. **Number of documents distributed per year**

Figure 7 depicts the number of publications per year. Due to its advantages, BC has been widely used to combat counterfeiting in recent years. The total number of articles has increased significantly from 2020 to the present, reaching its highest in 2023. In 2023, the number of articles accounted for more than 41% of total publications during the research period.

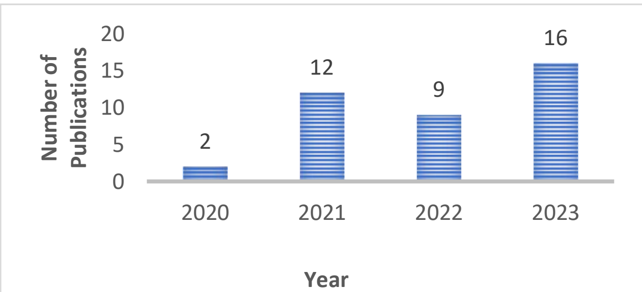

Figure 6 Year of publications.

Number of documents distributed per sector

Table 3 presents the distribution of papers by sector. The majority of previous research has concentrated on the Pharmaceutical supply chain (Kordestani *et al.*, 2023; Mani *et al.*, 2022; Munasinghe & Halgamuge, 2023; Rai, 2022; Rastogi *et al.*, 2022). Counterfeiting drugs has been a global concern for years (Zoughalian *et al.*, 2022). For instance, authors Mani *et al.* (2022) proposed a cloud-based BC technology system. Additionally, the authors Rai (2022) proposed a BC-based traceability system for counterfeited drugs.

Besides, expensive brands are among the most common targets for counterfeiters due to their substantial economic advantages. Additionally, many customers were unable to make purchases due to financial constraints. Therefore, several researchers have focused on using BC to prevent counterfeit luxury items, such as wine and watches (Chen, Guo, *et al.*, 2022; de Boissieu *et al.*, 2021; Yiu, 2021a).

Nonetheless, BC applications in the agricultural supply chain have been limited. Only two papers investigated the use of BC technology in fresh products and food companies (P. Liu, 2022; Tan *et al.*, 2023). Counterfeit products pose a risk to customers' health through the contamination of food and drugs. While many publications highlight medicines, they ignore food items and related products. Thus, using BC technology to prevent counterfeits in the agriculture supply chain is becoming increasingly crucial for future research.

Furthermore, BC papers have been published in different journals, as shown in Table 4. Based on our findings, 39 papers were published in 31 journals, with an average of 1.25 papers per journal. As a result, while BC has gained popularity in recent years, it is still in its early stages of development in terms of anti-counterfeiting applications. Some journals have more than two articles: Sustainability, Transportation Research Part E: Logistics and Transportation Review, Journal of Business Research, Computers and Industrial Engineering, Future Internet, and International Journal of Production Research.

4.2 Descriptive Statistics of Publications

4.2.1 Contributions of Previous Research

Figure 8 illustrates the contributions of previous research, which can be categorized into three main areas. The majority of papers aimed to propose new BC-based systems for preventing counterfeiting (Aniello *et al.*, 2021; Bapatla *et al.*, 2023; Chauhan *et al.*, 2021; Chen, Fang, *et al.*, 2022; Chen, Guo, *et al.*, 2022; Crossland *et al.*, 2023; Danese *et al.*, 2021; Jha, 2023; H. Lee & Yeon, 2021; Mani *et al.*, 2022; Mhatre *et al.*, 2023; Munasinghe & Halgamuge, 2023; Pandey & Litoriya, 2021; Preetha & Kumar, 2023; Rai, 2022; Sharma & Rohilla, 2023; Singh *et al.*, 2020; Tan *et al.*, 2023; Uddin, 2021; Yiu, 2021b).

Additionally, several articles have examined how BC can be adopted on online platforms to prevent counterfeiting (Hou *et al.*, 2023; Jiang & Chen, 2021; H. Lee & Yeon, 2021; P. Liu, 2022; Yu *et al.*, 2023). E-commerce development has many advantages and disadvantages. Customers are easily deceived into purchasing counterfeit products.

As a result, using BC for online platforms is an increasingly prevalent method to protect sellers and buyers. For example, Yu *et al.* (2023) examined the impact of consumers' anticipated regrets on pricing strategies, the decision sequence, and the profits of both the e-commerce platform and retailers.

Table 3 Publications distributed per sector.

Sectors	Number of Publications
Industries	34
Pharmaceutical Supply Chain	11
Luxury Products	3
Wine	3
Vaccines	2
Masks	1
Trading Cards	1
Education	1
Fresh Products	1
Food Company	1
Others	15
Deceptive Counterfeits	4
Not Mention Specific Sector	11
Total	**39**

Table 4 Selected articles.

No	Authors	Year	Country	Sector	Name of Journal	Databases
1	(Danese *et al.*, 2021)	2021	Italy	Wine	International Journal of Operations & Production Management	Emerald
2	(Jha, 2023)	2023	India	Education	Library Hi Tech News	Emerald
3	(de Boissieu *et al.*, 2021)	2021	France	Luxury Goods	Journal of Enterprise Information Management	Emerald
4	(Bapatla *et al.*, 2023)	2023	USA	Pharmaceutical	The Institution of Engineering and Technology.	Wiley
5	(Pun *et al.*, 2021)	2021	USA	Deceptive Counterfeits	Production and Operations Management	Wiley
6	(Sun *et al.*, 2022)	2022	China		Advanced Materials Technologies	Wiley
7	(Yu *et al.*, 2023)	2023	China		International Transactions in Operational Research	Wiley
8	(Chen, Guo, *et al.*, 2022)	2022	China	Luxury Products	Sustainability	MDPI
9	(Chen, Fang, *et al.*, 2022)	2022	China	Trading Cards	Symmetry	MDPI
10	(P. Liu, 2022)	2022	China	Fresh Products	Agriculture	MDPI
11	(H. Lee & Yeon, 2021)	2021	Korean		Sustainability	MDPI
12	(Jiang & Chen, 2021)	2021	China		Sustainability	MDPI
13	(Chauhan *et al.*, 2021)	2021	India	Vaccines	Vaccines	MDPI
14	(Zoughalian *et al.,* 2022)	2022	The UK.	Pharmaceutical	International Journal of Environmental Research and Public Health	MDPI
15	(Singh *et al.*, 2020)	2020	Denmark	Pharmaceutical	Sensors	MDPI
16	(Yiu, 2021b)	2021	The UK.	Bottle Wine	Future Internet	MDPI
17	(Yiu, 2021a)	2021	The UK.	Wine	Future Internet	MDPI
18	(Tan *et al.*, 2023)	2023	Malaysia	Food Company	Sustainability	MDPI
19	(A. Liu *et al.*, 2020)	2020	China		Journal of Management Science and Engineering	ScienceDirect
20	(Uddin, 2021)	2021	Brunei Darussalam	Pharmaceutical	International Journal of Pharmaceutics	ScienceDirect
21	(Li *et al.*, 2021)	2021	China		Transportation Research Part E: Logistics And Transportation Review	ScienceDirect
22	(Lu *et al.*, 2022)	2022	China		Computers and Industrial Engineering	ScienceDirect
23	(Naoum-Sawaya *et al.*, 2023)	2023	Canada	Deceptive Counterfeits	European Journal of Operational Research	ScienceDirect

Table 4 Selected articles (Cont'd)

No	Authors	Year	Country	Sector	Name of Journal	Databases
24	(Kordestani *et al.*, 2023)	2023	Sweden		Journal of Business Research	ScienceDirect
25	(Wang *et al.*, 2023)	2023	China	Deceptive Counterfeits	Computers and Industrial Engineering	ScienceDirect
26	(He *et al.*, 2023)	2023	China	Deceptive Counterfeits	Transportation Research Part E: Logistics And Transportation Review	ScienceDirect
27	(Munasinghe & Halgamuge, 2023)	2023	Australia	Vaccines	Expert Systems With Applications	ScienceDirect
28	(Crossland *et al.*, 2023)	2023	United States	Pharmaceutica	BC: Research And Applications	ScienceDirect
29	(Klöckner *et al.*, 2023)	2023	Switzerland	Luxury Watch Industry	Journal of Business Research	ScienceDirect
30	(Aniello *et al.*, 2021)	2021	UK.		International Journal of Information Security	Springer
31	(Rai, 2022)	2022	India	Pharmaceutical	Health Services and Outcomes Research Methodology	Springer
32	(Sharma & Rohilla, 2023)	2023	India	Medicine Supply Chain	The Journal of Supercomputing	Springer
33	(Pandey & Litoriya, 2021)	2021	India	Pharmaceutical	Wireless Personal Communications	Springer
34	(Preetha & Kumar, 2023)	2023	India	Pharmaceutical	Applied Nanoscience	Springer
35	(Mani *et al.*, 2022)	2022	India	Pharmaceutical Supply Chain	Journal of Cloud Computing: Advances, Systems and Applications	Springer
36	(Trautmann *et al.*, 2022)	2022	Germany	Pharmaceutical Supply Chains	International Journal of Logistics Research and Applications	Taylor & Francis
37	(Mhatre *et al.*, 2023)	2023	India		Journal of Applied Security Research	Taylor & Francis
38	(Shen *et al.*, 2023)	2023	China	Masks	International Journal of Production Research	Taylor & Francis
39	(Hou *et al.*, 2023)	2023	China		International Journal of Production Research	Taylor & Francis

Moreover, some papers investigated the factors influencing BC implementation, such as government support (Pun *et al.*, 2021) and quality inspection (Shen *et al.*, 2023). In addition, several articles focused on various topics, including the impact of BC on the healthcare system (Sarkar, 2023) and the identification of industry-specific motivations and barriers to the adoption of BC in the Swiss luxury watch industry (Klöckner *et al.*, 2023).

4.2.2 Methods Used

Previous researchers have used various methodologies, including case studies, computational experiments, game theory, and review (as shown in Table 5). The most widely used methods are computational experiments and game theory.

Most scholars used computational experiments to validate BC-powered frameworks (Aniello *et al.*, 2021; Bapatla *et al.*, 2023; Chauhan *et al.*, 2021; Chen, Fang, *et al.*, 2022; Chen, Guo, *et al.*, 2022; Crossland *et al.*, 2023; Danese *et al.*, 2021; Hou *et al.*, 2023; Mani *et al.*, 2022; Mhatre *et al.*, 2023; Munasinghe & Halgamuge, 2023; Preetha & Kumar, 2023; Pun *et al.*, 2021; Rai, 2022; Sharma & Rohilla, 2023; Shen *et al.*, 2023; Singh *et al.*, 2020; Sun *et al.*, 2022; Uddin, 2021; Yu *et al.*, 2023).

Furthermore, researchers employed game theory to determine whether to adopt the BC. Some examples of game theory are Stackelberg equilibrium theory (Jiang & Chen, 2021; P. Liu, 2022); Stackelberg-game and Stackelberg–Nash-game models (Li *et al.*, 2021); leader-follower Stackelberg competition (Naoum-Sawaya *et al.*, 2023); Stackelberg game model (He *et al.*, 2023; Wang *et al.*, 2023); Equilibrium analysis (Lu *et al.*, 2022); Markov model (Zoughalian *et al.*, 2022). For example, He *et al.* (2023) used the Stackelberg game model to analyze the manufacturer's strategies for counterfeiting under the scenarios with and without the BTS platform, respectively.

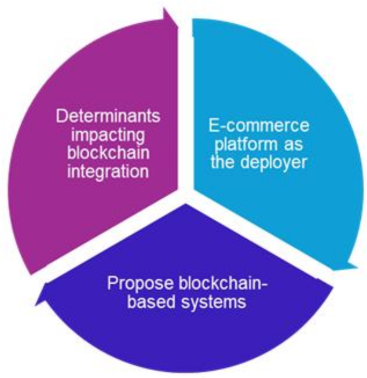

Figure 8 Contributions of previous research.

4.3 *Blockchain Technology Used for Anti-Counterfeiting*

4.3.1 Blockchain Technology Features

BC has numerous advantages in preventing counterfeiting. As shown in Table 6, the eight vital features of BC are Traceability, Decentralization, Transparency, Immutability, Privacy, Security, Anonymity, and Encryption.

Numerous researchers have repeatedly emphasized specific features, such as traceability, decentralization, transparency, and immutability. BC may boost supply chain management by ensuring product traceability and origin (de Boissieu *et al.*, 2021). Full traceability is a crucial capability of BC (Pun *et al.*, 2021). The characteristics of BC are transparency, decentralization, traceability, and anonymity (Jiang & Chen, 2021). BC is a decentralized ledger containing transactions as data blocks, with each block linked to its predecessors by a cryptographic pointer (Kouhizadeh *et al.*, 2021). Everyone involved has real-time access to detailed transaction information; BC enables people to share all information based on decentralization, security, and intelligent execution (Park & Li, 2021). BC aids in improving information security and transparency by sharing encrypted data among network members (J. Y. Lee, 2019). In BC, stored blocks are immutable, reliable, secure, and trusted, requiring verification and validation from most network nodes (Uddin, 2021).

Furthermore, BC provides privacy, security, anonymity, and encryption features. BC combines a distributed ledger, a decentralized structure, a consensus algorithm, asymmetric encryption, and smart contracts (Chen, Fang, *et al.*, 2022). Thus, due to the unique combination of these primary features, BC is the most effective method for preventing counterfeiting.

Table 5 Methods used.

Methods	References
Case study	(H. Lee & Yeon, 2021); (Yiu, 2021b); (Tan *et al.*, 2023); (A. Liu *et al.*, 2020);(Klöckner *et al.*, 2023); (Trautmann *et al.*, 2022); (de Boissieu *et al.*, 2021); (Jha, 2023); (Yiu, 2021a)
Computational experiments	(Pun *et al.*, 2021);(Chen, Guo, *et al.*, 2022); (Chen, Fang, *et al.*, 2022); (Chauhan *et al.*, 2021); (Crossland *et al.*, 2023); (Aniello *et al.*, 2021); (Rai, 2022);,(Preetha & Kumar, 2023); (Mani *et al.*, 2022); (Danese *et al.*, 2021) ; (Bapatla *et al.*, 2023) ; (Sun *et al.*, 2022) ; (Yu *et al.*, 2023) **;** (Singh *et al.*, 2020)**;** (Uddin, 2021)**;** (Munasinghe & Halgamuge, 2023)**;** (Sharma & Rohilla, 2023); (Mhatre *et al.*, 2023) ; (Shen *et al.*, 2023) ; (Hou *et al.*, 2023)
Game theory	Stackelberg equilibrium theory (P. Liu, 2022); (Jiang & Chen, 2021); Stackelberg-game and Stackelberg–Nash-game models (Li *et al.*, 2021); leader-follower Stackelberg competition (Naoum-Sawaya *et al.*, 2023); Stackelberg game model (Wang *et al.*, 2023); (He *et al.*, 2023); Equilibrium analysis (Lu *et al.*, 2022); Markov model (Zoughalian *et al.*, 2022)
Review	(Kordestani *et al.*, 2023)

4.3.2 Blockchain Technology Types

Table 7 summarizes the primary types of BC used for combating counterfeiting in the literature. Consortium BC was widely used because the nodes' authority can be configured flexibly, and data handling is faster (Jiang & Chen, 2021). In addition, most scholars selected to use Hyperledger Fabric, whose member nodes must be approved to participate and get accessibility (Chen, Guo, *et al.*, 2022). It additionally offers a reliable and confidential service for tracking every phase of the good through its supply chain (Mani *et al.*, 2022). Moreover, the Hyperledger Fabric BC platform offers several advantages, including anonymity and security, Processing efficiency, and Chaincode functionality (Uddin, 2021).

Table 6 Blockchain Technology's Advantages for preventing counterfeiting.

Types	Applications	References
Consortium	Hyperledger Fabric	(Chen, Guo, *et al.*, 2022), (Chen, Fang, *et al.*, 2022); (Uddin, 2021); (Munasinghe & Halgamuge, 2023); (Aniello *et al.*, 2021), (Pandey & Litoriya, 2021), (Mani *et al.*, 2022) ; (Sharma & Rohilla, 2023)
	Hyperledger Sawtooth	(H. Lee & Yeon, 2021)
Public	Ethereum blockchain	(Chauhan *et al.*, 2021); (Rai, 2022)
	Bitcoin	(Singh *et al.*, 2020)
Hybrid	Public-permissioned blockchains	(Crossland *et al.*, 2023)

Table 7 Blockchain types used for preventing counterfeiting.

Types	Applications	References
Consortium	Hyperledger Fabric	(Chen, Guo, *et al.*, 2022), (Chen, Fang, *et al.*, 2022); (Uddin, 2021); (Munasinghe & Halgamuge, 2023); (Aniello *et al.*, 2021), (Pandey & Litoriya, 2021), (Mani *et al.*, 2022) ; (Sharma & Rohilla, 2023)
	Hyperledger Sawtooth	(H. Lee & Yeon, 2021)
Public	Ethereum blockchain	(Chauhan *et al.*, 2021); (Rai, 2022)
	Bitcoin	(Singh *et al.*, 2020)
Hybrid	Public-permissioned blockchains	(Crossland *et al.*, 2023)

4.3.3 Key Performance Indicators for BC Platforms

Several indicators have been employed to assess the performance of blockchain-based frameworks, as illustrated in Table 8. The most commonly used metrics are throughput, cost, computational cost, and communication costs (Chen, Fang, *et al.*, 2022; Chen, Guo, *et al.*, 2022; Pandey & Litoriya, 2021; Tan *et al.*, 2023). Throughput is the speed at which transactions are recorded in the ledger, expressed in transactions per second (TPS) (Chen, Guo, *et al.*, 2022). Additionally, other metrics have been employed, including Security and Scalability (Bapatla *et al.*, 2023), Time Consumption (Zoughalian *et al.*, 2022), Encryption Time, and Energy Consumption (Singh *et al.*, 2020).

Previous researchers have mainly used a combination of indicators to evaluate the overall performance of proposal BTC platforms. For example, Bapatla *et al.* (2023) utilized Cost, Security, and Scalability to evaluate the proposed system's adaptability in the PharmaChain case, specifically in detecting and preventing counterfeit medication. Several researchers relied on single metrics, such as Time Consumption (Zoughalian *et al.*, 2022), Communication Cost (Crossland *et al.*, 2023), and Throughput (Pandey & Litoriya, 2021).

Table 8 Performance indicators.

Performance indicators	References
Cost, Security, Scalability	(Bapatla *et al.*, 2023)
Throughput, Transaction Latency, Resource Utilization, Computation Cost, Communication Costs	(Chen, Guo, *et al.*, 2022)
Computational Cost, Communication Cost	(Chen, Fang, *et al.*, 2022)
Consumption Of Gas, Mining Process, Difficulty, Transaction Cost Depends	(Chauhan *et al.*, 2021)
Time Consumption	(Zoughalian *et al.*, 2022)
Encryption Time, Energy Consumption	(Singh *et al.*, 2020)
Communication Costs, Throughput And Stability, And Fault Tolerance	(Tan *et al.*, 2023)
Data Traceability/Tracking, Distribution Zone-Based Distribution, Regulatory Compliance, Smart Contract Design for Compliance, Transaction Cost	(Munasinghe & Halgamuge, 2023)
Communication Cost,	(Crossland *et al.*, 2023)
Average Execution Time, Throughput, Average Latency,	(Rai, 2022)
Throughput	(Pandey & Litoriya, 2021)
Encryption And Decryption Time, Time Consumed	(Preetha & Kumar, 2023)
Throughput, Latency, And Success Rate (Average, Minimum, Maximum, And Percentile)	(Mani *et al.*, 2022)

5. THE MAIN BARRIERS WHEN ADOPTING BLOCKCHAIN FOR ANTI COUNTERFEITING

5.1 Technological Barriers

Although BC has been used in various industries and fields, it is still being developed and researched. Choosing the best BC platform is challenging because it has not yet been thoroughly researched (H. Lee & Yeon, 2021; Uddin, 2021).

Implementing BC may face some technical issues and challenges. For example, one of the most significant concerns regarding BC is the substantial energy demand associated with the block approval and update processes (Zoughalian *et al.*, 2022). Another BC issue is scalability, which may conflict with the level of decentralization in the current BC deployment context (Singh *et al.*, 2020; Yiu, 2021a). Additionally, it is challenging to integrate IoT devices with BC because IoT devices generate a large amount of data that BC cannot handle (Singh *et al.*, 2020). In addition, the limitation of the consensus algorithm in BC causes the consensus procedure to be slower, resulting in a longer delay; hence, storage and response times are decreased (Tan *et al.*, 2023). The most vulnerable part of BC is the connection between the physical item and its electronic file (Naoum-Sawaya *et al.*, 2023). As a result, technological barriers influence the adoption of BC (Klöckner *et al.*, 2023).

5.2 Organizational Barriers

One of the first moderating factors influencing the adoption of BC is organizational readiness. Organizational readiness is typically driven by management commitment, an understanding of BC technology and its unique characteristics, its implementation and investments, and development strategies for counterfeit prevention.

There are several reasons why organizations are hesitant to implement BC, all of which are related to organizational readiness. Prior research has indicated that industries do not fully comprehend BC technology (Danese *et al.*, 2021; Gayialis *et al.*, 2022; A. Liu *et al.*, 2020). Indeed, BC is an emerging technology that has been increasingly implemented in supply chain operations over recent years. Numerous enterprises are beginning to adopt it. All the examined BC projects are in the pilot phase and thus involve a limited number of companies and products (Danese *et al.*, 2021).

Besides, when integrating BC into their supply chains, luxury companies face several challenges, including a knowledge gap, various actors, and returns on investment (de Boissieu *et al.*, 2021). BC infrastructure necessitates critical management, including networking firewalls, audits, and other technical safety measures (Sarkar, 2023). As a result, when organizations fully comprehend BC, they will be willing to invest in and implement BC for anti-counterfeiting purposes.

Moreover, previous scholars have stated that cost is one of the challenges that organizations face when adopting BC (Bapatla *et al.*, 2023; Munasinghe & Halgamuge, 2023; Wang *et al.*, 2023). Due to the high expense, the manufacturer may be hesitant to improve the BC's anti-counterfeiting level significantly (Wang *et al.*, 2023). Manufacturers can strategically balance product quality and BC investment to combat counterfeiting (Naoum-Sawaya *et al.*, 2023). As a result, organizations should consider the cost of BC implementation as a valuable investment for future development.

5.3 Environmental Barriers

5.3.1 Government Policies

BC is being progressively investigated and utilized in various businesses and governments. The degree of BC acceptability and implementation varies by country. Many emerging countries are still in the early stages of research. Vietnam, for example, has announced its National Strategy for the Application and Development of Blockchain (BC) in 2024, with a vision for 2030. Vietnam has not formally deployed any BC-based counterfeiting remedies. Similarly, this occurs in Thailand and Indonesia. Most previous research has recommended BC-based solutions to combat counterfeiting commodities from large economies, as demonstrated in Table 4. Moreover, past research has demonstrated that financial assistance delivers more beneficial outcomes than reinforcement (Pun *et al.*, 2021; Wang *et al.*, 2024). As a result, the government must develop regulations to stimulate research and provide financial incentives for businesses to deploy BC-powered anti-counterfeiting systems.

5.3.2 Customer Awareness

As previously stated, there are two types of counterfeiting. It is challenging to solve non-deceptive counterfeiting. Customers intend to acquire these counterfeits. They purchased counterfeit items for various reasons, such as lower prices and the ability to flaunt their lifestyles. Consequently, BC cannot be appropriately implemented without consumer participation and support. BC requires the collaboration of various factors such as consumer awareness, physical supply chain, legal framework, extensive application, and managers' experiences (A. Liu *et al.*, 2020). Additionally, the platform's BC implementation relies on consumers' trust (Lu *et al.*, 2022). As a result, it is crucial to enhance client awareness of counterfeiting issues.

5.3.3 Inter-organizational Collaboration

One of the primary barriers to BC implementation is the need for stakeholders to share data. Batwa & Norrman (2021) emphasized that trust among supply chain partners is a key requirement for BC adoption. Besides, BC is an excellent choice for supporting data exchange and collaboration, as it stores documents while making them accessible to all users (Kumarathunga, 2020). However, many firms, particularly those in underdeveloped nations, are unwilling to provide information. According to Msimangira & Tesha (2014), significant challenges in developing nations such as Tanzania include a lack of trust, recordkeeping concerns, and counterfeit products. Similarly, Kritchanchai (2014) identified problems in Thailand's supply chains, including a lack of openness, which makes it challenging to manage and identify user and item information. Therefore, companies must build trust and collaboration to foster data transparency and sharing.

6. PROPOSING SOLUTIONS TO PROMOTING BLOCKCHAIN TECHNOLOGY ADOPTION

This study offers practical recommendations to address the aforementioned barriers.

6.1 Government Policies and Supports

BC is a novel technology; hence, its capabilities have been researched. However, BC has many possible characteristics that can help prevent counterfeit things. BC protects consumers and mitigates risks such as fraud, cash laundering, and online threats. BC could assist in ensuring the national economy and security. Hence, governments must play a primary role in promoting the investigation and application of BC.

The following are some of the duties of governments. Firstly, they should issue policies and regulations that offer clarity and stability for BC applications. As a result, businesses and customers are increasingly confident in implementing BC and undertaking BC transactions. Secondly, they can fund theoretical research and practical initiatives to assess BC's scalability, integration, and security. Additionally, the funding can help academics and businesses test BC anti-counterfeiting innovations under real-world circumstances. As a result, BC applications will be more reliable, affordable, and effective. Thirdly, they may invest in education projects, providing courses that promote BC skills and competence. They also organize and sponsor seminars and workshops that gather and connect scholars, developers, and industry leaders to explore and enhance BC knowledge.

6.2 Research on Blockchain-Based Anti-Counterfeiting Systems

BC is well-known in the cryptocurrency field. However, studies using BC to prevent counterfeiting are still insufficient. Researchers should focus on this topic. Researchers should concentrate on this subject. To overcome technological challenges, researchers play a key part in studying BC. More research is needed to understand better BC's powers to prevent counterfeiting. They can propose and implement BC-based anti-counterfeiting technologies. Researchers and industries are the inventors who discover new technologies and put them into practice. Thus, academics collaborate with governments and technology companies to develop adaptive BC systems tailored to specific industries, enabling faster implementation for organizations with limited technological capabilities.

6.3 Raising Customer Awareness

The first and second solutions help to overcome technological and organizational barriers. For the third barrier, educating consumers about the dangers of counterfeit goods and the significance of BC is vital. Governments and corporations should hold seminars, events, programs, and competitions. Incorporating lessons in schools and universities is crucial to nurturing generations that refuse counterfeits. Customers who purchase counterfeit items pose significant societal problems, including providing funds to counterfeiters. Customers must take responsibility for fighting criminals and protecting the integrity of our nation. Furthermore, BC implementation may benefit purchasers by promoting ethical purchasing, ensuring data privacy, and reducing carbon footprints.

6.4 Promoting Trust Among Stakeholders

To properly implement BC-powered anti-counterfeiting systems, participants must first build trust. There are various things they must undertake. They must ensure that the data exchanged with the parties involved is accurate and transparent. In addition, they must enter and validate data promptly. Besides, data must be kept confidential. The provided information should solely benefit business activities throughout the supply chain and have no detrimental influence on the enterprises involved. After establishing confidence, supply chain partners will be prepared to share information and facilitate the expedited flow of data. As a result, it encourages enterprises to utilize BC systems since they offer trustworthy, tamper-proof records.

7. CONCLUSION

Counterfeiting offers various consequences for consumers, businesses, and supply chain participants, including financial damages and health risks. Preventing such issues is crucial for protecting customers and businesses. This study conducted a systematic literature review to analyze the main barriers encountered when implementing BC to combat counterfeited products. The research identified the key barriers to BC adoption in terms of technological, organizational, and environmental aspects. As a result, this study proposes practical solutions to promote the use of BC in removing counterfeit items from e-commerce and supply chains.

This study provides extensive details on the effectiveness of using BC against counterfeiting. The following are some potential future proposes. This study aimed to acquire publications from several databases. However, due to accessibility and time constraints, this work was limited to specific databases, including ScienceDirect, Springer, Taylor & Francis, Emerald, Wiley, and MDPI. As a result, future research may involve gathering data from different sources. It would also be interesting to extend the search time. Additionally, in-depth interviews with industry managers can be conducted to understand their concerns thoroughly. Moreover, online shopping continues to grow at a significant rate. Thus, research into integrating BC into an online platform is crucial for ensuring the transparency of online transactions, mitigating ethical concerns, and promoting sustainability. Furthermore, it is crucial to examine the factors that influence customer behavior and purchasing intentions for non-deceptive counterfeits.

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DATA AVAILABILITY

The data that support the findings of this study are publicly available.

COMPLETING INTERESTS

The authors declare no competing interests.

REFERENCES

Aniello, L., Halak, B., Chai, P., Dhall, R., Mihalea, M., & Wilczynski, A. (2021). Anti-BlUFf: towards counterfeit mitigation in IC supply chains using blockchain and PUF. *International Journal of Information Security*, 20(3), pp. 445–460. https://doi.org/10.1007/s10207-020-00513-8

Attaran, M. (2022). Blockchain technology in healthcare: Challenges and opportunities. *International Journal of Healthcare Management*, 15(1), pp.70–83. https://doi.org/10.1080/20479700.2020.1843887

Bapatla, A. K., Mohanty, S. P., Kougianos, E., Puthal, D., & Bapatla, A. (2023). PharmaChain: A blockchain to ensure counterfeit-free pharmaceutical supply chain. *IET Networks*, 12(2), pp.53–76. https://doi.org/10.1049/ntw2.12041

Batwa, A., & Norrman, A. (2021). Blockchain technology and trust in supply chain management: A literature review and research agenda. *Operations and Supply Chain Management*, 14(2), pp.203–220. https://doi.org/10.31387/oscm0450297

Beltrami, M., Orzes, G., Sarkis, J., & Sartor, M. (2021). Industry 4.0 and sustainability: Towards conceptualization and theory. *Journal of Cleaner Production*, 312, 127733, pp. 1–21. https://doi.org/10.1016/j.jclepro.2021.127733

Bodkhe, U., Tanwar, S., Parekh, K., Khanpara, P., Tyagi, S., Kumar, N., & Alazab, M. (2020). Blockchain for Industry 4.0: A comprehensive review. *IEEE Access*, 8, pp. 79764–79800. https://doi.org/10.1109/ACCESS.2020.2988579

Chauhan, H., Gupta, D., Gupta, S., Singh, A., Aljahdali, H. M., Goyal, N., Noya, I. D., & Kadry, S. (2021). Blockchain enabled transparent and anti-counterfeiting supply of covid-19 vaccine vials. *Vaccines*, 9(11), pp. 1–18. https://doi.org/10.3390/vaccines9111239

Chen, C. L., Fang, C. C., Zhou, M., Tsaur, W. J., Sun, H., Zhan, W., & Deng, Y. Y. (2022). A Blockchain-Based Anti-Counterfeit and Traceable NBA Digital Trading Card Management System. *Symmetry*, 14(9), pp. 1–33. https://doi.org/10.3390/sym14091827

Chen, C. L., Guo, L. H., Zhou, M., Tsaur, W. J., Sun, H., Zhan, W., Deng, Y. Y., & Li, C. T. (2022). Blockchain-Based Anti-Counterfeiting Management System for Traceable Luxury Products. *Sustainability*, 14(19), pp. 1–37. https://doi.org/10.3390/su141912814

Crossland, V., Dellwo, C., Bashar, G., & Dagher, G. G. (2023). Janus: Toward preventing counterfeits in supply chains utilizing a multi-quorum blockchain. *Blockchain: Research and Applications*, 100157, pp. 1–21. https://doi.org/10.1016/j.bcra.2023.100157

Danese, P., Mocellin, R., & Romano, P. (2021). Designing blockchain systems to prevent counterfeiting in wine supply chains: a multiple-case study. International *Journal of Operations and Production Management*, 41(13), pp. 1–33. https://doi.org/10.1108/IJOPM-12-2019-0781

de Boissieu, E., Kondrateva, G., Baudier, P., & Ammi, C. (2021). The use of blockchain in the luxury industry: supply chains and the traceability of goods. *Journal of Enterprise Information Management,* 34(5), pp. 1318–1338. https://doi.org/10.1108/JEIM-11-2020-0471

Ding, J., & Bai, S. (2022). Optimal Decision and Coordination of Organic Food Supply Chain from the Perspective of Blockchain. *Discrete Dynamics in Nature and Society*, 2022, pp. 1–19. https://doi.org/10.1155/2022/6050185

Duan, K., Pang, G., & Lin, Y. (2023). Exploring the current status and future opportunities of blockchain technology adoption and application in supply chain management. *Journal of Digital Economy*, 2(January), pp. 244–288. https://doi.org/10.1016/j.jdec.2024.01.005

Dutta, P., Choi, T. M., Somani, S., & Butala, R. (2020). Blockchain technology in supply chain operations: Applications, challenges and research opportunities. *Transportation Research Part E: Logistics and Transportation Review*, 142(August), 102067, pp. 1–33. https://doi.org/10.1016/j.tre.2020.102067

European Union Intellectual Property Office. (2021). Anti-counterfeiting technology guide.

Gayialis, S. P., Kechagias, E. P., Papadopoulos, G. A., & Masouras, D. (2022). A Review and Classification Framework of Traceability Approaches for Identifying Product Supply Chain Counterfeiting. *Sustainability (Switzerland),* 14(11), pp. 1–20. https://doi.org/10.3390/su14116666

Gayialis, S. P., Kechagias, E., Papadopoulos, G. A., & Konstantakopoulos, G. D. (2019). Design of a blockchain-driven system for product counterfeiting restraint in the supply chain. In *IFIP Advances in Information and Communication Technology* (Vol. 566), pp. 474-481. https://doi.org/10.1007/978-3-030-30000-5_59

He, C., Tan, C., Ip, W. H., & Wu, C. H. (2023). Combating counterfeits with the Blockchain-technology-supported platform under government enforcement. *Transportation Research Part E: Logistics and Transportation Review*, 175(May 2022), pp. 1–24. https://doi.org/10.1016/j.tre.2023.103155

Hou, P., Zhang, C., & Li, Y. (2023). The interplay of manufacturer encroachment and blockchain adoption to combat counterfeits in a platform supply chain. *International Journal* *of Production Research*, pp. 1–17. https://doi.org/10.1080/00207543.2023.2192294

Islam, I., & Islam, M. N. (2022). Digital intervention to reduce counterfeit and falsified medicines: A systematic review and future research agenda. *Journal of King Saud University - Computer and Information Sciences*, 34(9), pp. 6699–6718. https://doi.org/10.1016/j.jksuci.2022.02.022

Jha, S. K. (2023). The counterfeit degree certificate: application of blockchain technology in higher education in India. *Library Hi Tech News*, 40(2), pp. 20–24. https://doi.org/10.1108/LHTN-02-2022-0023

Jiang, J., & Chen, J. (2021). Managing the product-counterfeiting problem with a blockchain-supported e-commerce platform. *Sustainability (Switzerland),* 13(11), pp. 1–15. https://doi.org/10.3390/su13116016

Klöckner, M., Schmidt, C. G., Fink, A., Flückiger, L., & Wagner, S. M. (2023). Exploring the physical–digital interface in blockchain applications: Insights from the luxury watch industry. *Transportation Research Part E: Logistics and Transportation Review*, 179(October), pp.1–21. https://doi.org/10.1016/j.tre.2023.103300

Kordestani, A., Oghazi, P., & Mostaghel, R. (2023). Smart contract diffusion in the pharmaceutical blockchain: the battle of counterfeit drugs. *Journal of Business Research*, 158(December 2022), pp.1–10.

Kouhizadeh, M., Saberi, S., & Sarkis, J. (2021). Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers. *International Journal of Production Economics,* 231(September 2019), pp.1–21. https://doi.org/10.1016/j.ijpe.2020.107831

Kritchanchai, D. (2014). A Framework for Healthcare Supply Chain Improvement in Thailand. *Operations and Supply Chain Management: An International Journal*, 5(2), pp.103–113. https://doi.org/10.31387/oscm0120080

Kumarathunga, M. (2020). Improving Farmers' Participation in Agri Supply Chains with Blockchain and Smart Contracts. 2020 *7th International Conference on Software Defined Systems,* SDS 2020, pp.139–144. https://doi.org/10.1109/SDS49854.2020.9143913

Lee, H., & Yeon, C. (2021). Blockchain-based traceability for anti-counterfeit in cross-border e-commerce transactions. *Sustainability*, 13(19), pp.1–20. https://doi.org/https://doi.org/10.3390/su131911057

Lee, J. Y. (2019). A decentralized token economy: How blockchain and cryptocurrency can revolutionize business. *Business Horizons,* 62(6), pp.773–784. https://doi.org/10.1016/j.bushor.2019.08.003

Li, Z., Xu, X., Bai, Q., Guan, X., & Zeng, K. (2021). The interplay between blockchain adoption and channel selection in combating counterfeits. *Transportation Research Part E: Logistics and Transportation Review*, 155(July), 102451, pp. 1–16. https://doi.org/10.1016/j.tre.2021.102451

Lima-Junior, F. R., & Carpinetti, L. C. R. (2017). Quantitative models for supply chain performance evaluation: A literature review. *Computers & Industrial Engineering*, 113, pp.333–346. https://doi.org/https://doi.org/10.1016/j.cie.2017.09.022

Liu, A., Liu, T., Mou, J., & Wang, R. (2020). A supplier evaluation model based on customer demand in blockchain tracing anti-counterfeiting platform project management. *Journal of Management Science and Engineering*, 5(3), pp.172–194. https://doi.org/10.1016/j.jmse.2020.06.001

Liu, P. (2022). Investment decisions of blockchain-based anti-counterfeiting traceability services in a high-quality fresh supply chain of China. *Agriculture (Switzerland),* 12(6), pp. 172–194. https://doi.org/10.3390/agriculture12060829

Lu, W., Jiang, Y., Chen, Z., & Ji, X. (2022). Blockchain adoption in a supply chain system to combat counterfeiting. *Computers and Industrial Engineering,* 171(July), 108408, pp. 1–12. https://doi.org/10.1016/j.cie.2022.108408

Ma, J., Lin, S. Y., Chen, X., Sun, H. M., Chen, Y. C., & Wang, H. (2020). A blockchain-based application system for product anti-counterfeiting. *IEEE Access*, 8, pp. 77642–77652. https://doi.org/10.1109/ACCESS.2020.2972026

Mani, V., Prakash, M., & Lai, W. C. (2022). Cloud-based blockchain technology to identify counterfeits. *Journal of Cloud Computing*, 11(1), pp. 1–15.. https://doi.org/10.1186/s13677-022-00341-2

Mhatre, M., Kashid, H., Jain, T., & Chavan, P. (2023). BCPIS: Blockchain-based counterfeit product identification system. *Journal of Applied Security Research*, 18(4), pp. 740–765. https://doi.org/10.1080/19361610.2022.2086784

Mohsen, B. M. (2023). Impact of Artificial Intelligence on Supply Chain Management Performance. journal of service science and management, 16(01), pp. 44–58. https://doi.org/10.4236/jssm.2023.161004

Msimangira, K. A. B., & Tesha, C. P. (2014). Global supply chain practices and problems facing developing countries: A study in Tanzania. *Operations and Supply Chain Management: An International Journal*, 7(3), pp. 130–138. https://doi.org/10.31387/oscm0180119

Munasinghe, U. J., & Halgamuge, M. N. (2023). Supply chain traceability and counterfeit detection of COVID-19 vaccines using novel blockchain-based Vacledger system. *Expert Systems with Applications*, 228(August 2022), 120293, pp. 1–25. https://doi.org/10.1016/j.eswa.2023.120293

Naoum-Sawaya, J., Elhedhli, S., & De Carvalho, P. (2023). Strategic blockchain adoption to deter deceptive counterfeiters. *European Journal of Operational Research*, 311(1), pp. 373–386.

Naz, F., Agrawal, R., Kumar, A., Gunasekaran, A., Majumdar, A., & Luthra, S. (2022). Reviewing the applications of artificial intelligence in sustainable supply chains: Exploring research propositions for future directions. *Business Strategy and the Environment*, 31(5), pp. 2400–2423. https://doi.org/10.1002/bse.3034

Nguyen, T. T. H. (2023). Applications of artificial intelligence for demand forecasting. *Operations and Supply Chain Management,* 16(4), pp. 424–434. https://doi.org/http://doi.org/10.31387/oscm0550401

Nishikawa-Pacher, A. (2022). Who are the 100 largest scientific publishers by journal count? A webscraping approach. *Journal of Documentation*, 78(7), pp. 450–463. https://doi.org/10.1108/JD-04-2022-0083

Pandey, P., & Litoriya, R. (2021). Securing e-health networks from counterfeit medicine penetration using blockchain. Wireless *Personal Communications*, 117(1), pp. 7–25. https://doi.org/10.1007/s11277-020-07041-7

Park, A., & Li, H. (2021). The effect of blockchain technology on supply chain sustainability performances. *Sustainability (Switzerland),* 13(4), pp. 1–18. https://doi.org/10.3390/su13041726

Preetha, A. D., & Kumar, T. S. P. (2023). Securing IoT-based healthcare systems from counterfeit medicine penetration using Blockchain. *Applied Nanoscience (Switzerland), 13*(2), pp. 1263–1275. https://doi.org/10.1007/s13204-021-01984-4

Pun, H., Swaminathan, J. M., & Hou, P. (2021). Blockchain Adoption for Combating Deceptive Counterfeits. *Production and Operations Management,* 30(4), pp. 864–882. https://doi.org/10.1111/poms.13348

Rai, B. K. (2022). BBTCD: blockchain based traceability of counterfeited drugs. *Health Services and Outcomes Research Methodology,* 23(3), pp. 337–353. https://doi.org/10.1007/s10742-022-00292-w

Rastogi, R., Sharma, B. P., Gupta, N., Gaur, V., Gupta, M., Kohli, V., Sharma, A., Komal, Srivastava, P., & Rai, A. (2022). NFC-enabled packaging to detect tampering and prevent counterfeiting: Enabling a complete supply chain using blockchain and CPS. *In Blockchain Applications for Healthcare Informatics: beyond 5G*, pp. 27–55. https://doi.org/10.1016/B978-0-323-90615-9.00002-5

Sarkar, S. (2023). Blockchain for Combating Pharmaceutical Drug Counterfeiting and Cold Chain Distribution. *Asian Journal of Research in Computer Science*, 16(3), pp.156–166. https://doi.org/10.9734/ajrcos/2023/v16i3353

Sharma, N., & Rohilla, R. (2023). A multilevel authentication-based blockchain powered medicine anti-counterfeiting for reliable IoT supply chain management. *The Journal of Supercomputing,* 80, pp. 4870–4913. https://doi.org/10.1007/s11227-023-05654-w

Shen, B., Cheng, M., Dong, C., & Xiao, Y. (2023). Battling counterfeit masks during the COVID-19 outbreak: quality inspection vs. blockchain adoption. *International Journal of Production Research,* 61(11), pp.3634–3650. https://doi.org/10.1080/00207543.2021.1961038

Shiksha Online. (2022). Evolution of Blockchain: 1991 to 2023. https://www.shiksha.com/online-courses/articles/evolution-of-blockchain-technology/

Singh, R., Dwivedi, A. D., & Srivastava, G. (2020). Internet of things based blockchain for temperature monitoring and counterfeit pharmaceutical prevention. *Sensors (Switzerland),* 20(14), pp.1–23.

Spink, J., Moyer, D. C., Park, H., & Heinonen, J. A. (2013). Defining the types of counterfeiters, counterfeiting, and offender organizations. *Crime Science*, 2(1), pp.1–10. https://doi.org/10.1186/2193-7680-2-8

Statista. (2024). eCommerce - Worldwide. https://www.statista.com/outlook/emo/ecommerce/worldwide

Sun, J., Parajuli, S., Shrestha, K., Park, J., Shrestha, S., Jung, Y., Park, H., Koirala, G. R., Nasir, N., Kim, S., Truong, H., Jang, H., Lee, J., Lee, J., & Cho, G. (2022). Printed four key-device units for unified platform of wireless anti-counterfeiting label to bridge in blockchain. *Advanced Materials Technologies*, 7(5), 2100969 .

Tan, J., Goyal, S. B., Singh Rajawat, A., Jan, T., Azizi, N., & Prasad, M. (2023). Anti-counterfeiting and traceability consensus algorithm based on weightage to contributors in a food supply chain of industry 4.0. *Sustainability (Switzerland),* 15(10), pp.1–19. https://doi.org/10.3390/su15107855

Thomé, A. M. T., Scavarda, L. F., & Scavarda, A. J. (2016). Conducting systematic literature review in operations management. *Production Planning and Control*, 27(5), pp. 408–420. https://doi.org/10.1080/09537287.2015.1129464

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management,* 14(3), pp. 207–222. https://doi.org/10.1111/1467-8551.00375

Trautmann, L., Hübner, T., & Lasch, R. (2022). Blockchain concept to combat drug counterfeiting by increasing supply chain visibility. *International Journal of Logistics Research and Applications*, pp. 1–27. https://doi.org/10.1080/13675567.2022.2141214

Tripathi, G., Ahad, M. A., & Casalino, G. (2023). A comprehensive review of blockchain technology: Underlying principles and historical background with future challenges. *Decision Analytics Journal,* 9(March), 100344, pp. 1–21. https://doi.org/10.1016/j.dajour.2023.100344

U.S. Customs and Border Protection. (2023). The Truth Behind Counterfeits. https://www.cbp.gov/trade/fakegoodsrealdangers

Uddin, M. (2021). Blockchain medledger: Hyperledger fabric enabled drug traceability system for counterfeit drugs in pharmaceutical industry. *International Journal of Pharmaceutics*, 597(January), 120235, pp. 1–16. https://doi.org/10.1016/j.ijpharm.2021.120235

Wang, J., Zhang, Q., & Hou, P. (2024). Combating deceptive counterfeits with blockchain technology under asymmetric information. *IEEE Transactions on Engineering Management,* 71, pp. 3951–3963. https://doi.org/10.1109/TEM.2022.3223899

Wang, J., Zhang, Q., Hou, P., & Li, Q. (2023). Effects of platform's blockchain strategy on brand manufacturer's distribution strategy in the presence of counterfeits. *Computers and Industrial Engineering*, 177(January), 109028, pp. 1–13. https://doi.org/10.1016/j.cie.2023.109028

Xie, R., Wang, Y., Tan, M., Zhu, W., Yang, Z., Wu, J., & Jeon, G. (2020). Ethereum-blockchain-based technology of decentralized smart contract certificate system. *IEEE Internet of Things Magazine*, 3(2), pp. 44–50. https://doi.org/10.1109/iotm.0001.1900094

Yiu, N. C. K. (2021a). Article toward blockchain-enabled supply chain anti-counterfeiting and traceability. *Future Internet*, 13(4), pp. 1–26. https://doi.org/10.3390/fi13040086

Yiu, N. C. K. (2021b). Decentralizing supply chain anti-counterfeiting and traceability systems using blockchain technology. *Future Internet*, 13(4), pp. 1–33. https://doi.org/10.3390/fi13040084

Yu, T., Guan, Z., Li, J., Zhang, J., & Dong, J. (2023). Optimal pricing strategies of e-commerce supply chain considering consumers' anticipated regrets under the background of blockchain anti-counterfeiting technology. *International Transactions in Operational Research*. https://doi.org/https://doi.org/10.1111/itor.13394

Zoughalian, K., Marchang, J., & Ghita, B. (2022). A blockchain secured pharmaceutical distribution system to fight counterfeiting. *International Journal of Environmental Research and Public Health*, 19(7), pp. 1–32. https://doi.org/10.3390/ijerph19074091

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