INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ECONOMICS & MANAGEMENT SCIENCES

OPEN ACCESS JOURNAL

Vol 14, Issue 3, (2025) E-ISSN: 2226-3624

Supply Chain Risk Management with Blockchain: A Literature Review and Future Research Directions

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DOI Link: http://dx.doi.org/10.6007/IJAREMS/v14-i3/26086

Published Online: 11 August 2025

Abstract

Coronavirus Disease 2019 (COVID-19) has put tremendous pressure on global supply chain risk management (SCRM). Recent technological advances, especially blockchain technology (BCT), a leader in distributed digital technology with its traceability, transparency, immutability, and district-centralization features, have shown some success in several areas of supply chain risk management. However, the literature lacks a comprehensive analysis of the relationship between blockchain and SCRM. The work in this paper provides a comprehensive review of the relatively limited literature in this area. An analysis of 51 shortlisted articles from the scopus database shows that the field is still in a rapid development phase and researchers have shown remarkable interest in it. The main objective of this study is to review the current state of research so that researchers can clearly understand the research gaps in the application of blockchain technology in supply chain risk management. In addition, this study provides an future outlook for researchers and practitioners to focus on the application of corporate blockchain in supply chain risk management in the wake of the COVID-19 pandemic.

Keywords: Blockchain, BCT, SCRM, Literature Review, Risk Management

Introduction

In recent years, the world has experienced a series of catastrophic events, including the global economic collapse, the Icelandic volcanic eruption, the Gulf of Mexico oil spill, large-scale power outages in Japan, political unrest in Africa and the Middle East, catastrophic tsunamis and blackouts in Japan, as well as political and economic crises. When the supply chain management process is disrupted or blocked by adverse factors, supply chain risks may emerge, causing irreparable losses to enterprises and even leading to operational shutdowns (Shahid et al., 2024; Seow et al., 2024). For example, supply chain disruptions may result in delays or shortages in raw materials or components, leading to production delays or even halts (Ye et al., 2024). Difficulties within the supply chain process can delay the entire

workflow and incur high costs (Elnur, 2025). Resilinc Corporation, a multinational company specializing in monitoring supply chain disruptions, reported that in 2022, the number of supply chain disruptions increased by 32% year-on-year (Lu et al., 2024). Therefore, managing uncertain risks in the future is a challenge that can enhance an enterprise's ability to survive, adapt, and develop amid turbulence and change.

In recent years, blockchain has emerged as one of the most promising technologies in various application fields such as the Internet of Things, smart cities, digital management, healthcare systems, supply chain management (Zhang & Chen, 2025), real estate, smart agriculture, smart retail, and smart grids (Malik et al., 2023). Due to the unique characteristics of blockchain technology (BCT), it can mitigate disruptions related to certain supply and demand risks (Alkhudary, 2024), eliminate uncertainty and complexity (Bai et al., 2024), and enhance supply chain risk management (SCRM) (Elnur, 2025). According to Baz & Ruel (2021), Hohenstein (2022), and Duong & Ha (2021), supply chain risk management consists of four stages: risk identification, risk assessment, risk mitigation, and risk control. In terms of risk perception, BCT can address disruption and supply-demand coordination risks in the supply chain because its traceability, transparency, information sharing, and decentralization features enhance its perceived usefulness in supply chain resilience and responsiveness (Cai et al., 2023; Dong et al., 2023). BCT can also reduce perceived risk motivations in remanufacturing processes (Wang et al., 2024). Regarding operational risks, BCT improves demand responsiveness (Ba et al., 2024) and production flexibility (Lotfi et al., 2024), plays a positive role in risk mitigation and inventory reduction, and helps control the chain reaction of risks.

In addition to preventing product loss and counterfeiting, blockchain also improves overall supply chain transparency and efficiency (Dash et al., 2024). Companies that adopt blockchain or possess blockchain capabilities to improve supply chain efficiency experience a smaller average negative stock price reaction during crises, with shareholder value loss reduced by an average of 8.24% (Bai, 2024). For example, the application of blockchain improved the cost-effectiveness of the mango supply chain, with simulation results showing a 0.035% reduction in mango loss and a decrease in operating costs (Lee et al., 2023). Supply chain operational risks are lower when using blockchain compared to traditional supply chains (Choi et al., 2023). In terms of financial risks, blockchain features are used to address supply chain financial risks, improve financing efficiency in clearing and settlement processes (Gao, 2023), and achieve positive results in managing supply chain-related risks, financial transaction reliability, and information reliability (Hong et al., 2023). According to a report by Grand View Research, the global blockchain technology (BCT) market is expected to grow at a compound annual growth rate (CAGR) of 90.1% between 2025 and 2030. This trend indicates that BCT has enormous potential and value in optimizing global supply chain risk management.

However, in the field of supply chain risk management, research on BCT adoption remains scarce, especially in business environments characterized by volatility, uncertainty, complexity, and ambiguity (VUCA), such as crises, disasters, and pandemics (Chowdhury et al., 2023). The main reason lies in the fact that most SCRM researchers come from the management field, while most BCT researchers are from the computer science field. BCT researchers tend to focus on computer science and finance, and the gap between the two disciplines is wide, lacking practical application guidance. A lack of BCT knowledge training for employees leads to low acceptance and inadequate technical readiness. The absence of clear

operational guidance is one of the obstacles to blockchain adoption at the organizational level. Due to insufficient technical preparation, companies are often unclear about how to operate or use blockchain in a meaningful and straightforward way (Xu, 2024), and this resistance eventually affects enterprise adoption of BCT. As a result, when researchers attempt to apply BCT to SCRM, they encounter numerous barriers. The knowledge gap between the two disciplines hinders further research efforts.

This literature review is necessary for the interdisciplinary integration of the two fields, SCRM and BCT, to bridge this research gap and to identify the value of applying BCT to SCRM. Reviews on SCRM-related topics (Okoye et al., 2024;Lee., 2024). However, to the author's knowledge, no attempt has been made to apply BCT to SCRM application literature in a digital technology environment. Previous SCRM literature reviews have focused on risky decision-making (Olawale et al., 2024;Crawford et al., 2024)), Natural disaster risk management factors (Merino et al., 2024;Dal et al., 2024). None of these articles specifically examined the use of BCT in SCRM and provided a comprehensive analysis. Because of these shortcomings, this study reviews the academic literature on the application of BCT in SCRM. This study aims to help researchers and practitioners learn more about empirical and theoretical studies on the application of BCT to corporate SCRM by exploring the development of previous studies. In addition, this study analyzes the potential directions of the application of BCT in the SCRM process by evaluating the current state of BCT in SCRM. This study aims to answer the following questions. (1) What is the current state of research on Blockchain in SCRM? (2) Which SCRM domains have used Blockchain so far, which blockchain technologies have been used, and how effective are these blockchain technologies? (3) What are the current gaps in blockchain research in the SCRM domain, and which areas need more attention?

This study provides a comprehensive analysis of the applied research on Blockchain in SCRM regarding the above three issues. The other parts of this study are organized as follows. The different parts of this study are organized as follows. Part II presents the methodology of the literature review. Parts III and IV present the results of the bibliometric analysis realized through computer software. Part V details the commonly used blockchain technologies, their application scenarios, and their applications in SCRM. Part VI presents future research directions.

Methods

Article Selection Process

This study screened articles related to "SCRM" and "blockchain" from the Scopus journal database. The first step is shown in Figure 1, where we select the Scopus academic database; second, we define the search terms. The keywords used in the search were "blockchain" and "SCRM". Third, to comprehensively include review articles on the target topics, the search scope of this study was limited to the end date of July 20, 2024, without considering the time limit of publication. In other words, we collected all articles published before July 20, 2024, in this Scopus Scholar database on blockchain and SCRM. The targeted article count search resulted in 544 articles. It was stored in the Research Information System (CSV) format including all important The targeted article count search resulted in 544 articles and was stored in the CSV format, including all critical article information such as title, publisher, journal name, country, author name, abstract, keywords, and references. Fourthly, papers, especially peer-reviewed academic papers, are usually of a high academic and professional

standard. They have gone through a rigorous screening and assessment process. In order to achieve the highest relevance and professionalism, ensure the accuracy and reliability of the content, be able to extensively cover the topics and fields of research, and provide rich data and information, only articles published in international journals are selected for analysis, thus excluding conference papers, editorials, textbooks, master's theses, etc., so that the researchers can ensure that their analyses are systematic and comprehensive, and that they can cover the field of Researchers can ensure that their analysis is systematic and comprehensive, covering the main research results and trends in the field, thus providing strong support and guidance for their research. And none of the journal lists were restricted to ensure comprehensiveness. This selection method reduced the number of articles collected to 249. Fifth, To keep the article on topic, we examined keywords to determine if they covered supply chain risk and blockchain topics. It was excluded if an article did not meet one of these filtering criteria. We also carefully evaluated the reference lists of the shortlisted articles to ensure that no other relevant articles were missed in the search. The content of each article was thoroughly reviewed to ensure it was researched in a blockchain environment, leaving 51 articles.

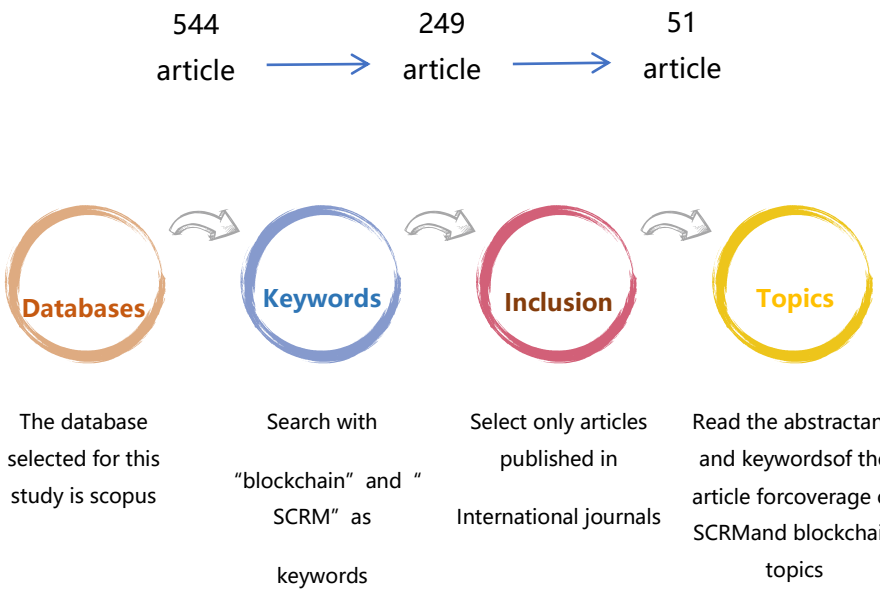

Fig. 1. Paper selection process

Descriptive Analysis

A rigorous screening of articles resulted in the final selection of the 51 papers most relevant to this study, and to present a clearer picture of the selected articles, this section provides a descriptive analysis of the publications, distribution of research areas, regional distribution, and published journals.

Annual Publications Citations

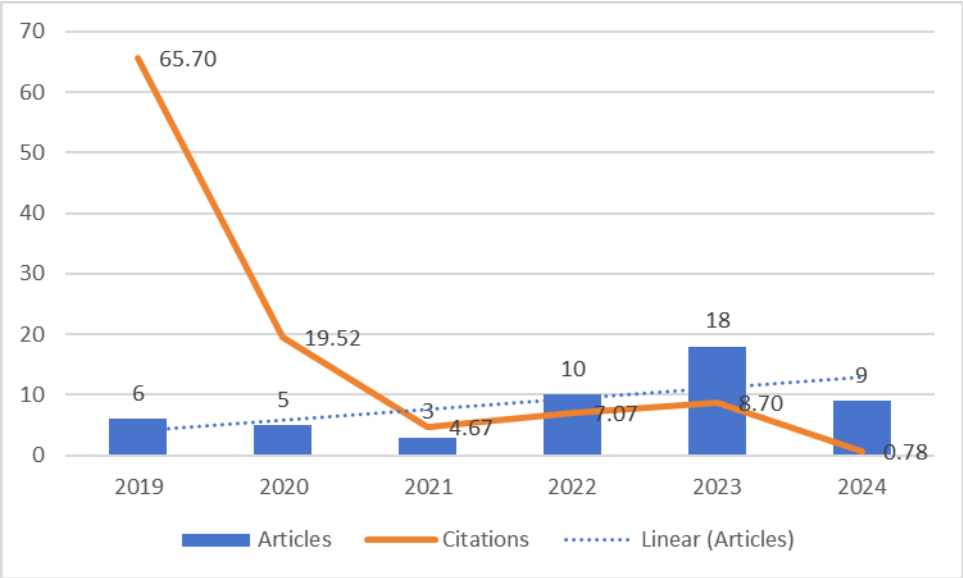

Fig. 2. Annual publication trend.

The number of papers on BCT and SCRM per year is shown in Figure 2, and we selected 51 articles from inside the Scopus database, and finally, our analysis, which was written within 5 years (2019 to 2024). As soon as the concept of blockchain was introduced in 2008, the related research continued for a long time, however, the research on the use of blockchain in SCRM was very late. The first research paper on the use of BCT in SCRM was published in 2019 and had the highest number of citations. 2021 saw a decline in the number of studies, followed by a rapid growth trend, suggesting that researchers are beginning to realize that the use of BCT will make SCRMs more efficient and increase the resilience of businesses to risk.

Regional Distribution

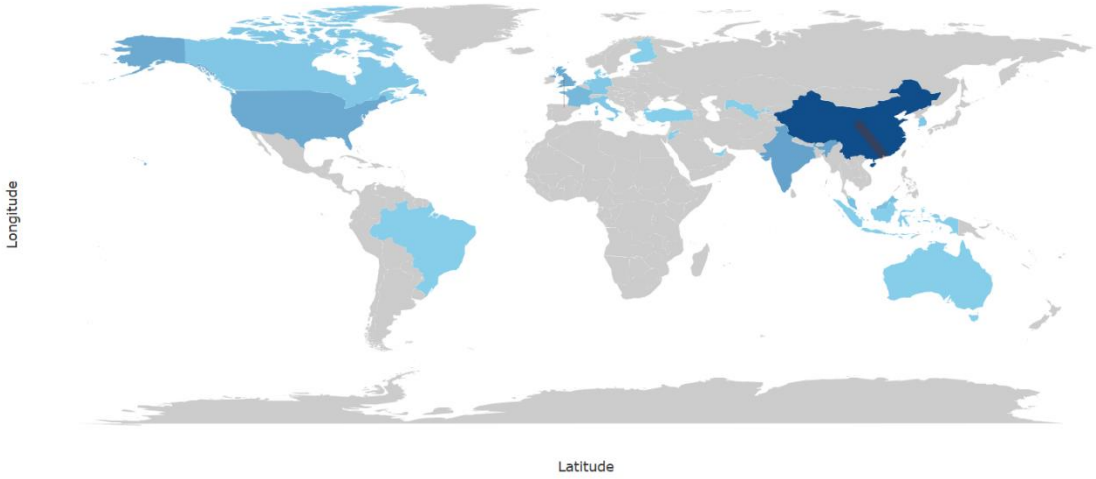

Fig. 3 . Country Network.

Determining the geographical distribution of articles helps to clarify the profile of researchers conducting SCRM research in each region. This section analyzes the country distribution of the mailing addresses of the authors of all articles and uses Biblioshiny to

visually depict the countries where these researchers are sitting, as shown in Figure 3. Existing research on SCRM blockchain technology applications is mainly focused on Southeast Asia and North America. This is because North America is a well-known global supply chain center, contracting most of the developed economies around the world. And CIOVD-19 erupted in China, affecting the world, especially Southeast Asian neighbors, coupled with, Southeast Asia's dual advantages of labor and natural resources, attracting many countries to transfer labor-intensive industries to Southeast Asia, making the Southeast Asian supply chain become an important part of the global economic development, so these regions are taking the lead in the use of emerging technologies, such as blockchain technology, to solve the SCRM problem in order to better prevent and mitigate the adverse impact of risk events on the development of global supply chains.

Bibliometric Analysis

Publication Sources

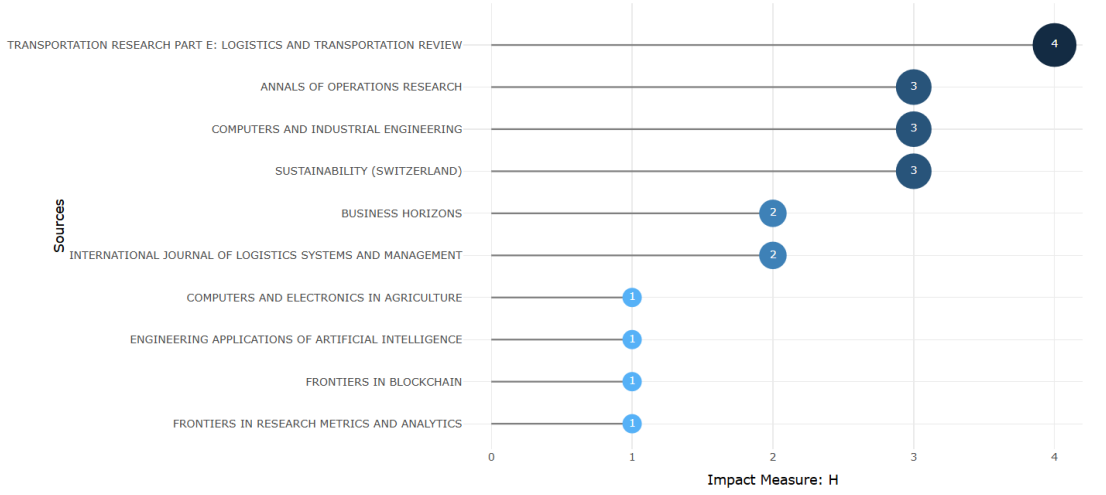

Fig. 4 . Journal sources.

Analyzing the journals that publish refereed articles helps to understand how well the journals are accepting papers in the field. Journals in various fields (e. g., computing, management, sustainability, business, logistics) publish articles on SCRM and blockchain algorithms. A total of 36 journals were included in this review. Figure 4 shows the top 10 contributing journals from the 51 articles reviewed. Of the 36 journals, only 9 published more than 2 articles. These journals are dispersed across logistics, management, and computing, indicating a trend toward fixed journal publishing in the field. Supply chain researchers are just starting to notice the benefits of Blockchain and trying to solve SCRM problems with BCT, such as TRANSPORTATION RESEARCH PART E: LOGISTICS AND TRANSPORTATION REVIEW, NNALS OF OPERATIONS RESEARCH NNALS OF OPERATIONS RESEARCH", "SUSTAINABILITY (SWITZERLAND)". In addition, some BCT researchers may be very interested in SCRM issues. Their perspectives on the field appear in several computing and interdisciplinary journals, such as COMPUTERS AND INDUSTRIAL ENGINEERING and COMPUTERS AND ELECTRONICS IN AGRICULTURE. Overall, the concerns of researchers in the field have provided guidance to address the crisis and have prompted other researchers and practitioners to take note of the benefits of BCT and apply it in practice.

Citation Analysis

Table1

Top 10 cited articles

NO.	Paper	Total Citations	TC per Year	Normalized TC
1	Ivanov d, 2019, int j prod res	1064	177. 33	2. 70
2	MIN H, 2019, BUS HORIZ	568	94. 67	1. 44
3	CHOI T-M, 2019, TRANSP RES PART E LOGIST TRANSP REV	308	51. 33	0. 78
4	MONTECCHI M, 2019, BUS HORIZ	266	44. 33	0. 67
5	Rogerson m, 2020, supply chain manage	263	52. 60	2. 69
6	DE GIOVANNI P, 2020, INT J PROD ECON	199	39. 80	2. 04
7	CHOI T-M, 2023, ANN OPER RES	115	57. 50	6. 61
8	F. U. Y, 2019, IEEE ACCESS	108	18. 00	0. 27
9	CAO Y, 2022, TRANSP RES PART E LOGISTIC TRANSP REV	77	25. 67	3. 63
10	CHOWDHURY S, 2023, ANN OPER RES	62	31. 00	3. 57

Citations are considered an essential indicator of an article's impact and for determining the acceptability of research in the field. Table 1 shows the 10 most frequently cited articles, including the cumulative number of citations in Scopus and the number of citations per year, based on how often other articles cite a particular article in Scopus. On average, these articles were cited approximately 59 times per year. The most cited study was "IVANOV D, 2019, INT J PROD RES", cited 1064 times. The second most cited article was "MIN H, 2019, BUS HORIZ", with 568 citations. The third most cited article was the study "CHOI T-M, 2019, TRANSP RES PART E LOGIST TRANSP REV" with 308 citations. Notably, the most cited article was published in 2019. However, throughout this study, the number of citations was very high, which shows that the number of articles in this field is small and widely accepted by researchers. These articles are distributed in many fields, such as logistics and computer science, which indicates that research on the use of BCT in SCRM has not become mainstream research. Most of the articles have appeared in the last few years. In the previous few years, researchers started paying attention to the advantages of BCT in supply chain risk.

Keyword Analysis

Keyword Co-Occurrence Analysis

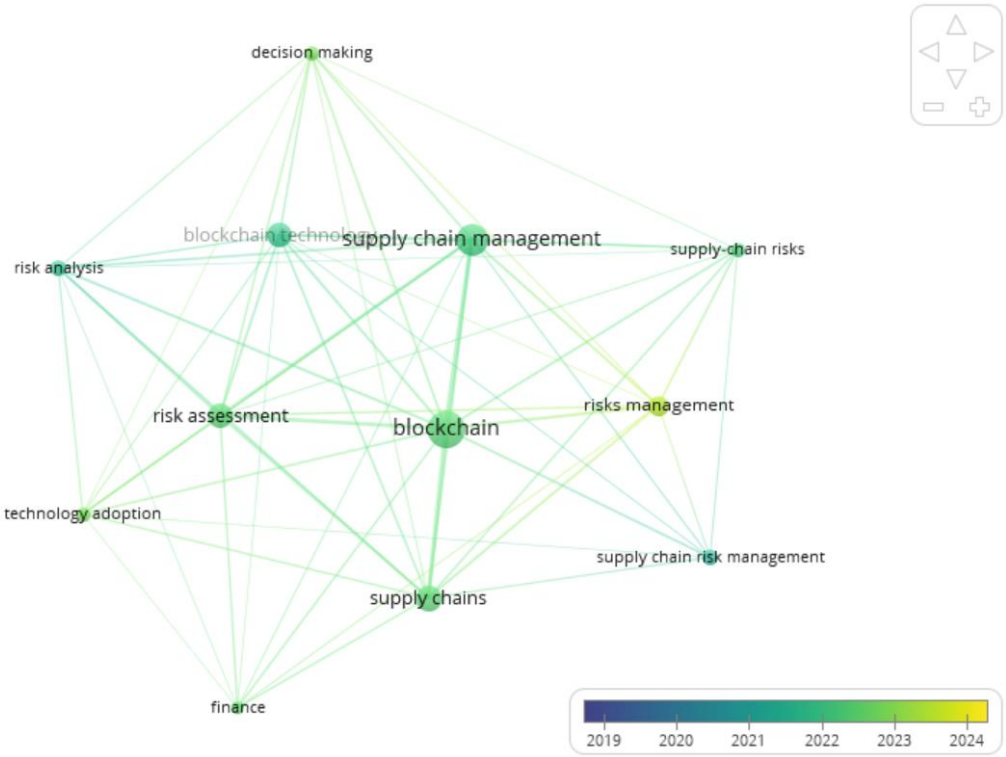

Fig. 5. Co-occurrence network of keywords.

Keyword co-occurrence refers to the simultaneous occurrence of two or more keywords in an article. Co-occurrence analysis, which utilizes the co-occurrence of word pairs or noun phrases in a collection of literature to identify relationships between topics in the discipline represented by that collection, is a content analysis method based on existing literature and is arguably the best means of identifying trends in a field. In this paper, 12 keywords from 51 documents were extracted and analyzed by VOSviewer to show the keyword sharing network about the applicability of BCT as shown in Fig. 5, which shows the keyword sharing network ever, which indicates that there is no specific concept of the application of Blockchain. Some researchers found Blockchain a handy tool for enhancing SCRM and chose BCT as a SCRM tool. Therefore, the application of BCT in SCRM should be distributed to more industries such as tourism, food, and pharmaceuticals. The fact that keywords such as 'blockchain', 'BCT', and 'supply chain risk' have only begun to receive attention in the last five years shows that previous researchers did not know enough about the field. The benefits of BCT in SCRM were not fully recognized until the last couple of years when BCT could help business managers cope with supply chain crises. However, as this benefit has been realized, researchers and practitioners have made more robust demands for risk management and have begun actively integrating new technologies for implementation. For example, the latest technology blockchain combined with IoT technology has already started to be used in SCRM decision-making.

Keyword Clustering Analysis

Table 2

The list of the keyword

Keyword	Occurrences	Total link length	Keyword	Occurrences	Total link length
Blockchain	62	288	Risk analysis	8	46
Risks management	33	166	Supply-chain risks	6	40
Supply chains	26	127	Decision making	6	34
Supply chain management	28	116	Technology adoption	6	32
Risk assessment	18	96	Finance	5	27
BCT	17	55	SCRM	8	25

Keyword clustering can be these research hot words according to a particular division pattern, categorization, divided into different clusters, and then summarize the research hotspots of this selection, the research theme, as shown in Table 2. The main goal of cluster analysis is to create clusters of topics. Keyword clustering uses metrics to categorize and condense complex keywords, making them more intuitive and easy to understand. In this paper, 3 clusters of keywords were derived from VOSviewer software, and the specific information is shown in Table 3.

Table 3

The list of the keyword clusters

Cluster	**item**	**Links**	**Items**	**Total link strength**	**Occurrences**
1	Blockchain	11	Risk management, supply chains, supply chain management, risk assessment BCT, Risk analysis, Supply-chain risks, Decision-making, Technology adoption, Finance, SCRM	110	39
2	risk assessment	10	Blockchain, Risk management, Supply chains, Risk assessment, BCT, Risk analysis, Supply-chain risks, Decision making, Technology adoption, finance, SCRM	71	18
3	finance	8	Blockchain, Risk management, Supply chains, Risk assessment, BCT, Risk analysis, Supply-chain risks, Technology adoption	19	5

After biblioshiny analysis, 3 clusters were formed. The first keyword cluster item is Blockchain, a hot keyword in Scopus, which refers to Blockchain and BCT, indicating that Blockchain is the hottest topic in SCRM. The second one is risk assessment, and there are 10 other items associated with it, indicating that risk assessment is another hot topic in Blockchain. The last keyword cluster item is finance. It can be seen that the main research

directions in supply chain risk management in the future are mainly reflected in the fields of blockchain and BCT, risk assessment, and finance.

Keyword Thematic Map Analysis

We found that previously analyzing keywords alone, if only by two dimensions, is insufficient. Some keywords appear very frequently but have little impact, especially in interdisciplinary research areas. Therefore, combining this Quadrant and analyzing the keywords with additional dimensions such as influence and density is also necessary.

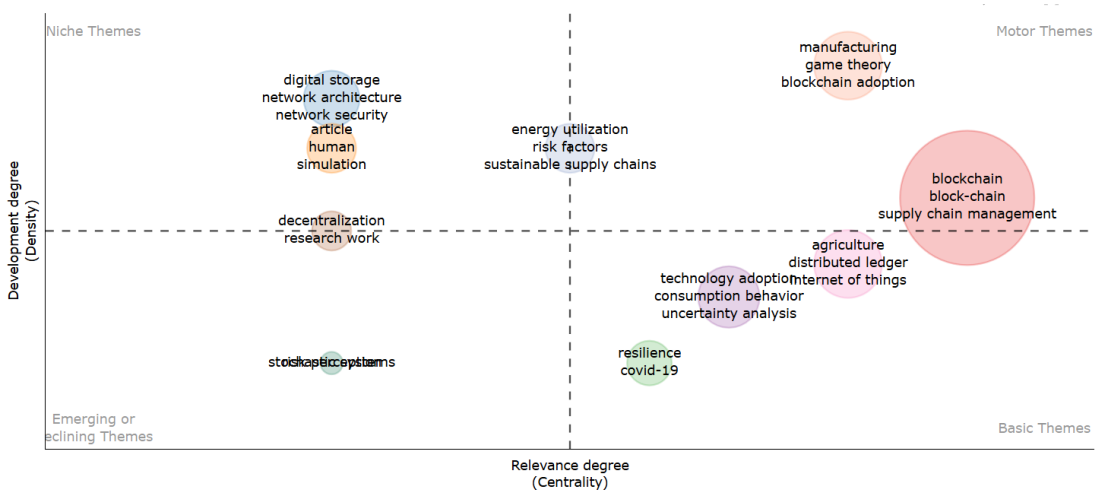

Fig. 6. Thematic Map

The significance and role of the Biblioshiny Thematic Map is to provide a scientific mapping and analysis tool to help researchers better understand and explore the structure and evolution of disciplinary knowledge by visualizing the distribution of topics and development trends within a subject area. Such a map shows the distribution of topics within a subject area and reveals the relationships and trends between these topics. Researchers can visualize which topics are the current hotspots in the research field, which are on the rise or decline, and the connections between these topics. This visualization tool is essential for interdisciplinary research, knowledge discovery, and innovation. As can be seen in Figure 6, the first Quadrant (top right): motor themes, manufacturing, game theory, blockchain adoption, competition, costs, remanufactured products, are among the themes that are both important and well developed; Quadrant 2 (top left): highly developed and isolated themes, digital storage, network architecture, network security, security, which are well developed but not crucial for the current field; Quadrant 3 (bottom left): blockchain adoption, manufacturing, game theory, blockchain adoption, competition, costs, manufactured products, which are both essential and well developed; Quadrant 4 (bottom left): blockchain adoption, digital storage, network architecture, security, which are both essential and well developed; and Quadrant (bottom left): emerging or declining themes, risk perception belong to marginal themes, and no good development, may have just emerged, may be about to disappear; Quadrant (bottom right): primary and transversal themes, agriculture , distributed ledger, Internet of things, authentication, food supply, technology adoption, consumption behavior, uncertainty analysis, resilience, covid-19, belong to the fringe themes. The topics important to the field but not well-developed are energy utilization, risk analysis, and covid-19. However, energy utilization, risk factors, and sustainable supply chains are in Quadrants 1 and 2 and

have good development themes: Blockchain Blockchain, supply chain management, risk Blockchain, Blockchain, supply chain management, risk assessment, risk management, risk management, BCT, risk analysis, and decision-making are in the first and fourth quadrants, which are essential but not well-developed themes; decentralization, risk factors, and sustainable supply chains are in the first and second quadrants, with good development themes. Decentralization and research work are in the second and third quadrants, belonging to the fringe topics that have less impact on the field and are rarely researched.

The Application of BCT

Over the past decade, we have witnessed the birth and growth of Blockchain. In 2008, Satoshi Nakamoto released his paper "Bitcoin: A Peer-to-Peer Electronic Cash System", in which he proposed a digital currency, bitcoin, and introduced the concept of Blockchain Blockchain applies distributed data storage technology, uses peer-to-peer data transmission, uses consensus mechanisms in data trust, and also applies encryption algorithms to secure data. Blockchain is a chained data structure where data is divided into many blocks and connected chronologically.

Blockchain Technology Overview

Blockchain can ensure that the distributed ledger is untameable and not easy to forge through cryptography and solves the consistency problem of decentralized database systems through specifications and protocols based on the negotiation of distributed nodes, also known as the consensus mechanism. The specific BCT and its features are shown in Table 4.

Table 4
Blockchain Technology Overview

NO.	BCT	functionality	specificities
1	Distributed Ledger Technology (DLT)	Distributed Ledger Technology (DLT) refers to multi-party systems that enables saving encrypted data across a peer-to-peer network of nodes, without central authority(Herbe et al., 2024). Distributed ledger technology is a ledger technology built on the distributed database architecture underlying the blockchain. Transaction records will not be destroyed or tampered with, thereby ensuring the validity and security of the data. Blockchain is a decentralized distributed ledger technology based on cryptographic methods that ensures transparency, security, and accountability (Denter et al., 2023).	Not be tampered with
2	Cryptography	The encryption algorithm based on blockchain makes all upstream information blocks public to the entire network. It is impossible to change the content of the block without destroying the chain, and the corresponding public key and private key are required to unlock the corresponding information. Because each block contains the	Anonymity/transparency

		hash value of the previous block, this means that if any changes are made to the content of a block, not only the block needs to be modified, but also all subsequent blocks in the chain. Therefore, all network nodes only have the function of recording information and cannot obtain the details of specific transaction information (Ressi et al., 2024)	
3	Consensus Mechanisms(CM)	In DLT, and in the context of blockchain, it is essential that all participants store the same version of the data on their private copy of the ledger. The component that ensures this global data consistency is called a consensus mechanism (Horvat., 2024).	de-neutralize
4	Smart Contract (SC)	SC An agreement automatically executed by a computer that ensures performance and execution without resorting to court or mitigating any human discretion. Therefore, a smart contract is a computer protocol designed to facilitate digital verification. It is deterministic, autonomous, rule-based, and has a unique address on the chain (Showkat et al., 2023)	traceability

The functions of the leading blockchain technologies in Table 3 reflect that BCT has four primary characteristics: anonymity/transparency, non-tampering, traceability, and decentralization.

Application of Blockchain in SCRM

From the analysis of commonly used BCT applications, the potential of blockchain in solving complex SCRM problems has not been fully explored, but the benefits of blockchain for SCRM have indeed been fully recognized. In order to make the results of the study more relevant to the topic, 41 articles selected from 51 journal articles that are closest to the application of BCT in supply chain risk management are analyzed in detail. According to the analysis in the previous three sections, BCT is mainly applied to the financial, operational and logistic risks of the supply chain. In this section, we will describe the areas SCRM and industries that need BCT the most, as well as the methods and theories used. The specific details are shown in Table 3.

Table 5
Published Review Papers on application of block in SCRM area between 2019 and 2024

Author	BCT	Risk Scope	Main finding	Sector	Theory	Method
Wang et al., 2024	Cryptography	Perceived risks	Choosing an appropriate blockchain adoption strategy can increase the remanufacturing rate.	Remanufacture	game-theory	Quantification
Kalbouneh et al., 2023	BCT	SCRM	BCT's impact on supply chain performance directly or indirectly through the SCRM cascade	Chemical	RBV	Quantification
Feitosa e et al., 2024	BCT	Performance	Improved supply chain visibility, reliability, security and risk management can be achieved through blockchain deployment and other digital	--	--	Qualitation
Choi et al., 2023	BCT	Finance	The blockchain-supported supply chain incurs a lower operational risk than the traditional supply chain.	Fashions	Mean-risk theory	Quantification
Dash et al., 2024	Cryptography	Logistic	The application of Blockchain in the	Pharmaceutical	--	Quantification

			pharmaceutical supply chain improves security, efficiency, and transparency.			
Chaudhuri et al., 2023	Cryptography	SCRM	Educating customers, interacting with them, and building local relationships are key behavioral mechanisms for using blockchain to improve social sustainability and minimize risk.	--	Agency theory	Qualitation
Beck et al., 2023	SC, DTL	Disruptions	visibility and validation are the most relevant blockchain characteristics for improving SCRES.	--	--	Qualitation
Cai et al., 2023	SC, Crypto, CM	Disruption, supply and demand coordinati	Blockchain can enhance supply chain resilience and responsiveness, as well as the ability to withstand the risk of disruption and the risk of supply and demand coordination encountered	--	TAM, TPB UTAUT) and technology–organization–environment theory (TOE)	Quantification

			in the supply chain.			
Bai et al., 2024	DLT, Cryptography, SM	Uncertainty risk	firms with blockchain capabilities have less mean negative stock price reaction-on average, a reduced 8. 24 % shareholder value loss across crisis stages. Across crisis stages.	Hardware	DCV、RBV	Quantification
Manzoor et al., 2024	Cryptography, SC	Disruptions	Adoption of BCT would implicitly enhance resilience	--	--	Qualitation
Chowdhury et al., 2023	BCT	Operations, SCM	User-friendly implementation of technology will significantly and positively impact the intention to adopt BCT for risk management in an OSCM environment.	--	TAM, technology readiness index (TRI) TPB	Quantification
Gozali et al., 2024	DLT, SM	Data storage and access	Determine the viability of blockchain as a means to support the reduction of risks associated with data use,	Agriculture pesticide	——	Qualitation

			including security, trust, traceability, sustainability, and cost.			
Gao., 2023	CM	Financial Risk	Blockchain decentralized technology can solve the risks of supply chain finance projects;	supply chain finance	——	Quantification
Gurtu., 2023	Cryptography, DLT	Transportation disruptions	Blockchain can potentially reduce transportation costs by offsetting the cost of reconciliation.	Logistics Truck transport	——	Qualitation
Liu et al., 2022	DLT, Cryptography, SC	Information asymmetry	Investing in BCT will undoubtedly bring new costs, shorten transaction times, increase the freshness of fresh products, and reduce transaction costs. And minimize transaction costs.	Fresh supply chain	newsboy, game, optimization t and supply chain coordination theory	Qualitation
Jaloliddin., 2023	BCT	Business	Provides insights and recommendations to policymakers, industry stakeholders, and investors to help them	Investors	--	Quantification

			respond to the changing landscape, seize opportunities, and mitigate the risks associated with digitization in the international trade and customs space.			
Hong et al., 2023	BCT	Finance	Companies adopting BCT have experienced positive outcomes in managing supply chain-related risks, financial transaction reliability, and information reliability.	Manufacturing	RBV, DVCand systems theory	Quantification
Liu et al., 2022	BCT	Information	The blockchain platform would benefit from the risk-averse manufacturer and retailer but suffer from risk-averse consumers.	Fresh food	MV	Quantification
Niu et al., 2022	SC	Products risk	Manufacturer-suppliers are more likely to adopt blockchain when	Manufacture	Rough set theory	Quantification

			consumers are not highly risk-averse, or when consumers are moderately risk-averse and there is less uncertainty about the quality of remanufactured products			
Tong et al., 2022	DLT	credit risk	BCT can enhance the credibility and accuracy of the data, providing a data guarantee for more rapid risk alerts.	Financial	--	Quantification
Lee et al., 2023	SC, CM	Logistics risk	Improved cost effectiveness of fruit (mango) supply chain.	Fruit	Fractal theory	Quantification
Wang ., 2023	SC, DLT	Supply, demand, and process risks	all three types of risk and the two main characteristics of Blockchain (i.e., blockchain traceability and security) positively contribute to the supply chain risk-BCT fit.	Manufacturing	technology–task t theory	Quantification

Cao et al., 2022	BCT	Finance, trust	The involvement of the blockchain-based platform can lead to increased production quantity and total surplus of the supply chain.	Agricultural	--	Quantification
Min et al., 2022	DLT	logistics , procurement	Safe and secure arms transfers and how to facilitate streamlined logistics and procurement operations for arms, ammunition and munitions.	International trade	--	Qualitation
Rogerson et al., 2020	DLT, Cryptography	Scrim	Blockchain is demonstrated as an enabler of visibility in supply chains.	food	--	Qualitation
Takhar et al., 2021	SC	Information risk	The SCCSR (supply chain chemical substance reporting' (SCCSR)) Blockchain enables the industry to implement greater efficiencies in collecting the required chemical substance information.	Chemotherapy	--	Qualitation

Vishnubhotla A. et al., 2020	BCT	Perceived risks	The value contribution of using Blockchain to improve the management of SCM risks. A number of the high-priority risks (in the initial scenario) could now be eliminated or managed due to specific characteristics of Blockchain.	Oil company	--	Qualitation/Quantification
De ., 2020	BCT	Business risks	The utility of smart wholesale price contracts and revenue sharing contracts to better coordinate relationships and negotiations for businesses	--	game theory	Quantification
Liu et al., 2019	SC	information sharing risk	Through BCT, transaction costs among members of the supply chain can be reduced, information sharing can be realized, and the benefits of the supply chain can be improved.	Manufacturing \Transactions	MV	Quantification

			The benefits of the supply chain can be improved.			
Fu et al., 2019	CM, SC	operation information risk	Provide ideas and model architecture for the development of blockchain system in the supply chain field, and will promote the development of blockchain application research in specific fields.	Service industry	--	Qualitation/Quantification
Matteo et al., 2019	BCT	Perceived risks	Its application can enhance assurances and reduce perceived risks via Blockchain.		Prospect theory	Qualitation
Choi et al., 2019	SC	operations risk	BCT can be applied to facilitate the implementation of mean-variance risk analysis for global supply chain operations.	Air logistics	MV	Quantification
Min et al., 2019	BCT	risk of interruption	his article unlocks the mystique of BCT and discusses ways to leverage BCT to enhance supply chain resilience in times of	--	--	Qualitation

			increased risks and uncertainty.			
Ivanov et al., 2019	BCT	Disruption risk	A positive impact reduction in risk mitigation inventory in ripple effect control.	Service industry	Control theory	Qualitation
Sheel et al., 2020	BCT	Perceived risk	Performance expectations, social influences, hedonic motives and price-value factors significantly influence the adoption of BCT	--	Unified theory	Quantification

From the analysis of Table 5, it can be seen that, firstly, the industry of BCT application, BCT application is mainly concentrated in the logistics and manufacturing industry, which shows that the research on the application of blockchain technology in the logistics and manufacturing enterprises has been widely concerned by the researchers, followed by the application of the financial, chemical, and food industries, and finally in the fields of agriculture, services, services, trade, oil companies, fashion, hardware, etc., which shows that the the wide range of BCT applications. Secondly, the main theories used in BCT application are game theory, mean-variance (MV) theory, and resource-based view theory (RBV); followed by technology acceptance model (TAM), theory of planned behavior (TPB), and dynamic capability theory(DCV), which shows the richness of BCT application theories. Again, as seen from the analysis in Table 5, most of the researchers used quantitative analysis. Finally, the application role of BCT is very obvious from the research results of the current researchers, according to the blockchain's possesses traceability, security (reliability), trust, transparency characteristics, and different positive impacts on various industries, such as, increasing the supply chain resilience responsiveness, reducing the supply chain risk, reducing the supply chain costs such as transactions, transportation, improving productivity, facilitating transactions, improving the credibility and accuracy of data, enhancing supply chain effectiveness, streamlining logistics processes, improving supply chain performance, enhancing social sustainability, etc. This section helps researchers identify supply chain risk areas, commonly used theories and methods for blockchain applications, and provides appropriate reference guides and maps for researchers and practitioners.

Future Research Directions

This section summarises potential future research directions based on our previous analysis of Blockchain and SCRM. Specifically, this section includes the following 3 main points.

Enhancing the Dissemination of Guidelines on BCT

The descriptive analysis in section 2 shows that the number of articles is increasing yearly, with a sharp increase in the trend of articles published in the last 1-2 years. Supply chain stakeholders have recognized the benefits of blockchain applications in SCRM and are actively involved in research in this area. By analyzing the total number of articles, which is only 51, in Section 3 (bibliometric analysis), it is clear that there are not many studies on applications in this area, which may be due to the general problem of interdisciplinary research. Although blockchain is becoming a mainstream tool for research applications, it still confuses many supply chain practitioners and researchers. For example, in order to analyze the challenges of adopting BCT in the automotive supply chain, Xu et al (2024) found that the immaturity of technology, lack of guidance and industry standards, lack of cooperation among chain members, and vague legislation are the biggest obstacles to the adoption of BCT. In the study of the application of blockchain technology in SCF accounting processes, it was found that there may be knowledge, willingness, trust, and courage to venture into a field. These are the main obstacles (Rijanto, 2024). They found that lack of familiarity with BCT is one of the most critical barriers to BCT adoption. Manzoor et al. (2024) found that lack of acceptance, standardization, and complexity are critical barriers to adopting BCT to enhance S. C. resilience. However, in the S. C. industry, the value of BCT In the industry, solutions are expected to be between $1. 4 billion and $4. 21 billion by 2028 (Medina et al., 2024). Furthermore, the sustainability of S. C. has recently been revolutionized by the emergence of technologies such as BCT (Dehshiri and Amiri, 2024; Zhang et al., 2024). The importance of Blockchain can be seen due to the adoption of BCT, which provides continuous tracking of products and real-time information sharing. It makes S. C. s more accountable for following standards and improves sustainability functionality through the intermediary of S. C. integration (Ferdous et al., 2023; Surucu-Balci et al., 2024). Therefore, researchers may combine training and awareness to enhance the trust aspect of managers' future adoption of BCT and improve its application in SCRM.

Broaden Research Theories and Methods

From the literature analysis in the fifth part, it can be found that with the development of BCT, enterprises can use BCT to achieve effective SCRM. Firstly, through the analysis of BCT application fields, it is found that BCT is mainly used in traditional fields. In the future, the application of BCT in the context of Industry 4. 0 and social sustainability can be studied (Emrouznejad, 2023); and advanced risk management models that address current limitations and challenges can be established, such as developing more powerful models that can adapt to the rapidly changing global environment and mitigate risks caused by outdated models and over-reliance on historical data (Nnaji et al., 2024). Secondly, in terms of research theory, from the initial application of control theory, prospect theory, and unified theory to game theory research, and then to the application of dynamic theories such as TAM, TPB, RBV, and DVC, it can be seen that the research on BCT application in this field is sustainable and gradually develops into technology application research. Therefore, in the future, in risk management, enterprises can increase the research of practice verification in SCRM with the support of BCT, and provide a reference for enterprises to actually use BCT to deal with supply chain risk

events brought about by uncertain environments; in terms of usage methods, most journals use quantitative research, a small number use qualitative research, and most qualitative research stays in the systematic literature. Therefore, more thorough qualitative methods are recommended in the future, such as case studies and interviews, which may be beneficial to future research (Kumar., 2024).

Other Future Research Directions

Fistly, Governance conditions such as laws and regulations restrict the development of blockchain technology in the German automotive supply chain, and interviews with executives of original equipment manufacturers show that "legal regulatory uncertainty" is the biggest obstacle to corporate adoption of blockchain technology (Xu et al., 2024). In addition to regional restrictions, regulatory ambiguity and the lack of industry standards may delay the adoption of blockchain and the Internet of Things (Chavalala., 2024).

Secondly, The analysis of the keyword thematic map in the fourth part shows that there is a lack of literature research on policies and policy measures to support the application of BCT in enterprises. Kaur (2024) proposed that policymakers should increase the use of BCT infrastructure to reduce the cost of blockchain adoption by SMEs and accelerate its adoption. In order to mitigate the impact of BT adoption in Agri-Food Supply Chain, policymakers should take necessary ideas to formulate policies on the impact of BCT adoption in Agri-Food Supply Chain (Yogarajan, 2023). It can be seen that the improvement of policies is very necessary for the application of blockchain technology. which shows how significant the improvement of policies is for the application of blockchain technology. Li (2024) suggests that for financial network transactions, the government and regulators can collaborate with academics and the financial industry to develop the best practices and standards to facilitate the practical application of BCT and that future exploration can focus on implementing policies and regulations. Future research should focus on interdisciplinary collaboration, policy and regulation development, data privacy and security, employee training, and practical application of technology (Li et al., 2024). In addition, Manzoor (2024) recognizes that global technology standards and the development of government policies that support blockchain will help create an enabling environment for BT adoption. Therefore, in future studies, researchers can incorporate policies to enhance support for managers' future adoption of BCT and improve its use in SCRM.

Lastly, Increased uncertainty response enterprises can achieve supply chain traceability, security (reliability), trust, and transparency through BCT, and then adjust supply chain inventory and production plans so that the supply chain can launch emergency plans in time, thereby reducing supply chain disruptions. Therefore, in future risk management, enterprises can continuously enhance flexibility and improve enterprise resilience with the support of new BCT to cope with supply chain risk events brought about by uncertain environments.

Conclusions

This study systematically reviews the current state of development of BCT in SCRM and answers the three questions posed in Section 1. This study collects 51 blockchain and supply chain risk articles published in the Scopus database up to the first half of 2024. Parts 2 and 3 provide a comprehensive analysis of years, journals, citations, and keywords and answer the current state of research on Blockchain in SCRM in question 1. Sections 4 and 5 answer

question 2 and show that BCT has been applied to SCRM, e. g., for increasing logistics transparency, financial decentralization, etc., and has proved to be an excellent tool to help supply chain managers better cope with risks. Section 6 gives future research directions in Problem 3, which needs to focus more on blockchain security, technology acceptance, policy supervision and support, uncertainty analysis, and resilience. In addition, it can be concluded from the analysis in Section 6 that changes in the external environment have made supply chain practitioners deeply aware of the importance of SCRM. Enterprises can continuously enhance supply chain flexibility with the support of new blockchain technologies to better cope with supply chain changes brought by the uncertain environment.

This study still has some limitations that need to be addressed before concluding. First, this paper only considered articles from Scopus data repositories for screening, which is small in scope and can be expanded to Science Direct, Web Of Science, Wiley Online Library, Springer Nature, JSTOR, Taylor&Francis, IEEEXplore, Emerald, and Google Scholar databases to increase the richness of articles. Second, this study is based on keyword searches, so results are limited to keyword combinations, and keywords may not capture some work. Despite these limitations, this study summarizes the current state of research in the field. For researchers, this study demonstrates the application of BCT in the field and can inform the selection of further research topics. This study allows practitioners to understand how BCT can benefit SCRMs and help them better cope with supply chain changes caused by uncertain environments.

Funding Sources

This work is funded by Ministry of Higher Education of Malaysia under the FRGS Grant scheme FRGS/1/2023/SS02/USM/02/1.

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