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Blockchain adoption in supply chains: implications for sustainability

Tianyu Zhang[a], Fu Jia[a,b] and Lujie Chen[c]

[a]College of Business Administration, Capital University of Economics and Business, Beijing, China; [b]School for Business and Society, University of York, York, UK; [c]International Business School Suzhou, Xi'an Jiaotong-Liverpool University, Suzhou, China

ABSTRACT

This study aims to systematically review the current academic literature on blockchain and supply chain management (SCM) to explore the antecedents and sustainable outcomes of blockchain adoption and identify factors that influence blockchain adoption at different stages of implementation in supply chains (SC). This review follows the 6 steps and 14 decisions of conducting a systematic literature review (SLR) to comprehensively review 69 papers published in Academic Journal Guide (AJG) 3 and above journals between 2008 and 2023. Based on the content analysis of the selected papers, this study identifies antecedents and outcomes for blockchain adoption. This study further identifies influential factors in each blockchain implementation stage. A conceptual framework is developed to facilitate the conceptual development of blockchain adoption for sustainability in SCs. This study extends the prior studies of blockchain adoption in SCM with the consideration of how blockchain affects the SCM from the aspects of economic, social, and environmental. This review identifies four major themes in the topic of blockchain implementation and SCM, thus assisting researchers in avoiding focusing on the investigation of mature and saturated topics. The research gaps are identified, and future research directions are recommended for scholars, thereby enabling the comprehensive development of blockchain adoption in SCs.

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Blockchain; supply chain management; sustainability; literature review

SUSTAINABLE DEVELOPMENT GOALS
SDG 9: Industry, innovation and infrastructure

1. Introduction

Blockchain is a technology that is featured with a decentralized storage system and immutability, aiming at promoting visibility, transparency, traceability, and security in the business network (Manzoor, Sahay, and Singh 2022). Blockchain is an open and distributed ledger. Transactions between the two parties can be effectively recorded on a blockchain in a verifiable and permanent manner. Through some programming, the ledge itself can trigger transactions automatically (Iansiti and Lakhani 2017).

As one of the most disruptive technologies in the era of Industry 4.0, blockchain has been adopted in the field of supply chain management (SCM) from raw material procurement to the service or product delivery to customer services (Gligor et al. 2022; Roeck, Sternberg, and Hofmann 2020). In a supply chain (SC) context, blockchain technology is found to improve transparency, reliability, and information decentralisation and security in the SC (Rodrigues, Lourenzani, and Satolo 2021). Some studies have justified that blockchain can effectively improve the economic sustainability of a SC by improving operational efficiency, controlling risks, and promoting innovation (Li et al. 2022; Wang et al. 2019; Xiong et al. 2021).

The needs for SC transparency, social responsibility, and accountability have dramatically driven the discussion on the blockchain application in sustainable supply chain management (SSCM) (Li, Lee, and Gharehgozli 2021). There is growing interest among academics in extending the benefits of blockchain on SSCM beyond the economic sustainability of the triple bottom line and exploring how the blockchain can contribute to the environmental and social sustainable performance of an SC (Li, Lee, and Gharehgozli 2021). Studies have explored how blockchain can promote the design and production of environmentally friendly green products (Saberi et al. 2019) and ensure food safety and customer health (Kayikci et al. 2022; Mangla et al. 2021). Additionally, practitioners have been aware of the usefulness of blockchain to the overall improvement of sustainable performance. Companies such as Walmart have worked together with its SC partners to jointly develop a blockchain system to track the movement of their food products to reduce food fraud and to improve the social sustainability in the food SC (Kshetri 2021).

Although the effect of blockchain on SSCM has attracted the attention of both academics and practitioners, it remains under-researched in academia (Queiroz, Telles, and Bonilla 2020). Müßigmann et al. (2020) conduct a bibliometric review of blockchain in SCM and logistics. The authors recognise sustainability as a relevant theme in the research of blockchain and SCM and further claim that the relationship

CONTACT Fu Jia jeff_fujia@hotmail.com College of Business Administration, Capital University of Economics and Business, Beijing, China; Lujie Chen Chen@xjtlu.edu.cn International Business School Suzhou, Xi'an Jiaotong-Liverpool University, Suzhou, China

between sustainability and blockchain is largely neglected by SCM researchers nowadays. Queiroz, Telles, and Bonilla (2020) conduct a systematic literature review (SLR) of blockchain and SCM, proposing that investigating the potential of blockchain adoption in SSCM through improving tracking and visibility on the SC is a significant gap in the existing studies. Only Vu, Ghadge, and Bourlakis (2021) conduct an SLR that explores the relationship between blockchain adoption and SSCM, focusing on its effects on sustainable agriculture SCM. However, the scope of this review is limited to the context of agri-food SC, which makes the results difficult to generalise to other industries. Meanwhile, although this review has identified three stages in the blockchain implementation process and summarised four groups of factors that may affect the blockchain implementation, it fails to correlate the influential factors with specific stages of blockchain implementation. This omission hinders organizations' ability to assess their preparedness for progressing to subsequent stages of blockchain implementation. In light of this, the purpose of this review is aiming at answering the following questions:

RQ1: How does blockchain adoption affect sustainable SCM?

RQ2: What are the factors that influence blockchain adoption at different stages of implementation in supply chains?

To answer these questions, this paper reviewed 69 papers identified in the Scopus and Web of Science (WOS) research databases from 2008 to 2023. It examines the antecedents of blockchain adoption and how the blockchain can generate sustainable outcomes on SCs. A blockchain implementation process in sustainable SC is identified together with the influential factors in each stage.

Following the introduction section, Section 2 describes the SLR method and elaborates the whole SLR processes, including paper selection, data analysis and coding processes. Sections 3 and 4 present the results of descriptive and thematic findings respectively. In Section 5, this review proposes an integrated conceptual framework for blockchain implications on SSCM, and further discusses the identified research gaps and recommended future research direction. Section 6 provides a comprehensive conclusion, in which the contributions and limitations are summarised.

2. Methodology

An SLR approach proposed by Tranfield et al. (2003) is adopted to comprehensively analyse the recent literature on the overlap between blockchain adoption and SSCM. This section elaborates on the SLR process adopted in this review. Based on the detailed analysis of the existing studies, SLR can identify research status, major themes, and potential research direction, thereby contributing to the theory and conceptual content development in a specific field (Durach, Kembro, and Wieland 2017; Seuring et al. 2020). As shown in Figure 1, We strictly followed the 6 steps and 14 decisions of the SLR process proposed by Sauer and Seuring (2023), which is the most comprehensive and latest guidance for conducting an SLR. The tenth decision, conducting a subsequent (statistical) analysis, is optional for an SLR (Sauer and Seuring 2023), and thus it is not included in this review. Overall, this review is conducted through three stages, namely planning, conducting, and composing. Each of the three stages and related steps are demonstrated as follows.

2.1. SLR planning

The SLR planning stage follows step 1 and step 2. This stage aims at justifying the necessity of this review further establishing research questions and determining the SLR scope. The review protocol is confirmed in this stage (D1). We adopted an inductive approach for this review (D2). The framework proposed by Vu, Ghadge, and Bourlakis (2021) is employed as the theoretical basis for this review. Vu, Ghadge, and Bourlakis (2021) conduct an SLR of blockchain implementation and its effect on sustainable agriculture SCM, in which the author demonstrated three stages of blockchain implementation and identified influential factors during the stages. We further referred to Xu et al. (2023), in which the authors identified the drivers and outcomes of applying technology in SC decarbonization. Thus, we confirmed the theoretical constructs for this review (D3), including antecedents and outcomes for blockchain implementation, blockchain implementation stages, and related influential factors in each stage.

We then set a broad inclusion criterion for the first-round paper selection and a group of detailed inclusion and exclusion criteria for the second-round paper selection (D4). For the broad inclusion criteria, we only focused on papers that specify the blockchain application in the field of SCM. As for the detailed inclusion and exclusion criteria, we only selected papers that (1) focus on blockchain application at the supply chain level instead of the organizational level; (2) specify the adoption of blockchain, instead of using blockchain as a supportive technology for other emerging technologies such as artificial intelligence (AI); and (3) adopt empirically qualitative or quantitative research method, instead of mathematical modelling as these papers do not provide any empirical evidence of the impact of blockchain on SCM.

2.2. SLR conducting

The SLR conducting stage follows steps 3, 4, and 5. In this stage, the qualified papers are finally confirmed, and the findings identified from the papers are synthesized. We first determined to use the Scopus database for the paper selection (D5), which is one of the most extensive literature databases (Zamani et al. 2022). To ensure the comprehensiveness of the literature retrieval, the WOS research database was also adopted for the initial searches.

As shown in Figure 2, to capture all the papers in blockchain adoption in achieving sustainable SC. We first identified all possible combinations of keywords between blockchain (Blockchain OR 'distributed ledger' OR 'digital ledger' OR 'shared ledger' OR 'decentrali*' OR 'decentralized ledger system' OR 'smart contract' OR traceability OR Ethereum) and SCM ('supply chain*' OR 'supply chain management' OR 'SCM' or 'supply chain finance' OR 'logistic*' OR 'digital supply chain' OR 'value chain' OR 'supply chain

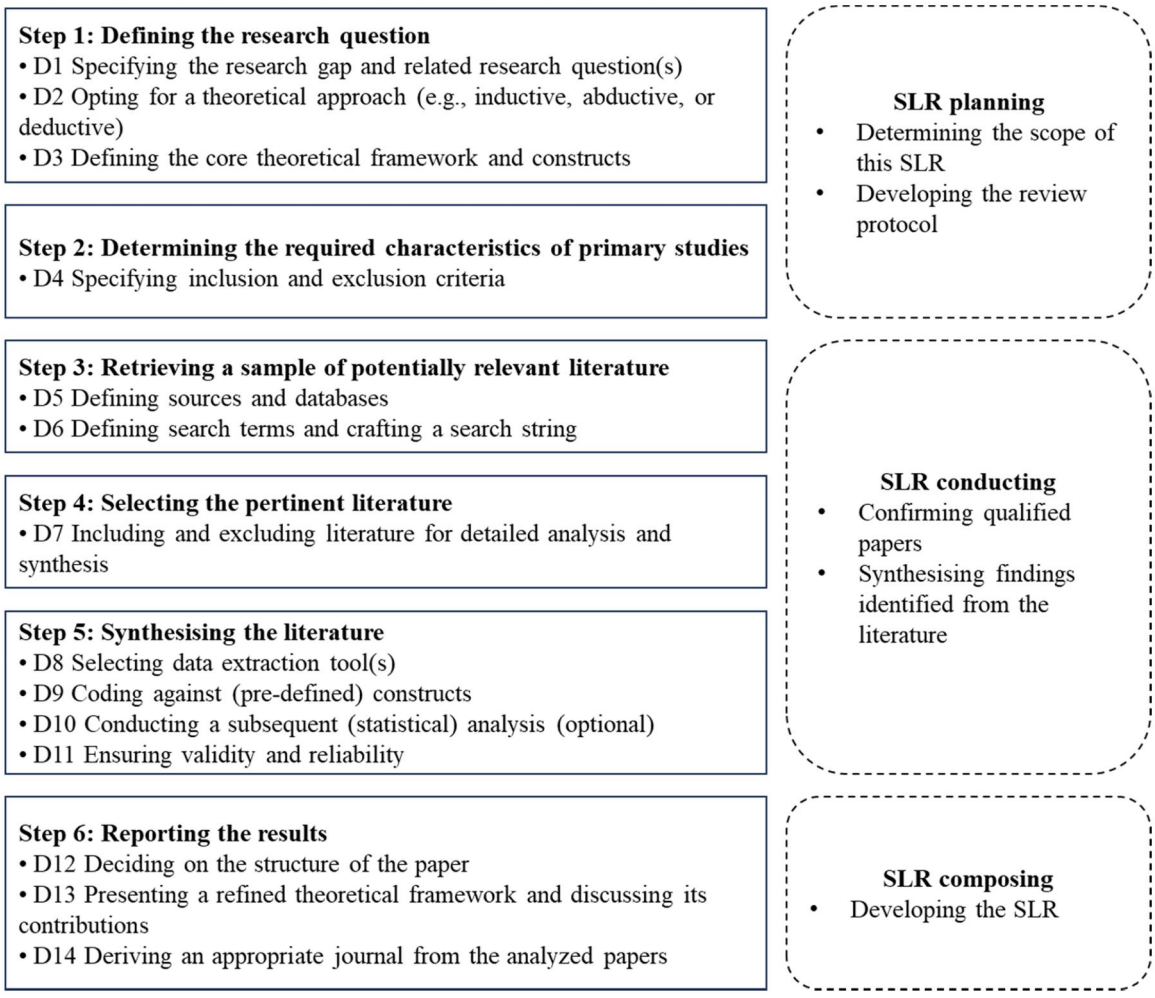

Figure 1. Review protocol.

network' OR 'supply chain channel' OR 'procurement' OR 'demand chain*' OR 'alliance*' OR 'purchas*' OR 'sourcing'). To guarantee the comprehensiveness of our search results, sustainability related keywords are not used, as we plan to extract the sustainability related contents in all related studies of blockchain implementation in SCM. The keywords regarding blockchain technology are summaries based on the previous literature review (Li, Lee, and Gharehgozli 2021; Manzoor, Sahay, and Singh 2022), and the keywords relating to SCM are determined based on Xu et al. (2018) (D6).

We conducted the initial searches in Scopus and Web of Science (WOS) research databases in the 'Article title', 'Abstract' and 'Keywords' search fields. We deployed the following process to obtain the results for the first-round paper selection. We limited the language type to English only and set the study period from January 2008 to June 2023. We set the start time as January 2008 because the concept of blockchain is proposed this year and all the studies related to blockchain adoption and SCM are deemed to be published after 2008. We then set the limitation on the source type to 'Journal' and further constrain the source title to 3, 4, and 4* journals of the Association of Business Schools' Academic Journal Guide (AJG) 2021. We chose AJG because it is an acknowledged and influential journal ranking system. The methodology behind AJG is based upon disciplinary expert review, editorial, and expert judgments and is informed by statistical information relating to citations. Reviewing papers ranked as 3, 4, and 4* in AJG can ensure the quality of the selected papers and enhance the rigour of the results.

After setting these restrictions, 1068 and 992 papers were identified from Scopus and WOS respectively. After removing duplicated papers, 1317 papers remained after the first-round selection. These papers were then analyzed by reading the titles and abstracts based on a broad criterion (see Figure 2), and 449 papers remained for the second-round selection. In this round of selection, the same inclusion and exclusion criteria were applied to screen the papers (see Figure 2). After reading the full text of these 449 papers, we eventually selected 69 papers (as shown in the Appendix) for the content analysis of the review (D7). The entire screen process is conducted independently by two authors to avoid omitting relevant studies and including irrelevant studies.

Then the information of the selected papers is extracted into a spreadsheet for the next step of coding and analysis (D8). The coding process (D9) followed the pre-defined theoretical construct, thereby, we coded the reviewed papers into antecedents, outcomes, blockchain implementation stages, and influential factors. We inductively identified three subthemes under antecedents, which describe the factors

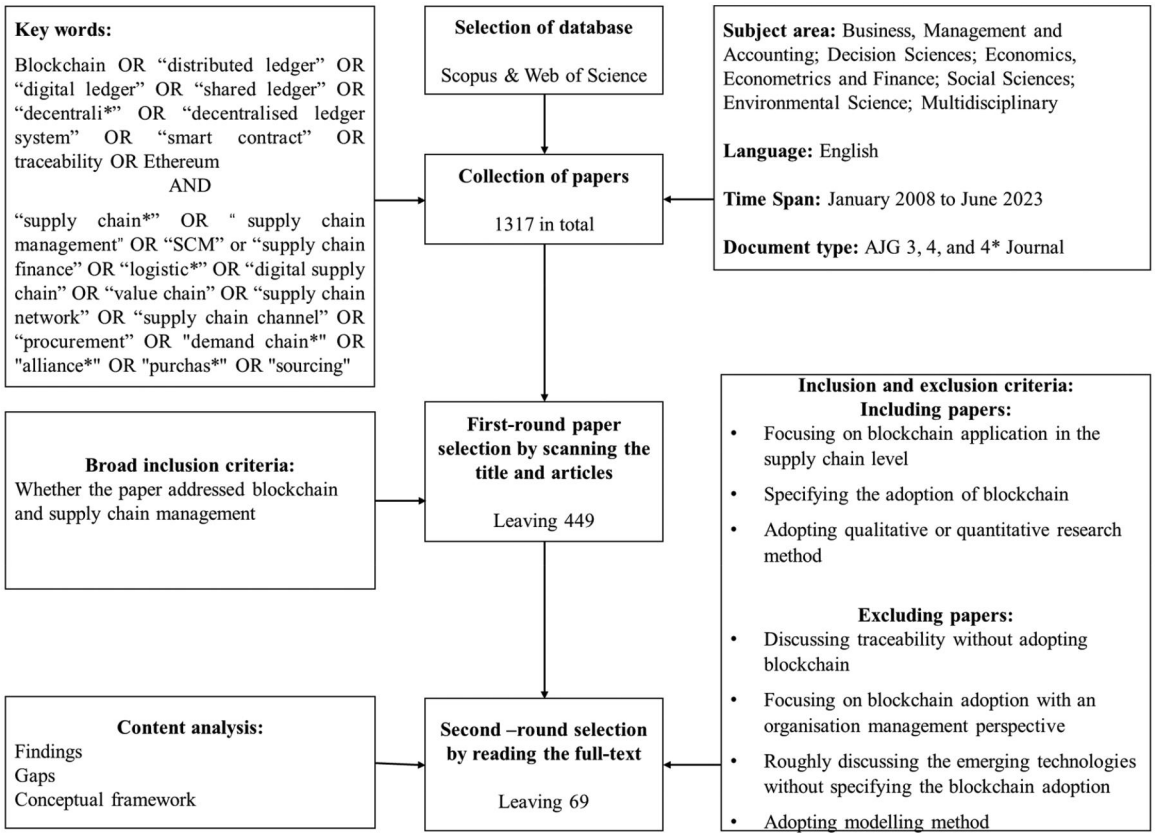

Figure 2. Research methodology.

that motivate blockchain adoption along the SC. The first two antecedents are related to the organization's internal requirement (traceability-orientation, operational-orientation), while the third concerns the external requirement (stakeholder-orientation).

Second, we categorized the blockchain implementation stage into initiation, pilot adoption, and implementation, which follows the framework proposed by Vu, Ghadge, and Bourlakis (2021). We further coded the influential factors that may either positively or negatively affect each stage during the blockchain implementation. Concluded from the selected papers, three groups of major factors were identified, including intra-organizational, inter-organizational, and external factors.

Last, we coded the sustainable outcomes of implementing blockchain in SCs based on the three pillars of sustainable development, namely economic, environmental, and social. Several subthemes are further identified under each of the outcomes. The coding process is conducted by two authors separately to reduce the validity and reliability threat because of the research bias (D11)

2.3. SLR composing

In this stage, step 6 is executed, and SLR is finally developed. We first confirmed the structure of this review (D12) as suggested by Sauer and Seuring (2023). Then the findings are synthesised and the contents of descriptive findings and thematic findings were confirmed. Afterwards, a redefined integrated conceptual framework of blockchain adoption in SSCM is proposed and its contributions to the field of blockchain implementation in SSCM is discussed (D13). Eventually, based on the findings in the journals of publication, the appropriate journals are determined for the final submission (D14).

3. Descriptive findings

Figure 3 demonstrates the number of papers in relation to the topic published during the period of 2008–2023. During the decade from 2008 to 2019, academics and practitioners were concentrating on exploring the application of blockchain in business, therefore, only 4 related papers were published. Then the number of papers experienced a dramatic increase in 2020 and 2021, with the number of publications reaching 13 and 19 respectively. The peak period for publications were the year of 2022, with 27 papers were published in total. In 2023, 6 papers have been published up to June, when the last search was conducted.

Figure 4 demonstrates the sources (AJG 3 and above journals) that have published papers on this topic. Among all these sources, *Annals of Operations Research* contributed the most (13 papers), followed by *Production Planning & Control* (10), *International Journal of Production Research* (9), and *Supply Chain Management: An International Journal* (8), and *IEEE Transactions on Engineering Management*, and *Transportation Research Part E: Logistics and Transportation Review*, each of which published 6 papers during the study period. *International Journal of Production Economics*, *International Journal of Operations & Production Management* and *Journal of Business Logistics* published 5 papers respectively. Papers published on *Production and Operations Management* and *Omega* are the

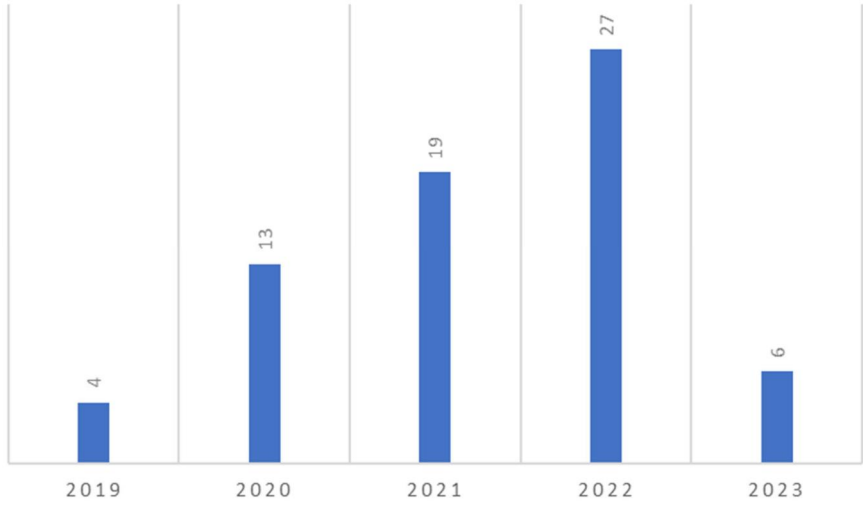

Figure 3. Years of publication.

Figure 4. Journals of publication.

least among the journals, with only one related publication in each journal within the study period. The distribution of the journals also suggests that blockchain adoption on SCM is an attractive research topic for operation management and operation research journals.

Figure 5 displays the distribution across different industries. As for the industry focus, a large number of papers (20) do not specify their industry focus in their studies. Among those focusing on specific industries. Blockchain adoption in agriculture or agri-food SCs was the most common (12), followed by the manufacturing (8) and logistics (7) industries. There are three papers respectively investigate blockchain implementation in the humanitarian SC and automobile industry, while two papers respectively explore the effect of blockchain adoption on the financial SC and healthcare industry. The service industry is studied by one paper.

As for the focus of country or region, 36% of papers do not explore blockchain adoption in a specific country or region. Of the studies with a specific country focus (as shown in Figure 6), 38% of papers focus on developing countries, such as China, India, Pakistan, and Turkey among others. Only 17% of papers study blockchain adoption in developed countries or regions, such as the US, UK, and Australia, while the remaining 9% of the studies mention both types of countries at the same time.

4. Thematic findings

Concluded from the sample papers, this review identifies four themes in the research regarding blockchain and SSCM, including (1) the antecedent of blockchain adoption in SCs; (2) the blockchain implementation process in SCs; (3) influential factors of blockchain implementation in SCs, and (4) benefits of blockchain adoption to SSCM. The following section will discuss each theme in detail.

4.1. Antecedent of blockchain adoption in supply chains

Based on the sample papers, this review inductively identifies three types of orientations that motivate the adoption of blockchain technology in SCs: (1) traceability-orientation; (2) operation-orientation; and (3) stakeholder-orientation. These antecedents are considered as the major drivers for the

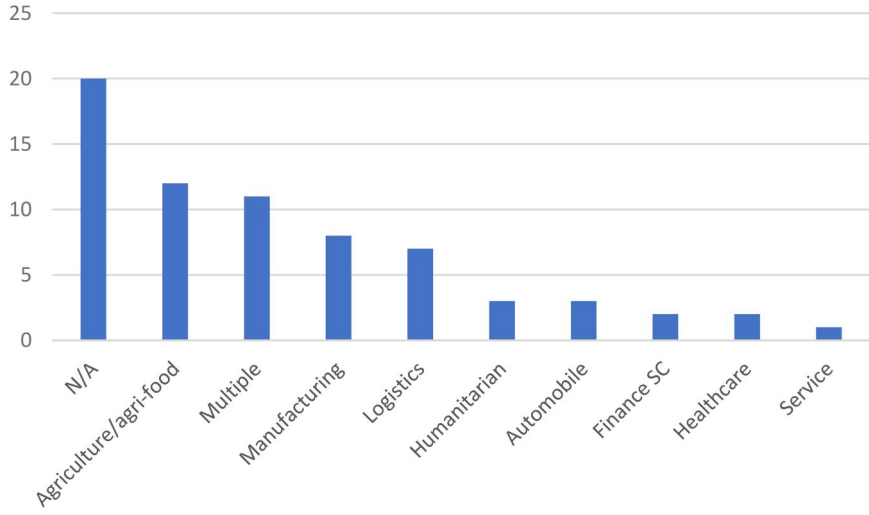

Figure 5. Sector distribution.

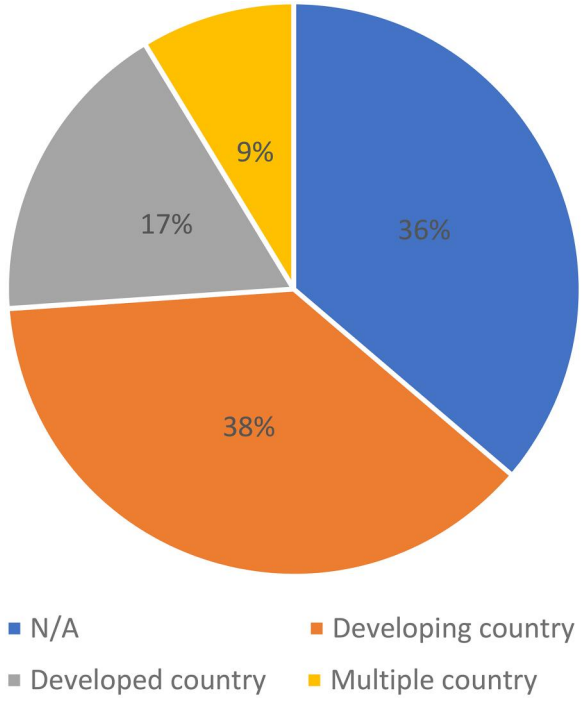

Figure 6. Distribution by country.

enterprises to implement blockchains in SSCM. Table 1 summaries the detailed contents of each motive and related references.

4.1.1. Traceability-orientation

Traceability is considered as one of the most essential enablers for blockchain adoption (Sternberg, Hofmann, and Roeck 2021; Sauer, Orzes, and Culot 2022). Traceability-oriented motives indicate that organizations' adoption of blockchain technology in their SCM practices is driven by the requirement of information traceability in terms of products, transactions, and assets among others (Sharma, Al Khalil, and Daim 2022).

In the context of agricultural SC, Sharma, Al Khalil, and Daim (2022) analyze multiple drivers of blockchain adoption, and find the traceability issues originating from data fragmentation and centralized control. In this case, organizations' requirement of superior traceability drives the blockchain adoption in agri-food SC (Sharma, Al Khalil, and Daim 2022). Van Hoek (2020a) discovers that the requirement of improving traceability and transparency in the SC is an essential antecedent of blockchain adoption in the food SC. This is because based on the improved traceability and transparency, organizations can be more responsive to the SC processes requiring further improvement.

In other industries, an organization's need for improving SC traceability is also one of the most fundamental antecedents of blockchain adoption. For example, Chowdhury et al. (2023) find that DHL's blockchain adoption is driven by the need for information traceability and product trackability. Song, Han, and Yu (2023) illustrate that blockchain adoption in supply chain finance (SCF) derives from the organization's need of tracing the SC transactions to ensure transaction verifiability. Sauer, Orzes, and Culot (2022) conduct four case studies in four different industries and generalize that the drivers of an organization's blockchain adoption are derived from the need to increase the traceability or trackability in their SC, further promote the customers' perceived value, enhance efficiency and reduce the cost of the SC.

4.1.2. Operation-orientation

The second type of motives identified in the literature is the operation-oriented motive. Organization's adoption of blockchain in SCs is driven by their needs for operational improvements, such as improving data integrity and availability, controlling transaction costs, managing operational risks, and improving competitiveness (Agi and Jha 2022; Bhatia et al. 2023; Chowdhury et al. 2023; Deng et al. 2022; Galati 2022; Martinez et al. 2019; Sharma, Al Khalil, and Daim 2022). Chowdhury et al. (2023) indicate that organization's intention to use blockchain technology in risk management is largely dependent on its usefulness to operations managers and ease of using the technology. Queiroz et al. (2020) conduct an empirical study on blockchain adoption in SCM in an emerging economy, concluding that organization's expectancy of

Table 1. Antecedents of blockchain adoption in SC.

Antecedents	Contents	Reference
Traceability-oriented motives	Organization's requirement of information traceability in terms of products, transactions, and assets among others.	Van Hoek (2020a); Sternberg, Hofmann, and Roeck (2021); Sauer, Orzes, and Culot (2022); Sharma, Al Khalil, and Daim (2022); Chowdhury et al. (2023); Song, Han, and Yu (2023)
Operation-oriented motives	Organization's adoption of blockchain in SC is driven by their needs for operational improvements, such as improving data integrity and availability, controlling transaction costs, managing risks, and improving competitive power	Martinez et al. (2019); Agi and Jha (2022); Yang (2019); Alzahrani, Daim, and Choo (2022); Rogerson and Parry (2020); Queiroz et al. (2020); Deng et al. (2022); Sharma, Al Khalil, and Daim (2022); Galati (2022); Bhatia et al. (2023); Chowdhury et al. (2023)
Stakeholder-oriented motives	Pressure from stakeholders, such as SC partners, government, and peer companies	Agi and Jha (2022); Kamble, Gunasekaran, and Arha (2019); Kouhizadeh, Saberi, and Sarkis (2021); Gligor et al. (2022); Chittipaka et al. (2022); Deng et al. (2022); Gong et al. (2022); Deng et al. (2022); Wong et al. (2023)

productivity and efficiency can significantly affect the organization's intention to adopt blockchain.

Yang (2019) validates that the requirement of customs clearance and management and operational digitalisation are the major factors driving the organizations to adopt blockchain in their SC. Rogerson and Parry (2020) also affirm that full operational digitization of the SC is the prerequisite for the blockchain adoption as digitization can minimise human data entry, reduce human error, and thus ensure the trustworthiness of the data recorded on the blockchain. Alzahrani, Daim, and Choo (2022) examine blockchain adoption in the healthcare SC and find that healthcare organizations' adoption of blockchain is driven by their requirement for operational cost reduction and decentralized operation.

4.1.3. Stakeholder-orientation

Third, blockchain implementation in SCs is largely driven by pressure from stakeholders, who require the reduction of information asymmetry within organizations (Chittipaka et al. 2022; Gligor et al. 2022). For example, customer's growing interest in the traceability of product-related data on the blockchain can significantly improve management team's commitment to the blockchain adoption and increase the available data from intra- and inter-organizational levels, thus facilitating the blockchain adoption in the SC (Agi and Jha 2022; Deng et al. 2022). In the financial SCs. the stakeholders such as banks demand organizations to be more transparent to reduce their risks in providing SC financing services (Gong et al. 2022).

Pressure from the government is stressed by a number of studies (Chittipaka et al. 2022; Deng et al. 2022; Wong et al. 2023). Chittipaka et al. (2022) claim the fundamental roles of government regulations and policies affecting the dissemination of the emerging technology and identify the positive relationship between government regulatory support and blockchain adoption. However, this positive relationship is rejected in the study of Wong et al. (2020), in which the authors find that blockchain adoption by Malaysian SMEs is not significantly affected by government regulatory support. Another critical stakeholder-oriented antecedent of blockchain adoption is industry involvement. Peer organization's successful implementation of blockchain plays a decisive role in affecting the organization's awareness of the importance of blockchain (Kamble, Gunasekaran, and Arha 2019).

When examining the effect of blockchain adoption in SSCM, Kouhizadeh, Saberi, and Sarkis (2021) find that the mass organization's involvement in adopting blockchain technology can exert a mimetic pressure that facilitates successful blockchain adoption for SSCM. The authors further state that pressures from the government and other external stakeholders (e.g. non-governmental organizations) can increase industries involvement in blockchain adoption. Similarly, Wong et al. (2020) find that pressure from competitors is one of the major drivers for the SME's adoption of blockchain in Malaysia. While Deng et al. (2022) find that competitive pressure cannot significantly impact the Chinese SMEs' blockchain adoption in SCs.

4.2. Influential factors of blockchain implementation in supply chains

This review further elaborated the influential factors that can either enable or hamper each stage of blockchain implementation in SCM. Based on the content analysis, this review categorised the factors according to their primary characteristics. Three groups of factors are identified in this review including intra-organizational, inter-organizational and external factors. Table 2 summaries the detailed contents of each factor and related references.

4.2.1. Intra-organizational factors

Intra-organizational factors describe the firm-specific factors that influence blockchain implementation in SCM. Intra-organizational factors include the organization's readiness and the top management support for blockchain adoption. Organization's readiness illustrates the technology, financial and data readiness for adopting blockchain in SCs (Sternberg, Hofmann, and Roeck 2021; Wamba and Queiroz 2022; Xu et al. 2022). While the top management support indicates the organization manager's understanding of blockchain and their judgement of the necessity of implementing this technology (Falcone, Steelman, and Aloysius 2021).

First, from the perspective of organization's readiness, Sternberg, Hofmann, and Roeck (2021) conclude that sufficient IT training investment and infrastructure can increase the organization's technology readiness and financial readiness, which is an important positive factor for blockchain

Table 2. Influential factors on blockchain adoption in SC.

Influential factors	Contents	Reference
Intra-organizational	Organization's readiness	Wamba and Queiroz (2022); Alzahrani, Daim, and Choo (2022); Rogerson and Parry (2020); Sternberg, Hofmann, and Roeck (2021); Nayal et al. (2021); Xu et al. (2022); Xu and He (2022); Gong et al. (2022); Kayikci et al. (2022); Deng et al. (2022)
	Top management support	Agi and Jha (2022); Wang et al. (2019); Van Hoek (2020b); Falcone, Steelman, and Aloysius (2021); Kouhizadeh, Saberi, and Sarkis (2021); Wong et al. (2020); Nayal et al. (2021); De Giovanni (2022); Vafadarnikjoo et al. (2021); Wong et al. (2023)
Inter-organizational	Implementation cost	Gong et al. (2022); Baharmand, Maghsoudi, and Coppi (2021); Nayal et al. (2021); Casino et al. (2021); Nguyen et al. (2022); Sodhi et al. (2022)
	Governance	Rogerson and Parry (2020); Nayal et al. (2021); Nguyen et al. (2022); Xu and He (2022); Kouhizadeh, Saberi, and Sarkis (2021); Wong et al. (2020); Xu et al. (2022)
	Collaboration	Agi and Jha (2022); Wamba, Queiroz, and Trinchera (2020); Kouhizadeh, Saberi, and Sarkis (2021); Wong et al. (2020); Naef, Wagner, and Saur (2022); Sauer, Orzes, and Culot (2022); Sodhi et al. (2022); Xu et al. (2022)
External	Government support	Nayal et al. (2021); Kouhizadeh, Saberi, and Sarkis (2021); Wong et al. (2020); Xu et al. (2022); Xu and He (2022)
	Data input	Wang et al. (2019); Kouhizadeh, Saberi, and Sarkis (2021); Xu et al. (2022); Sauer, Orzes, and Culot (2022); Sternberg, Hofmann, and Roeck (2021)
	Data security and privacy	Kouhizadeh, Saberi, and Sarkis (2021); Rogerson and Parry (2020); Sternberg, Hofmann, and Roeck (2021); Xu and He (2022); Wong et al. (2023)

adoption in SCs; they also mention that sufficient availability of data in SCs promotes the smooth implementation of blockchain among the SC partners.

Due to the nature and characteristics of emerging technology, the issue of complexity exists in blockchain adoption in SCs (Alzahrani, Daim, and Choo 2022; Xu and He 2022). Also, the lack of standardisation and interoperability among different blockchain solutions can constrain the effect of blockchain, thus impacting its adoption in SCs (Nayal et al. 2021). Rogerson and Parry (2020) find that the interoperability issue makes some SC partners difficult to access data on the blockchain, thus hampering the usability of the blockchain. Wamba and Queiroz (2022) study blockchain adoption in Indian and American companies and find organization's technology infrastructure availability such as IT infrastructure and specialized IT personnel can significantly minimise the complexity of blockchain adoption. While sufficient technology readiness requires organizations to develop interfaces between blockchain and the existing management system among different SC partners, thereby increasing the blockchain interoperability and partners' willingness to adopt blockchain in SCs (Gong et al. 2022).

To ensure successful blockchain implementation, organizations should have an available and integrated infrastructure, which is compatible with the blockchain implementation (Alzahrani, Daim, and Choo 2022; Kayikci et al. 2022). The incompatibility of the blockchain with the organization's current IT infrastructure can generate extra costs during the blockchain implementation process, which can reduce the organization's willingness to do so (Rogerson and Parry 2020).

On the contrary, Deng et al. (2022) put forwards the opposite opinion, claiming that organizational readiness is not a significant factor that affects blockchain adoption in SCs. For example, In the case study of blockchain adoption in Chinese small-and-medium enterprises (SME), Deng et al. (2022) find that owing to the immaturity of the SME's information system infrastructure, blockchain technology is not necessarily compatible with the existing enterprise system. Moreover, the authors indicate that blockchain technology is not exclusive for large companies by verifying that Chinese SMEs' adoption of blockchain is not significantly affected by the organizational, technological, and financial readiness of SMEs in China.

Second, top management support is determined by the organization manager's understanding of blockchain and their consideration of the necessity of blockchain implementation. It is important for related partners to understand the potential benefits of blockchain and have confidence in applying the technology to improve processes and create business value (Falcone, Steelman, and Aloysius 2021). Wong et al. (2023) claim that the effectiveness and reliability of blockchain technology are unsubstantiated. Therefore, users may be concerned about the risks associated with the use of blockchain decreasing their confidence on the technology. Kouhizadeh, Saberi, and Sarkis (2021) emphasize that successful blockchain adoption relies on intangible resources such as management support and expertise and professional knowledge regarding blockchain. Therefore, top managers' better understanding of blockchain is essential and can improve their confidence in blockchain adoption to solve issues in SCM practices (Agi and Jha 2022). Without adequate blockchain knowledge, top managers' understanding of the technology is weak and fragmented, which can negatively affect their belief in the usefulness of the technology and influence their intentions for blockchain adoption (Nayal et al. 2021; Vafadarnikjoo et al. 2021; Wong et al. 2020). Not only is the top management's commitment required, but engagement from middle management is also essential for the organization's successful initiation of blockchain technology (Van Hoek 2020b).

As for the necessity evaluation of blockchain adoption, organizations tend to evaluate the cost-effectiveness to examine the necessity of using the new technologies, as many problems can simply be tackled with traditional information communication technologies (Wang et al. 2019). De Giovanni (2022) notices that the insufficient rewards and encouragement programme by the focal organizations is another reason for SC partners to perceive blockchain as unnecessary.

4.2.2. Inter-organizational factors

Inter-organizational factors describe influential factors from the supply chain level. It includes three facets: SC partner

collaboration, the implementation cost of blockchain and governance issues in the blockchain.

First, the issues of collaboration among stakeholders pose a significant barrier to blockchain implementation. Successful blockchain adoption in SCs requires sufficient participants, especially for employing this technology for SSCM, participants need to have built a strong understanding towards blockchain and a shared common vision on using this technology for better sustainable performance (Mathiyazhagan et al. 2013). However, the lack of collaboration among them can make blockchain adoption in SCs even harder (Alzahrani, Daim, and Choo 2022; Sauer, Orzes, and Culot 2022; Vafadarnikjoo et al. 2021).

Collaboration requires knowledge sharing among partners within the SC, which is fundamental to blockchain adoption (Wamba, Queiroz, and Trinchera 2020). The problems in SC collaboration and communication between partners can disable the integration of blockchain technology into the SCM practice (Kouhizadeh, Saberi, and Sarkis 2021). The adoption of blockchain requires wide collaboration with all relevant parties including technology providers, government bodies and standardization bodies, and blockchain users (Agi and Jha 2022; Wong et al. 2020). Therefore, the identification of appropriate collaborators to establish effective governance structures is essential for successful blockchain adoption (Kouhizadeh, Saberi, and Sarkis 2021; Naef, Wagner, and Saur 2022). Meanwhile, issues of collaboration among SC partners may result from the lack of perceived benefits from blockchain adoption (Sauer, Orzes, and Culot 2022; Sodhi et al. 2022). Sauer, Orzes, and Culot (2022) illustrate the issue of motivating downstream SC partners to collaborate in the blockchain programme before the benefits of blockchain can be fully realized. Xu et al. (2022) also point out the issue of the non-cooperation of SC members during the blockchain adoption in SCs, mainly lies in their worries about cost and uncertainty of return on investment.

Meanwhile, some research recognises cost as one of the major challenges in the early stage of blockchain adoption (Sodhi et al. 2022; Nguyen, Chen, and Du 2022). The required resources are costly such as the software and hardware infrastructure development and the information sharing culture (Nguyen, Chen, and Du 2022). Gong et al. (2022) state that SMEs adopt blockchain to increase their access to SCF business, but the resulting cost is high and thus impeding the SME's blockchain adoption. Baharmand, Maghsoudi, and Coppi (2021) argue that the cost incurred from the blockchain pilot and implementation, skills training, and gathering qualified data on the chain, can hamper the blockchain implementation in the humanitarian SC.

However, Nayal et al. (2021) challenge this viewpoint and empirically find that cost is not a barrier, but instead an enabler, to blockchain adoption. Because the authors believe that blockchain implementation can reduce paperwork and administrative work, thereby increasing operational efficiency (Nayal et al. 2021). It can lead to overall cost-saving in the SCM practice, which can offset the cost (Casino et al. 2021)

Additionally, a large number of studies illustrate the governance issues that negatively affect blockchain adoption in SCM (Nayal et al. 2021; Rogerson and Parry 2020). Governance factors consist of two facets, organizational and governmental. From the organizational perspective, in the case of container shipping blockchain adoption, compared with the centralized system, Nguyen, Chen, and Du (2022) find that the decentralized system leads to higher operational uncertainty and uncontrollability, which results in governance pressure for the organization. Xu and He (2022) find that the development of blockchain standards and governance models is a key challenge for blockchain adoption in modern logistics; they claim that logistics companies tend to face a situation of coexisting multiple public blockchains in the market, which will inevitably cause standards-related confusion and entangle the organizational governance practices.

4.2.3. External factors

Insufficient support from the government is considered as the first external factor that affects blockchain implementation in SCs. From the government perspective, the absence of sound and up-to-date legislation also hampers blockchain implementation in SC (Nayal et al. 2021; Xu and He 2022). The lack of proper government regulation and policies leads to insufficient support for blockchain adoption (Kouhizadeh, Saberi, and Sarkis 2021; Wong et al. 2020). A specific example can be seen in the research of Xu et al. (2022), in which the authors claim that one of the biggest obstacles to blockchain adoption in the automobile industry is the lack of governmental guidance and industry standards.

Some studies demonstrate that data-related factors such as data input and data security are essential external factors that affect blockchain adoption in SCs (Kouhizadeh, Saberi, and Sarkis 2021; Vafadarnikjoo et al. 2021). Data input issues are mainly related to the immutability characteristics of blockchain. Once the incorrect information has been recorded, it cannot be removed from ledges, and the erroneous record will be always stored in the blockchain (Kouhizadeh, Saberi, and Sarkis 2021). Another data input issue origins from the fact that some of the data in SCs is poorly documented, or the data integration among SC partners is extremely difficult owing to the heterogenous ERP systems and data formats (Sauer, Orzes, and Culot 2022; Xu et al. 2022). Sometimes convincing stakeholders to share data in the blockchain is challenging due to the requirement of sharing sensitive and personalized information in the blockchain (Sternberg, Hofmann, and Roeck 2021; Wang et al. 2019)

Data security and privacy are considered as another strong predictor of blockchain resistance in SCM (Wong et al. 2023). Wong et al. (2023) state that owing to the decentralized feature of blockchain, the trustworthiness of any party in the network is not required to be assessed. Thus, users are apprehensive about the reliability of sharing confidential information on the blockchain, which can affect blockchain implementation. Meanwhile hacking, inaccurate information dispersal, and access to sensitive information may increase users' concerns about data security (Kouhizadeh, Saberi, and Sarkis 2021; Xu and He 2022). Rogerson and Parry (2020)

approve the issue of data security in blockchain in the case of the World Wildlife Fund blockchain project, in which the interviewees agree that with the increasing volume of data recorded on the blockchain, stakeholders will encounter problems of masking commercially sensitive data. Protecting personalized data can be even problematic, as blockchain can reveal personalized data, such as personal information about frontline SC workers (Sternberg, Hofmann, and Roeck 2021).

4.3. Implementation stages of blockchain technologies in supply chains

Wamba and Queiroz (2022) investigate blockchain diffusion in SCs in the context of Industry 4.0 and propose a multi-stage of blockchain adoption including intention, adoption, and routinisation. Vu, Ghadge, and Bourlakis (2021) refer to the AI adoption process in SCs and further consider that blockchain, also one of the emerging technologies, should have a similar adoption process as other technology adoption. According to Vu, Ghadge, and Bourlakis (2021), blockchain implementation in the food SC can be divided into three stages: initiation, adoption, and implementation. Organizations tend to have a different focus in each stage and therefore the factors that may affect the blockchain implementation in different stages would be different. This section first identifies the three stages of blockchain implementation in the SCs and further illustrates the relationship between the implementation stages and influential factors identified in the previous section.

The first stage is the initiation stage, in which organizations obtain blockchain knowledge, evaluate the necessity and potential value of adopting blockchain, and put forward appropriate solutions to initiate blockchain technology based on their current situation (Tiwari et al. 2023; Wamba and Queiroz 2022). In the case of blockchain adoption in SCF, Gong et al. (2022) find that in the initiation stage, organizations tend to thoroughly examine their SCF situation to evaluate its fitness with the blockchain. The exanimation results are highly related to the SC agents' perception of the technology (Falcone, Steelman, and Aloysius 2021), while their perception is largely affected by their knowledge and understanding of the technology (Wong et al. 2023). Meanwhile, the fitness evaluation is based on organizational readiness such as technology readiness, financial readiness, and data readiness, to comprehensively evaluate whether the organizational status quo is suitable for the deployment of the blockchain (Gong et al. 2022; Tiwari et al. 2023). Therefore, the initiation stage is mainly affected by the intra-organizational factors (organization readiness and top management support).

In the second stage of blockchain pilot adoption, organizations start to evaluate the blockchain solutions proposed in the previous stage and manage to find the most appropriate adoption model and started the pilot adoption of blockchain in the simple SC structure (Tiwari et al. 2023). Intra-organizational factors such as top management support and understanding of blockchain still have a positive influence in this stage (Wamba and Queiroz 2022). Meanwhile, decision-makers still need to reason about the necessity of implementing blockchain in the pilot adoption (Van Hoek 2020b). In this stage, inter-organizational factors such as blockchain implementation cost are essential in this stage, as pilot adoption required resources such as software and hardware infrastructure and skilled personnel should be in place, indicating that the implementation cost of blockchain will influence the pilot adoption stage (Nguyen, Chen, and Du 2022).

The third stage is the final implementation stage, in which the blockchain technology is deployed at the SC level. Organizations should routinise the blockchain operation and facilitate the integration of technologies into their existing structure (Vu, Ghadge, and Bourlakis 2021; Wamba and Queiroz 2022). This stage is rarely discussed in the literature, owing to the immaturity of blockchain adoption in SCM practices (Tiwari et al. 2023). This stage of large-scale blockchain implementation in SCF solutions requires more stakeholder's active participation in the blockchain platform and the development of new laws and regulations related to the blockchain (Gong et al. 2022), indicating that government support can positively influence this stage. Moreover, as blockchain adoption is extended to the SC level, organizations need to consider the data issues to ensure the sufficiency of data provided by participants and ensure that the shared data, especially sensitive data can be securely recorded on the chain (Wong et al. 2023). Meanwhile, intra-organizational factors can affect blockchain adoption in the final implementation stage. As stated by Wamba and Queiroz (2022), in the final implementation stag, organizations need to further consider and evaluate whether their SC partners' organizational readiness is compatible to blockchain adoption.

4.4. Sustainable outcomes of blockchain adoption in supply chains

Blockchain adoption in SC is found to have a significant effect on SC sustainability from the three aspects of economic, environmental, and social (Bai and Sarkis 2020; De Giovanni, 2022; Khan et al. 2021; Nayal et al. 2021). The combination of blockchain technology with other emerging technologies (e.g. AI) can greatly contribute to the overall sustainable SCM development (Kazancoglu et al. 2023). The following Table 3 demonstrates the details of the benefits of blockchain to SCM.

4.4.1. Economic sustainability

Economic sustainability is the most discussed outcome of blockchain adoption in SCs. The improvement of economic sustainability mainly originates from the visibility improvement brought by the blockchain (Chaudhuri et al. 2021; Li et al. 2022; Nandi et al. 2020; Samad et al. 2022; Xu and Yang 2021). Visibility is the most important benefit of blockchain adoption to SCM, as blockchain enables the real-time management, control, and sharing of information in SCs, including production, inventory, distribution, and transaction

Table 3. Benefits of blockchain adoption to sustainable SC.

Benefits	Contents	Reference
Economic sustainability	Visibility improvement	Martinez et al. (2019); Wang et al. (2019); Nandi et al. (2020); Dubey et al. (2020); Rodríguez-Espíndola et al. (2020); Guggenberger, Schweizer, and Urbach (2020); Choi, Guo, and Luo (2020); Chaudhuri et al. (2021); Mangla et al. (2021); Giri and Manohar (2023); Baharmand, Maghsoudi, and Coppi (2021); Kamble et al. (2021); Xu and Yang (2021); Gligor et al. (2022); Li et al. (2022); Samad et al. (2022); Xu et al. (2022); Sharma, Al Khalil, and Daim (2022); Brookbanks and Parry (2022); Pattanayak et al. (2023)
	Stablising the SC operation	Casino et al. (2021); Xiong et al. (2021); Yang et al. (2022); De Giovanni (2022); Pattanayak et al. (2023)
	Efficiency improvement	Wang et al. (2019); Nandi et al. (2020); Rodríguez-Espíndola et al. (2020); Roeck, Sternberg, and Hofmann (2020); Karamchandani et al. (2021); Casino et al. (2021); Sundarakani, Ajaykumar, and Gunasekaran (2021); Li et al. (2022); Tian et al. (2022); Samad et al. (2022); Gopal et al. (2022); De Giovanni (2022); Markus and Buijs (2022)
	Innovation improvement	Yang (2019); Kurpjuweit et al. (2021); Li et al. (2022); Song, Han, and Yu (2023)
Environmental sustainability	Ensuring the design and production of environmentally friendly green products	Saberi et al. (2019); Nayal et al. (2021); Khan et al. (2021); De Giovanni (2022); Samad et al. (2022)
Social sustainability	Facilitating product quality control and ensuring the user's safety	Nandi et al. (2020); Mangla et al. (2021); Durach et al. (2021); Kayikci et al. (2022); Tsolakis et al. (2022); Xu et al. (2022); Zhou, Zhu, and Xu (2022)
	Preventing corruption; ensuring human rights and fair, safe work practices.	Chaudhuri et al. (2021); Sharma, Al Khalil, and Daim (2022); Bhatia et al. (2023)

(Guggenberger, Schweizer, and Urbach 2020; Kamble et al. 2021; Mangla et al. 2021; Martinez et al. 2019; Pattanayak et al. 2023; Wang et al. 2019; Xu et al. 2022).

Giri and Manohar (2023) adopt the organizational information processing theory and recongnise blockchain-based collaboration as a form of information processing competence, which promotes SC visibility through promoting real-time information sharing among SCM players. Gligor et al. (2022) study the case of blockchain adoption between a small artisan coffee producer and a start-up blockchain service provider and conclude that blockchain enhances the value of SC visibility through enabling the verification of the provenance of raw material and documentation of real-time material flow throughout the SC. Stakeholders can conduct fair financial audits with the help of blockchain technology, because of its capability to permanently and securely store verifiable information (Choi, Guo, and Luo 2020; Sharma, Al Khalil, and Daim 2022). Brookbanks and Parry (2022) approve the positive effect of blockchain on improving SC visibility, introducing common trusted data, and reducing data duplication.

In the context of humanitarian SC, Dubey et al. (2020) argue that blockchain is a repository, in which immutable and searchable data is recorded. Hence, blockchain-enabled SC visibility provides actors, who participated in disaster relief chains, with opportunities to collect and share data within the same network system, thus helping the improvement of trust among them (Baharmand, Maghsoudi, and Coppi 2021; Dubey et al. 2020). It is necessary to adopt blockchain to increase the visibility and traceability for all types of transactions, which allows donors and external organizations to trace their contributions and increase accountability of the budget (Baharmand, Maghsoudi, and Coppi 2021; Rodríguez-Espíndola et al. 2020).

Additionally, blockchain can stablise the SC operation with enhanced data sharing and risk control in the SC (De Giovanni 2022; Pattanayak et al. 2023; Xiong et al. 2021; Yang et al. 2022). De Giovanni (2022) discusses the adoption of blockchain in the circular close-loop SC and finds that the overall SC visibility is promoted by the technology by means of recording information on collected goods and operational activities. Xiong et al. (2021) find the stabilising effect of blockchain on the SC in the context of Covid-19. This conclusion is echoed by a number of studies, in which the authors demonstrate that the adoption of blockchain and other emerging technologies can assist firms to go through turbulent period and improve SC resilience and operational sustainability (Casino et al. 2021; Yang et al. 2022).

Blockchain adoption encourages the use of smart contracts in SCs, resulting in efficiency improvement in SCM and thus improving SC economic sustainability (Wang et al. 2019). The blockchain-enabled smart contracts can accelerate the SC processes (e.g. procurement) by triggering the immediate request of items once the required assessment is in place (Li et al. 2022; Nandi et al. 2020).

Rodríguez-Espíndola et al. (2020) find that smart contracts can reduce the complexity of interactions between organizations and suppliers, shortening the procurement lead times. Meanwhile, the authors claim that blockchain can reduce inconsistency and corruption among SC participants by enabling them to access the decentralized system, and the provision of real-time information in the system can support efficient decision-making. Tian et al. (2022) study blockchain usage in cross-border trade and find that smart contracts can reduce the contract signing cycle through smart algorithms, thus increasing the efficiency of an SC. In the logistics SC, the adoption of smart contract can speed up settlement and

payment and reduce costs (Samad et al. 2022). Meanwhile, blockchain-enabled smart contract facilitates the integration of monitoring and enforcement, thus reducing the ex-post coordination costs in SCs (Roeck, Sternberg, and Hofmann 2020).

Apart from the blockchain-based smart contract, the intrinsic feature of blockchain technology (shared immutable ledger) can promote SC efficiency by means of reducing operational cost, documentation loss and information distortion, and optimizing inventory and delivery process (Casino et al. 2021; Gopal et al. 2022; Roeck, Sternberg, and Hofmann 2020; Samad et al. 2022; Sundarakani, Ajaykumar, and Gunasekaran 2021).

De Giovanni (2022) evaluates the effect of blockchain platform on SCM from the transaction cost economics perspective and state that blockchain-based collaboration, which triggers inter- and intra-organizational real-time information sharing, can facilitate effective SCM through increasing efficiency and minimizing the cost of every transaction. Karamchandani et al. (2021) examine the benefits of blockchain in the Indian manufacturing SC and discover that blockchain promotes overall efficiency and profitability of the SC for the aspect of the product and information quality, customer relationship, mass customization, supply uncertainly, and delivery reliability. Markus and Buijs (2022) study the effect of blockchain adoption on SC performance in multiple industries, including food, manufacturing, automobile, and trade and accounting. The authors find blockchain adoption enables the adoption of a shared immutable ledger in the SC, with which the speed, quality, and dependability of the SC are improved, while the cost is reduced.

Lastly, blockchain adoption can improve innovation in the SC, thereby benefiting the economic sustainability of SCs. Blockchain alters the value creation and capturing of organizations and optimise the value chain through integrating innovation resources (Li et al. 2022). Yang (2019) claims that blockchain can revolutionise the operational routine in maritime shipping, which can lead to industry upgrading and transformation. Kurpjuweit et al. (2021) examine blockchain-enabled addictive manufacturing and argue that blockchain can strengthen the impact of additive manufacturing on the SC value-creating process and promote the innovative business model with high specialization, in which customers and new actors are involved in the value chain. In the financial SCM, Song, Han, and Yu (2023) find that blockchain adoption in SCF can enhance the transparency, traceability, and verification of information transmission, leading to the transformation of new business models in SCF.

4.4.2. Environmental sustainability

One of the major benefits of blockchain adoption in SCs is traceability improvement. The improved traceability in the SC can ensure the design and production of environmentally friendly green products (Saberi et al. 2019). Nayal et al. (2021) study blockchain technology adoption in the agriculture SC and prove the positive relationship between blockchain technology capabilities and a sustainable agriculture SC. De Giovanni (2022) finds that blockchain can well control risks and increase information sharing on close-loop SC activities, which promotes the development of a circular economy and related sustainable outcomes. Samad et al. (2022) find that real-time information sharing through the blockchain can optimize traffic data to promote effective vehicle routeing, thus reducing the carbon footprint. Khan et al. (2021) conduct a survey targeting managers of manufacturing SMEs in China and Pakistan and prove that blockchain can directly facilitate green SC practices and indirectly by affecting green information systems.

4.4.3. Social sustainability

Social sustainability is the least discussed among the reviewed papers. the benefits of blockchain technology on SC social sustainability mainly emphasises the aspect of food safety, consumer health, and human rights (Han et al. 2022; Kayikci et al. 2022; Mangla et al. 2021).

Mangla et al. (2021) state that blockchain adoption in the milk SC is critical for improved traceability in the milk SC and can help achieve social sustainable goals through decreasing food fraud and thus increasing food safety and promoting good health for human beings. In the case study of Thai fish SC, Tsolakis et al. (2022) notice the combination of AI and blockchain increases the overall digital level of the SC and further improves the material and product handling conditions, through which the consumer's health and safety can be ensured. In the case of the German automobile SC, Xu et al. (2022) state that blockchain can easily identify the product's current production stages, its location in the SC, and related suppliers. It enables organizations to conduct better quality control, reduce counterfeit products and avoid fraudulent practices, thus ensuring the user's safety (Durach et al. 2021; Nandi et al. 2020; Xu et al. 2022; Zhou, Zhu, and Xu 2022).

Owing to the immutability of the blockchain-recorded information, Chaudhuri et al. (2021) consider that blockchain can potentially contribute to SC social sustainability as immutability can prevent corruption and ensure human rights and fair, safe work practices. In the context of financial SCM in the agriculture industry, Bhatia et al. (2023) discover that blockchain-enabled SCF can reduce inefficiencies and increase transparency in the current system and thus guarantee that farmers have the equal right to access financial resources. Sharma, Al Khalil, and Daim (2022) find blockchain-based solutions can help agriculture SC achieve better social responsibility as the blockchain implementation (e.g. blockchain-enabled GPS nodes) can ease the complexity of farm management and reduce cost, thereby improving their quality of life.

5. Discussion

Based on the identified themes in the literature review, this study proposes a conceptual framework (Figure 6), in which the antecedents of blockchain adoption, implementation stages, influential factors on each stages, and the effects of blockchain adoption on the SSCM are integrated. Although

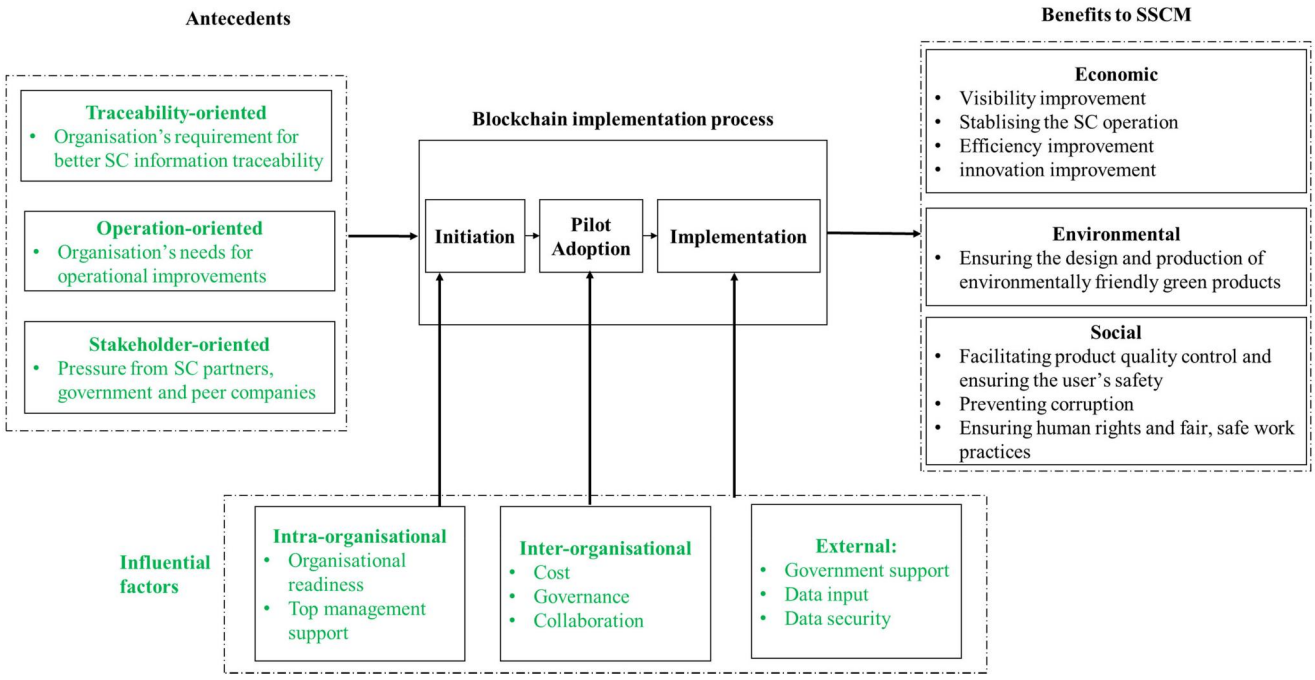

Figure 7. Conceptual framework of blockchain and SSCM.

blockchain adoption in SCM is a hot topic, the effect of blockchain adoption on sustainable SCM requires further exploration.

5.1. Conceptual framework

As shown in Figure 7, based on the thematic findings, this paper proposes an integrated framework of blockchain adoption in SCs. Antecedents are shown on the left of the framework and are categorized according to their attributes. The organization's requirement for enhancing traceability along the SC is categorized as a traceability-oriented motive. An organization's intention to improve overall SC operation is categorized as the operation-oriented motive. Pressures from SC participants, governments, and competitors are categorized as the stakeholder-oriented motive.

In the middle of the framework, the blockchain implementation process in the SC is summarised and three stages of blockchain implementation are concluded, including stages of initiation, pilot adoption, and full implementation. Three groups of influential factors on blockchain adoption are also presented in the framework, including intra-organizational, inter-organizational, and external factors. The benefits of blockchain implementation to SCs are shown on the right of the framework, where the benefits are described from the aspect of economic, social, and environmental.

Compared with the previous framework (Vu, Ghadge, and Bourlakis 2021), this newly proposed model comprehensively integrated the antecedent, outcomes, blockchain implementation process, and influential factors for each process. First, antecedents are not concluded in the previous review. While in our model, three different antecedents that facilitate the enterprises' blockchain implementation are clearly identified and are further categorized based on their distinct attributes. Meanwhile, outcomes are not mentioned in the previous review; however, this review explicitly illustrated how blockchain implementation can contribute to the comprehensive sustainable SCM from the aspect of environmental, social, and economic.

As for the influential factors, Vu, Ghadge, and Bourlakis (2021) have determined several groups of influential factors. This review redefined the factors based on the existing studies and further built links between each group of factors and specific blockchain implementation process. The initial stage is influenced by intra-organizational factors and actor-related factors; the second pilot adoption stage is affected by both intra- and inter-organizational factors, and the third implementation stage is found to be affected by all three groups of factors.

The framework has the potential to promote the conceptual development of blockchain implementation for sustainable SCM. The antecedent concluded in the framework illustrates the driving force for companies to initiate blockchain implementation activities. The blockchain implementation process and related influential factors can provide companies with guidance to implement blockchain in their SC. The outcomes can be used to evaluate the results of blockchain implementation in the SCs.

5.2. Research gaps and future research directions

First, the existing literature has built the relationship between blockchain adoption and sustainable SCs in terms of economic, environmental, and social. Economic sustainable performance in SCM attracts the most attention from academics. However, the number of studies paying attention to social and environmental sustainability is insufficient, especially for social sustainability. Blockchain applications generate great opportunities for better environmental and social sustainability in the SC (Bai, Quayson, and Sarkis 2022;

Singh et al. 2023), thus future research can further study how the blockchain application in SCs can improve environmental sustainability such as enhancing green production and green SC design for example. Meanwhile, social sustainability improvements resulting from blockchain adoption in SCs are worth more investigation. For example, future research can examine how the attributes of blockchain technology can help monitor the maintenance of a safe working environment and protect workers from exploitation (Upadhyay et al. 2021).

Second, this review notices the lack of country or region focus in the existing literature, especially in developed countries. As stated by Wamba and Queiroz (2022), there are significant differences in the enablers of blockchain adoption between developing and developed countries. For example, in the initiation stage, actor-related factors such as top management understanding and support are essential enablers in the Indian cases, however, not it is not the case for the US. Future research can further investigate the difference in the enabler of blockchain adoption in different regions and provide a detailed explanation for the difference. Also, future research can pay more attention to cases of blockchain adoption in developed countries or regions, where the organization's overall technology capability is at a higher level, thus enabling the better adoption of blockchain in SCs (Xu et al. 2022).

Third, although the effect of blockchain on SCM is influenced by the industry type (Nandi et al. 2020; Wamba, Queiroz, and Trinchera 2020), this review finds that the industry focuses in the existing literature are unbalanced. Most studies with a specific industry focus investigate the agricultural or agri-food industry. Only a few papers discuss blockchain adoption in other industries, such as healthcare, humanitarian, and logistics. This can be explained by the different stages of blockchain adoption in various industries, However, future research should conduct more industry-focused research related to blockchain adoption in SCs as it progresses. Meanwhile, SCF is found to be a promising aspect of SCM to use blockchain, especially the sustainable SCF, in which the features of blockchain, such as immutability and traceability, can effectively promote the development of sustainable SCF to further facilitate the sustainable development at a SC level (Jia, Zhang, and Chen 2020). Therefore, future research can explore the promoting effect of blockchain on sustainable SCF.

Fourth, in terms of influential factors of blockchain adoption in SCs, the arguments in the existing literature conflict with each other. For example, some studies consider implementation cost as an essential barrier to blockchain adoption, while other studies considered that it can be offset by the cost-saving brought by the blockchain. Meanwhile, the opinions on the effect of organization-related factors are also devided. Organization readiness is considered to be highly related to the smooth implementation of blockchain in the SC (Gong et al. 2022; Rogerson and Parry 2020). However, Deng et al. (2022) state that technology and financial readiness will not significantly affect SME blockchain adoption in China. Future research can further resolve these inconsistent findings and investigate whether the company size can affect the factors that impact blockchain adoption in SCM.

Fifth, as for the data-related factors, although, some studies believe that blockchain can ensure the public accessibility of information while protecting information security (Dubey et al. 2020). Data security issues are still considered as one of the major barriers hampering blockchain adoption in SCs (Singh et al. 2023). Data security can be resolved to a large extent in the public chain. However, in the context of SCM, SC partners usually establish a private chain or consortium chain to integrate blockchain into their SCM practices. As the number of blocks on these two types of blockchain is far less than that on the public chain, such types of blockchain are still vulnerable to issues such as cyberattacks and sensitive information protection (Kouhizadeh, Saberi, and Sarkis 2021; Xu and He, 2022). However, we find limited empirical research aims to address this issue. Therefore, future research can focus on investigating approaches to effectively protect the SC partners' data security in the context of the private chain. Especially in the context of sustainable SCM, SC partners are required to disclose more sustainable related data (Longoni and Cagliano, 2018). Properly managing the data security can increase the SC partners willingness to participate in the blockchain programme for SSCM.

Sixth, in terms of the implementation stages, blockchain adoption in SC is limited and its function in improving SSCM practices has not been fully explored (van Hoek 2020a). Most of the existing literature tends to focus on the initiation and pilot adoption stages (Khan et al. 2022), while the blockchain's full implementation stage is rarely discussed (Gong et al. 2022), indicating that the current findings regarding the benefits of blockchain on SSCM are not comprehensive. Meanwhile, the existing studies on blockchain adoption in SCs lean towards discussing the enablers and barriers, with a few papers actually investigating real-life cases to explore how firms collaborated to overcome the barriers or make use of the enablers to promote blockchain adoption in sustainable SC (Naef, Wagner, and Saur 2022). Future research can focus on some qualified case studies, such as Walmart and Nestle among others, to further justify the benefits of blockchain to SSCM and how organizations leverage the influential factors to facilitate blockchain adoption in SC.

6. Conclusion

Blockchain technology application in SCs has been established as an important research area in SCM; however, it requires further exploration by both academics and practitioners. This review has explored the relationship between blockchain adoption and SSCM and conducted a content analysis of relevant literature published from January 2008 to June 2023.

This review makes an important theoretical contribution to the blockchain and SSCM literature. First, to the best of our knowledge, this paper is the first systematic review of blockchain implementation for SSCM. Previous literature review tends to emphasize the economic outcomes of blockchain adoption and focuses on the identification of enablers

and barriers of blockchain adoption in SCs, thus limiting the contribution to exploring the effect of blockchain on SSCM. This review develops a theoretical framework to comprehensively explain how blockchain affects the SCM from the aspects of economic, social, and environmental. Also, the framework helps to clarify what factors can influence blockchain implementation in different stages of initiation, pilot adoption and implementation.

This review identifies four major themes (antecedents, implementation stages, influential factors, and benefits to SCM) in the topic of blockchain implementation and SCM. These themes can assist researchers in avoiding focusing on the investigation of mature and saturated themes. In addition, the research gaps are identified, and future research directions are recommended for scholars, thereby enabling the comprehensive development of blockchain adoption in SCs.

In the theoretical framework, blockchain implantation stages and related influential factors are concluded from case study research. This endows this SLR with managerial theoretical as well as practical contributions. Companies can employ this framework as guidance for their blockchain project initiation and large-scale implementation in the SC. Moreover, the identified relationship between influential factors and blockchain implementation stages can assist companies in evaluating their readiness for the progression to the next stage of blockchain implementation. In addition, this review has proved that blockchain can comprehensively improve sustainable SCM outcomes, which can provide some insight to policymakers, who can enact preferential policies to encourage organizations to initiate blockchain projects, to leverage the strength of this emerging technology to further promote sustainable development.

This paper is not free from limitations. First this review only includes papers published in AJG 3 and above journals, while the conference paper and research reports are excluded. However, blockchain adoption is an emerging topic in SCM research, and thus including these grey references might facilitate a better understanding of blockchain and its related functions in SCM. Second, in the second-round selection, papers employing modelling methodology are excluded. Including these papers may generate more conclusions of the blockchain's implications on sustainable SCM.

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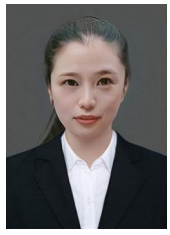
Notes on contributors

Tianyu Zhang (Ph.D., University of York) is a Postdoctoral Researcher at College of Business Administration, Capital University of Economics and Business. His research interests primarily revolve around supply chain management including supply chain finance, supply chain finance ecosystem, and Fin-tech and sustainability in supply chain finance. Dr. Zhang has published in various journals including *International Journal of Production Economics, Business Strategy and the Environment, Journal of Cleaner Production* among others.

Fu Jia, PhD, is a Chair Professor of Supply Chain Management at the School for Business and Society, the University of York, England. His research interests have been in supply chain management including agricultural supply chain and cooperatives and sustainability. He has published extensively in leading international OM/SCM journals such as *Journal of Operations Management, International Journal of Operations and Production Management, International Journal of Production Economics, Supply Chain Management: An International Journal, International Business Review* among others. Prof. Jia is an Associate Editor to *International Journal of Operations and Production Management* (IJOPM), *Journal of Purchasing and Supply Management* (JPSM); and *International Food and Agri-business Management Review* (IFAMR).



Lujie Chen is a Senior Associate Professor of Management at Xi'an Jiaotong-Liverpool University and an Honorary Associate Professor at the University of Liverpool in the UK. She is a Fellow of the Higher Education Academy in the UK and an expert in the fields of supply chain management and business analytics. Prof. Chen have published over 60 high-quality and impactful papers in top-tier journals such as the *Journal of Operations Management* (UTD 24), *Harvard Business Review* (FT50), *International Journal of Operations and Production Management* (ABS 4), *British Journal of Management* (ABS 4), and *European Journal of Operational Research* (ABS 4), among others. She has served as a guest editor for special issues of several respected journals such as *International Journal of Operations and Production Management*, *IEEE Transactions on Engineering Management*, *Industrial Marketing Management*, *International Journal of Production Economics*, *Journal of business Logistics* and *Journal of Business Research*. She is currently serving as an Associate Editor for the *International Journal of Operations and Production Management* (ABS 4).

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Appendix. Table of reviewed 69 papers

No	Author(s)	Year	Journal	Methodology	Industry	Region	Findings
1	Wang et al.	2019	IJPE	Case study	N/A	N/A	This paper used sensemaking approaches to explore how blockchains may transform supply chain practices.
2	Kamble et al.	2019	IJPR	Survey	N/A	India	The study found that the TRI constructs-Insecurity and discomfort have an insignificant effect on the perceived ease of use and usefulness. Perceived usefulness, attitude, and perceived behavioural control affect behavioural intention. Subjective norm has a negligible impact on behavioural intention.
3	Yang	2019	TRE	Survey	Logistics	China	This paper conducts a comprehensive blockchain applications and future improvements survey, and empirically evaluates its effects on intention to use. The results suggested that customs clearance and management, digitalising and easing paperwork, standardisation, and platform development dimensions positively affected intention to use.
4	Martinez et al.	2019	IJOPM	Case study	Manufacturing	N/A	Blockchain improves the efficiency of the process: it reduces the number of operations, reduces the average time of orders in the system, reduces workload, shows traceability of orders and improves visibility to various supply chain participants.

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No	Author(s)	Year	Journal	Methodology	Industry	Region	Findings
5	Choi	2020	TRE	Case study	N/A	N/A	This paper investigates how the blockchain technology would potentially improve the use of social media analytics for supply chain operations management.
6	Nandi et al.	2020	SCMIJ	Qualitative content analyses	Multiple	N/A	This paper finds though quality compliance and improvement, process improvement, flexibility, reduced cost, and reduced process time, present BCT-SCS efforts are mainly oriented towards improving information sharing and coordination capabilities rather than integration and collaboration capabilities, However, the performance outcomes vary with industry type, based on the risks that the industry faces.
7	Van Hoek	2020	SCMIJ	Case study	Multiple	US/Europe/North America	This paper extends the framework for the mindful consideration of blockchain use cases in the supply chain and answers the question of what to adopt and where to start in the blockchain adoption in SCM.
8	Wong et al.	2020	IJPR	empirical	Multiple	N/A	This paper reveals that facilitating condition, technology readiness and technology affinity have a positive influence on intention to use blockchain for supply chain management and regulatory support moderates the effect of facilitating condition.
9	Dubey et al.	2020	IJPR	Survey	Humanitarian	N/A	This paper proposes a theoretical model to understand how blockchain can influence operational supply chain transparency and swift-trust among actors engaged in disaster relief operations. Blockchain-enabled swift-trust can further improve collaboration among actors engaged in disaster relief operations and enhance supply chain resilience.
10	Bai and Sarkis	2020	IJPR	Empirical	N/A	N/A	This paper introduces blockchain technology performance measures incorporating various sustainable supply chain transparency and technical attributes.
11	Wamba et al.	2020	IJPE	Survey; Modelling	N/A	US and India	This paper suggests that knowledge sharing and trading partner pressure play an important role in blockchain adoption, and that supply chain performance is significantly influenced by supply chain transparency and blockchain transparency. The industry variable has a moderation effect on the outcomes.
12	Rodríguez-Espíndola et al.	2020	IJPR	Case study	Humanitarian	Mexico	This study finds that adopting emerging technologies such as blockchain and 3D printing can reduce congestion in the supply chain, enhance simultaneous collaboration of different stakeholders, decrease lead times, increase transparency, traceability and accountability of material and financial resources, and allow victims to get involved in the fulfilment of their own needs.
13	Van Hoek	2020	SCMIJ	Interview	Multiple	N/A	This paper suggests that enablers for blockchain adoption include achieving greater transparency and visibility, as well as, improving processes and reducing costs; Barriers include a lack of understanding of costs and benefits of blockchain in the supply chain.
14	Guggenberger et al.	2020	TEM	Case study	healthcare	Germany	This paper describes how companies utilise decentralized technologies, such as blockchain, to facilitate information sharing.
15	Rogerson and Parry	2020	SCMIJ	Case study	Agri-food	Multiple	This paper considers blockchain as an enabler of visibility in supply chains. Applications at scale are most likely for products where the end consumer is prepared to pay the premium currently required to fund the technology, e.g. baby food. Challenges remain in four areas: trust of the technology, human error and fraud at the boundaries, governance, consumer data access and willingness to pay.

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No	Author(s)	Year	Journal	Methodology	Industry	Region	Findings
16	Roeck et al.	2020	IJPR	Case study	Multiple	N/A	This study reveals that the effects of distributed ledger technology on supply chain transactions are two-sided. It further finds six effects of distributed ledger technology solutions that have a cost-reducing or cost avoidance impact on supply chain transactions.
17	Casino et al.	2021	IJPR	Case	Agri-food	Greece	This paper presents a blockchain-based framework for food supply chain traceability and various traceability functionalities provided along with the various stakeholders/processes/products involved as well as their interrelationships are detailed.
18	Mangla et al.	2021	TRE	Case study	Agri-food (milk)	Turkey	This study finds that blockchain technology can be incorporated into the existing system so that transparent and end-to-end accurate tracking of the supply chain is made possible, while creating decentralized recording of transactions. It finds that blockchain adoption in milk supply chain can help achieve the sustainable development goals of providing safe food, promoting good health and better well-being for everyone.
19	Baharmand et al.	2021	IJOPM	Case study	Humanitarian	UK	This paper finds main drivers and main barriers for blockchain adoption, and further reveals that the blockchain application could have added value to improve visibility and traceability, thus contributing to improve transparency.
20	Chaudhuri et al.	2021	AOR	Interview	Multiple	N/A	This paper identifies that developing user-friendly applications, developing secure digital payment systems, providing support for suppliers and farmers, and adapting to local conditions as the key outcome-based mechanisms. Educating and engaging with customers, and building local relationships are found to be the key behavioural mechanisms needed to improve social sustainability and minimise risks using blockchain.
21	Xiong et al.	2021	IJOPM	Empirical	N/A	N/A	This study demonstrates the role of blockchain-enabled supply chains in mitigating the negative impact caused by the COVID-19 pandemic. The mitigating role of blockchain-enabled supply chains is more pronounced for firms with lean and complex supply chain.
22	Khan et al.	2021	AOR	Empirical	Manufacturing	China and Pakistan	This study finds that blockchain technology and green information systems positively influence sustainable supply chain practices.
23	Falcone et al.	2021	JBL	Empirical	N/A	US	This study finds that trustworthiness regarding competence and perceived distributive justice is the focal drivers of managers' willingness to use the technology. Both risk and interactional justice are not drivers of willingness to use blockchain technology despite significant claims to that effect.
24	Vafadarnikjoo et al.	2021	AOR	Empirical	manufacturing	developing, N/A	The study finds that 'transaction-level uncertainties' comprise the most critical barrier and have the highest weight in the final ranking followed by 'usage in the underground economy', 'managerial commitment', 'challenges in scalability', and 'privacy risks'.
25	Queiroz et al.	2021	IJPR	Empirical	N/A	Brazil	This paper reveals that facilitating conditions, trust, social influence, and effort expectancy are the most critical constructs that directly affect BCT adoption, while performance expectancy appeared not decisive in terms of predicting BCT adoption.
26	Xu and Yang	2021	AOR	Empirical	Logistics	China	This paper explores how the blockchain helps reduce logistics costs, improve transparency and solve the problems in transportation.

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No	Author(s)	Year	Journal	Methodology	Industry	Region	Findings
27	Karamchandani et al.	2021	IJPR	Empirical	Manufacturing	India	This paper finds that blockchain is perceived to drive improvement in six supply chain dimensions of the manufacturing industry. The breadth of organization size and geographical dispersion moderate the mediation relationship between blockchain benefits and incremental profitability.
28	Kouhizadeh et al.	2021	IJPE	Empirical	N/A	N/A	This paper reveals that supply chain and technological barriers are the most critical barriers among both academics and industry experts.
29	Nayal et al.	2021	AOR	Survey	Agriculture	India	This study finds that green and lean practices, supply chain integration, supply chain risks, internal and external conditions, regulatory support, innovation capability, and cost positively influence blockchain technology adoption. Blockchain technology positively influences sustainable agriculture supply chain performance.
30	Kurpjuweit et al.	2021	JBL	Case study	Manufacturing	Europe	This study suggests opportunities that are related to intellectual property rights management, the monitoring of printed parts throughout their lifecycle, process improvements, and data security. The most important barriers for blockchain adoption in additive manufacturing are an absence of blockchain-skilled specialists on the labour market, missing governance mechanisms, and a lack of firm-internal technical expertise.
31	Sternberg et al.	2021	JBL	Case study	Service	N/A	This study reveals a paradox as well as several tensions between drivers for and against (positive and negative determining factors, respectively) of blockchain technology adoption that must be managed in an interorganizational setting. In this vertical context, the adoption and integration decision of one supply chain actor recursively affects the adoption and integration decisions of the other supply chain actors.
32	Durach et al.	2021	JBL	Survey	Manufacturing	Germany	This paper identifies that verified customer reviews and product quality certification are the most relevant blockchain usages in SC transactions.
33	Kamble et al.	2021	AOR	Survey	Automotive	India	This paper confirms that blockchain technology positively influences sustainable supply chain performance. The results recognise the role of supply chain integration as a significant mediating variable between the blockchain technology and sustainable supply chain performance.
34	Wong et al.	2021	TEM	Empirical	Manufacturing	Malaysia	This study reveals that functional risk barrier has the highest level of importance towards blockchain resistance, followed by usage barrier, security and privacy barrier, and information barrier.
35	Sundarakani et al.	2021	Omega	Case study	Logistics	N/A	This paper uses two cases study to identify key implementation guideline and issues for blockchain in supply chain management.
36	Markus et al.	2022	SCMIJ	Interview	Multiple	N/A	The paper finds that blockchain can affect supply chain performance directly – via one of its core technological features – and indirectly via the broader business project through which blockchain technology is implemented.
37	Sauer et al.	2022	PPC	Case study	Multiple	US/Europe	This paper highlights that the setup of blockchain projects depends on the presence of different drivers on customer value or efficiency and the focus towards products/components or raw materials. Based on how tracking and tracing drivers and focus influence the initial blockchain setup, contingent factors are discussed and possible evolutionary patterns are identified.

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No	Author(s)	Year	Journal	Methodology	Industry	Region	Findings
38	Brookbanks and Parry	2022	SCMIJ	Case study	Agri-good	UK	This paper finds that a blockchain-based platform introduces common trusted data, reducing data duplication and improving supply chain visibility.
39	Naef et al.	2022	PPC	Case study	Multiple	N/A	This paper indicates that the combination of centralized and decentralized control is a great benefit for the successful development and implementation of blockchain applications. For companies, to obtain benefit from blockchain technology in supply chain applications, an important collaborative organizational effort is necessary.
40	Galati	2022	SCMIJ	Case study	Agri-food	N/A	This paper highlights the importance of managers' sensemaking for investigating technology adoption and argues a relationship between competitive opportunities at the firm level and the idea to adopt the blockchain.
41	Tsolakis et al.	2022	AOR	Interview/ observation	Agri-food	Thailand	This paper illustrates the central role of AI and BCT in digital supply chains' management, while the associated sustainability and data monetisation impact depends on the parameters and objectives set by the involved system stakeholders.
42	Xu and He	2022	PPC	Case study	Logistics	N/A	This study finds six key areas for optimal use of blockchain in modern logistics information sharing: supply chain finance, logistics tracking, logistics collaboration, process optimisation, data security management, and logistics business mode innovation.
43	Xu et al.	2022	PPC	Case study	Automobile	Germany	This paper finds that blockchain applications have advantages in aggregating product information, securing transaction information, and establishing a reliable supply chain. Biggest obstacles for blockchain technology adoption in the automotive supply chain include: technology immaturity, lack of guidance and industry standards, non-cooperation of chain members, and legislative ambiguity. Blockchain technology is perceived to have great potentials in reducing process costs, ensure product quality, and enhance the automotive supply chain's visibility and digitization.
44	Deng et al.	2022	AOR	Empirical	N/A	China	This paper reveals that cost saving, complexity, relative advantage, top management support, SC cooperation, and government support positively affect BCT adoption in SCM. Whereas compatibility, technological readiness, financial readiness, and competitive pressure had no significant impact on BCT adoption in SCM among MSMEs in China.
45	Yang et al.	2022	TEM	Empirical	N/A	China	This paper reveals that high vigilance to potential supply chain disruptions will motivate enterprises to develop emerging IT capability, which will enhance supply chain resilience as well as economic, environmental, and social performances.
46	Giovanni	2022	IJOPM	Survey	N/A	N/A	This paper finds that the blockchain facilitates a more efficient CE system and the close-loop supply chain network can benefit from an active return approach by developing appealing incentives for collectors and enhancing the positive effects of the blockchain.
47	Wamba and Queiroz	2022	PPC	Empirical	N/A	US and India	This paper finds that from one country to another, there are essential differences in the variables that determine blockchain innovation and in the stage of diffusion.
48	Tian et al.	2022	PPC	Empirical	N/A	China	This paper finds that blockchain usage reduces the intermediary agencies of cross-border trade and settlement payment for traders, also improves the timeliness of business processing and the efficiency of cross-departmental business collaboration.

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No	Author(s)	Year	Journal	Methodology	Industry	Region	Findings
49	Gopal et al.	2022	AOR	Empirical	N/A	N/A	This paper finds that blockchain technology will help supply chain managers to manage inventories across the chain and will overcome the shortages of the products.
50	Samad et al.	2022	AOR	Empirical	Logistics	India	This study identifies three groups of enablers: prominent enablers, influencing enablers, and resulting enablers. 'Real-time connectivity and information flow' were identified as the most influencing enabler, whereas traceability was found to be the most prominent and resulting enabler.
51	Sodhi et al.	2022	POM	Empirical	N/A	N/A	This paper finds that the characteristics of the emerging technologies do not inform user expectations at the early stages of adoption.
52	Chittipaka et al.	2022	AOR	Empirical	N/A	India	This paper finds that the role of blockchain technology adoption in supply chains may significantly improve firm performance improving transparency, trust and security for stakeholders within the supply chain.
53	Chowdhury et al.	2022	AOR	Empirical	N/A	UK	This paper suggests that understanding the benefits of blockchain, involvement in resilient organizational practices and user-friendly implementation of the technology will have a significant and positive influence on the intention to adopt blockchain for risk management in the operation and supply chain management context.
54	Sharma et al.	2022	TEM	Empirical	Agri-food	Multiple	This study finds differences of the enabling factors among the four economies, and it also identified that policies are the most important enabler of BCT adoption in the agriculture supply chain.
55	Alzahrani et al.	2022	TEM	Modelling; Interview	Healthcare	US	The study identifies 17 most important factors influencing blockchain adoption and a healthcare organization's readiness for adoption. The factors are grouped into five perspective: financial, social, technical, organizational, and regulations & legal.
56	Li et al.	2022	TRE	Empirical	Manufacturing	China	This study finds that companies with high strategic emphasis on business model efficiency can achieve higher firm performance and Supply chain resilience through blockchain usage than those without such a focus.
57	Nguyen et al.	2022	TRE	Survey	Logistics	Australia	This study explores the potential risk situation in container shipping BISs with inputs from the industry, and its results enable a comprehensive view of the potential failure modes of blockchain applications.
58	Zhou et al.	2022	IJPE	Empirical	Agri-food	China	This study suggests that supply chain traceability can improve economic performance while supply chain-based process integration and management is essential, and supply chain-based quality strategy and leadership is partially necessary.
59	Agi and Jha	2022	IJPE	Empirical	N/A	France	This study suggests that the relative advantage of the technology and the external pressure are the most prominent categories of enablers that impact blockchain adoption in the supply chain.
60	Chaudhuri et al.	2022	PPC	Case study	Multiple	N/A	This study develops a generalisable framework for blockchain implementation and identifies common social and technical capabilities, such as empathising with customers and system design, to facilitate implementation and contingent capabilities that vary across different types of blockchain implementation projects.
61	Gligor et al.	2022	JBL	Case study	Agri-food	Italy	This paper conducts a case study a blockchain implementation project between a small artisan coffee producer and a start-up BCT service provider and provides theoretical insights about how the mechanisms in structuring, bundling, and leveraging processes operate to offer SCT to stakeholders, and the value creation derived as a result.

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No	Author(s)	Year	Journal	Methodology	Industry	Region	Findings
62	Gong et al.	2022	PPC	Case study	Finance SC	China	Findings from the multiple case analysis indicate that BCT can cope with challenges in traditional SCF, including financing range, financing cost, financing efficiency, and risk management.
63	Kayikci et al.	2022	PPC	Case study	Agri-food	Inda	The study investigates the suitability of blockchain technology in resolving major challenges, such as traceability, trust, and accountability in the food industry.
64	Song et al.	2023	IJOPM	Case study	Finance SC	China	The success of blockchain enabled supply chain finance depends on the profiles of its expectancy, instrumentality, and valence. Blockchain can solve information asymmetry problems and enhance financing performance through supporting transparency, traceability and verification of transmissions and facilitating a transformation to new business models.
65	Tiwari et al.	2023	TRE	Interview	Logistics	N/A	This paper uncovers the status of BCT adoption in 3PL and the challenges that are hampering the adoption of this technology.
66	Pattanayak et al.	2023	TEM	Case study	Multiple	N/A	This study reveals key issues associated with contemporary supply chain networks and the capabilities that can be enhanced by blockchain-enabled supply chains to mitigate such issues.
67	Bhatia et al.	2023	PPC	Case study	Agri-food/ financial SC	N/A	This study finds blockchain-enabled SCF solutions can reduce different types of transaction costs such as costs associated with information search, negotiation and contracting costs, and costs of accessing finance.
68	Kazancoglu et al.	2023	AOR	Empirical	Automotive	Turkey	This study finds the most important issues to be addressed during COVID-19 are top management support, purchasing process planning and supply chain traceability. The use of emerging technologies such as blockchain can increase the sustainability and resilience of supply chains, especially in an uncertain environment.
69	Giri and Manohar	2023	SCMIJ	Empirical	N/A	India	This paper reveals that partial mediation exists between blockchain-based collaboration (private and public) and behavioural intention to use.