Leveraging Blockchain for Social Sustainability in the Supply Chains: A Systematic Literature Review and Framework Development

Abstract

Purpose- This research systematically examines the complex relationship between blockchain technology and social sustainability management in global supply chains (GSCs). As GSCs have become more intricate, managing social sustainability has emerged as a significant challenge. Traditional centralized information management systems in supply chains are prone to vulnerabilities like single-point failures, and blockchain technology presents a viable solution to enhance traceability and transparency. However, there is a pressing need for more research on its broader applications, particularly in the social aspects of sustainability.

Design- Through an analysis of 40 selected literatures employing the Technology, Organisation, and Environment (TOE) framework, this study explores the drivers, barriers, and practices of blockchain integration for social sustainability in supply chains.

Findings-The emerging conceptual model indicates that blockchain adoption is influenced by technical, organizational, and environmental factors, with challenges arising from internal and external organizational barriers, system-related issues, and external constraints. The application of blockchain in enhancing supply chain social sustainability shows promise in improving traceability and transparency, promoting ethical sourcing, and empowering marginalized actors, signalling its potential for future growth. However, further comprehensive industry research, theoretical development, and more precise regulations are essential to fully realize its capabilities.

Originality/Value- The developed framework serves as a strategic compass for researchers and managers, directing them towards harnessing blockchain for socially sustainable supply chains.

Keywords: social sustainability, blockchain, supply chain

1. Introduction

The globalization of supply chains has led to production being outsourced to countries where labour costs are lower, but this often results in challenges related to the transparency and traceability of production processes. Such challenges raise concerns about the social sustainability of supply chains, which encompasses the management of practices to ensure the welfare and human rights of those involved (Hannibal and Kauppi, 2019; Khan et al., 2022). Blockchain technology, characterized by its decentralized, secure, and transparent nature, offers promising solutions to enhance the visibility and accountability in supply chains, addressing critical social sustainability issues such as ethical sourcing and workers' rights (Saberi et al., 2019; Dutta et al., 2020; Kshetri, 2022).

Social sustainability within supply chains is critical for safeguarding the rights and welfare of workers and communities, impacting a wide range of aspects including safety, health, and labour rights (Nakamba et al., 2017; Sodhi and Tang, 2018; D'Eusanio et al., 2019; Khan et al., 2022; Croom et al., 2018). Blockchain's capabilities in ensuring the provenance of goods and facilitating the traceability of social conditions within supply chains are well-recognized, making it a vital tool in combating issues like modern slavery and unethical practices (Queiroz and Wamba, 2019; Hanson et al., 2017; Behnke and Janssen, 2020; Tönnissen and Teuteberg, 2020).

Despite its potential, the application of blockchain in addressing social sustainability in supply chains is still emerging, with limited research on the specific drivers and barriers to its adoption (Elhidaoui et al., 2022). This study aims to fill this gap by exploring how blockchain technology can contribute to social sustainability in supply chains, focusing on key drivers and barriers to its adoption. Through a systematic literature review, we aim to shed light on blockchain's role in enhancing supply chain social sustainability, guided by two research questions:

RQ1: What are the drivers and barriers to adopting blockchain in supply chains for social sustainability?

RQ2: How does blockchain technology contribute to social sustainability in supply chains?

This investigation is timely and crucial for understanding the potential of blockchain in making supply chains more socially sustainable and ethically responsible.

2. Research design and methods.

To systematically explore the integration of blockchain technology in enhancing social sustainability within supply chains, we employed a streamlined systematic literature review methodology. This approach was instrumental in navigating the research landscape, ensuring an unbiased and comprehensive understanding of the topic. The review hinged on peer-reviewed articles, published in English between 2016 and 2023, identified using Scopus — reflecting the emerging discourse around blockchain's role in sustainable supply chain management (Tranfield et al., 2003; Pittaway et al., 2004).

Key steps in our refined review process included:

- Keyword Identification: We began with a broad set of keywords around Supply Chain Social Sustainability (SCSS) and Blockchain, refining these as our review progressed to capture the nuanced aspects of SCSS within supply chain management (SCM).
- Search and Selection: Focused searches were conducted within a specific timeframe, recognizing the foundational works on blockchain for social sustainability in supply chains. This led to an initial retrieval of 668 records.

- Refinement and Relevance: Articles were filtered based on language, publication years, and their peer-review status, reducing the pool to 430 articles. Further scrutiny based on relevance to our research questions narrowed this down to 142.
- In-depth Review: A detailed examination of these articles resulted in a final selection of 40 papers, directly focusing on the interplay between blockchain technology and social sustainability within supply chains.

This approach allowed us to efficiently distil key insights and identify gaps in the current body of knowledge, laying a robust foundation for our investigation. Through this meticulous process, we aimed to map the landscape of blockchain technology's potential to foster social sustainability in supply chains, guided by scholarly rigor and a focus on relevance to our research objectives.

Table I. Procedure for selection of articles in this review paper

Step	Details	No. of articles
Step 1: Keywords search	Keywords used in search space of title and abstract were "supply chain" OR "logistics" OR "distribution" OR "supply chain management" OR "supply network" AND blockchain* OR "distributed ledger technology" OR "smart contracts" OR "cryptocurrency" OR "digital ledger" OR "decentralized systems" AND "social sustainability" OR "social responsibility" OR "ethical sourcing" OR "fair trade" OR "social impact" OR "social equity" OR "labor rights" OR "sustainability" OR "social justice" OR "modern slavery"	668
Step 2: 1st stage of filtering of articles	Inclusion criteria: only peer-review articles Language of paper: English Year of publication: from 2016 to 2023	430
Step 3: 2nd stage of filtering of articles	Removal of duplicate and irrelevant papers Abstract analysis	142
Step 4: Final selection of articles	Full paper analysis	40

Total	40

Table II below, present articles inclusion and exclusion criteria.

Table II. Articles inclusion and exclusion criteria

Inclusion Criteria	*Exclusion Criteria*
● *Articles that were specifically addressed social issues within the supply chain and the application of blockchain technology in supply chain management.* ● *Peer-review articles and written in English.*	● *Articles that were solely concentrated on supply chain topics without a direct emphasis on social issues, or those that solely focused on social issues without a direct linkage to supply chains.* ● *Written in other languages.*

Articles that solely focused on supply chains without addressing social issues, or those that discussed social issues without linking to supply chains, were excluded from further analysis. This refinement process narrowed the selection from 142 to 40 relevant articles, as illustrated in Fig. 1.

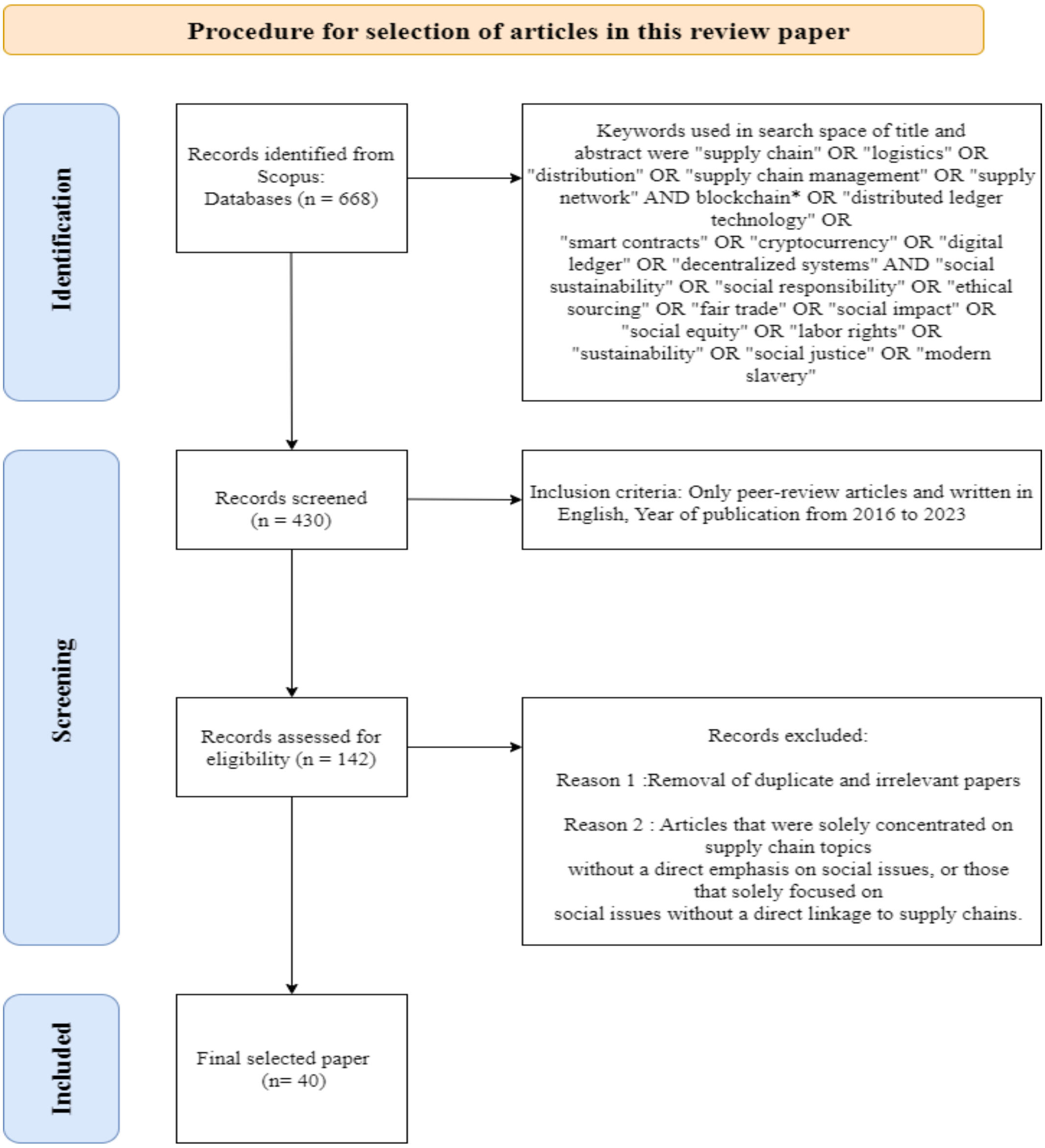

Figure 1. Procedure for selection of articles in this review paper

Figure 2 depicts a word cloud constructed from the author-provided keywords of the 40 articles under consideration generated by wordclouds.com.

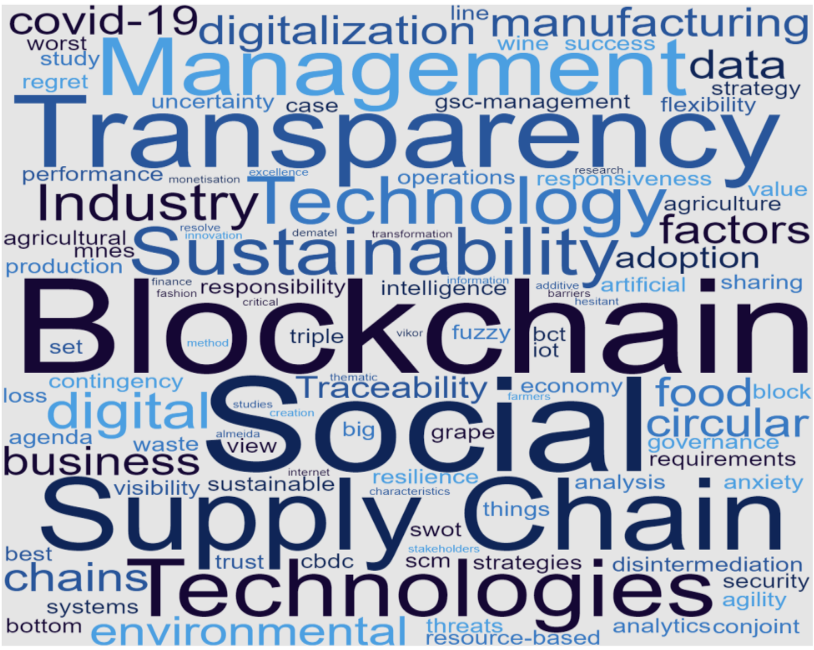

Figure 2. Word cloud of selected literature review

3. Descriptive analysis

In our descriptive analysis, we observed key trends in the literature on leveraging blockchain technology for social sustainability in supply chains, focusing on the period from 2018 to July 2023 as seen in Figure 3. A significant uptick in research interest was noted starting in 2020, evidenced by a substantial number of publications in this field. This trend underscores the growing academic and practical recognition of blockchain's potential in enhancing supply chain operations. While the volume of publications in 2023 appears lower, this may be due to incomplete data for the year.

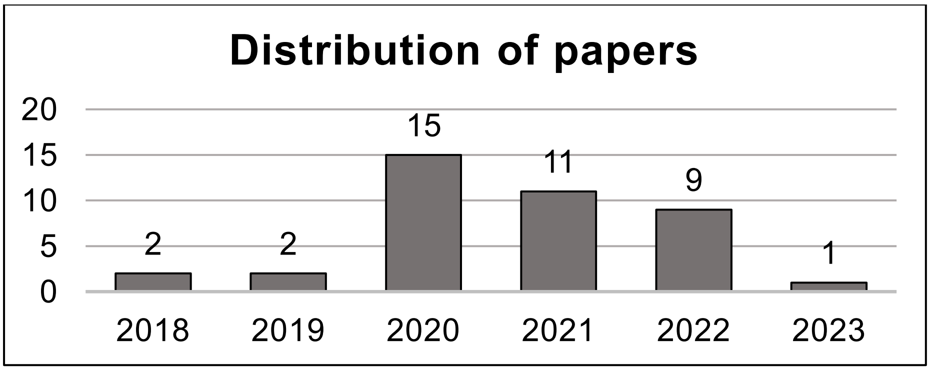

Figure 3. Distribution of papers published from 2018 through July 2023

Our analysis also revealed a preference for theoretical and conceptual research methodologies among the studies reviewed, indicating a foundational phase in exploring blockchain's applications and implications for social sustainability in supply chains. Geographically, the United States and China emerged as leading contributors, reflecting their pivotal roles in blockchain technology research and application as shown in Figure 4. The United Kingdom and India also showed significant engagement, highlighting the global interest in this topic.

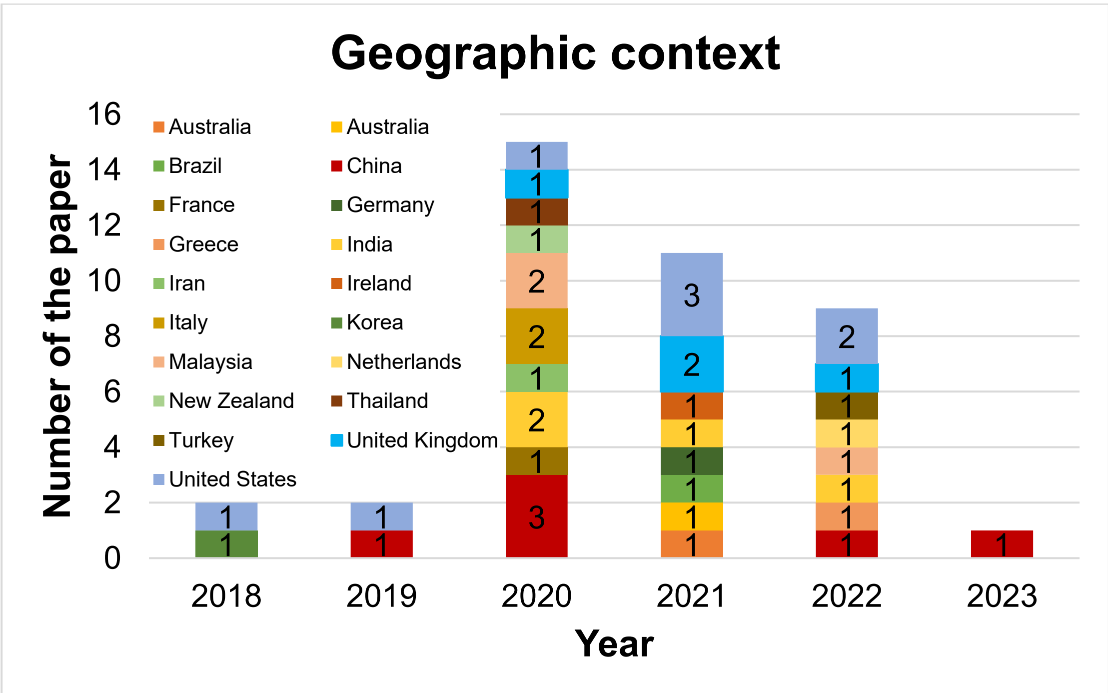

Figure 4. Distribution of geographic context

Moreover, the diversity in journal publications, with the "International Journal of Information Management" and the "International Journal of Production Research" among the top contributors, suggests a wide-ranging disciplinary interest. This multidisciplinary appeal underscores the comprehensive impact of blockchain technology across different facets of supply chain management and sustainability.

These trends collectively point to an evolving research landscape, where the exploration of blockchain technology in the context of sustainable supply chain management is expanding both in depth and geography, signalling a broad, interdisciplinary interest and a promising avenue for future research.

4. Thematic analysis

Our research adopts a mixed-method approach that incorporates abductive reasoning (Bell et al., 2022). This approach begins with an established foundation in supply chain knowledge, distributed ledger technologies, and an awareness of current academic discussions on social sustainability. We then meticulously analyse selected articles to identify emerging themes, which include catalysts, barriers, issues, conflicts, practices, and the effectiveness of blockchain technology in enhancing social sustainability within supply chains. This methodology not only allows for a grounded analysis based on existing knowledge but also facilitates the discovery of new insights and perspectives through a systematic examination of the literature (Bell et al., 2022).

We selected The Technology-Organization-Environment (TOE) framework that provides a comprehensive approach to understanding the factors influencing the adoption of technological innovations (Kuan and Chau 2001). This framework encapsulates three key aspects that influence a firm's technological adoption: Technological (T), Organizational (O), and Environmental (E) contexts (Baker 2012). The Technological context focuses on the features and accessibility of the technological innovation. The Organizational context pertains to the structure of the firm, its available resources, and internal communication dynamics. The Environmental context encompasses market dynamics, industry characteristics, and regulatory landscapes. As blockchain represents a novel technological innovation, the drivers propelling its application towards achieving social sustainability in supply chains can be examined within the purview of the TOE framework.

4.1 Drivers

In exploring the facilitators for blockchain adoption in supply chains, it becomes evident that certain driving forces are pivotal in encouraging organizations to embrace this technology for enhancing social sustainability. The drivers of leverage blockchain technology towards social sustainability in supply chains are presented in Appendix 1.

4.1.1 Technological context

Blockchain traceability

Blockchain technology inherently possesses characteristics of traceability (Saberi et al., 2019). The capability of identifying and verifying the components and sequence of events within supply chains is facilitated by production and logistics traceability (Zhang et al., 2012). Hastig and Sodhi (2020) highlight that blockchain technology is considered by various stakeholders as a key mechanism to eliminate forced child labor from the cobalt supply chain and a blockchain-enabled system for tracking cobalt could flag output from dubious mines and highlight if seemingly legitimate mines are generating quantities greater than anticipated, implying potential mineral blending (Hastig and Sodhi, 2020). Additionally, traceability is crucial for ensuring the quality and safety of food products. Although traditional Internet of

Things (IoT) traceability systems offer practical means for monitoring the quality and tracing the origins of food across supply chains, these systems predominantly function on a centralized server-client model. This centralization often restricts consumers from accessing complete transaction data and authenticating the provenance of products. Solutions built on blockchain bolster the trust mechanisms of traceability, offering consumers and stakeholders a more reliable system (Feng et al., 2020).

Blockchain transparency

Supply chain transparency pertains to the availability of information to both end-users and firms within a supply chain (Francisco and Swanson, 2018). The absence of transparency in supply chains can engender a myriad of challenges, particularly those related to business, environmental, and social responsibilities. These concerns are accentuated by heightened pressures placed on organizations due to factors such as supply chain cost efficiency, safety imperatives, and the demand for ethical production practices (Bai and Sarkis, 2020). According to Kouhizadeh et al. (2021), By mitigating information asymmetries, blockchain technology can alleviate social and financial burdens often experienced by smaller entities and farmers, thus fostering a more equitable supply chain ecosystem. Moreover, blockchain's inherent transparency features can significantly curtail unethical practices, corruption, and counterfeiting, thereby fortifying its contribution to the enhancement of social sustainability within supply chains. The augmented transparency afforded by blockchain technology within supply chains can enhance accountability measures which serve to identify and hold culpable parties responsible for social and individual transgressions, contributing to a more transparent and fair supply chain environment (Venkatesh et al., 2020).

Smart contract

Smart contracts are governed by predefined stipulations encompassing regulations and punitive measures, which are constructed on the blockchain using a Turing-complete contract language (Upadhyay et al., 2021). Such an approach not only allows the creation but also the autonomous execution of intricate contracts and the stipulations of these contracts are transparently accessible to every node within the blockchain network (Upadhyay et al., 2021). Activation of a smart contract occurs upon receipt of specific data, which is then evaluated against its present contract terms. When these conditions align, the desired outcome transpires, namely, the transaction is completed. Smart contracts serve to automate transactions within the supply chain, thereby enhancing operational efficiency and reducing the propensity for human-induced errors and cost.

Reliability

Guaranteeing human rights forms the bedrock of a company's social sustainability certification. Elements such as fair working conditions, working hours, living wages, social welfare, and equity are all integral to labor and human rights in supply chain social sustainability (Hutchins and Sutherland, 2008). Upadhyay et al. (2021) illuminated the potential of blockchain technology in affirming consumer confidence with regards to ethical production and supply chain practices. Specifically, they underscored how blockchain can help provide assurances to customers that the products they purchase are free from child labour and that human rights were upheld throughout the production and supply chain process. Venkatesh et al. (2020) contends that through a blockchain network, retailers, governments, and NGOs can access workers' working hours, thereby determining whether companies are infringing upon overtime restrictions and if living wages are being disbursed in a timely manner. These actions and endeavors are documented within the blockchain network, which can be seen as a tool for substantiating social sustainability certifications. Blockchain technology offers an array of features tailored to bolster modern supply chains, with key attributes including unparalleled transparency, trustworthiness, and security of data, and the elimination of intermediaries, positioning it as a compelling choice for supply chain advancements (Kouhizadeh et al., 2021).

Data immutability

Saberi et al. (2019) opined that owing to its technical features, blockchain technology prevents unauthorized modifications to information and offering a robust deterrent against asset seizure by unscrupulous individuals, governmental entities, or organizations. Workplace health and safety is a significant aspect that focuses on the well-being and safety of employees within their working environment. Negligence of proper health and safety practices can lead to reduced work productivity and potentially grave incidents and risks (Haas and Yorio, 2016). According to Venkatesh et al. (2020), the integration of blockchain technology within a supply chain can facilitate the creation of immutable records, such as the presence of necessary fire and building safety certifications. Relevant authorities, third-party assessment agencies, and industry associations may play a role in constructing the blockchain by issuing and validating these certifications. Blockchain's ability to integrate with other technologies can enhance its utility in managing complex supply chain processes, thus driving its adoption. For example, environmental data associated with work conditions can be gathered by Internet of Things (IoT) technologies and then stored on the blockchain network. This data can be exploited to enhance workplace environment management and overall business performance (Venkatesh et al., 2020).

4.1.2 Organisational context

Organizational Structure

While the expertise needed may be extensive, the expenditure required to develop a blockchain-based system is not beyond reach, particularly for larger businesses with abundant resources. Zhang et al. (2020) believed that these businesses should consider investing in this novel technology as a means to enhance their sustainability performance and bolster their reputation. Recent empirical research indicates that shareholders tend to reward businesses that excel in sustainability and penalize those that overlook their social responsibilities. Large businesses, with their influence and resources, are in a prime position to encourage their supply chain partners and incentivize them towards the adoption of blockchain technology. In terms of internal corporate control, Venkatesh et al. (2020) proposes a system architecture for a Blockchain-Based Supply Chain Social Sustainability Management (BSCSSM) system. This system is anticipated to consistently provide feedback on social sustainability performance throughout the supply chains to focal firms and their stakeholders, thereby enhancing the transparency of compliance and follow-up processes.

Internal Communication Dynamics

Managerial readiness to support or pose barriers to technology adoption serve as indicators of whether companies possess the requisite technical and financial resources for technological ventures (Wong et al., 2020). The term "upper management support" delineates the extent to which senior leadership grasps the significance of, and is actively involved in, the adoption of technologies like blockchain (Wong et al., 2020). A strong directive from the top serves as a powerful motivator and aligns the organization towards SCM goals (Fawcett et al., 2006; Hohn and Durach, 2023). Decisions surrounding adoption are profoundly influenced by managerial challenges (Bai and Sarkis, 2020), and these decisions are frequently aligned with a firm's strategic objectives, particularly during technological implementations (Wong et al., 2020).

4.1.3 Environmental context

Regulatory Landscape and Industry Pressure

Sustainability is viewed as a balance between environmental, social, and economic aspects, often referred to as the triple bottom line (Seuring et al., 2008). The push for Sustainable Supply Chain Management (SSCM) has social, competitive, and regulatory underpinnings (Kouhizadeh et al., 2021). The implementation of Supply Chain Compliance (SCC) has recently come under intense scrutiny due to a multitude of issues requiring vigilant monitoring and follow-up audits. This is particularly the case in the aftermath of major industrial incidents, including the labor exploitation scandal at Unilever, the collapse of the Rana Plaza building, employee suicides at Foxconn, and fire accidents in Karachi (Venkatesh et al., 2020). Such incidents do more than just tarnishing the brand reputation; they also bring into question the governance of social sustainability compliance and the efficacy of its monitoring mechanisms across various layers of the supply chain. These developments underscore the urgency for more rigorous and transparent systems to ensure adherence to social sustainability standards throughout the entire supply chain.

Consumer Expectations

The emphasis on supply chain sustainability has grown exponentially, becoming a significant driver for consumer demand and loyalty. With the proliferation of digital media, end consumers are now better informed and anticipate instantaneous updates and information. Their growing awareness has led to heightened expectations around the provenance of the product, with a particular emphasis on its environmental and social sustainability credentials (Kittipanya-ngam and Tan, 2020).

4.2 Barriers

Implementing blockchain for social sustainability in supply chains faces several critical barriers, categorized into intra-organizational, inter-organizational, system-related, and external factors.

4.2.1. Intra-organizational challenges include management's reluctance to embrace new technologies due to perceived risks or misalignment with core values (Kouhizadeh et al., 2021; Mangla et al., 2017), resistance within the organizational culture to change existing systems or practices (Gorane and Kant, 2015; Mougayar, 2016), and a general lack of understanding or knowledge about blockchain technology (Kouhizadeh et al., 2021; Mougayar, 2016).

4.2.2. *Inter-organizational barriers* involve issues such as concerns over data privacy and the reluctance to share information that could undermine competitive advantage (Saberi et al., 2019; Kouhizadeh et al., 2021), and the diversity in capacity and readiness among supply chain members, which can hinder cohesive adoption and integration of blockchain solutions (Saberi et al., 2019; Wong et al., 2020).

4.2.3. System-related obstacles are highlighted by the nascent state of blockchain technology, presenting scalability, usability, and interoperability challenges (Saberi et al., 2019), along with concerns about energy consumption due to the computationally intensive processes required (Kouhizadeh et al., 2021).

4.2.4. External factors include regulatory uncertainties and the absence of supportive policies (Kamble et al., 2019; Govindan et al., 2018), market competition and uncertainty which may deter firms from adopting new technologies (Kouhizadeh et al., 2021; Mangla et al., 2017), and the need for engagement with external stakeholders to ensure the technology's acceptance and alignment with social sustainability goals (Kouhizadeh et al., 2021).

Addressing these barriers is essential for the successful adoption of blockchain in enhancing social sustainability within supply chains, requiring strategic planning, education, and collaboration among all stakeholders involved.

4.3 Applications of Blockchain in Supply Chain for Social Sustainability:

4.3.1 Enhancing Traceability

Blockchain's integration with IoT and big data analytics is pioneering unprecedented traceability in supply chains. This synergy offers real-time visibility into product origins and lifecycle, meeting the consumers' demands for sustainability and safety. Examples include the Responsible Sourcing Blockchain Network (RSBN), which tracks cobalt from mines to manufacturing facilities, ensuring transparency and ethical sourcing (Song et al., 2018; Kittipanya-ngam and Tan, 2020; Venkatesh et al., 2020; Feng et al., 2020; Kshetri, 2022).

4.3.2 Improving Transparency: Blockchain is instrumental in addressing transparency challenges within vulnerable supply chains, such as cocoa. By facilitating access to crucial trading information and enabling direct transactions, blockchain platforms like the Olam Farmer Information System (OFIS) promote sustainable practices and greater fairness in industries previously riddled with corruption and deception (Bai et al., 2022; Quayson et al., 2020).

4.3.3 Assuring Ethical Sourcing

Blockchain technology is reforming sourcing practices to assure transparency and ethical dealings. In Colombia's coffee sector, iFinca's blockchain solution provides detailed insights about the coffee's journey and the farmers behind it, ensuring fair compensation and ethical practices are maintained throughout the supply chain (Chaudhuri et al., 2021).

4.3.4 Empowering Marginalized Stakeholders

In sectors like mining, blockchain technology offers a platform for marginalized groups such as artisanal and small-scale miners, ensuring their representation and compliance with sustainability standards. Through platforms like Circulor, blockchain facilitates the traceability of raw materials, promoting ethical sourcing practices and empowering those at the lower tiers of the supply chain (LeBaron, 2021; Kshetri, 2022).

In summary, blockchain technology is playing a pivotal role in making supply chains more transparent, traceable, ethical, and inclusive, addressing both consumer demands and the needs of marginalized stakeholders.

5. Discussion & Conclusion

This paper investigates the drivers, barriers, and practices involved in integrating blockchain technology into supply chains to enhance social sustainability. Understanding the interconnections among these drivers, barriers, and practices is crucial for advancing the adoption of blockchain technology to foster social sustainability within the supply chain. These interconnections are illustrated through the conceptual framework presented in Figure 7.

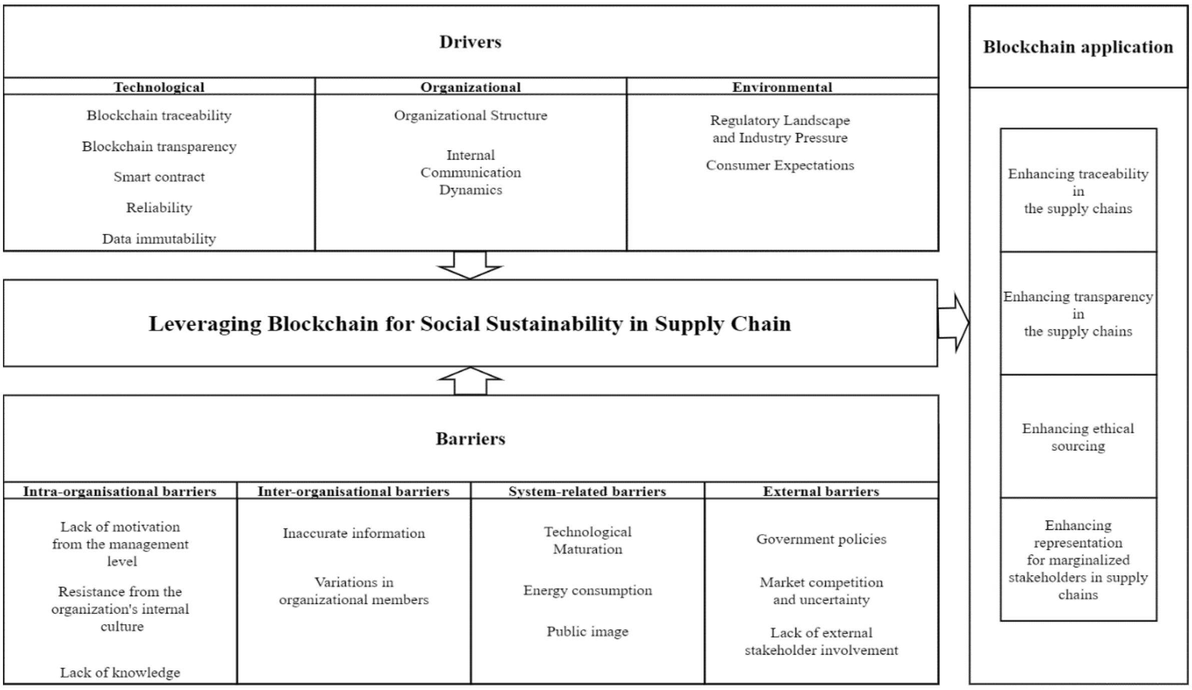

Figure 5. Conceptual framework

In our study, we thoroughly address two pivotal research questions. The first, RQ1: "What are the drivers and barriers to adopting blockchain in supply chains for social sustainability?" is meticulously answered through our literature review. We delineate a range of factors - technical, organizational, and environmental - that influence blockchain adoption, providing insights into both the catalysts for and the challenges against its implementation in enhancing social sustainability.

For the second research question, RQ2: "How does blockchain technology contribute to social sustainability in supply chains?" our review methodically illustrates blockchain's significant role. We delve into how blockchain technology not only enhances traceability and transparency but also promotes ethical practices and empowers marginalized supply chain participants. This analysis extends beyond mere identification, offering a deeper understanding of the multifaceted impact of blockchain on social sustainability within supply chains, and how it might shape future practices and policies in this evolving field.

5.1 Contribution to Research and Practice

Though it is still in its infancy, the multidisciplinary study field at the nexus of digitalisation and sustainability trends is expanding quickly (Despeisse, et. al 2022). The study reveals several key considerations for utilizing blockchain in supply chain social sustainability. Firstly, despite some industries being extensively studied, there is a pressing need for evidence-based research across a wider range of industries to fully understand blockchain's impact on social sustainability. Secondly, the current academic discourse reveals a significant gap in theories specifically addressing social sustainability within supply chains. This gap underscores the necessity for a comprehensive framework capable of both quantifying and accurately evaluating this dimension of sustainability. Thirdly, while the decentralization of blockchain offers inherent benefits in terms of trust and transparency, it also presents challenges in contexts where overarching control is required.

In addressing the balance between decentralization and control within blockchain applications for social sustainability in supply chains, it is essential to consider the unique attributes and purposes of both public and private blockchains. Public blockchains, characterized by their decentralization, provide unmatched transparency and security, making them ideal for fostering trust in supply chain sustainability practices. They enable transparent product tracking, verification of ethical sourcing, and assurance of fair labour practices, which are vital for social sustainability.

Conversely, private blockchains offer a more controlled environment, granting selective access to participants. This is beneficial for supply chains needing to protect sensitive data or to comply with specific industry regulations. While they sacrifice some degree of decentralization, private blockchains offer improved scalability and efficiency, crucial for managing large, complex supply chains. A hybrid approach, incorporating elements of both public and private blockchains, might provide an optimal solution in some cases, leveraging the transparency of public blockchains for external validation of sustainability practices, while using private blockchains for internal processes requiring confidentiality.

Ultimately, the decision to use public, private, or hybrid blockchains in enhancing social sustainability in supply chains should be driven by the specific needs and context of each supply chain, balancing the need for transparency and trust with that of control and efficiency.

Despite various proposed governance models, an in-depth exploration of these models is essential and the regulatory landscape surrounding blockchain remains unclear, highlighting the need for clear, industry-specific guidelines and legal frameworks.

Numerous scholars have contributed to the discourse on social sustainability in blockchain-based supply chains, examining its structure, governance mechanisms, barriers, and themes (Saberi et al., 2019; Kouhizadeh et al., 2021; Hastig and Sodhi, 2020; Erol et al., 2022; Bai and Sarkis, 2020). Many researchers have pointed out that the adoption of blockchain technology for fostering social sustainability within the supply chain is still in an embryonic stage, calling for more detailed inquiries (Saberi et al., 2019; Kouhizadeh et al., 2021; Christ and Helliar, 2021; Venkatesh et al., 2020). Specifically, there is a need for more comprehensive analysis that includes the implications and impacts on external stakeholders (Kouhizadeh et al., 2021). This paper introduces the relatively unexplored concept of leveraging blockchain for social sustainability in supply chains, establishing a conceptual framework through thematic analyses of drivers, barriers, and practices.

5.2 Limitations and Future Research Avenues

Our investigation into the integration of blockchain technology for social sustainability in supply chains identifies several promising areas for future research. The current literature, predominantly focused on specific industries like the food sector (Kittipanya-ngam and Tan, 2020; Bai et al., 2022), mining (Kshetri, 2022), personal protective equipment (Wang, 2023), and certain developing countries (Kshetri, 2021; Wong et al., 2020), suggests the need for a broader application across a range of industries. This expansion is crucial for a more comprehensive understanding of blockchain's impact on supply chain social sustainability.

Furthermore, there is a notable lack of theoretical frameworks specifically addressing social sustainability within supply chains. The development of such frameworks is critical for a more precise and quantifiable evaluation of this sustainability dimension (Saberi et al., 2019; Kouhizadeh et al., 2021). Future research should focus on formulating these frameworks to facilitate both academic understanding and practical application in diverse supply chain contexts.

The Multi-Level Perspective (MLP) could offer a robust theoretical framework for future research into strengthening social sustainability in supply chains through blockchain technology. This theory dissects the interaction between technological innovations, like blockchain, and the existing systems at three levels: the niche, the regime, and the landscape (Geels, 2019). In the context of supply chains, MLP can illuminate how blockchain as a niche innovation, challenges and integrates into established practices, revealing both obstacles and opportunities for enhancing social sustainability.

By employing MLP, future researchers could gain a holistic view of how blockchain technology can transition into mainstream supply chain practices by considering broader socio-technical factors such as global economic trends, regulatory environments, and cultural norms. This approach has been vital for developing actionable strategies for businesses and policymakers (Skeete, 2019), and therefore could guide future stakeholders towards more sustainable, transparent, and equitable supply chain ecosystems.

Additionally, while the decentralization of blockchain offers transparency and trust benefits, challenges in governance and regulatory frameworks remain underexplored. The need for in-depth examination of governance models, such as network participant-driven governance (Saberi et al., 2019), and smart contract-enabled oversight (Venkatesh et al., 2020), as well as a clearer understanding of the legal and regulatory environment surrounding blockchain (Kouhizadeh et al., 2021), is evident.

Finally, from a technology perspective, as organizations use blockchain to support social sustainability in supply chains, the rapid advancements in artificial intelligence (AI) present both challenges and opportunities. One key concern is the potential of advanced AI models to break the cryptographic protocols on which blockchain security heavily relies. This risk is particularly relevant as blockchain's immutable ledger is crucial for ensuring transparency and trust in sustainable practices across supply chains.

However, the field of cryptography, integral to blockchain technology, is continuously evolving. Development of more robust encryption methods is ongoing, like quantum-resistant algorithms (Allende et al., 2023; Chawla and Mehra, 2023), to mitigate potential AI-related security threats. This evolution is vital for maintaining the integrity of blockchain networks that track and verify socially sustainable practices in supply chains.

Moreover, the resilience and adaptability of blockchain technology means that it can evolve alongside emerging AI capabilities. The integration of AI with blockchain can enhance supply chain management, offering improved analytics and operational efficiency. For organizations focused on social sustainability, this integration could lead to more effective monitoring and reporting of sustainable practices.

Thus, while the advancements in AI necessitate vigilance regarding blockchain security, they also offer avenues for enhanced performance in supporting social sustainability. Organizations must stay informed about the latest developments in AI and cryptography to ensure their blockchain systems remain secure while leveraging the potential of AI to advance their sustainability goals. This balanced approach is crucial for maintaining the integrity and effectiveness of blockchain applications in socially sustainable supply chains.

This study lays the groundwork for these future explorations, aiming to enhance the understanding of blockchain's potential and its limitations in the realm of sustainable supply chain management.

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Appendix I. Drivers of leverage blockchain technology towards social sustainability in supply chains

Category	Specific driver	Sources
Technological	Blockchain traceability	Saberi et al. (2019); Hastig and Sodhi (2020); Feng et al. (2020); Kouhizadeh and Sarkis (2018); Venkatesh et al. (2020); Upadhyay et al. (2021); Chang and Chen (2020); Kittipanya-ngam and Tan (2020); Friedman and Ormiston (2022); Khan et al. (2022); Chaudhuri et al. (2021); Sahoo et al. (2022); Wang et al. (2023); Kshetri (2022).
	Blockchain transparency	Saberi et al. (2019); Kamble et al. (2020); Wong et al. (2020); Bai and Sarkis (2020); Venkatesh et al. (2020); Chang and Chen (2020); Ko et al. (2018); Kshetri (2021); Friedman and Ormiston (2022); Mukherjee et al (2022); Massaro et al. (2020); Erol et al. (2022); Bai et al. (2022); McGrath et al. (2021); Kshetri (2022).
	Smart contract	Yadav and Singh (2020); Upadhyay et al. (2021); Chang and Chen (2020); Sahebi et al. (2020); Mukherjee et al (2021).
	Reliability	Upadhyay et al. (2021); Kouhizadeh et al. (2021); Kamble et al. (2020); Yadav and Singh (2020); Kittipanya-ngam and Tan (2020); Mukherjee et al (2022); Schinckus (2020); Massaro et al. (2020); Bechtsis et al. (2022); Asokan et al. (2022); Venkatesh et al. (2020).
	Data immutability	Yadav and Singh (2020); Friedman and Ormiston (2022); Mukherjee et al (2022); Massaro et al. (2020); Bechtsis et al. (2022); Christ and Helliar (2021); Venkatesh et al. (2020); Saberi et al. (2019).
Organizational	Organizational Structure	Kouhizadeh et al. (2021); Zhang et al. (2020); Kshetri (2021); Hervani et al. (2022); Adams et al. (2021); Chaudhuri et al. (2021); McGrath et al. (2021).

	Internal Communication Dynamics	Wong et al. (2020); Bai and Sarkis (2020); Di and Varriale (2020); Chang and Chen (2020); Park and Li (2021); Khan et al. (2022); Hervani et al. (2022).
Environmental	Regulatory Landscape and Industry Pressure	Kamble et al. (2020); Saberi et al. (2019); Wong et al. (2020); Kouhizadeh et al. (2021); Choi and Luo (2019); Kshetri (2021); Erol et al. (2022); Christ and Helliar (2021).
	Consumer Expectations	Choi and Luo (2019); Kittipanya-ngam and Tan (2020); Kshetri (2021).

Appendix II. Barriers of leverage blockchain technology towards social sustainability in supply chains.

Category	Barriers	Sources
Intra-organisational barriers	Lack of motivation from the management level	Saberi et al. (2019); Kouhizadeh et al. (2021); Kamble et al. (2020); Bai and Sarkis (2020); Venkatesh et al. (2020); Hervani et al. (2022); Erol et al. (2022); Bai et al. (2022); Christ and Helliar (2021).
	Resistance from the organization's internal culture	Saberi et al. (2019); Kouhizadeh et al. (2021); Kamble et al. (2020); Venkatesh et al. (2020); Friedman and Ormiston (2022); Asokan et al. (2022).
	Lack of knowledge	Saberi et al. (2019); Kouhizadeh et al. (2021); Kamble et al. (2020); Kouhizadeh and Sarkis (2018); Wong et al. (2020); Venkatesh et al. (2020); Zhang et al. (2020); Bai et al. (2022); Christ and Helliar (2021).
Inter-organisational barriers	Inaccurate information	Saberi et al. (2019); Kouhizadeh et al. (2021); Kamble et al. (2020); Hastig and Sodhi (2020); Wong et al. (2020); Choi and Luo (2019); Venkatesh et al. (2020); Upadhyay et al. (2021); Kshetri (2021); Friedman and Ormiston (2022); Mukherjee et al (2022); Christ and Helliar (2021); Chaudhuri et al (2021); McGrath et al. (2021); Asokan et al. (2022); Kshetri (2022); Khan et al. (2022).
	Variations in organizational members	Saberi et al. (2019); Kouhizadeh et al. (2021); Kamble et al. (2020); Friedman and Ormiston (2022); Hastig and Sodhi (2020); Wong et al. (2020); Venkatesh et al. (2020); Kittipanya-ngam and Tan (2020); Upadhyay et al. (2021); Kshetri (2021); Mukherjee et al (2022); Christ and Helliar (2021); Kshetri (2022).

System-related barriers	Technological Maturation	Saberi et al. (2019); Kouhizadeh et al. (2021); Kamble et al. (2020); Feng et al. (2020); Wong et al. (2020); Esmaeilian et al. (2020); Venkatesh et al. (2020); Zhang et al. (2020); Ko et al. (2018); Kshetri (2021); Sahebi et al. (2020); Asokan et al. (2022); Kshetri (2022); Di and Varriale (2020).
	Energy consumption	Saberi et al. (2019); Kouhizadeh et al. (2021); Esmaeilian et al. (2020); Feng et al. (2020); Venkatesh et al. (2020); Böckel et al. (2021); Schinckus (2020).
	Public image	Saberi et al. (2019); Kouhizadeh et al. (2021); Ko et al. (2018).
External barriers	Government policies	Saberi et al. (2019); Kouhizadeh et al. (2021); Kamble et al. (2020); Feng et al. (2020); Wong et al. (2020); Choi and Luo (2019); Venkatesh et al. (2020); Upadhyay et al. (2021); Zhang et al. (2020); Ko et al. (2018); Kshetri (2021); Sahebi et al. (2020); Friedman and Ormiston (2022); Bechtsis et al. (2022); Christ and Helliar (2021); Wong et al. (2020); Esmaeilian et al. (2020).
	Market competition and uncertainty	Saberi et al. (2019); Kouhizadeh et al. (2021); Wong et al. (2020); Sahebi et al. (2020).
	Lack of external stakeholder involvement	Saberi et al. (2019); Kouhizadeh et al. (2021); Wong et al. (2020).