The Impact of Blockchain on Supply Chains: A systematic Review

Jakia Sultana
RMIT University, Melbourne, Australia

Say Yen Teoh
RMIT University, Melbourne, Australia
sayyen.teoh@rmit.edu.au

Stan Karanasios
University of Queensland, Brisbane, Australia

Abstract

Supply chains face many challenges around coordination, information asymmetry, quality assurance, complex disruptions, and traceability. Blockchain is arguably a technology that can address these challenges and make a significant impact. To shed light on the impact of blockchain, we undertake a cross-discipline systematic literature review on blockchain and supply chains. This review focused on identifying blockchain's current and proposed impacts on the supply chain at three levels: organisational, inter-organisational, and industry. The findings identified twelve core supply chain themes across pre-implementation, post-implementation, and emerging tensions associated with adopting blockchain. These findings extend knowledge by going beyond understanding blockchain and its application and articulating multi-levels of impacts. Based on our review, we propose future research directions. By providing an overview of the current impact of blockchain, the review also offers insights to help managers to make informed decisions around the implementation and use of blockchain in supply chains.

Keywords: Blockchain, impact, levels, supply chain, systematic review.

1 Introduction

There has been rapid growth in blockchain research across various academic disciplines. Within the field of information systems (IS), researchers view blockchain as a 'revolution' (Gomber et al., 2016) or as 'transformative' (Beck et al., 2016; Kshetri, 2018; Puschmann et al., 2018), echoing trends in the technology-practitioner, media and the wider academic community. Most early research focused on blockchain in banking and capital markets (Beck et al., 2016; Egelund-Müller et al., 2017; Guo & Liang, 2016). Recently academics, media and industry have discussed blockchain in different settings, such as in business (Attaran & Gunasekaran, 2019; Li et al., 2018), academia (Treiblmaier et al., 2020), healthcare (Kumari & Saini, 2020), supply chain (Di Vaio & Varriale, 2020; Korpela et al., 2017) and government (Allen et al., 2019).

One area that has received much attention is the supply chain (Bai & Sarkis, 2020; Kshetri, 2018; Treiblmaier, 2018). Supply chains face challenges such as coordination, information asymmetry, quality assurance, the complexity of disruptions, and traceability (Chang et al., 2020; Etemadi et al., 2021). Organisations in supply chains also struggle with counterfeited products and illegal practices (de Boissieu et al., 2021). Numerous examples of such practices exist. For instance, the toxic industrial chemical melamine was found in milk powder in China,

horse meat was found in beef labelled packaging in Europe, and corn syrup was mixed with honey in Australia (Bedo, 2018; Behnke & Janssen, 2020). According to the FBI's intellectual property rights unit, fraudulent imitations reportedly result in organisations losing almost $600 (USD) billion yearly (Schlesinger & Day, 2019). Such illegal practices trade approximately 3.3% of global trade and continuously growing (Kapadia, 2019). According to the international chamber of commerce, by 2022, the counterfeited product trade will reach $4.2 trillion and risk 5.4 million jobs (Borrell, 2020). Blockchain is arguably critical to addressing these issues (Chang et al., 2019; Kshetri, 2018; Min, 2019; Tönnissen & Teuteberg, 2020).

Existing studies have predominantly examined how blockchain could benefit supply chains (Akram & Bross, 2018; Korpela et al., 2017; Sternberg & Baruffaldi, 2018) or focused on the design of blockchain solutions (Arena et al., 2019; Chen et al., 2020; Yong et al., 2020). However, a lack of understanding of blockchain's impact on supply chains remains.

This is evident in previous reviews conducted, which, while useful (summarised in Table 1), are limited in understanding impacts across the supply chain in three main ways. First, they focused on the suitability of blockchain to supply chains. Because of this, a second limitation is that they tend to offer a techno-optimistic view because they consider *potential* impact rather than *actual* impact. Third, they zoom in on limited aspects of blockchain of the supply chain (such as information sharing) and hence do not provide an overarching picture of impact across the supply chain network.

Study	Focus
Blossey et al. (2019)	Explored different applications of blockchain in the supply chain
Gurtu and Jestin (2019)	The potential value of blockchain in supply chain management
Pranto et al. (2019)	Understanding the applicability of blockchain technology
Queiroz et al. (2019)	Blockchain applications in supply chain management, challenges of adoption and plan for future research
Wang et al. (2019)	Blockchain impact on future supply chain practices and policies
Chang and Chen (2020)	Potential application and future directions
Pournader et al. (2020)	Co-citation analysis in four clusters and future directions
Wan et al. (2020)	Impact of blockchain technology for information sharing within a supply chain
Lim et al. (2021)	Exploring research on blockchain-based supply chains in terms of value, scholarly attractions, methodologies and industries

Table 1. Previous literature reviews

In particular, existing research and reviews do not provide a comprehensive picture of the impact of blockchain at different levels of the supply chain (e.g., organisational level, inter-organisational level, industry level). Understanding blockchain impact on the supply chain and its succession of impact in a multitiered supply chain is crucial (i) to obtain a deeper understanding of the blockchain and supply chain landscape and realise the value of blockchain, and (ii) to guide future blockchain research. Hence, guided by this motivation, we undertake a systematic review of blockchain and supply chain papers to address the research question: *what is the impact of blockchain on supply chains?* By addressing this research question, we address calls to go beyond understanding what blockchain is and explore its applications (Risius & Spohrer, 2017). While studies tend to focus on the leading business blockchain solution, including Ethereum, IBM Blockchain, Hyperledger Fabric, Hyperledger Sawtooth, R3 Corda, Quorum, etc. (Lawton, 2021); our review is agnostic in terms of blockchain solutions, instead focuses on blockchain in general.

The remainder of the paper is structured as follows. First, we outline our review process and then we present the findings of our systematic review. Our discussion focuses on the impact of blockchain in supply chains at the organisational, inter-organisational, and industry levels, and we outline implications for research and practice. The paper concludes by summarising the key takeaways and identifying the limitations of our research.

2 The Review

A systematic literature review can be described as "a systematic, explicit, and reproducible method for identifying, evaluating, and synthesising the existing body of completed and recorded work" (Fink, 2005, p. 3), which stands on its own as a complete research activity (Okoli & Schabram, 2010). Systematic literature reviews have been crucial for (i) analysing the research progress of a particular phenomenon, (ii) advancing the depth of understanding of a research topic; (ii) synthesising conceptual debate and empirical evidence; (iii) developing theories; and (iv) identifying and providing conceptual pillar for subsequent topics or research domains that need more attention (Okoli, 2015). They help become oriented in an emerging domain and aid in teaching, research, informing policy and supporting practice (Okoli & Schabram, 2010).

The purpose of the systematic review in this paper is to analyse research progress on blockchain in supply chains by synthesising themes to offer an overarching understanding of the impact of blockchain. Such knowledge helps to set the foundation to outline future directions of blockchain research relevant to supply chains.

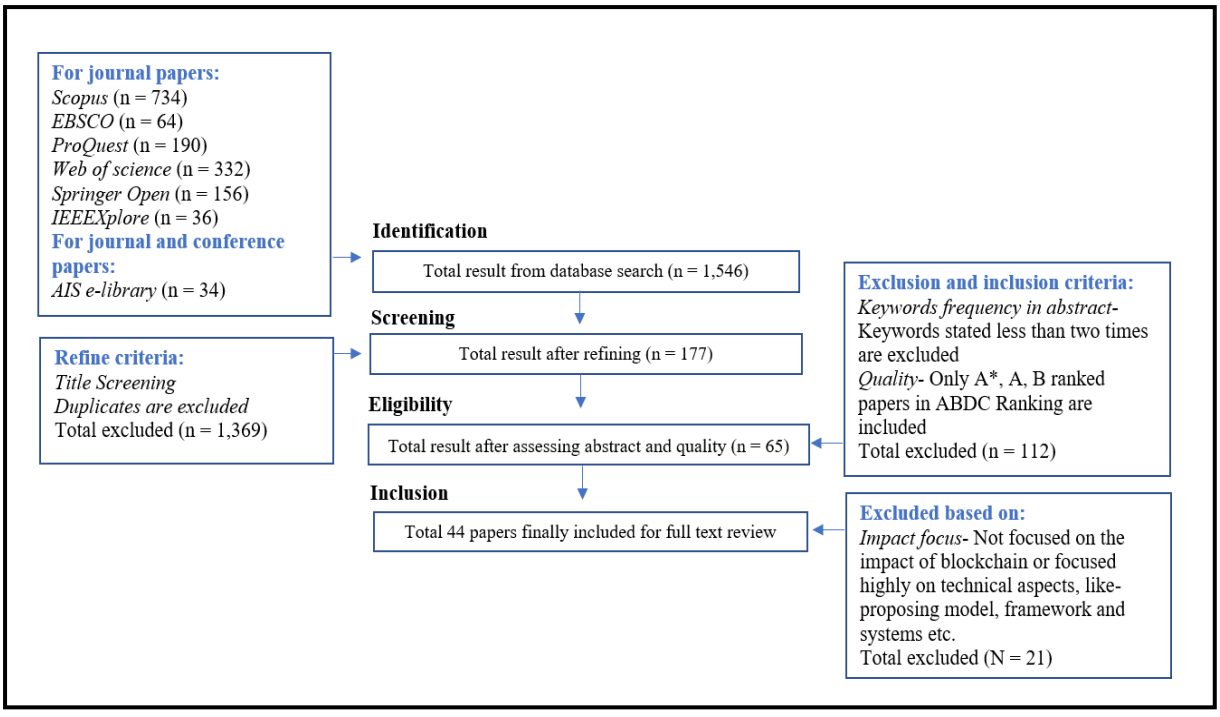

Figure 1. PRISMA framework of the selection process, based on Moher et al. (2009)

Our review followed the "Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA)" guidelines for systematic reviews (Moher et al. 2009). A rigorous and explicit review methodology ensured quality and transparency throughout the review process (Okoli, 2015). It also helped mitigate biases in the selection and review process. PRISMA has

been applied in other reviews of IS phenomenon (Frizzo-Barker et al., 2020; Litchfield & Khan, 2019), as well as in blockchain (Chukwu & Garg, 2020; Kuo et al., 2019) and related management reviews (Paliwal et al., 2020; Rocha et al., 2021).

PRISMA consists of four phases*: identification*, *screening*, *eligibility* and *inclusion*. Figure 1 outlines how these phases were applied in this review. Subsequently, each phase is described in detail.

2.1 Identification

For journal papers, we began our search in critical online academic databases: Scopus, EBSCO, ProQuest, Web of Science, Springer Open, IEEEXplore and AIS e-library. Our research focus demanded a broad search framing to help avoid the risk of missing relevant articles (Pranto et al., 2019). For instance, some databases, such as the AIS e-Library, were more specific in their orientation, although we recognise there is overlap across these databases. Additionally, for conference papers, we considered top IS proceedings AMCIS, PACIS, ECIS, ICIS, and HICSS from the AIS e-library. For conference papers, we limited the search from 2017 because conference articles from 2016 would likely appear as journal articles 3 to 4 years later (Günther et al., 2017).

Based on an initial literature review and external consultation with researchers and practitioners, we selected a set of keywords related to blockchain and supply chain, as listed in Table 2. The search keywords were used primarily on 'title' and in the paper's abstract/keywords/body (dependent on the database search interface) from 2016 to June 2021 (see Appendix A for search queries of different databases). This period was set because even though the introduction of blockchain can be traced to 2008 and the emergence of Bitcoin (Nakamoto, 2008), its application in the supply chain has only attracted industry attention since 2016. After this phase, a total of 1,546 papers were returned.

Search keywords
"blockchain" AND "supply chain"
"blockchain" AND "supply chain management"
"blockchain technology" AND "supply chain management"
"blockchain" AND "SCM"
"distributed ledger technology" AND "Supply chain"
"DLT" AND "Supply chain"
"DLT" AND "SCM"
"blockchain" AND "supply chain" and ("impact" OR "functional" OR "issues" OR "integration" OR "information sharing" OR "performance")

Table 2. Search keywords

2.2 Screening

Because we searched multiple databases, we undertook a further phase of refining the sample papers. Duplicates were identified by exporting all references into Endnote to locate and eliminate duplicates. Furthermore, we screened paper titles to remove papers that were not relevant to blockchain in the supply chain and didn't mention the keywords in the title. Research-in-progress, emergent research forum, and TREO talks were also removed. In total, 1,369 references were removed. Appendix B provides examples of excluded papers of each stage. The next step was filtering papers based on the assessment of eligibility.

2.3 Eligibility

In this phase, we further set the conditions for our review. We first limited the results to high-quality publications. We relied on the Australian Business Deans Council Journal quality list, and selected journals ranked A*, A, or B[1] . This list includes all the IS Senior Scholars' Basket of Journals and leading supply chain journals such as the Journal of Operations Management, Journal of Supply Chain Management, Supply Chain Management Journal, International Journal of Operations and Production Management and International Journal of Production and Economic.

Then, we read each remaining paper abstract to examine if the paper would be suitable for further review. We eliminated papers that did not connect blockchain (or related keywords) with the supply chain or mentioned it less than two times in the abstract. In other words, one of the paper's key focuses had to be on blockchain and the supply chain. Often omitted key papers mentioned blockchain *en passant*, such as an emerging technology or a growing trend (see Appendix B for examples of excluded papers).

2.4 Inclusion

We aimed to arrive at a set of papers for this systematic review focusing on blockchain in the supply chain. We went beyond the title/abstract/keyword in the final phase and examined the remaining papers for deeper relevance. Papers that were technical or did not consider blockchain application or its impact on the supply chain were excluded. This led to excluding papers that proposed technical solutions and frameworks. Whereas the included papers focused on different blockchain features or studied various blockchain issues through the model, analysis of case studies, or empirical data.

As a result, 44 papers were included for analysis. Among these 44 papers, 38 are journal articles from 23 different journals, and 6 are conference papers from two conferences. Of these papers, 75% are conceptual papers, and 25% are empirical. The list of identified papers and a list of outlets with the number of papers are given in Appendix C and Appendix D, respectively.

2.5 Data Analysis Procedures

We followed a multidimensional approach to analyse the papers and provide an in-depth understanding of the impact of blockchain across the supply chain network. We first classified papers based on whether they were concerned with the organisational, inter-organisational and industry levels. We then identified major themes within these levels. This analysis approach helped address our research question in three ways. Firstly, the organisational level review identifies how blockchain impacts organisations and their activities within the supply chain. Secondly, the inter-organisational level review identifies how blockchain impacts the interactions between organisations in the supply chain network. Lastly, the industry level review identifies a more holistic understanding of the blockchain impact from the supply chain industry level. Figure 2 outlines the data analytical process.

To guide the analysis, a review framework (Table A, in Appendix E) was used to guide our analysis. This help to focus the research on the method, findings, limitations and implications

[1] The 2019 List endorses 2,682 journal entries with the following classifications: A* 7.41% (199), A 24.27% (651), B 31.69% (850), C 36.61% (982) https://abdc.edu.au/research/abdc-journal-quality-list/

of the identified papers. Appendix E provides a guide on how we examine the paper and examples of themes with representative data provided.

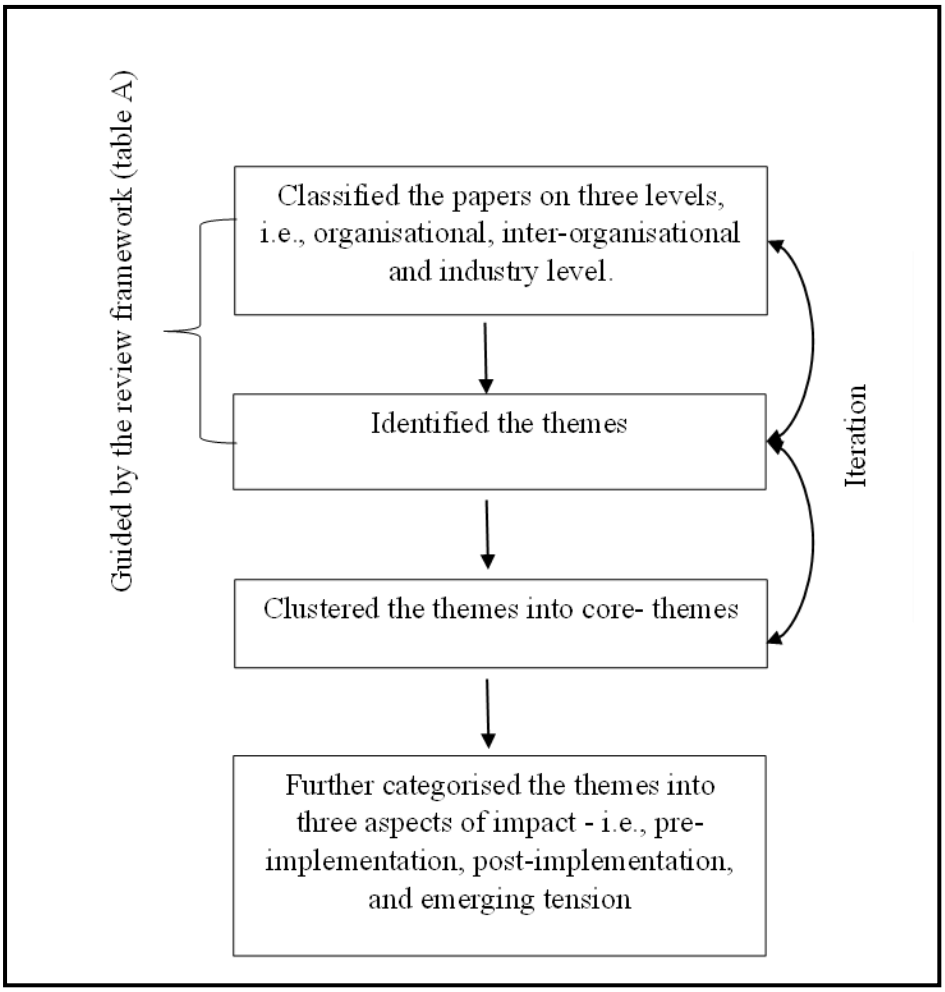

Figure 2. Data analytical process

At the same time, we examined whether the themes represent pre-implementation or post-implementation or focused on emerging tension driven. 'Pre-implementation driven' focuses on the impact of blockchain related to preparations/ conditions that demand before implementing blockchain in the supply chain. 'Post-implementation driven' focuses on the impact of blockchain related to changes blockchain could bring in the supply chain after implementation. 'Emerging tension' focuses on the tensions arising from blockchain implementation in supply chain networks.

3 Findings

This section will present the analysis of the papers and address the research question by understanding the impact of blockchain on the supply chain. After reviewing 44 papers, 12 core themes were identified from three-level of the supply chain. The findings are presented in Table 3 by organisational, inter-organisational and industry levels. Column one categorises the papers by the level, column two shows the main themes, column three summarises the sub-themes, whilst columns four to six indicate the focus on impact. While some of the research that we reviewed cuts across these levels, our categorisation demonstrates the research and progress within each category before making links across these levels of analysis.

Identified core themes, themes, and aspects of the impact					
Levels	**Core themes** (Areas blockchain impact supply chain)	**Themes**	**Current Aspects of Impact**		
			Pre-imple-menta-tion	Post-imple-menta-tion	Emerg-ing Tensio n
Organisational	Supply chain process and business model	Redesign of supply chain process (Chang et al., 2019; Tönnissen & Teuteberg, 2020)	*	*	
		Changes and innovations to business models (Tönnissen & Teuteberg, 2020)	*		
		Transformation of business process (Sunny et al., 2020)	*		
	Efficiency and risk	Reduce the average time of orders (Martinez et al., 2019)		*	
		Reduce transaction costs (Roeck et al. 2020; Schmidt & Wagner 2019; van Hoek 2019, Bumblauskas et al. 2020; Zheng et al. 2019)		*	
		Reduce the risk and cost of product recalls (Bumblauskas et al., 2020)		*	
		Reduce security and operational risk (Choi, 2020; Min, 2019)		*	
		Reduce supply chain risk (Lai et al., 2021)		*	
		Optimise supply chain management (Lai et al., 2021)		*	
		Reduce errors (Rao et al., 2021)		*	
	Visibility, transparency, resilience	Enhance supply chain resilience (Min, 2019)		*	
		Improve visibility (Martinez et al., 2019; van Hoek, 2019)		*	
		Efficient and transparent transactions (Bai & Sarkis, 2020; Schmidt & Wagner, 2019)		*	
		Enhance supply chain transparency and traceability (Ali et al., 2021; Kohler & Pizzol, 2020)		*	
		Enable selective transparency, authenticity and trust (Röck, 2020)		*	
	Profit and performance	Valid and effective measurement of outcomes (Kshetri, 2018)		*	
		Increase profit (Choi, 2020; Hayrutdinov et al., 2020; Zheng et al., 2019)		*	
		Improve supply chain performance (Hald & Kinra, 2019; Wamba et al., 2020)		*	
		Reduce supply chain performance (Hald & Kinra, 2019)			*
		Ensure product quality (Bai & Sarkis, 2020)		*	
		Protect brand images (Howson, 2020)		*	
Inter-organisational	Integration and collaboration	Pre-conditions to adopt blockchain (Behnke & Janssen, 2020; Fan et al., 2020)	*		
		Simplify B2B, supply chain and technology integration (Ali et al., 2021; Korpela et al., 2017)		*	
		Supply chain actors' recursive impact on adoption and integration (Sternberg et al., 2020)		*	
		Enhance collaboration (Ali et al., 2021)		*	
		Required collaboration of actors (Sharma, 2021)	*		

		Integration with supply chain objectives and existing technology is required (van Hoek, 2020)	*		
		Requirement for blockchain-based collaboration (Herm & Janiesch, 2021)	*		
		Challenges in the integration of logistic activities(Sternberg & Baruffaldi, 2018)			*
	Equality in Information, data sharing and management	Data management, safety and decentralisation (Kohler & Pizzol, 2020; Yadav & Singh, 2020)		*	
		Improve information sharing (Hayrutdinov et al., 2020; Zheng et al., 2019)		*	
		Challenges in providing transparency and obtaining tamperproof data (Ghode et al., 2021)			*
		Challenges related to coordination and data sharing (Ghode et al., 2021)			*
		Addressing societal changes (Ghode et al., 2021)			*
		Supply chain parties' willingness to share(Straubert et al., 2021)	*		
		Questioning blockchain information vs real-world information(Straubert et al., 2021)			*
	Inter-organisational trust	Enhance inter-organisational trust among stakeholders (Howson, 2020; Kumar et al., 2020)		*	
		Challenges for inter-organisational trust (Ghode et al., 2020; Ghode et al., 2021)			*
		Enable mutual trust (Röck, 2020)		*	
	Network provenance, relational governance, interdependency	No disintermediation and new reintermediation (Tönnissen & Teuteberg, 2020)	*	*	
		Provenance in the network (Kumar et al., 2020; Rogerson & Parry, 2020)		*	
		Relational governance (Ghode et al., 2020)			*
		Change in power distribution (Roeck et al., 2020)			*
		Reduce dependency (Roeck et al., 2020)		*	
		Governance challenges (Ghode et al., 2021)			*
	Network profit and cost	Choosing a profit-earning product for blockchain (Ghode et al., 2021)			*
		Improve the overall profit of the chain (Hayrutdinov et al., 2020; Zheng et al., 2019)		*	
		Reduce transaction costs of members (Zheng et al., 2019)		*	
Industry	Industry performance and sustainability	Enhance industry performance and reduce costs (Zheng et al., 2019)		*	
		Questioning sustainable performance (Chen et al., 2020; Di Vaio & Varriale, 2020)			*
		Improve supply chain quality management (Li et al., 2020)		*	
		Fix and transform the world's food system (Bumblauskas et al., 2020)		*	
		Improve economic sustainability (Niu et al., 2021)		*	
	Industry coordination, traceability and digital model	Coordination among industry players (Di Vaio & Varriale, 2020)	*	*	
		End-to-end digitisation is required (Rogerson & Parry, 2020)	*		
		Access to complete information, traceability and transparency (Hew et al., 2020; Kamble et al., 2020)		*	

	Industry standards and regulations	Defining an open and standard data format (Chen et al., 2020)			*
		Essential for regulatory assurance and end-user desirability (Sharma et al., 2019)	*		
		Lack of government regulation and trust (Yadav et al., 2020)			*
		Lack of regulatory forum (Howson, 2020)			*

Table 3. Identified core themes, themes, and aspects of the impact

3.1 Impact of Blockchain at the Organisational Level

Based on our review, we found that at the organisational level, the impact of blockchain emerged based on the four core themes. They are supply chain process and business model; efficiency and risk; visibility, transparency and resilience; and profit and performance.

3.1.1 Supply chain process and business model

Blockchain implementation impacts the supply chain as it demands redesigning supply chain processes and business models to improve efficiency (Chang et al., 2019). Redesigning is required to address frictions associated with manual processes, centralised authentication and interference from intermediaries. With blockchain, these frictions can be overcome through process automation, peer-to-peer authentication and disintermediation (Chang et al., 2019). At the same time, such transformations are fraught with challenges, especially in large supply chains (Sunny et al., 2020).

Additionally, ongoing blockchain application in the supply chain process could lead to unanticipated changes to the business model (Tönnissen & Teuteberg 2020). For instance, Tönnissen & Teuteberg (2020) found that while initially, there are no intermediaries in blockchain applications (i.e., Agri-food and Cognizant Retail applications), over time, blockchain service providers could become established intermediaries.

3.1.2 Efficiency and risk

Blockchain can impact supply chain efficiency, including time savings (Martinez et al., 2019) and transaction cost (Roeck et al., 2020; Schmidt & Wagner, 2019; van Hoek, 2019, Bumblauskas et al., 2020; Zheng et al., 2019). Efficiency is achieved with blockchain as it replaces intermediaries with the crowd of nodes on the system to avoid dependence on intermediaries. For instance, enabling peer-to-peer authentication introduces disintermediation and decentralisation, which eventually optimises the supply chain activities (Lai et al., 2021). Such optimisation reduces intermediaries' fees, the required number of operations and order processing time (Martinez et al., 2019), and operational and security risks related to intermediaries' intervention, privacy and other compliance issues (Choi, 2020; Min, 2019).

The level of automation blockchain introduces in data exchange and interconnection helps to reduce risks, including errors caused by manual interventions (Rao et al., 2021) that occurred during planning, sourcing, making deliveries, and returns (Lai et al., 2021). This includes overproduction or underutilisation risks during planning, trust issues related risk due to unknown supply sources, defects and disruption risk in the making, transport-level tampering and misplacing risk in the delivery, intermediaries, manipulation and verification error risk in returns (Lai et al., 2021). For many organisations, this is a crucial attraction of blockchain as it means that risk and expenses related to health and recalls in the food supply chain are reduced

(Bumblauskas et al., 2020). Hence, blockchain can help organisations to be more efficient in supply chain processes, enhance transactions (Martinez et al., 2019; Schmidt & Wagner, 2019) and reduce transaction costs, which are also considered the main motivators for organisations to adopt blockchain (van Hoek 2019).

3.1.3 Visibility, transparency and resilience

Organisational impacts also include visibility, transparency and resilience (Ali et al., 2021; Martinez et al., 2019; Min, 2019; Schmidt & Wagner, 2019; van Hoek, 2019). To impact visibility, blockchain demands new information sharing and information processing capabilities from organisations (Martinez et al., 2019). To safeguard confidentiality and sharing of valuable information organisations can predetermine the conditions and access rights on which blockchain solutions will work. By doing so, organisations can control over-sharing information and unintentional information disclosure while enforcing the desired level of transparency (Röck, 2020).

Blockchain-enabled transparency impacts organisations in multiple ways. Transparency through blockchain allows organisations to better plan and forecast to reduce supply-demand uncertainty cost-effectively. For instance, information about the origins of raw materials making their way to a final product or service, including all the touchpoints, can be recorded and tracked (Bai & Sarkis 2020). This technical attribute of blockchain facilitates an environment for transparency (Kohler & Pizzol, 2020; Schmidt & Wagner, 2019).

Information transparency provided by blockchain also helps to strengthen resilience positively within the supply chain. Especially during times of uncertainty and risk by allowing better forecasting with information sharing, enabling strong security measures against fraud and modification, and detecting tangible and invisible risks such as cyberattacks, computer hacking, credit failures, and contract frauds (Min, 2019). These beneficial impacts of blockchain drive organisations to continue blockchain adoption within the supply chain network (van Hoek, 2019). However, a critical concern in ensuring transparency is the continuous feeding of information into the blockchain by organisations in the supply chain network (Schmidt & Wagner, 2019).

3.1.4 Profit and performance

Profit and performance are the end consequence of different efforts through blockchain. So far, blockchain has shown to offer a positive impact on organisations by enhancing organisational profit and reducing transaction costs (Zheng et al., 2019) through disintermediation, especially in certain supply chains where the intermediaries' fees are high (Choi, 2020). Blockchain can also impact profitability by facilitating valid and effective performance measures (Kshetri, 2018) and influencing price sensitivity through effective information sharing (Hayrutdinov et al., 2020). Through information sharing with stakeholders, organisations (especially large organisations) can ensure transparency to protect organisational brand image (Howson, 2020) and ensure quality and sustainable practices (Bai & Sarkis, 2020) in the supply chain network. This led to two possible impacts on organisation performance. First is positive organisational supply chain performance (Hald & Kinra, 2019; Wamba et al., 2020). Second, blockchain might impede organisational supply chain performance by challenging the adaptability of organisations with current resources and reducing organisational human resource competencies through automation (Hald and Kinra, 2019).

3.2 Impact of Blockchain at the Inter-organisational Level

At the inter-organisational level, five core themes emerged: integration and collaboration; equality in information, data sharing and management; inter-organisational trust; network provenance, interdependency, relational governance; network profit and cost (refer to Table 3).

3.2.1 Integration and collaboration

Studies' findings show that blockchain simplifies the impact of technology integration and collaboration with actors in the network by providing security, peer-to-peer authentication, smart contract, and transparent information sharing (Ali et al., 2021; Korpela et al., 2017). The critical factors for facilitating successful blockchain-based inter-organisational integration are the shared understanding of supply chain data, fundamental functionality of the current system embedded in the blockchain, and standards for inter-operability (Korpela et al., 2017) and collaboration from supply chain partners (Sharma, 2021). However, achieving this is not straightforward (Sternberg & Baruffaldi, 2018), especially in inter-organisational settings. Studies also found that collaboration requirements in the supply chain network are multidimensional (Herm & Janiesch, 2021). It includes data exchange, data privacy, platform implementation, administration, certification authorities etc. (Herm & Janiesch, 2021). The reason is that one supply chain actor's adoption and integration decision would trigger recursive effects on other partners in the supply chain network (Sternberg et al., 2020).

Scholars recognise that blockchain should not be seen as a solution for all types of supply chain problems but rather for achieving specific objectives (van Hoek, 2020). Blockchain can offer inter-organisational transparency and traceability impact on the supply chain, but to achieve that, the supply chain needs to fulfil some boundary conditions before using blockchain, such as standardisation of processes and interfaces, having a joint platform and independent governance are prime boundary conditions (Behnke and Janssen, 2020). Other conditions, such as end-customer awareness, costs of supplier and manufacturer, and usage cost of blockchain in the network, would also require attention to determine should organisations need to adopt blockchain (Fan et al., 2020).

3.2.2 Equality in information, data sharing and management

Blockchain can facilitate equality in information and data sharing between organisations in the supply chain network by maintaining the information-sharing effort throughout the product life-cycle (Hayrutdinov et al., 2020; Zheng et al., 2019), ensuring data safety, quality and accessibility (Yadav & Singh, 2020) and improving data management (Kohler & Pizzol, 2020). Sharing information in the network (such as cost-revenue) helps build long-term relationships among the supply chain actors (Hayrutdinov et al., 2020). However, providing transparency and obtaining tamperproof data concerning shielding confidentiality is challenging. Tamper resistance is subjective to technical attributes like smart contract coding, as bad coding on smart contracts hampers the tamperproof feature of the blockchain (Ghode et al., 2021). At the same time, blockchain information does not necessarily always match real-world information. Since faulty sensors and intentional manipulation of the input can impact transparency (Straubert et al., 2021). Regardless of blockchain's functionality, if organisations resist sharing data in the supply chain network, it will impact the transparency in the supply chain (Straubert et al., 2021).

3.2.3 Inter-organisational trust

Inter-organisational trust enhances the inter-organisational relationship. However, improving inter-organisational trust in the network is challenging (Ghode et al., 2020; Ghode et al., 2021). Kumar et al. (2020) proposed that blockchain should be deployed in a supply chain network lacking inter-organisational trust. This is because blockchain is argued to mend trust issues within the supply chain (Howson, 2020) and enable mutual trust (Röck, 2020). For example, the global seafood network struggles with trust issues regarding the funds from charitable causes. These trust issues can be solved with blockchain-based fundraising and data sharing (Howson, 2020).

3.2.4 Network provenance, relational governance, and interdependency

Blockchain can influence network provenance, relational governance and interdependency in the supply chain network. Enabling provenance in the network is one of the attractions of blockchain. The exchange of reliable information within the network helps enhance network provenance (Kumar et al., 2020; Rogerson & Parry, 2020) and maintain relationships among partners (Ghode et al., 2020). In a supply chain network, the long-term and trusted relationship among partners is maintained through relational governance. Relational governance can influence the integration, scope of flexibility and control using authority. However, cooperation management among the members in the network for relational governance is challenging, and this could further impact the adoption of blockchain in the network (Ghode et al., 2020). Obeying the governance rules of organisations is also challenging to implement blockchain in the supply chain (Ghode et al., 2021).

Interdependency within the supply chain network can be reduced due to the transparency enabled by blockchain. This is because the distribution of information reduces the need for intermediation, as intermediaries lose their information sovereignty or monopoly. This also has a subsequent impact on power shift and change in power distribution in the network. While reducing dependence seems to have a positive impact, the change in power distribution might cause disadvantages (Roeck et al., 2020). However, Tönnissen and Teuteberg (2020) suggest that blockchain creates re-intermediation instead of disintermediation, which questions the dependence reducing impact of blockchain on the third party.

3.2.5 Network profit and cost

In addition to organisational level financial benefits, blockchain enhances the overall profit in the supply chain network by reducing the participation cost (Zheng et al., 2019), minimising the risk of partners in the network (Zheng et al., 2019), and facilitating information sharing (Hayrutdinov et al., 2020; Zheng et al., 2019). Research shows that network profit will be higher for the participants in the supply chain network who adopted blockchain than those who did not adopt blockchain technology when participants were risk-neutral (Zheng et al., 2019). Another study investigated information sharing efforts and found that blockchain enhances the network's profit through proper information sharing, reducing transaction costs and decreasing price sensitivity in the network (Hayrutinov et al., 2020). However, choosing a profit-earning product for adopting blockchain is challenging (Ghode et al., 2021). Hence, blockchain adoption displays a promising impact on network profit and cost through a wise selection of products, proper information sharing, and a certain risk environment.

3.3 Impact of Blockchain at the Industry Level

Three core themes emerged at the industry level: industry performance and sustainability; industry coordination, traceability and digital model; industry standards and regulations (refer to Table 3).

3.3.1 Industry performance and sustainability

Blockchain influences industry performance and sustainability by reducing costs (Zheng et al., 2019) and enhancing supply chain quality management through sharing information properly with the correct partner (Li et al., 2020). Focusing on the food supply chain, Bumblauskas et al. (2020) argue that creating a transparent and traceable supply chain by blockchain also helps to solve issues such as safety, contamination, economic loss etc., and transform the world's food system for the better.

Information transparency allows individual organisations to monitor the movements of the products with the consent of other organisations in the supply chain network. This helps to minimise possible corruption practices and counterfeit products, which enhance industry performance. As such investigating the aircraft industry, Di Vaio and Varriale (2020) also argued that blockchain helps improve efficiency, effectiveness, and sustainability. Managing disruptions, stakeholders' collaborations and involvements are key to improving efficiency, effectiveness, and sustainable performance (Di Vaio & Varriale 2020). A lack of stakeholders' collaboration and involvement (Di Vaio & Varriale 2020), privacy issues, and intolerance of blockchain immutability can impact performance and sustainability (Chen et al. 2020). Furthermore, blockchain can impact economic sustainability but is subject to factors like product quality, retailers' brand image and power, supplier variance of supply uncertainty and customer surplus (Niu et al., 2021). Overall, to bring sustainability in performance, managers and policymakers need to step up to create a forum for facilitating collaboration (Di Vaio & Varriale 2020), participation (Niu et al., 2021) and discussing issues upfront.

3.3.2 Industry coordination, traceability and digital model

Blockchain promotes industry coordination by reducing fragmentation, discoordination and inefficient operation (Di Vaio & Varriale, 2020). Blockchain can impact end-to-end digitisations requirements to facilitate coordination and visibility in the network (Rogerson & Parry, 2020). Without that requirement, human data entry onto blockchains remains open to doubt as the occurrence of potential error or corruption is still possible. However, with complete digitisation within the network, difficulty could arise in terms of masking sensitive data, endangering the identity of actors and the quantity of data produced (ibid). Additionally, by capturing and allowing stakeholders complete access to supply chain information, blockchain can help ensure traceability and transparency at the industry level (Hew et al., 2020). Blockchain is highly acknowledged for enabling and providing traceability in different industries, such as the halal food industry, healthcare, etc. Traceability is also considered one of the core enablers of blockchain implementation (Kamble et al., 2020). Therefore, blockchain implementation impacts access to information and digitisation requirements to enable coordination and traceability at the industry level.

3.3.3 Industry standards and regulations

Research emphasises the need to establish industry standards and regulations to scale up blockchain implementation and adoption in supply chains. The lack of established government regulations (Yadav, et al., 2020), data standardisation (Chen et al., 2020) and trust

among stakeholders (Yadav et al., 2020) have meant that blockchain hadn't been adopted widely at the industry level. Industry standards and regulations are still embryonic across different countries. Some argue that regulatory requirements for blockchain will help to record information on product's touchpoints and facilitate the information to the regulatory authorities, authorised actors and the end-users (Sharma et al., 2019). Regulatory forums can be attractive for those keen on adhering to compliance (Howson, 2020). Challenges will remain for those who operate illegally and disobey compliance (Howson, 2020).

4 Discussion

This systematic review set out to obtain a deeper understanding of the blockchain and supply chain landscape, realise blockchain's value, and guide future blockchain research. In addressing the research question, we found core areas of the supply chain impacted by blockchain and aspects of impact on those core areas from three different levels. These stress the impact of blockchain at different levels, which contribute to scholarship by (i) enriching knowledge on the current state of blockchain's impact on the supply chain; (ii) going beyond current research focus to understanding the broader impact of blockchain technology in the organisation, inter-organisation and industry level; and (iii) laying the foundation for further substantial blockchain impact research in the areas of the supply chain. Each of the levels and key findings is discussed below. Following the discussion on summarised findings, we also articulate research questions to guide future research. The summarised findings of blockchain's impact on the supply chain are provided in Table 4.

Firstly, one of the critical challenges of using technology is to match its' specifications with organisational or business needs (Davenport, 1998). The case of blockchain is not different. At the organisational level, most pre-implementation impacts are related to evaluating organisational technology needs or organisational readiness for using technology. This includes identifying inefficiency, the need for technology, understanding downstream and upstream impacts etc. At the same time, at the inter-organisational level and industry level, pre-implementational impact focuses on understanding and embracing network needs for implementing blockchain and industry requirements respectively. This is important as the successful implementation of blockchain as an inter-organisational technology depends on the understanding needs of actors in the supply chain network with support from industry level initiatives. In the practitioner literature, there are arguments that most of the current implementations of blockchain solutions are political moves in the organisation, championed by powerful actors in the supply chain, or a consequence of technological hype around the industry (Furlonger & Valdes, 2017). The pre-implementation impact shows that there are different aspects at different levels that require attention and consideration before implementing blockchain. Thus, blockchain implementation should not be based on the decision of one organisation and influenced by hype only, but rather based on the consideration of technical, organisational and the perspective of multiple actors.

Secondly, with the emergence of new technology, there is a tendency in IS literature to study its applications or view it as a tool for solving business issues (Rossi et al., 2019). Similarly, blockchain's post-implementation impact at different levels shows mostly optimistic views of blockchain. Extensive exploration of blockchain's potential impact, application and benefit could be the reason. The realisation of impact based on empirical evidence is yet to be fully developed.

Thirdly, implementing new technology (like blockchain) within complex organisational and social systems can raise practical tensions (Treiblmaier, 2019). However, so far emerging tensions impact of blockchain at the organisational level are mostly proposed and not realised in detail. This may be linked to a lack of operational blockchain use cases (Clohessy & Acton, 2019; Verhoeven et al., 2018) and the lack of empirical studies (Cole et al., 2019; Frizzo-Barker et al., 2020). At the inter-organisational level, emerging tensions are mostly similar to typical technology barriers (i.e., standards for inter-operability or fundamental functionality of the current system), obvious inter-organisation system barriers (i.e., collaboration or cooperation) or linked with participating organisations' attitudes (i.e., resistance to share or obeying governance rules). Also, the tensions are mostly derived from the pre-implementation impact, and less from post-implementation impact. Whilst industry level tensions communicate more on how the industry has been slow in taking initiative, and less on blockchain impact on the emergence of tension. This is because there is still lack of detailed guidance on how the industry should prepare, incentivise, and facilitate blockchain adoption. Tensions from different levels are also linked, as such handling tension of one level could help to solve other level tensions as well.

	Core -themes	**Pre-implementation impact**	**Post-implementation impact**	**Emerging tension impact**
Organisational	Supply chain process and business model	- Identification of inefficient process - Need for blockchain	- Changes in business models	- Unanticipated changes in the business model - Re-intermediation
	Efficiency and risk	- Automation in data exchange	- Increased efficiency - Cost structure - Optimise supply chain activities	
	Visibility, transparency, and resilience	- Predetermine the conditions and access rights	- Organisational reaction during uncertainty - Better forecasting with information sharing - Solve traceability issues	- Continuous information feeding in the blockchain
	Profit and performance	- Evaluating current intermediaries' impact	- Influence price sensitivity - Protecting brand image - Facilitate sustainable practice	- Questioning cost-effectiveness - Reducing supply chain competencies - Questioning long-term sustainability
Inter-organisational level	Integration and collaboration	- Require organising existing supply chain - Consideration for effective integration - Fulfilling boundary conditions	- Recursively impact adoption decision - Large-scale collaboration becomes easier - Establishment of reputation	- Missing fundamental functionality of the current system - Standards for interoperability - Analysing collaboration requirements
	Equality in Information, data	- Information sharing efforts	- Change in the current mode of data	- Obtaining tamperproof data

	sharing and management		sharing and interaction - Information Ownership - Sustainability in building long-term relationships	- Inconsistency in blockchain information VS real-world information - Intentional manipulation in the input - Resistance to share
	Inter-organisational trust	- Identifying trust issues	- Acceptance of blockchain - Enhance the inter-organisation relationship	- The success of blockchain in an untrusted network
	Network provenance, relational governance, and interdependency	- Understanding the need for provenance	- Reliable data exchange - Integration - Scope of flexibility - Control in the use of authority - Reduce information monopoly - Change in power distribution	- Cooperation management - Dependence reducing - Obeying the governance rules
	Network profit and cost	- Risk attitude of participants - Wise selection of products for adopting blockchain	- Facilitate information-sharing - Reduce participation cost - Decrease price sensitivity	- Choosing a profit-earning product
Industry	Industry performance and sustainability	- Create a forum for collaboration and discussion	- Reduce fragmentation, inefficiency, and uncoordinated operations - Management of disruption - Reduce economic loss	- Lack of stakeholders' collaboration and involvement - Privacy issue - Intolerance of blockchain immutability
	Industry coordination, traceability and digital model	- Digitisation requirement	- Access to information - Change in the economic model	- Masking sensitive data - Endangering the identity of actors
	Industry standards and regulations	- Regulatory forums	- Facilitating the information to the regulatory authorities, authorised actors and the end-users	- Lack of established government regulation - Data standardisation - Disobeying compliance

Table 4. Summarised findings

Based on these findings, this review proposes possible several research directions (in the form of research questions) that consider the implications of blockchain in the supply chain.

(i) How does blockchain implementation impact cost structure and cost-effectiveness?

(ii) How does the change in the business model by blockchain impact organisational supply chain activities?
(iii) How does re-engineering the supply chain process with blockchain introduce new tensions in the organisations while solving current tensions?
(iv) How do supply chain competencies impact blockchain implementation?
(v) How does blockchain impact socio-organisational elements and activities?
(vi) How agile is the blockchain solution in solving traceability issues during an uncertain situation?
(vii) What factors need to consider before blockchain implementation at the organisational level?
(viii) How can blockchain impact organisations' long-term performance and sustainable practices?
(ix) How to realise the business value of blockchain within a supply chain network?
(x) How does blockchain impact inter-organisational trust and interaction?
(xi) How does integrating and adopting blockchain by one actor impact other actors in the network?
(xii) How does governance facilitate blockchain deployment in the supply chain network?
(xiii) How do blockchain impact power distribution and information monopoly?
(xiv) How blockchain mediated change in information sharing and interaction impact information ownership?
(xv) How could blockchain change information ownership by challenging actors' relationships in the supply chain?
(xvi) How can blockchain facilitate sustainability in relation-building, collaboration and reputation management?
(xvii) How should the need for blockchain in the network be evaluated in terms of provenance and trust?
(xviii) How does blockchain facilitate information symmetry toward a circular economy?
(xix) How established government regulation impact organisational trust?
(xx) How should the industry level blockchain initiative be introduced and how will it impact digitising the supply chain?
(xxi) How do industry level incentives facilitate the adoption of blockchain?
(xxii) How practical is the blockchain for wide industry level adoption?

This study's findings enhance the existing literature on the blockchain-based supply chain. The proposed future agenda on blockchain-based supply chain studies will help academics with research directions toward substantial research in the future. In practice, this research sets a foundation for managers to understand the current impact of blockchain within the supply chain. It allows them to prepare appropriately and strategically to adequately realise the blockchain value in the supply chain. Acknowledging the different dimensions of impact will help them recognise blockchain business value and prepare to adopt blockchain solutions in the supply chain. Understanding the pre-implementation impacts will help managers to prepare for blockchain implementation. Moving forward, knowledge of the post-implementation impacts will allow them to recognise how much value blockchain could bring to the supply chain. Finally, sensing the emerging tensions and subsequent impacts will support managers to act proactively on the emerging tensions and facilitate blockchain adoption.

To further support managers in understanding the interaction between the impact of blockchain at different levels and phases, we propose a blockchain impact framework below (Figure 3) that illustrates the impact of blockchain in three critical phases, from preparation to blockchain adoption. It also shows how understanding different types of impacts helps to get prepare, recognise the value and adopt blockchain in the supply chain network and what understanding managers need to have in each phase. Thus, this framework is useful in guiding managers' understanding and actions on key impacts at three critical phases.

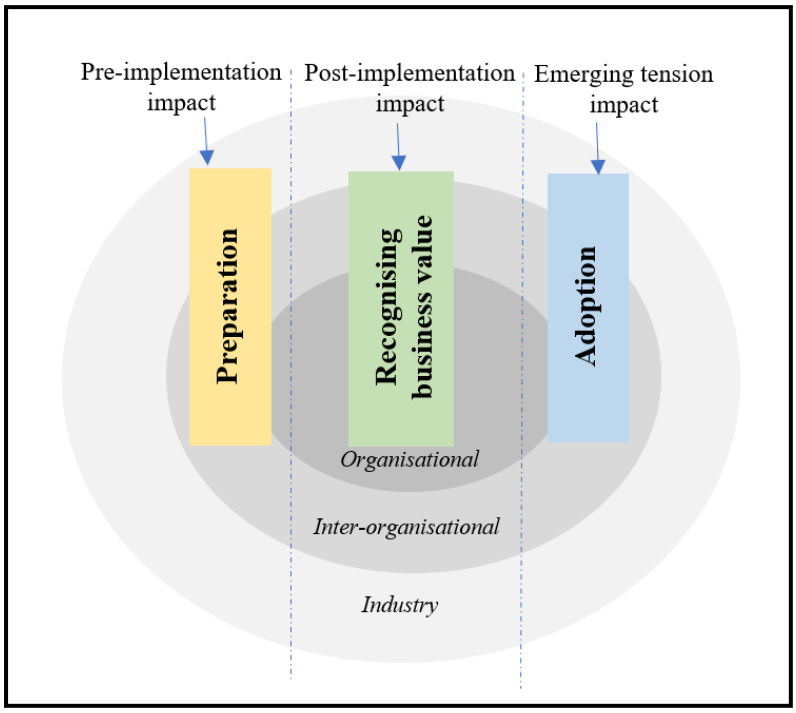

Figure 3. Blockchain impact framework

5 Conclusion

This systematic review investigates the academic research on the impact of blockchain on supply chains and presents directions to guide future research focus based on the current research landscape. The study provides a clearer view of how blockchain impacts supply chains and how it has triggered a succession of organisational, inter-organisational, and industry level impacts. We categorise the existing research into twelve core themes across pre- and post-implementation phases and tensions that blockchain introduces. By bringing together this research, we go beyond understanding what blockchain is and its possible applications and provide a deeper understanding of the blockchain and supply chain literature. A contribution of our work is a model that brings together three critical phases: preparation, implementation and adoption, types of impact and where the impact takes place. Our insights also lay the foundation for further blockchain impact studies in the supply chain, whereby we presented 22 questions that can drive future research.

Like all reviews, this review comes with several precautions and certain inescapable compromises, such as the reliance on database searches and the underlying assumption that they provide coverage of blockchain and supply chains (Boell & Cecez-Kecmanovic, 2015). While this study undertook a broad search in a range of databases, there remains the possibility that papers may have been omitted. In addition, given that blockchain is a new

technology, it is essential to consider that the impact of blockchain is likely to evolve over time. This review finds the early impacts of the technology. This review also identifies that most papers remain conceptual, which signals the embryonic nature of blockchain applications. We believe there should be more empirical research as this technology matures that can be informed by the directions for research we articulated.

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Zheng, K., Zhang, Z., Chen, Y., & Wu, J. (2019). Blockchain adoption for information sharing: risk decision-making in spacecraft supply chain. *Enterprise Information Systems*, 1-22. https://doi.org/10.1080/17517575.2019.1669831

Appendices

Appendix A

Search Queries Examples	
Scopus	(TITLE-ABS-KEY (“blockchain” AND “supply chain”) AND PUBYEAR > 2015 AND PUBYEAR < 2022) AND (LIMIT-TO (SRCTYPE, "j") OR LIMIT-TO (SRCTYPE, "p") OR EXCLUDE (SRCTYPE, "p")) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ar") OR EXCLUDE (DOCTYPE, "cp")) AND (LIMIT-TO (SUBJAREA, "BUSI")) AND (LIMIT-TO (LANGUAGE, "English"))
EBSCO	Boolean/Phrase: TI “blockchain” AND “supply chain” Expanders * Apply equivalent subjects Limiters * Full Text, * Peer Reviewed * Published Date: 20160101-20210630 * Publication Type: Academic Journal * Document Type: Article * Language: English
ProQuest	ti(“blockchain” AND “supply chain”) Date: From 01 January 2016 to 30 June 2021, Additional limits-Source type: Scholarly Journals, Document type: Article, Language: English
Web of Science	TI= (“blockchain” AND “supply chain”) | Timespan: 2016-01-01 to 2021-06-30 (Publication Date) Refined By: Document Type: Article, Language: English
Springer Open	“blockchain” AND “supply chain” (date cannot be specified, year 2016 to 2021)
IEEEXplore	("Document title”: “blockchain" AND “Document Title”: “supply chain”) Filters Applied: Journals, 2016 - 2021
AIS e-library	title:(“blockchain" AND “supply chain”) (Date: From 01 January 2016 to 30 June 2021)-For journal title:(“blockchain" AND “supply chain”) (Date: From 01 January 2017 to 30 June 2021)- For conference
Note* the blue colour is the place for different search keywords from table 2	

Appendix B

Example of Excluded papers		
PRISMA stages	**Exclusion rationale**	**Examples of papers excluded**
Screening	Papers **not** mentioning “blockchain” and “supply chain” in the title, rather focusing only on the blockchain or only supply chain are screened.	• Ma, C., Kong, X., Lan, Q. *et al.* (2019). The privacy protection mechanism of Hyperledger Fabric and its application in supply chain finance. *Cybersecur, 2*(5), https://doi.org/10.1186/s42400-019-0022-2 • Zwitter, A., Boisse-Despiaux, M. (2018). Blockchain for humanitarian action and development aid. *Int J Humanitarian Action 3*(16), https://doi.org/10.1186/s41018-018-0044-5 • Park, J. (2021). Promises and challenges of Blockchain in education. *Smart Learn. Environ. 8*(33), https://doi.org/10.1186/s40561-021-00179-2 • Zhao, J.L., Fan, S. & Yan, J. (2016). Overview of business innovations and research opportunities in blockchain and introduction to the special issue. *Financ Innov, 2*(28), https://doi.org/10.1186/s40854-016-0049-2 • Guo, Y., Liang, C. (2016). Blockchain application and outlook in the banking industry. *Financ Innov,* 2(24). https://doi.org/10.1186/s40854-016-0034-9 • Pedersen, Asger B.; Risius, Marten; and Beck, Roman (2019). A Ten-Step Decision Path to Determine When to Use

		Blockchain Technologies, *MIS Quarterly Executive, 18* (2). https://doi.org/10.17705/2MSQE.00010
Eligibility	Papers keywords stated less than two times in abstract or studying blockchain as en passant, such as an emerging technology or a growing trend around the topic are excluded.	• Cai, YJ, et al. (2021). Platform Supported Supply Chain Operations in the Blockchain Era: Supply Contracting and Moral Hazards, *Decision Sciences*, 52 (4), 866-892. https://doi.org/10.1111/deci.12475 • Juan, IHS 2020, 'The Blockchain Technology and the Regulation of Traceability: The Digitization of Food Quality and Safety', *European Food and Feed Law Review*, *15*(6), 563-570. https://doi.org/10.13140/RG.2.2.11987.20008 • Xu, XP, et al. 2021, 'Coordination of a Supply Chain with an Online Platform Considering Green Technology in the Blockchain Era', *International Journal of Production Research*, *ahead-of-print* (ahead-of-print), 1-18 https://doi.org/10.1080/00207543.2021.1894367
	Papers that don't meet the quality standard that this paper focuses on like- published in c ranked in ABDC ranking, or not ranked at all.	• Abelseth, B (2018). Blockchain Tracking and Cannabis Regulation: Developing a Permissioned Blockchain Network to Track Canada's Cannabis Supply Chain, *Dalhousie Journal of Interdisciplinary Management*, *14*. • Ada, N, et al. (2021). Blockchain Technology for Enhancing Traceability and Efficiency in Automobile Supply Chain—a Case Study, *Sustainability*, 13 (24), 13667. https://doi.org/10.3390/su132413667 • Azizi, N, et al. (2021). Iot–Blockchain: Harnessing the Power of Internet of Thing and Blockchain for Smart Supply Chain, *Sensors*, *21*(18), 6048. https://doi.org/10.3390/s21186048 • Bannor, RK & Kyire, SKC (2021). A Review on Understanding Blockchain Technology in Global Supply Chains; Opportunities and Challenges for Agribusinesses, *Indian Journal of Economics and Development*, *17* (4), 917-927. https://doi.org/10.35716/IJED/21283 • Clasby, D & Wollega, EP (2020). Blockchain Technology Key to Veracity in Supply Chain Transaction Data, *Journal of Management & Engineering Integration*, *13*(2), 1-7.
Inclusion	Principally technical papers focusing on, for example, proposing models, technical solutions, frameworks and systems on different blockchain platforms are excluded	• Agrawal, TK, et al. (2021). Blockchain-Based Framework for Supply Chain Traceability: A Case Example of Textile and Clothing Industry, *Computers & Industrial Engineering*, *154*, 107130. https://doi.org/10.1016/j.cie.2021.107130 • Dolgui, A, et al. (2020). Blockchain-Oriented Dynamic Modelling of Smart Contract Design and Execution in the Supply Chain, *International Journal of Production Research*, 58 (7), 2184-2199. https://doi.org/10.1080/00207543.2019.1627439 • Helo, P & Hao, Y (2019). Blockchains in Operations and Supply Chains: A Model and Reference Implementation, *Computers & Industrial Engineering*, *136*, 242-251. https://doi.org/10.1016/j.cie.2019.07.023 • Reddy, KRK, et al. (2021). Developing a Blockchain Framework for the Automotive Supply Chain: A Systematic Review, *Computers & Industrial Engineering*, 157. https://doi.org/10.1016/j.cie.2021.107334

		• Yong, B, et al. (2020). An Intelligent Blockchain-Based System for Safe Vaccine Supply and Supervision, *International Journal of Information Management*, *52,* 102024 https://doi.org/10.1016/j.ijinfomgt.2019.10.009

Appendix C

List of papers	
No	**Papers (journals)**
1	Ali, MH, et al. (2021). A Sustainable Blockchain Framework for the Halal Food Supply Chain: Lessons from Malaysia, *Technological Forecasting and Social Change*, 170, 120870. https://doi.org/10.1016/j.techfore.2021.120870
2	Bai, C & Sarkis, J (2020). A supply chain transparency and sustainability technology appraisal model for blockchain technology, *International Journal of Production Research*, *58*(7), 2142-2162. https://doi.org/10.1080/00207543.2019.1708989
3	Behnke, K., & Janssen, M. F. W. H. A. (2020). Boundary conditions for traceability in food supply chains using blockchain technology. *International Journal of Information Management,* 52(2020), 101969. https://doi.org/10.1016/j.ijinfomgt.2019.05.025
4	Bumblauskas, D., Mann, A., Dugan, B., & Rittmer, J. (2020). A blockchain use case in food distribution: Do you know where your food has been? *International Journal of Information Management*, 52(2020), 102008. https://doi.org/10.1016/j.ijinfomgt.2019.09.004
5	Chang, S. E., Chen, Y. C., & Lu, M. F. (2019). Supply chain re-engineering using blockchain technology: A case of smart contract based tracking process. *Technological Forecasting and Social Change,* 144, 1-11. https://doi.org/10.1016/j.techfore.2019.03.015
6	Chen, S., Liu, X., Yan, J., Hu, G., & Shi, Y. (2020). Processes, benefits, and challenges for adoption of blockchain technologies in food supply chains: a thematic analysis. *Information Systems and e-Business Management,* 19, 909–935. https://doi.org/10.1007/s10257-020-00467-3
7	Choi, T. M. (2020). Supply chain financing using blockchain: impacts on supply chains selling fashionable products. *Annals of Operations Research,* 1-23. https://doi.org/10.1007/s10479-020-03615-7
8	Di Vaio, A., & Varriale, L. (2020). Blockchain technology in supply chain management for sustainable performance: Evidence from the airport industry. *International Journal of Information Management,* 52. https://doi.org/10.1016/j.ijinfomgt.2019.09.010
9	Fan, Z. P., Wu, X. Y., & Cao, B. B. (2020). Considering the traceability awareness of consumers: should the supply chain adopt the blockchain technology? *Annals of Operations Research, 309*(2), 837-860. https://doi.org/10.1007/s10479-020-03729-y
10	Ghode, D., Yadav, V., Jain, R., & Soni, G. (2020). Adoption of blockchain in supply chain: an analysis of influencing factors. *Journal of Enterprise Information Management, 33*(3), 437-456. https://doi.org/10.1108/JEIM-07-2019-0186
11	Ghode, D. J., Yadav, V., Jain, R., & Soni, G. (2021). Blockchain adoption in the supply chain: an appraisal on challenges: IMS. [Blockchain adoption in the supply chain]. *Journal of Manufacturing Technology Management, 32*(1), 42-62. http://dx.doi.org/10.1108/JMTM-11-2019-0395
12	Hald, K. S., & Kinra, A. (2019). How the blockchain enables and constrains supply chain performance. *International Journal of Physical Distribution and Logistics Management, 49*(4), 376-397. https://doi.org/10.1108/IJPDLM-02-2019-0063
13	Hayrutdinov, S., Saeed, M. S. R., & Rajapov, A. (2020). Coordination of Supply Chain under Blockchain System-Based Product Lifecycle Information Sharing Effort. *Journal of Advanced Transportation, 2020*, 10. http://dx.doi.org/10.1155/2020/5635404
14	Hew, J. J., Wong, L. W., Tan, G. W. H., Ooi, K. B., & Lin, B. (2020). The blockchain-based Halal traceability systems: a hype or reality? *Supply Chain Management*. *25* (6), 863-879. https://doi.org/10.1108/SCM-01-2020-0044
15	Howson, P. (2020). Building trust and equity in marine conservation and fisheries supply chain management with blockchain. *Marine Policy*, *115*, 103873. https://doi.org/10.1016/j.marpol.2020.103873

16	Kamble, S. S., Gunasekaran, A., & Sharma, R. (2020). Modeling the blockchain enabled traceability in agriculture supply chain. *International Journal of Information Management, 52*, 101967. https://doi.org/10.1016/j.ijinfomgt.2019.05.023
17	Kohler, S., & Pizzol, M. (2020). Technology assessment of blockchain-based technologies in the food supply chain. *Journal of Cleaner Production, 269*, 122193. https://doi.org/10.1016/j.jclepro.2020.122193
18	Kshetri, N. (2018). Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management, 39*, 80-89. https://doi.org/10.1016/j.ijinfomgt.2017.12.005
19	Kumar, A., Liu, R., & Shan, Z. (2020). Is Blockchain a Silver Bullet for Supply Chain Management? Technical Challenges and Research Opportunities. *Decision Sciences, 51*(1), 8-37. https://doi.org/10.1111/deci.12396
20	Lai, J. Y., Wang, J. T., & Chiu, Y. H. (2021). Evaluating blockchain technology for reducing supply chain risks. *Information Systems and E-Business Management, 19*(4), 1089-1111. https://doi.org/10.1007/s10257-021-00533-4
21	Li, J. Y., Maiti, A., Springer, M., & Gray, T. (2020). Blockchain for supply chain quality management: challenges and opportunities in context of open manufacturing and industrial internet of things. *International Journal of Computer Integrated Manufacturing, 33*(12), 1321-1355. https://doi.org/10.1080/0951192x.2020.1815853
22	Martinez, V., Zhao, M., Blujdea, C., Han, X., Neely, A., & Albores, P. (2019). Blockchain-driven customer order management. *International Journal of Operations and Production Management, 39*, 993-1022. https://doi.org/10.1108/IJOPM-01-2019-0100
23	Min, H. (2019). Blockchain technology for enhancing supply chain resilience. *Business Horizons, 62*(1), 35-45. https://doi.org/10.1016/j.bushor.2018.08.012
24	Niu, B., Shen, Z., & Xie, F. (2021). The value of blockchain and agricultural supply chain parties' participation confronting random bacteria pollution. *Journal of Cleaner Production, 319*. https://doi.org/10.1016/j.jclepro.2021.128579
25	Rao, S. K., Gulley, A., Russell, M., & Patton, J. (2021). On the quest for supply chain transparency through Blockchain: Lessons learned from two serialized data projects. *Journal of Business Logistics, 42*(1), 88-100. https://doi.org/10.1111/jbl.12272
26	Roeck, D., Sternberg, H., & Hofmann, E. (2020). Distributed ledger technology in supply chains: a transaction cost perspective. *International Journal of Production Research, 58*(7), 2124-2141. http://dx.doi.org/10.1080/00207543.2019.1657247
27	Rogerson, M., & Parry, G. C. (2020). Blockchain: case studies in food supply chain visibility. *Supply Chain Management, 25*(5), 601-614. https://doi.org/10.1108/SCM-08-2019-0300
28	Schmidt, C. G., & Wagner, S. M. (2019). Blockchain and supply chain relations: A transaction cost theory perspective. *Journal of Purchasing and Supply Management, 25*(4). https://doi.org/10.1016/j.pursup.2019.100552
29	Sharma, M. G. (2021). Supply chain, geographical indicator and blockchain: provenance model for commodity. *International Journal of Productivity and Performance Management*. *ahead-of-print* (ahead-of-print). https://doi.org/10.1108/ijppm-05-2021-0288
30	Sternberg, H. S., Hofmann, E., & Roeck, D. (2020). The Struggle is Real: Insights from a Supply Chain Blockchain Case. *Journal of Business Logistics*. *24*(1), 71-87. https://doi.org/10.1111/jbl.12240
31	Sunny, J., Undralla, N., & Pillai, V. M. (2020). Supply chain transparency through blockchain-based traceability: An overview with demonstration. *Computers & Industrial Engineering, 150*. https://doi.org/10.1016/j.cie.2020.106895
32	Tönnissen, S., & Teuteberg, F. (2020). Analysing the impact of blockchain-technology for operations and supply chain management: An explanatory model drawn from multiple case studies. *International Journal of Information Management, 52*, 101953. https://doi.org/10.1016/j.ijinfomgt.2019.05.009
33	van Hoek, R. (2020). Developing a framework for considering blockchain pilots in the supply chain – lessons from early industry adopters. *Supply Chain Management, 25*(1), 115-121. https://doi.org/10.1108/SCM-05-2019-0206
34	van Hoek, R. (2019). Unblocking the chain–findings from an executive workshop on blockchain in the supply chain. *Supply Chain Management: An International Journal*. *25* (2), 255-261. https://doi.org/10.1108/SCM-11-2018-0383

35	Wamba, S. F., Queiroz, M. M., & Trinchera, L. (2020). Dynamics between blockchain adoption determinants and supply chain performance: An empirical investigation. *International Journal of Production Economics*, *229*(2020), 107791. https://doi.org/10.1016/j.ijpe.2020.107791
36	Yadav, S., & Singh, S. P. (2020). An integrated fuzzy-ANP and fuzzy-ISM approach using blockchain for sustainable supply chain. *Journal of Enterprise Information Management, ahead-of-print* (ahead-of-print). https://doi.org/10.1108/JEIM-09-2019-0301
37	Yadav, V. S., Singh, A. R., Raut, R. D., & Govindarajan, U. H. (2020). Blockchain technology adoption barriers in the Indian agricultural supply chain: an integrated approach. *Resources, Conservation and Recycling, 161*. https://doi.org/10.1016/j.resconrec.2020.104877
38	Zheng, K., Zhang, Z., Chen, Y., & Wu, J. (2019). Blockchain adoption for information sharing: risk decision-making in spacecraft supply chain. *Enterprise Information Systems*, 1-22. https://doi.org/10.1080/17517575.2019.1669831
	Papers (Conference)
39	Herm, L-V & Janiesch, C (2021). Towards an Implementation of Blockchain-Based Collaboration Platforms in Supply Chain Networks: A Requirements Analysis, in *Hawaii International Conference on System Sciences 2021 (HICSS-54)*, https://aisel.aisnet.org/hicss-54/st/blockchain_engineering/5/
40	Korpela, K, Hallikas, J & Dahlberg, T (2017). Digital supply chain transformation toward blockchain integration, in *proceedings of the 50th Hawaii international conference on system sciences*, https://aisel.aisnet.org/hicss-50/in/digital_supply_chain/2/
41	Röck, D (2020). The Foundation of Distributed Ledger Technology for Supply Chain Management, *in 53rd Hawaii International Conference on System Sciences*, https://aisel.aisnet.org/hicss-53/in/digital_supply_chain/4/
42	Sharma, RS, et al. (2019). Design Principles for Validating Use Cases of Blockchain for Food Supply Chains, in *AMCIS 2019 Proceedings*, https://aisel.aisnet.org/amcis2019/green_is_sustain/green_is_sustain/4
43	Straubert, C, et al. (2021). Blockchain Technology for Tracking and Tracing in Supply Chains: A Critical Viewpoint, in *Hawaii International Conference on System Sciences 2021 (HICSS-54)*, https://aisel.aisnet.org/hicss-54/os/blockchain/5/
44	Sternberg, H & Baruffaldi, G (2018). Chains in Chains–Logic and Challenges of Blockchains in Supply Chains, in *51st Hawaii International Conference on System Sciences*, 3936-3943, https://aisel.aisnet.org/hicss-51/in/digital_supply_chain/3/

Appendix D

List of outlets		
No	**Outlets (Journal)**	**No. of papers**
1	Technological Forecasting and Social Change	2
2	International Journal of Production Research	2
3	International Journal of Information Management	6
4	Information Systems and e-Business Management	2
5	Annals of Operations Research	2
6	Journal of Enterprise Information Management	2
7	Journal of Manufacturing Technology Management	1
8	International Journal of Physical Distribution and Logistics Management	1
9	Journal of Advanced Transportation	1
10	Supply Chain Management	4
11	Marine Policy	1
12	Journal of Cleaner Production	2
13	Decision Sciences	1
14	International Journal of Computer Integrated Manufacturing	1
15	International Journal of Operations and Production Management	1
16	Business Horizons	1
17	Journal of Business Logistics	2
18	Journal of Purchasing and Supply Management	1
19	International Journal of Productivity and Performance Management	1
20	Computers & Industrial Engineering	1

21	International Journal of Production Economics	1
22	Resources, Conservation and Recycling	1
23	Enterprise Information Systems	1
	Outlets (Conferences)	
24	Hawaii International Conference on System Sciences (HICSS)	5
25	Americas Conference on Information Systems (AMCIS)	1

Appendix E

Table A: Review Framework	
Focus of the paper	• What research question do they address? • What was the objective of the paper?
Method	• Is it empirical or conceptual? • Is it qualitative or quantitative? • Type and amount of data analysed. • How is the data analysed?
Findings of the paper	• What conclusions are drawn?
Limitations and future research	• What limitations are expressed? • What future scope is outlined?
Implication	• What are the stated implications?

Table B: Theme identification		
Levels	**Quotes from Studies' Focus and Findings**	**Themes identified**
Organisational	This study focuses on the feasibility and inceptive application of supply chain processes. We proposed a blockchain-based framework along with the use of an affiliated technology, i.e., smart contracts, to derive the feasible benefits of the supply chain process design. (Chang et al. 2019, p. 2)	> Redesign supply chain process
	Supply chain activities are among the ones that are most likely to be transformed by blockchain. Among other things, blockchain facilitates valid and effective measurement of outcomes and performance of key supply chain processes (Kshetri 2018, p. 88)	> valid and effective measurement of outcomes > supply chain processes
	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 (Martinez et al. 2019, p. 993)	> efficiency of the process > reduces the average time of orders > Reduces workload > shows traceability > improves visibility
	The results of our research are based on 10 different applications from the logistics industry. …… In addition, our investigation is based on a snapshot of the use cases. Especially the blockchain technology shows a high dynamic and leads to permanent changes in the business models of the companies. (Tönnissen & Teuteberg 2020, p. 9)	> changes in the business models

	Our study reveals that the effects of DLT on supply chain transactions are two-sided. We found six effects of DLT solutions that have a cost-reducing or cost avoidance impact on supply chain transactions. In addition, we found two effects that change the power distribution between buyers and suppliers in transactions and a single effect that reduces the dependency of supply chain transactions on third parties. While cost reducing and avoidance, as well as dependency-reducing effects, are positive effects, the change in power distribution might come with disadvantages. (Roeck et al. 2020, p. 2124)	> supply chain transactions cost reduction > reduce dependency > change in power distribution
	Blockchain is projected to be the latest revolutionary technology and is gaining increasing attention from academics and practitioners. Blockchain is essentially a distributed and immutable database that enables more efficient and transparent transactions. Blockchain reduces transaction costs, as it allows for transparent and valid transactions. (Schmidt & Wagner 2019, p. 1)	> efficient and transparent transactions. > reduces transaction costs
	Workshop participants reported that adoption of blockchain in the supply chain today is very limited but actively considered by many. Drivers for this consideration include achieving greater transparency and visibility, as well as, improving processes and reducing costs (van Hoek 2019, p. 255).	> achieving greater transparency and visibility > improving processes and reducing costs
	By creating traceable and transparent supply chains for food, consumers can attain the information they need to make informed choices about the food they buy and the companies they support. For stakeholders in the food supply chain, having traceability and transparency builds better relationships with their customers, increases efficiency, and reduces the risk and cost of food recalls, fraud, and product loss. (Bumblauskas et al. 2020, p. 1)	> traceability and transparency > increases efficiency > reduces the risk and cost of food recalls,
	We have shown that if the service fees by banks are sufficiently high, adopting blockchain technology is a mean-risk dominating policy which brings a higher expected profit and a lower risk for the supply chain, (Choi 2020, p. 1)	> Increased profit > lower risk
	The blockchain is a peer-to-peer network of information technology that keeps records of digital asset transactions using distributed ledgers that are free from control by intermediaries such as banks and governments. Thus, it can mitigate risks associated with intermediaries' interventions, including hacking, compromised privacy, vulnerability to political turmoil, costly compliance with government rules and regulation, instability of financial institutions, and contractual disputes. This article unlocks the mystique of blockchain technology and discusses ways to leverage blockchain technology to enhance supply chain resilience in times of increased risks and uncertainty. (Min 2019, p. 1)	> Reduce security and operational risk > enhance supply chain resilience
	The analysis identified four different blockchain identities which enable SCM and improve supply chain performance: information lighthouse, exploitation technology, exploration technology and relationship-building technology. However, the analysis also identified three different blockchain identities which constrain SCM and reduce supply chain performance: domination technology, straitjacket and deskiller (Hald & Kinra 2019, p. 15)	> improve supply chain performance > reduce supply chain performance

	Accordingly, we administered a survey in order to review the opinions and views of supply chain practitioners. The results support the model and indicate that blockchain applications can improve supply chain performance. (Wamba et al. 2020, p. 1)	> improve supply chain performance
	Based on the implementation of a blockchain technology evaluation, supply chains can identify and prioritise opportunities for improvement which may lead to the supply chain transparency impacts that are associated with their blockchain technology, resulting in potentially ensuring product quality and reducing natural environmental concerns (Bai & Sarkis 2020, p. 2159)	> supply chain transparency > ensuring product quality
	Blockchain technology is enabling larger companies to cost effectively protect their brand images. (Howson 2020, p. 5)	> protect brand images
	The study results show that the product lifecycle information sharing effort under the Blockchain system increases the profit of the whole chain (Hayrutdinov et al. 2020, p. 1)	>Increase profit >Information sharing effort
	We have shown that if the service fees by banks are sufficiently high, adopting blockchain technology is a mean-risk dominating policy which brings a higher expected profit and a lower risk for the supply chain, (Choi 2020, p. 1)	> higher expected profit > lower risk for the supply chain
	The use of blockchain technology can reduce transaction costs among spacecraft supply chain members and fulfil information sharing, thus improving the overall profit of spacecraft supply chain system (Zheng et al. 2019, p. 16)	> reduce transaction costs > Information sharing > improving the overall profit
	our findings indicated that blockchain, as disruptive technology, can help halal food SMEs achieve food SC transparency (Ali et al. 2021, p. 11)	>enhance transparency
	our findings indicated that blockchain, as disruptive technology, can help halal food SMEs achieve food SC transparency (Ali et al. 2021, p. 11)	>enhance transparency
	The results highlight how blockchain is not a stand-alone technology, but rather one element in a system of technologies. While blockchain-based technologies are expected to bring a variety of impacts, only some are directly attributable to the blockchain element: increased transparency, traceability, and trust. (Kohler & Pizzol 2020, p. 1)	>increased transparency, traceability, and trust
	This study…...find that BCT can be used to reduce SCRs and optimize SCM in various processes of planning, sourcing, making, delivery, and returns. SCRs may be reduced through the implementation of BCT, including decentralization, transparent and open data, traceability, non-tamperability, and encryption security, enabling companies to more accurately and securely operate their SC activities. (Lai et al. 2021, p. 1106)	>Reduce supply chain risk >Optimise supply chain management
	we found evidence to suggest that a substantial majority of errors in the process were indeed manual (consistent with Craig et al., 2015), and enhancing SCT through automated, serialized data exchange may provide a path to reduce said errors …….(Rao et al. 2021, p. 97)	>reduce error
	In order to adopt blockchain applications into an ongoing business process, a severe transformation is needed in the work culture. This transformation will be extremely difficult for large supply chains as they hold many participants.(Sunny et al. 2020, p. 11)	>Transformation of the business process required
	the study indicated that DLT enables steady data availability, selective transparency, high authenticity and mutual trust in supply chains. (Röck 2020, p. 4532)	>enables selective transparency, authenticity and trust

Inter-organisational	Our findings imply that supply chain systems have first to be modified and organizational measures need to be taken to fulfil the boundary conditions, before blockchain can be used successfully (Behnke & Janssen 2020, p. 1)	>fulfil boundary condition
	The findings in the article endorse that the TSCM can be made efficient by integrating the BC technology considering five most driving characteristics, namely, data safety and decentralization, accessibility, documentation, data management, and quality. (Yadav & Singh 2020, p. 1)	> data management, safety and decentralization
	The use of blockchain technology can reduce transaction costs among space craft supply chain members and fulfil information sharing, thus improving the overall profit of spacecraft supply chain system (Zheng et al. 2019, p. 16)	> reduce transaction costs of members > Information sharing > improve the overall profit of the chain
	Our investigation into ten blockchain logistics applications show that there is no disintermediation. In one case, existing intermediaries are replaced by a new intermediary so that reintermediation takes place. (Tönnissen & Teuteberg 2020, p. 8)	> Disintermediation and reintermediation
	Marine conservation and global seafood production networks have a trust problem. ……This short commentary has considered how blockchain technology is being leveraged to mend trust issues, enabling new forms of resourcing and fundraising for healthy oceans as well as more transparent fish supply chains. (Howson 2020, p. 5)	>Inter-organizational trust
	We identified and prioritized key factors: inter-organizational trust and relational governance as organizational challenge that influences adoptability of BT in SC. (Ghode et al. 2020, p. 437)	> Absence of existing inter-organizational trust > relational governance
	The open source blockchain technology seems to offer functionalities beyond those of current legacy technologies; additionally, this technology offers data security and cost-effective transmission of transactions security and cost-effective transmission of transactions in peer-to-peer networks with no central system. In this way, blockchain technology simplifies B2B integration and enables micro level IoT integration (Korpela et al. 2017, p. 10)	>B2B and technology integration
	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. (Sternberg et al. 2020, p. 1) P-1	> supply chain actors' recursive impact on adoption and integration
	Our analysis in this article suggests that blockchain technology should be deployed selectively, mainly for interorganizational transactions among untrusted parties, and in applications that need high levels of provenance and visibility (Kumar et al. 2020, p. 31)	> Inter-organizational trust > provenance and visibility
	The paper shows that blockchain can be utilised as part of a system generating visibility and trust in supply chains. From live case studies, we provide empirical evidence that blockchain provides visibility of exchanges and reliable data in fully digitised supply chains. This provides provenance and guards against counterfeit goods. (Rogerson & Parry 2020, p. 601)	> visibility and trust > provenance in network

	Our study reveals that the effects of DLT on supply chain transactions are two-sided. We found six effects of DLT solutions that have a cost-reducing or cost avoidance impact on supply chain transactions. In addition, we found two effects that change the power distribution between buyers and suppliers in transactions and a single effect that reduces the dependency of supply chain transactions on third parties. While cost reducing and avoidance as well as dependency-reducing effects are positive effects, the change in power distribution might come with disadvantages. (Roeck et al. 2020, p. 2124)	> supply chain transactions cost reduction > reduce dependency > change in power distribution
	The study results show that the product lifecycle information sharing effort under the Blockchain system increases the profit of the whole chain (Hayrutdinov et al. 2020, p. 1)	>Increase profit of the whole chain > Information sharing effort
	From the findings, this research postulates extensive SC integration and regulatory intervention (internal and external competencies respectively) as universal enablers, The fostering of SC integration between firms is mandatory. Blockchain remains a technology that aims to simplify and enhance the collaboration between two parties in the SC. (Ali et al. 2021, p. 10)	>Enhance collaboration >supply chain integration
	The results show that it is conditional for the supply chain to adopt the blockchain technology, and the condition is related to the traceability awareness of consumers, the production costs of the supplier and manufacturer, and the cost of using the blockchain technology. We also find that under a certain condition, the revenue sharing contract can realize a Pareto improvement for the supply chain that adopts the blockchain technology.(Fan et al. 2020, p. 837)	>pre condition to adopt
	This study presents some key challenges, i.e. to develop trust within SC management system, obey the governance rules and regulations of institution while implementation of BT in SC, provide transparency of data, obtain tamperproof data to avoid fraud, improve coordination and information sharing among the SC partners, choose a profit-earning product SC for adoption of BT, adopt societal changes and train the participants to strengthen behavioral intention towards adoption of BT in SC.(Ghode et al. 2021, p. 56)	> governance challenges >Provide transparency of data and obtain tamperproof data > inter-organizational trust, >improve coordination and information sharing > Choosing profit earning product for blockchain >adopt societal changes
	Other impacts such as improved data management are a side-effect of digitizing non-digital processes. (Kohler & Pizzol 2020, p. 1)	>improved data management
	To implement de-commodification, disintermediation and adoption of blockchain requires both financial and collaboration of all the actors in the supply chain. (Sharma 2021, p. 14)	>Required collaboration of actors
	Blockchain needs to fit into supply chains and existing technology and may not be the right technology for all supply chain problems at all. In fact, blockchain adoptions may remain targeted on very specific local context and supply chain objectives (van Hoek 2020, p. 120)	>alignment with existing technology >alignment with context and supply chain objective
	The use of the blockchain within SCNs can thus make fraud attempts and manipulations more difficult…. The objective of our contribution was to identify requirements for such a blockchain-based collaboration platform. The requirements should enable a transfer into practice. (Herm & Janiesch 2021, p. 6872)	>requirement for blockchain-based collaboration

	The logic of blockchains in supply chains give us that we either need a mechanism to establish physical trust, such as a reputation system or a central authority creating trust. Industrial experience and our experiences in the ReLog project reveal that the integration of logistics activities and adoption of supply chain technology may not be straightforward (Sternberg & Baruffaldi 2018, p. 3941)	>Challenges integration of logistic activities
	the study indicated that DLT enables steady data availability, selective transparency, high authenticity and mutual trust in supply chains. (Röck 2020, p. 4532)	>enable mutual trust
	blockchains currently do not seem to be the Holy Grail for TnT in SCs. An often-touted advantage of blockchains is that they represent a single point of truth. …. Regardless of the technology used, the SC parties must be willing to collect and share track-and-trace data. therwise, transparency and traceability in supply chains are not possible.(Straubert et al. 2021, p. 5585)	>Supply chain parties' willingness to share >questioning blockchain information vs real-world information
Industry	the use of blockchain technology can reduce transaction costs among space craft supply chain members and fulfil information sharing, thus improving the overall profit of spacecraft supply chain system (Zheng et al. 2019, p. 16)	> information sharing >overall SC profit
	All four of our cases demonstrate Kshetri's (2018) assertion that blockchain offers both immutability and transparency, while WWFTraSeable, Techrock and Demeter all support the position that unit-level visibility is possible. All of our cases highlight the need for end-to-end supply chain digitisation (Rogerson & Parry 2020, p. 608) (food industry)	> immutability and transparency, > visibility > end-to-end supply chain digitisation
	This is one of the main blockchain technology applications in the airport industry. It promotes cooperation between the main players in the aviation industry and the air traffic controllers (ATCs) to reduce fragmentation, inefficiency, and uncoordinated operations (Di Vaio & Varriale 2020, p. 1) It also allows information and data sharing, but it is still not possible to observe a high level of sustainable performance (Di Vaio & Varriale 2020, p. 1)	> Cooperation among industry players >Questioning sustainable performance
	The transparency of information in blockchain-based systems causes issues of private protection. The non-reversibility mechanisms of blockchain result in error intolerance. The theme Standardization of data presents benefits of blockchain adoption, which facilitates supply chain data management in complex food systems. However, all the stakeholders face great challenges to define an open and standard data format so as to obtain the benefits (Chen et al. 2020, p. 22)	>privacy issue and error intolerance in performance > data standardization >Defining standard data format
	Blockchain, a technology that could ensure security and transparency, resembles a sound solution. With the participation from all stakeholders along the Halal supply chain, a blockchain-based Halal traceability system allows end consumers to access complete supply chain information from the origin to their hands (Hew et al. 2020, p. 14)	> ensure security and transparency >access complete SC information
	The findings from the study suggest that, among the identified enablers, traceability was the most significant reason for BT implementation in ASC followed by auditability, immutability, and provenance (Kamble et al. 2020, p. 1)	> traceability >auditability, >immutability, >provenance
	The results reveal that "lack of government regulation and lack of trust among agro-stakeholder to use blockchain" are significant adoption barriers of blockchain in Indian ASC (Yadav et al. 2020, p. 1)	> lack of government regulation >lack of trust among stakeholders

	For stakeholders in the food supply chain, having traceability and transparency builds better relationships with their customers, increases efficiency, and reduces the risk and cost of food recalls, fraud, and product loss. The blockchain technology and this business are creating a case for fixing and transforming the world's food system. (Bumblauskas et al. 2020, p. 1)	> fix and transform the world's food system
	Challenges for promoting greater equity between fisheries stakeholders in the Global South will likely prove difficult where compliance attracts unaffordable costs. Regulatory forums may prove attractive to fishing outfits keen to prove their compliance. They are unlikely to attract the interest of fishers who operate illegally. (Howson 2020, p. 5)	> Lack of regulatory forum
	The focus of this paper is on a potential application of blockchain in SCQM with detailed analysis of its technical feasibility and the methods of transitioning between the current approaches to a blockchain-oriented platform. …. The survey concludes that blockchain along with IIoT can improve SCQM in an Open Manufacturing model (Li et al. 2020, p. 1321)	>improve supply chain management
	we identify the industry requirement for the application of blockchain for agriculture. ..Application of blockchain technology will be important for regulatory assurance and end-user desirability (Sharma et al. 2019, p. 7)	> important for regulatory assurance and end-user desirability
	We find that the powerful retailer and the supplier selling high-quality products are better off in blockchain. We further find that blockchain improves the supply chain's economic sustainability,….(Niu et al. 2021)	> improves the supply chain's economic sustainability

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