Towards a Triple Bottom Line Perspective of Blockchains in Supply Chain

Full Paper

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Abstract

The blockchain technologies underlying cryptocurrencies have recently gained considerable attention for having potential applications in other fields. This is due to potential benefits such as decentralisation, immutability, disintermediation, transparency and traceability. One of the earliest and most active industries to explore blockchain technologies has been the supply chain and logistics industry. However, the literature in this area is fragmented and lacks an overarching framework to integrate the findings and systematically guide research and practice. This paper analyses 37 recent studies retrieved from the literature. The analysis synthesises the themes into a cohesive conceptual framework by taking the concept of Triple Bottom Line (TBL) as an overall perspective. This framework will assist both practitioners and researchers in better understanding the issues involved in implementing blockchains in the supply chain context, by not only considering potential operational economic benefits but also social and environmental impacts.

Keywords: Blockchain, Supply Chain, Triple-Bottom-Line, Literature Review, Conceptual Framework

1 INTRODUCTION

Blockchain technologies (also known as distributed ledgers), became widely known with the advent of Bitcoin and other cryptocurrencies. The possible application of blockchains has been explored in a wide range of other industries due to potential benefits such as: decentralisation, immutability, disintermediation, transparency, traceability and reliability (Jabbar and Bjørn 2018). One of the earliest and most active industries to explore blockchain technologies has been the supply chain and logistics industry. Blockchains are thought to potentially have a significant impact on various parties along the supply chain. There have been a number of supply chain pilots implemented in the real-world, but very few full implementations have been documented to date.

Numerous research studies have been conducted on the topic of blockchain in the past 5 years, with many issues, benefits, problems and limitations raised. Some have questioned the maturity of blockchain technologies and their feasibility in business contexts. There are different perspectives of blockchain from business (Wang et al. 2019), academia (Montecchi et al. 2019) and government (Allen et al. 2019; Millard 2018). The understanding of blockchains, and their application in supply chains in particular, is therefore widely varied, fragmented and conflicting.

To help achieve the full potential of blockchain technologies to transform supply chains (SCs), a more cohesive understanding of the issues is needed. To help the understanding of the current state of research on this topic, this paper addresses the research question: “What do we know, how well do we know it, and what do we need to know about blockchain-enabled supply chain applications?”. To achieve this goal, a systematic literature review of blockchain technology in supply chains papers was conducted. Further analysis led to the development of an integrated framework focussing on the triple bottom line of using blockchain technologies in supply chains.

2 RESEARCH APPROACH

This study followed the systematic literature review methodology outlined by Booth et al. (2012) (see Figure 1). A preliminary scan of the literature found several comprehensive literature review papers of blockchain in supply chains had already been conducted: Wang et al. (2018) and Queiroz et al. (2019). This study, therefore, chose to focus on the most recent publications, from 2018 to 2019.

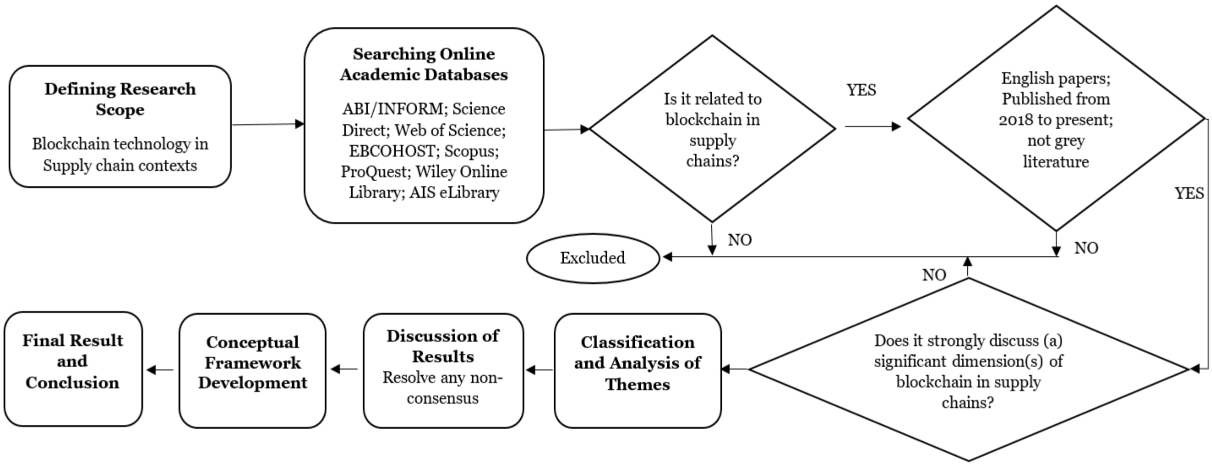

Figure 1: Research Methodological Framework (adapted from (Booth et al. 2012))

2.1 Paper Selection Process

The search terms used for this study were: ‘blockchain(s)’ or ‘distributed ledger(s)’, together with ‘supply chain(s)’ and/or ‘logistics’. The initial searches of all the databases, using the search terms, produced 595 potential papers, excluding duplicates. Initially paper titles were examined, and any paper title not appearing to discuss blockchains in supply chains was excluded. Papers that were not in English were also excluded. In the next stage, each paper was examined in detail to determine if the paper included significant discussion of blockchain in supply chains. Only papers from journals and highly regarded Information Systems conferences were included. Papers from workshops and symposiums were excluded. The selection process finally resulted in a total of 43 short-listed articles in two groups: 37 papers that directly addressed the topic of blockchain and supply chains, and 6 papers that discussed blockchains in general or technical issues of blockchains, but were essential in understanding the topic.

2.2 Paper Classification

The full texts of the 37 papers were treated as qualitative data for content analysis. Details of the studies were analysed, including authors, years, title, journal ranking, research method, data collection and analysis method, related theories, industry focus/level, key findings, implications and limitations. The results show that there were 17 papers published in 2018 and 20 papers in the first 6 months of 2019. 19 out of 37 papers come from academic journals ranked by the Australian Business Deans Council (ABDC), three from conference proceedings and the last 15 papers from other peer-review journals. Section 3 provides more details in relation to the research method, theories and countries of publication.

2.3 Analysis and Theme Development

After the papers were selected, the content of the papers was analysed using thematic analysis, resulting in a set of themes. Many of the themes were integrated from 3 key papers: (Kshetri 2018; Saberi et al. 2018; Wang et al. 2018). Other themes arose from the analysis of all the papers. The themes generated from the analysis were: Seamless data sharing, Transparency, Traceability, Flexibility, Cost, Speed, Disintermediation and Opportunism, Trust, Privacy and Security, Provenance, Anti-corruption, Identification and Verification, Resource—optimised use and Recycling exchange tokenization. Section 4 presents a table that shows these themes cross referenced against the papers that discussed each of those themes (Table 3).

2.4 Conceptual Framework Development and TBL Integration

Two of the 37 papers reviewed specifically mentioned the concept of Triple Bottom Line (TBL): Economic, Social and Environmental (Elkington 1999). Treiblmaier (2019) suggests that blockchains may help in integrating triple bottom line goals into supply chains. Saberi et al. (2018) state that "the promising features of blockchain technology might be a panacea for such complexity in the triple-bottom-line of sustainability". While the other papers didn't specifically mention TBL, it was found that many of the papers encompassed discussion of economic, social and environmental issues.

The concepts from TBL were therefore used as an overall perspective to group and synthesise the themes into a cohesive framework that is presented and elaborated on in Section 5. The TBL perspective provides a more holistic view of the role Blockchains may take in transforming supply chains.

3 CLASSIFICATION OF PAPERS BY METHOD, THEORY AND COUNTRIES

3.1 Methods of research

The research methods used by the selected papers are summarised in Table 1.

Research methods	References
Literature review (4 papers)	(Wang et al. 2018), (Lu 2018), (Hughes et al. 2019), (Queiroz et al. 2019)
Conceptual study (15 papers)	(Saberi et al. 2018), (Treiblmaier 2018), (Hald and Kinra 2019), (Cole et al. 2019), (Allen et al. 2019), (Montecchi et al. 2019), (Choi et al. 2019), (Min 2019), (Chang et al. 2019), (Galvez et al. 2018), (Francisco and Swanson 2018), (Dobrovnik et al. 2018), (Treiblmaier 2019), (Antonios et al. 2019), (Edvard et al. 2019)
Case study (8 papers)	(Verhoeven et al. 2018), (Kshetri 2018), (Lacity 2018), (Behnke and Janssen 2019), (Tönnissen and Teuteberg 2019), (Azzi et al. 2019), (Jabbar and Bjørn 2018), (Akram and Bross 2018)
One-on-one interview (1 paper)	(Wang et al. 2019)
Survey (5 papers)	(Kamble et al. 2018), (Queiroz and Wamba 2019), (Kamble et al. 2019), (Pan et al. 2019), (Blossey et al. 2019)
Experimental study (4 papers)	(Kim and Laskowski 2018), (Westerkamp et al. 2019), (Sternberg and Baruffaldi 2018), (Xu et al. 2019)

Table 1. Research methods in the selected papers

3.2 Theories of research

A range of theories were discussed in the reviewed papers. Table 2 summarises these theories.

Theories	References
Diffusion of Innovation (Rogers 1995)	(Dobrovnik et al. 2018), (Treiblmaier 2019)
Technology Acceptance and Use (ie., TAMs, UTAUT)	(Kamble et al. 2018), (Queiroz and Wamba 2019), (Francisco and Swanson 2018), (Treiblmaier 2019), (Min 2019)
Transaction cost economics (Williamson 1987)	(Saberi et al. 2018), (Treiblmaier 2018), (Treiblmaier 2019)
Resource-based view (Barney 1991)	(Saberi et al. 2018), (Treiblmaier 2018), (Treiblmaier 2019)
Information Processing Theory (Galbraith 1974) Normalisation Process Theory (May and Finch 2009)	(Saberi et al. 2018)
Triple-bottom-line (Elkington 1999)	(Saberi et al. 2018), (Treiblmaier 2019)
Mindful Use (Sun et al. 2016)	(Verhoeven et al. 2018)
Sensemaking (Weick 1977)	(Wang et al. 2019)

Table 2. Theories used and discussed in the selected papers

3.3 Countries of research

The papers selected in this study originated from four main areas of the world: (1) Europe (13 countries - Austria, Croatia, Denmark, France, Germany, Greece, Italy, Spain, Sweden, Switzerland, Netherlands, Romania, UK), (2) The Americas (Canada, USA and Brazil), (3) Asia (China, Hong Kong, Taiwan, India), and (4) Australia.

4 THEMES ARISING FROM ANALYSIS OF THE PAPERS

Table 3 presents the themes that were developed by analysing the content of the papers, cross referenced against the papers that discussed each of those themes.

5 TRIPLE BOTTOM LINE BLOCKCHAIN MODEL FOR SUPPLY CHAINS

The themes that arose from the analysis were further developed into a framework by using Triple Bottom Line as an overall perspective (see Figure 2). The framework is elaborated further in this section.

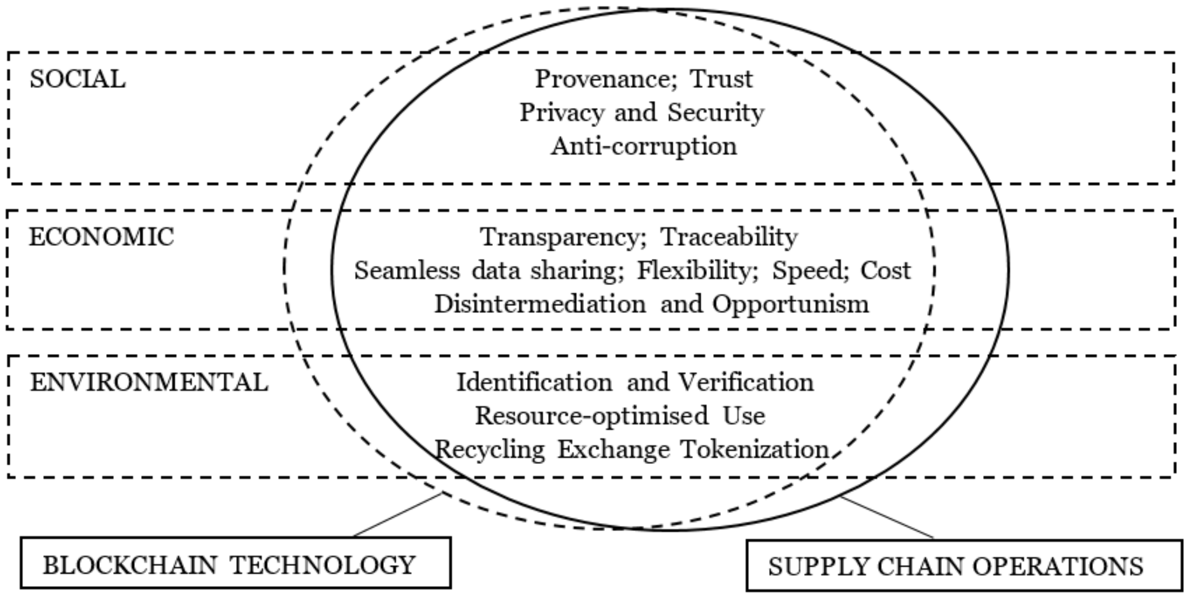

Figure 2: Triple-bottom-line blockchain model for supply chains

Drivers of Blockchain deployment	**Economic issues**							**Social issues**				**Environmental issues**		
Driver dimensions	Seamless data sharing	Transparency	Traceability	Flexibility	Cost	Speed	Disintermediation and Opportunism	Trust	Privacy and Security	Provenance	Anti-corruption	Identification and Verification	Resource-optimised use	Recycle exchange tokenization
Kamble et al., (2018)		✓	✓					x			✓			
Saberi et al., (2018)	✓x	✓	✓	✓	✓x		✓	✓	✓	✓		✓		✓
Wang et al., (2018)	✓x	✓x	✓	✓x	✓x	✓x	✓	✓	✓x	✓	✓		x	
Verhoeven et al. (2018)	✓	✓	✓		x	✓	✓	✓	x	✓				
Lu (2018)	✓		✓		✓				✓					
Kshetri (2018)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		
Lacity (2018)	✓	✓	✓		✓		✓	✓	✓					
Treiblmaier (2018)	x	✓	✓	✓	✓		✓	✓						
Queiroz & Wamba (2019)		✓	✓		✓	✓		x						
Hughes et al. (2019)	✓	✓	✓	✓x	✓x	✓x	✓	✓	✓x					
Queiroz et al. (2019)		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	x	
Hald & Kinra (2019)	✓	✓	✓	✓x			✓		✓					
Cole et al. (2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓	x				
Allen el at. (2019)			✓	✓	✓	✓	✓	✓	✓	✓				
Wang et al. (2019)	✓	✓	✓	✓x	x		✓	✓	✓x	✓	✓		✓	
Kim & Laskowski (2018)			✓							✓				
Montecchi et al. (2019)			✓		✓			✓		✓				
Behnke & Janssen (2019)	x	x	x											
Pan et al. (2019)	✓		✓	✓	✓			✓	✓					
Choi et al. (2019)	✓		✓	✓	✓		✓							
Min (2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Tönnissen & Teuteberg (2019)	✓	✓	✓	✓	✓	✓	x	x	✓					
Xu et al. (2019)		✓	✓		x	x								
Chang et al. (2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Galvez et al. (2018)	x	✓x	x	✓x	✓	✓x	✓	✓	✓	✓		✓		
Kamble et al. (2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			x	
Azzi et al. (2019)	✓	✓	✓		✓	✓	✓	✓						
Westerkamp et al. (2019)	✓		✓		x	x				✓				
Jabbar & Bjørn (2018)	✓			✓		✓		✓						
Francisco & Swanson (2018)	✓	✓	✓				✓	✓	✓			✓		
Dobrovnik et al. (2018)	✓	✓	✓		✓x	✓	✓	✓	✓			✓		
Treiblmaier (2019)	✓	✓	✓		✓	✓		✓	✓				✓	
Antonios et al. (2019)	✓	✓	✓		✓x	✓	✓	✓	✓	✓				
Edvard et al. (2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓x					
Sternberg & Baruffaldi (2018)	✓	✓x	x	✓x				x	x					
Akram & Bross, (2018)	✓x	✓x	✓					✓	✓x	✓				
Blossey et al. (2019)	✓	✓	✓	✓	✓	✓								

(✓ indicates a potential benefit of blockchain; **x** indicates challenges of blockchain)

Table 3. Blockchain potential benefits and challenges in supply chains

5.1 Economic Issues

5.1.1 Seamless data sharing

As shown in Table 3, the potential for blockchain-based technologies to enable more efficient data sharing was frequently proposed in the literature. It is argued that the distributed nature of the blockchain environment could simplify the validation and reconciliation of transactions (Dobrovnik et al. 2018; Hughes et al. 2019), or even to eliminate the need for reconciliation entirely (Lacity 2018). This could be operationalised through the use of smart contracts which are trusted applications installed in the blockchain executed using verified information thereby enabling automation (Blossey et al. 2019; Kamble et al. 2018). The work of Jabbar and Bjørn (2018) is an example of a study investigating the implementation of blockchain within the shipping industry. This included analysis of transactions (e.g. via digitisation of the Bill of Ladings) and specific logistics functions (e.g. port-to-port shipping, container-weight rules). This study demonstrates a significant potential role for distributed ledgers to seamlessly transfer data among actors in the shipping chains so that the industry can solve bottlenecks at port gates. However, the study also revealed challenges of implementation that the authors discuss in terms of 'infrastructural grind' (Jabbar and Bjørn 2018). The heterogeneity of organisational data formats is also a barrier to the integration of IT systems and databases of various parties along the SC which impedes seamless data sharing solutions (Galvez et al. 2018; Wang et al. 2019). Further, organisations may be resistant to sharing information or data with other organisations (Akram and Bross 2018; Queiroz and Wamba 2019; Saberi et al. 2018; Treiblmaier 2018; Wang et al. 2018). This is further complicated by regulatory requirements in the food supply chain and authors such as Behnke and Janssen (2019) propose that data governance and organisational processes need to be standardised within the food supply chain before blockchain applications can be successfully implemented.

5.1.2 Transparency and Traceability

Almost all of the papers in the review mention 'transparency' and 'traceability' as potential benefits of distributed and immutable blockchains (with some papers using the term 'visibility' interchangeably with transparency). Traceability is about sharing information to 'track the flow of product or product attributes through the production process or supply chain' (Garcia-Torres et al. 2019). Solving the inter-organisational disconnection is a major motivational driver of blockchain deployments (Wang et al. 2018). Traceability, which follows the inter-organisational processes in detail, acts as measurement against fraud of products, towards food safety and security in food SC contexts, and to trace outbreaks (Behnke and Janssen 2019; Galvez et al. 2018; Pan et al. 2019). Complex products require commensurably advanced traceability systems however manually written documents with significant potential for human error are still prevalent in SC. Therefore, the synchronised digitalisation of SC processes and electronic data management systems are the biggest challenges in the global SC (Galvez et al. 2018). Blockchain can only assist digital records by creation of 'digital tokens' (Edvard et al. 2019; Westerkamp et al. 2019), but physical tracking still has loopholes and needs other technologies such as IoT (Sternberg and Baruffaldi 2018).

Transparency and Visibility is the 'extent to which actors within a supply chain have access to or share information which they consider as key or useful to their operations and which they consider will be of mutual benefit'. Transparency is 'not merely about sharing information but also about acting transparently' (Garcia-Torres et al. 2019). Blossey et al. (2019) indicate that poor end-to-end transparency is the cause of the bullwhip effect in SC management. The applications of IoT and blockchain can boost transparency and allow real-time sharing of location and status data between multiple SC members to enhance collaborative planning (Blossey et al. 2019) and SC resilience (Min 2019; Pettit et al. 2019).

However, authors also note limitations of blockchain technologies in relation to traceability and transparency. Blockchain technology is not sufficiently mature, leading to scepticism and a lack of confidence in business which, is a barrier to the widespread adoption amongst the supply chain industry (Wang et al. 2019). There are also concerns about the privacy of transport workers (Sternberg and Baruffaldi 2018) and resistance to the list of actors in the supply chain being disclosed to all (Behnke and Janssen 2019). Akram and Bross (2018) state logistic companies may be resistant to increased transparency out of concern for greater scrutiny regarding delivery standards and reimbursement for product damage.

5.1.3 Disintermediation and Opportunism

Disintermediation is the removal of intermediaries from the supply chain. This is an effect of applying blockchain technology to a supply chain, resulting in some intermediaries becoming redundant (Saberi et al. 2018). This effect is described in contexts such as supply chain finance, especially in the global trade SC, whereby actors can simplify transaction procedures and reduce transactional costs (Blossey et al. 2019). In the case study of the Moyee coffee supply chain using a blockchain enabled by bext360, middlemen who buy coffee from farmers at a low-price and sell high to factories can be controlled and eliminated (Kshetri 2018). It has been suggested that customs clearance agents or freight forwarding could be replaced or modified by automation (Wang et al. 2019). However, Tönnissen and Teuteberg (2019) analysed 10 blockchain-enabled logistics case studies, and found that no disintermediation happened in the pilots, and that just one case showed the replacement of existing intermediaries by new ones.

The existence of intermediaries and agencies in a supply chain increases the potential for opportunistic behaviour such as abusing power and intentionally taking advantage, so organisations have to keep track of SC activities by auditing and monitoring (Saberi et al. 2018). It is argued that a key feature of blockchain is that it can facilitate transactions in low-trust environments and increase transparency, therefore reducing the scope for Opportunism (Lacity 2018; Saberi et al. 2018). Blockchain is said to reduce opportunism by, for example, preventing counterfeit and fraudulent goods (Choi et al. 2019; Edvard et al. 2019). Hald and Kinra (2019) also describe anti-opportunism benefits of blockchain such as 'enforcement surveillance' in supply chain management.

5.1.4 Flexibility

This feature is described as the reduction of paperwork leading to an increase in the flexibility of supply chain processes. Goods could potentially be moved through customs more quickly and the sharing of data between parties can lead to less physical steps in the supply chain (Sternberg and Baruffaldi 2018; Wang et al. 2019). Although system integration is a desired goal of blockchain-enabled SC, one of the major challenges to integration is having to comply with existing local and regional legal systems of multiple countries (Allen et al. 2019; Galvez et al. 2018; Lacity 2018; Millard 2018; Sternberg and Baruffaldi 2018; Wang et al. 2018). Hughes et al. (2019) also stress that immutability does not allow the modification of transactions, which is more rigid rather than flexible.

5.1.5 Speed

Numerous scholars in Table 3 anticipate that the electronic sharing of data (via the blockchain distributed database) could speed up the work of existing paper-based supply chains allowing transactions to be executed faster than the status quo. For example, customs and payment procedures could be performed much more quickly (Jabbar and Bjørn 2018). Blockchain-based smart contracts could even automate some of the steps, minimising lead times (Kshetri 2018; Wang et al. 2019).

However, the scalability potential of blockchains has been questioned by many. The speed of creating new blocks in the blockchain network can limit scalability leading to low response rates (Galvez et al. 2018; Hughes et al. 2019). Many studies have considered the integration of IoT and blockchains (Azzi et al. 2019; Makhdoom et al. 2019; Reyna et al. 2018; Westerkamp et al. 2019) to track temperatures and locations during delivery. However, the storage capacity and scalability of blockchains with IoT is under debate. IoT devices potentially generate gigabytes of data in real-time which could make integration with blockchains a challenge (Antonios et al. 2019; Reyna et al. 2018). Xu et al. (2019) developed a real-world trial use case, and indicate that blockchain-enabled solutions experience more latency than a conventional SC transaction. Westerkamp et al. (2019) analysed the maximum transactions processing per block which shows the transactional speed limitations, and recommend the solution is for industry-specific permissioned ledgers to mitigate the shortcomings.

5.1.6 Cost

Many of the papers propose that blockchains can lower costs in supply chains. The primary themes noted in the analysis were that blockchains can help reduce the amount of paperwork between parties in the supply chain, lower transaction costs by sharing information and reduce the need of intermediaries, thus simplifying the supply chain: all leading to potential reduction of costs.

Blockchain-based smart contracts can offer automated and self-executed solutions to digitalise SC operation, which simplifies transactional procedures, minimises lead times and saves costs (Kshetri 2018; Wang et al. 2019). Risks are potential future costs, and transparent and trustworthy information, shared through a blockchain, can help to mitigate SC risks such as finance, physical and performance risks (Montecchi et al. 2019). On the other hand, the cost of distributing data (Hughes et al. 2019), upgrading infrastructure (Saberi et al. 2018) and shifting data to a new blockchain-based legal system (Dobrovnik et al. 2018) could be highly expensive. There can be a burden on overhead costs (Antonios et al. 2019), and may also be more challenging for poor countries (Verhoeven et al. 2018). Reyna et al. (2018) recommend that it is important to analyse the costs involved in achieving improvements. To achieve an autonomous digitalised economy, we need to have a conceptual transformation both at the design and development stages (Makhdoom et al. 2019).

5.2 Social Issues

5.2.1 Provenance (Traceability)

A social perspective of traceability was termed Provenance by several authors and is the tracing and tracking of the social aspects of the supply chain between business and society (Allen et al. 2019), (Verhoeven et al. 2018). Provenance encompasses human rights and fair and safe work practices (Saberi et al. 2018) such as identifying low-paid outsourcing or the use of child labour. Ingredients, raw materials, and packaging of products can be identified and monitored regarding their environmental standards (Garcia-Torres et al. 2019; Saberi et al. 2018). Cole et al. (2019) state that transparency of supply chains to trace back origins could have an impact on organisational reputation, as any unethical or downgraded production standards influences the entire supply chain.

5.2.2 Trust

Many of the studies analyse and propose the impact of blockchain immutability and transparency on business and societal interrelationship, i.e. to reduce the pressure of trust (Cole et al. 2019), to segregate the SC relationship (Hald and Kinra 2019) or to propose a matrix of trust and automation to treat different scenarios (Cole et al. 2019). It may also be possible that the use of smart contracts embedded in a blockchain to process transactions automatically could work as a new method of trust (Treiblmaier 2018; Wang et al. 2018).

However, reintermediation is still possible (Wang et al. 2018), as people still need intermediaries to supervise business transactions (Tönnissen and Teuteberg 2019; Wang et al. 2018; Wang et al. 2019) or need to establish trust to run the blockchain-based operation (Auinger and Riedl 2018; Queiroz and Wamba 2019).

5.2.3 Privacy and Security

Immutable and distributed ledgers enable security by maintaining a complete history at each node (public blockchains) or related nodes of the network (private and consortium blockchain) which secure the network from hackers more efficiently than centralised systems (Edvard et al. 2019; Saberi et al. 2018; Wang et al. 2018). Users (the owner of each node) can opt to remain anonymous or provide proof of identity to others, which preserves the privacy of users (Wang et al. 2019). Chang et al. (2019) introduces a blockchain-enabled SC tracking process framework where relevant data of logistics and payment are put on-chain and other business data are off-chain, which is efficient in data storage and privacy. On-chain and off-chain data concepts can solve the concern of many professionals in relation to sharing confidential information (Akram and Bross 2018; Wang et al. 2019). To strengthen the privacy and security of SC platforms and minimise the conflict of information transparency, Sternberg and Baruffaldi (2018) advocate the utilisation of private and consortium blockchains rather than public blockchains.

However, blockchain uses ‘public key encryption for transaction authentication and execution’, and a private key to secure an account, so an incident such as ‘a party loses and unwittingly publishes their private key’ has ‘no safety mechanism to provide additional security’ (Hughes et al. 2019). A public peer-to-peer distributed network also has no centralised authority to contact once an evident security breach happens (Edvard et al. 2019).

5.2.4 Anti-corruption

A social variation of opportunism is that of corruption, in which parties involved in a supply chain illegally extract personal advantage from it, such as the payment of bribes. Kamble et al. (2018) describe a blockchain network as an ‘incorruptible chain’. The added transparency in a blockchain based supply chain can potentially shine more light on corrupt practices. Saberi et al. (2018) argue that blockchain technology could have a significant impact on blocking nefarious agents from both social and individual misdeeds. Wang et al. (2018, 2019) also propose that blockchain-enabled SC system can reduce bribery and fraud, particularly in the circumstances of developing countries and humanitarian supply chains, where the problem prevails. This is a significant societal potential of blockchain but is not discussed widely in the literature.

5.3 Environmental Issues

5.3.1 Identification and Verification (Traceability)

Enabling traceability to verify and identify the origin of products and their transactions facilitates the analysis of environmental impacts in SC operations more than ever before (Saberi et al. 2018). Green products and environmental-friendly standards are difficult to verify, but blockchain can allow improved traceability and provide a potential solution for the SC industry (Dobrovnik et al. 2018; Saberi et al. 2018). This could include making information about pesticides used in agricultural products and other environmental impact information available for customers at the end of the SCs (Francisco and Swanson 2018; Galvez et al. 2018; Kshetri 2018; Saberi et al. 2018). This information also assists organisations to trace and measure the carbon footprint of products in real-time (Saberi et al. 2018), and to select green suppliers and sustain their supply chains (Dobrovnik et al. 2018; Queiroz et al. 2019). Tracking substandard products back through the supply chain can reduce rework and recalls, leading to lower resource consumption and greenhouse emissions (Saberi et al. 2018).

5.3.2 Resource-optimised Use

Further to the economic benefits for organisations of resource optimisation, blockchain technologies also demonstrate the potential for environmental consumption benefits such as operating paperless transactions (Wang et al. 2019) and minimising traffic movement to reduce energy, fuel usage and emissions (Treiblmaier 2019). However, the energy required to operate the blockchain creates an overhead cost and could be a significant environmental concern (Kamble et al. 2019; Queiroz et al. 2019; Wang et al. 2018).

5.3.3 Recycling Exchange Tokenization

One potential of blockchains is to use tokenization to enhance the recycling efficiency of supply chains. Saberi et al. (2018) indicate this potential by discussing a blockchain use case in Europe which saw the introduction of cryptographic tokens in exchange for depositing recyclable materials (i.e. plastic containers, cans, and bottles) as financial incentives to reduce plastic waste.

6 DISCUSSION AND CONCLUSION

This paper outlines the current understanding of the potential benefits and limitations of blockchain technologies in the supply chain context, by conducting a comprehensive literature review of the most recent publications. The widespread themes were integrated into a cohesive framework using the concept of Triple Bottom Line as an overarching perspective. The developed framework helps shine a spotlight on the social and environmental aspects of blockchain implementation. For industry professionals, the framework provides organisations with a more holistic overview of blockchains in supply chains. Practitioners can not only focus their resources on investigating the potential economic benefits of blockchains, but also take into account the social and environmental benefits and impacts.

The results of the analysis and the framework development show that the current understanding of blockchain implementations in supply chains is still at an exploratory stage. As this review was limited to academic publications, further work is needed to explore the latest developments of blockchains in supply chains by analysing the grey literature and social network content. Further studies are also needed to identify what makes a successful blockchain supply chain implementation: economically, socially and environmentally.

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