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BLOCKCHAIN ADOPTION CHALLENGES IN SUPPLY CHAIN

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Introduction

Today's supply chains are inherently complex in nature and consist of geographically disjointed entities competing to serve diverse consumers worldwide (Lambert and Enz, 2017; Saberi et al., 2019b). Globalisation, diverse regulatory policies, and varied cultural and human behaviour in supply chain networks make it a daunting task to evaluate information and manage risk across these complex networks (Ivanov et al., 2019; Saberi et al., 2019b). Inefficient transactions, fraud, pilferage, and poorly performing supply chains lead to a lack of trust amongst business partners, necessitating the need for collaboration, better information sharing, and verifiability systems to be in place to tackle these issues (Saberi et al., 2019b). In this regard, blockchain is considered as a potential solution to address these issues. Blockchain is expected to speed up the processes of information sharing and make it a more reliable system (Kamble et al., 2019).

Recent studies (from 2015 onward) embark on demonstrating the usefulness of adopting blockchain technology in supply chains (Wang et al., 2019b; Queiroz et al., 2019; Wang et al., 2019a). Some of the potential benefits highlighted in the operations and supply chain management (OSCM) literature are (i) to improve transparency, authenticity, trust and security (Wang et al., 2019b; Queiroz et al., 2019); (ii) to improve efficiency and reduce cost/waste (Wang et al., 2019b); (iii) to extend visibility and product traceability (Wang et al., 2019a); (iv) supply chain digitalisation and disintermediation (Wang et al., 2019a); and (v) the ability to automate the process through the introduction of smart contracts (Wang et al., 2019a).

While the literature portrays the positive aspects of transforming supply chains through the adoption of blockchain applications, significant challenges exist with its implementation. First, and one of the most important challenges, is the current infancy level of blockchain technology (Wang et al., 2019b). Due to its infancy, there is a lack of understanding of the technicalities of how and where the technology is best deployed and a skills shortage, both of which contribute to the scepticism and low level of confidence for individual users to adopt blockchain technology (Wang et al., 2019b; Wang et al., 2019a). At present, only large global firms such as Unilever, Walmart and Sainsbury are investing in and trialling the use of blockchain technology to improve the transparency (and sustainability) of their supply chain with expected financial rewards to follow (Cole et al., 2019). The second key challenge is the complexities of integrating all supply chain partners using blockchain technology (Wang et

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al., 2019b). Particularly, in a global supply chain context, complexity arises when needing to comply with diverse laws, regulations and institutions (Wang et al., 2019a). In addition to that, one of the real hurdles that are evident in the implementation stage is that all partners must be convinced of the benefits of sharing data and be prepared to invest time, human and financial resources to a project which they do not consider to be high. Many partners may not be willing to share their data with all. Third, integrating all supply chain partners into the system based on blockchain technology needs financial support and infrastructural investments (Chang et al., 2019).

A brief review of recent literature suggests that studies just embark on identifying potential challenges of adopting blockchain technology for a supply chain. No empirical research has yet been conducted to identify and prioritise those challenges to develop effective strategies. Considering this gap in the literature, the aim of this study is at identifying and prioritising the challenges of blockchain adoption in the global supply chain.

In line with the research objective, our study uses an extensive literature review to identify blockchain adoption challenges and use these challenges to develop a conceptual model. Then we use the fuzzy analytic hierarchy process (AHP) technique to prioritise the challenges using expert opinion. Theoretical and managerial significance are discussed.

Blockchain-based supply chain

This section outlines the potential aspect of blockchain technology and its application to supply chains. It also outlines a blockchain structure and possible areas for managing information in a blockchain-based supply chain. Evidence shows that the blockchain-based supply chain has emerged significantly in the last five years, showing many benefits in various supply chain activities (Saberi et al., 2019b; Roeck et al., 2020).

Blockchain is an evolving technology rooted in cryptography (unique codes to keep information safe in computer networks); it was conceived and popularised by Nakamoto (2008). In a seminal paper, Nakamoto showed how this technology could be applied to develop a cryptocurrency (bitcoin). Conceptually, blockchain is a chain of decentralised computer–terminal–participants ("nodes") that are linked together through a key access system (Nowiński and Kozma, 2017). The linking of nodes enables direct contracting between buyer and seller (peer-to-peer) for making a transaction without the need for traditional intermediaries and creates an unalterable transactional ledger (Letourneau and Whelan, 2017). A ledger is a book or computer file that records transactions. Blockchain is also known as distributed ledger technology (DLT) (Ramachandran and Rehermann, 2017).

The breakthrough of DLT is the advancement of the paper ledger to the trusted electronic ledger. The electronic ledger enables direct communication across supply chain actors without the involvement of a centralised body or intermediaries. Consequently, blockchain-based supply chain actors can save time and money that would otherwise be absorbed by intermediaries (Saberi et al., 2019b; Verhoeven et al., 2018). From this perspective, the following four dominant actors play a significant role in the blockchain-based supply chain (Saberi et al., 2019b):

1. *Registrars,* who provide unique identities to actors in the network.
2. *Standard organisations*, which define standard schemes, technological requirements and blockchain policy.
3. *Certifier*, who provides certifications to actors for supply chain network participation.
4. *Actors*, including suppliers, manufacturers, retailers and customers.

There are use cases that present investments in blockchain technology projects throughout a range of economies, industries and supply chains. For example, small island economies (Allessie et al. 2019) are leading the charge when it comes to the whole economy/industry implementations. For example, Aruba is developing an Etheruem-based platform for travel bookings, promoting direct bookings and disintermediating large foreign-owned intermediaries who keep a large percentage of the transaction in fees (Kwok and Koh, 2019). The Caribbean islands have issued and promoted the use of a regional government-endorsed cryptocurrency (Callahan, 2018), while the Vanuatu government announced the digital national plan which will see the issuance and roll out of Volcano Coin (VCoin) as a way to promote tourism and develop the digital economy (Access Wire 2018). Government officials are articulating the vision for VCoin to become a universal payment digital currency for immigration, tourism, aviation, gaming and real estate industries within Vanuatu and the South Pacific region.

Blockchain technology also has significance for the telecommunications industry in four specific areas. First, blockchain technology is viewed as the "new generation of access technology selection mechanism required for the enablement of 5G networks" (p. 15). Second, the communication and authentication of machines and devices will see blockchain technology guide production processes in the era of the internet of things (IoT). The third use of blockchain technology stands to improve fraud detection and reduce the incidence of roaming fraud, where a subscriber accesses communication resources from a third-party telco and where they are not able to charge the subscriber, yet are still committed to paying the third-party telco for the provision of services. Lastly, telcos are using blockchain technology through an eSIM solution with identity and authentication based on cryptographic identity.

The financial services sector, which is known to spend millions of dollars automating front-end systems measuring advantageous time savings in nanoseconds, has the opportunity to realise an estimated saving of $20 billion annually by focusing on the automation of back-end systems. Settlement processing, regularity reporting and cross-border payments are the main areas identified for cost savings. However, the replacement of paper certificates, letters of credit, recording of property transactions, and validation and transfer of luxury goods have also been areas cited for blockchain technology. Fanning and Centers (2016) also predict the disruptive elements of blockchain technology will have an impact on foreign exchange transactions and auditing functions, both of which should prepare for the disruptive effects to take hold in the near future.

Blockchain technology is also viewed as a solution in the healthcare sector. Blockchain technology connects independently managed healthcare stakeholders who are open to collaboration without ceding control to a central organisation or intermediaries. According to Kuo et al. (2017), they view the preservation and continuous availability of records such as electronic health records, improvements to privacy and security with real-time processing of information in insurance claims in particular, and the immutable audit trail of critical information surrounding client-centred data and consent as the key drivers for acceptance of the technology in the industry.

In the logistics sector, Di Gregorio et al. (2017) report a number of cases within shipping, where there has been a move by carriers and terminal operators to streamline the process of mandatory reporting of verified gross mass (VGM) data before loading using blockchain technology (Hellenic Shipping News 2017). In addition the work done by IBM-Maersk to move to paperless processing is being replicated by the Ports of Rotterdam and Antwerp, realising the reduction of fraud, costs and time delays. As well as this, the Malaysian Institute of Supply Chain Innovation in collaboration with universities is addressing fragmentation, low information sharing and frequent details by using blockchain solutions to improve the less-than-container load (LTCL).

Supply chain management is the enabler for coordinating and integrating key business processes that add value to customers and other stakeholders (Lambert and Cooper, 2000). The main focus of these integrations among the value creation activities (source to produce, market, purchase, and consume goods and services) in the supply chain is to achieve a desired level of performance that can lead to gaining a competitive advantage (Cooper et al., 1997; Gunasekaran and Kobu, 2007). From this perspective, blockchain technology can facilitate the integration of value creation activity and thereby hold the key to enabling the realisation of long-term and sustained competitive advantage (Tian, 2016; Yiannas, 2018).

Blockchain technology enables transparency between supply chain actors by making visible transactions to anyone participating in the supply chain network and providing security, durability and process integrity (Hasan and Salah, 2018; Saberi et al., 2019b). Many organisations, such as Bosch, IBM, Microsoft, Samsung, Toyota and Visa, are embracing blockchain technologies in their supply chain (Letourneau and Whelan, 2017). For example, the Commonwealth Bank of Australia, Wells Fargo and Brighann Cotton successfully applied blockchain technology in the first trade transaction between two independent banks (Ramachandran and Rehermann, 2017). To make this operation successful, they applied a combination of the IoT and smart contracts on a blockchain platform (Ramachandran and Rehermann, 2017).

The IoT, also called the internet of everything or the industrial internet, is a new technology paradigm (Qian, 2018). The IoT is recognised as one of the significant areas of future technology increasingly receiving attention from a wide variety of industries (Makhdoom et al., 2019). The use of IoT is contributing to the economy around the world and improving the quality of consumers' life. The expected contribution of IoT is predicted at about US$7.1 trillion in the global economy by 2020 (Lund et al., 2014). The following are the five IoT technologies widely used for the development of IoT-based products and services (Qian, 2018): radio frequency identification (RFID), wireless sensor network (WSN), middleware, cloud computing and IoT application software.

Similarly, the concept of smart contracts is increasingly receiving attention in global supply chains. Smart contracts is a software application that stores rules (if this happens, then that occurs) for negotiating the terms of contracts between trading partners. Smart contracts can automatically verify and execute the contract based on the agreed terms recorded on the blockchain platform (Ryan, 2017). To this end, smart contracts enable automating complex multistep processes as per the contract's terms in a transparent, secure and traceable manner. The transparent transaction processes enable all parties to save time and money simultaneously, improving supply chain performance (Gatteschi et al., 2018). Blockchain provides reliability, traceability and authenticity of the information flows across the supply chains (Letourneau and Whelan, 2017). It provides consumers with the capability of verifying the provenance relating to products or processes in the supply chain (Saberi et al., 2019b). For example, Letourneau and Whelan (2017) indicate a conceptual link between the traditional supply chain and blockchain transaction. According to Saberi et al. (2019b), a general graphic presentation of a traditional supply chain transformation to a blockchain-based supply chain is shown in Figure 9.1.

However, despite these use cases, blockchain is in its infancy in the supply chain practices, and the widespread adoption of blockchain is only the first step of a very long journey (Letourneau and Whelan, 2017; Queiroz and Wamba, 2019). It is expected that the next generation blockchain could address many problems, some of which include the passage of a typical contract of sale, security and loan arrangement, or lease of applications across a supply chain (Gatteschi et al., 2018; Ryan, 2017; Letourneau and Whelan, 2017). The following section examines the challenging factors that affect blockchain adoption in the supply chain.

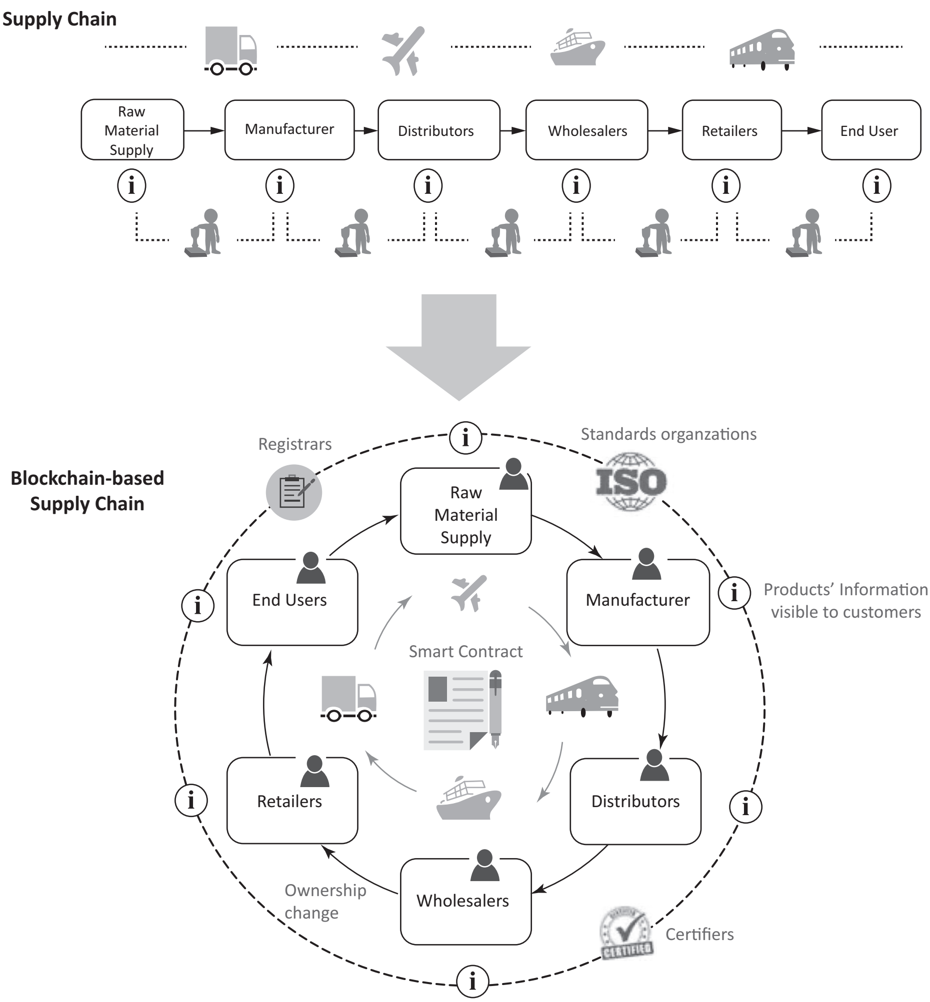


Figure 9.1 A blockchain-based supply chain.

Blockchain adoption challenges

This section provides an extensive literature review on blockchain adoption challenges in supply chains and provides a list of challenges. Within the last five years the literature has explored the possibilities of adopting blockchain into the supply chain (Tian, 2016; Wu, 2017; Lyu, 2018). The published research addressed numerous advantages related to blockchain adoption across the supply chain (Saberi et al., 2019b; Francisco and Swanson, 2018). Many researchers have identified that a substantial change will occur across supply chains around the globe due to the disruptive and transformative properties of blockchain technologies (Collomb and Sok, 2016; Tapscott and Tapscott, 2017; Letourneau and Whelan, 2017). These transformation effects will disrupt how supply chain processes are currently managed (Nowiński and Kozma, 2017) and will profoundly affect the nature of value creation activities in the supply chain (Tapscott and Tapscott, 2017).

Table 9.1 Blockchain misconceptions and factual realities

General misconception	*Vs*	*Factual reality*
By definition, blockchain is distributive ledger technology.		Blockchain technology is formed with the idea of distributive ledger technology and (DLT) do not often follow (BC) technology.
Blockchain only uses bitcoin.		Bitcoin is a cryptocurrency and an application of blockchain technology.
Smart contract legally binds two parties.		Without a separate contractual agreement paper smart contracts are not legally enforceable.
Blockchain is the best database for business solutions.		Traditional database creation is faster and one single point of control, ideal for enterprises that rely on performance.
In the blockchain, transactional data are absolutely secured.		Depends on architecture, as in the public blockchain privacy is the biggest concern.

One of the key barriers to adopting blockchain technology is the hype and misconceptions arising from the volatility of bitcoin. Lu et al. (2019) point out four key misconceptions and sought to clarify things by presenting corresponding factual realities. These are shown in Table 9.1.

A recent Deloitte survey on blockchain attitudes amongst the C-suite show executives believe blockchain is overhyped, and are concerned about how blockchain may disrupt their industry and the potential loss of competitive advantage that arises from not using blockchain technology. In contrast, to the positive use cases and the attitudes surrounding blockchain, there is relatively limited literature that indicates the challenges to blockchain adoption in the supply chain (Saberi et al., 2019b; Queiroz and Wamba, 2019). To investigate blockchain technology and its relationship to sustainable supply chain management, Saberi et al. (2019b) discussed four significant barriers relating to blockchain adoption in the supply chain. The barriers were classified as intra-organisational barriers, inter-organisational barriers, system-related barriers and external barriers. These barriers lead to blockchain adoption challenges that need to be overcome before implementation in complex supply chains is likely to increase (Saberi et al., 2019b).

The complexity of supply chains is the result of the involvement of multiple numbers of partners (one too many or many too many) and a series of related activities (coordinating, planning, and controlling of product and services) occurring through the network (Büyüközkan and Göçer, 2018; Chowdhury and Quaddus, 2016). Due to such complexity, the lack of visibility in shipping or transporting goods or services from one part of the world to another is challenging. Blockchain adoption could minimise such visibility by enabling open access to members of the supply chain, thereby improving transparency, traceability, accountability, knowledge sharing and integration with upstream and downstream partners (Martinez et al., 2019; Rahmanzadeh et al., 2020). In this regard, however, building the technological infrastructure to be made available to the entire supply chain or industry is challenging (Queiroz and Wamba, 2019; Saberi et al., 2019b; Chowdhury, 2016). Furthermore, the high cost of compliance and upgrading of legacy systems is challenging many supply chains and industries (Nikolakis, 2018).

Blockchain technology can support vital information sharing in the supply chain such as data collection, data storage and management, and it can also aid environmental supply chain sustainability (Saberi et al., 2019b). The application of blockchain in the supply chain can improve recycling, reduce carbon emissions and ensure fraud prevention in the supply chain. Blockchain technology has the potential to contribute to social supply chain sustainability. For example, the blockchain-based Social Plastic project contributes to improving the supply chain (Saberi et al., 2019b). Figure 9.2 demonstrates blockchain-based logistics activities in the supply chain.

However, many challenges must be overcome in order to adopt blockchain technologies in supply chains. Such challenges include technology implementation challenges, business process challenges, lack of government policies, lack of top management support, high costs, lack of ethical and safe practice, lack of skilled people, and lack of knowledge (Saberi et al., 2019b). Based on the literature review, the following challenges have been identified:

- Implementation challenges: To implement blockchain technology in the supply chain, it is essential to build blockchain-compatible infrastructure across the supply chain. As blockchain in its infant stage, there is a lack of appropriate business models, and relatively limited trained people and expertise are available. For instance, such an infrastructure building is quite a costly operation.
- Operational challenges: To gain day-to-day operational success by adopting blockchain in the supply chain, a better understanding of supply chain integration is vital through the entire supply chain. Supply chain integration relates to both internal and external integration. Supply chain integration is a broader concept. All partners in the supply chain needed to understand the scalability of integration to execute their major business processes across the supply chain.
- Business process challenges: The application of blockchain could create value in the business process through the entire supply chain. However, selecting the appropriate design in the business process is relatively challenging in the supply chain.
- Legal challenges: Lack of industry involvement and safe practice make it harder to adopt blockchain in the supply chain. More important, jurisdictional problems as the ledger can span multiple locations, and it is possible to fall under different regulations.
- Sustainability challenges: Blockchain adoption in the supply chain requires a large scale of IT infrastructure building, which initiates electricity consumption challenges. In some stages, it is challenging to adopt blockchain in the supply chain due to individual, privacy, and ethical issues.

Based on the review of literature, blockchain adoption challenges in the supply chain are presented in Table 9.2.

Methodology

The aim of this study is to identify the crucial challenges which hinder the process of mass blockchain adoption in the supply chain. In line with the research objective, we conducted an extensive literature review to identify blockchain adoption challenges in the supply chain. Then we sought opinions from three experts to validate the findings from literature and categorise the challenges. The challenges have been categorised into five major categories, which comprise a total of 23 sub-categories (see Figure 9.3), depending on their relevancy.

Once the challenges were categorised, based on expert opinion, we prioritised the blockchain adoption challenges in the context of the global supply chain using the fuzzy AHP technique. The fuzzy AHP method is explained in the next section.

Fuzzy AHP application and data computation

AHP was first introduced by Saaty (1988) as a decision-making tool in the field of economics and management. AHP has been widely used by many researchers and professionals around the world to identify the best alternative, especially when decision-makers must consider several

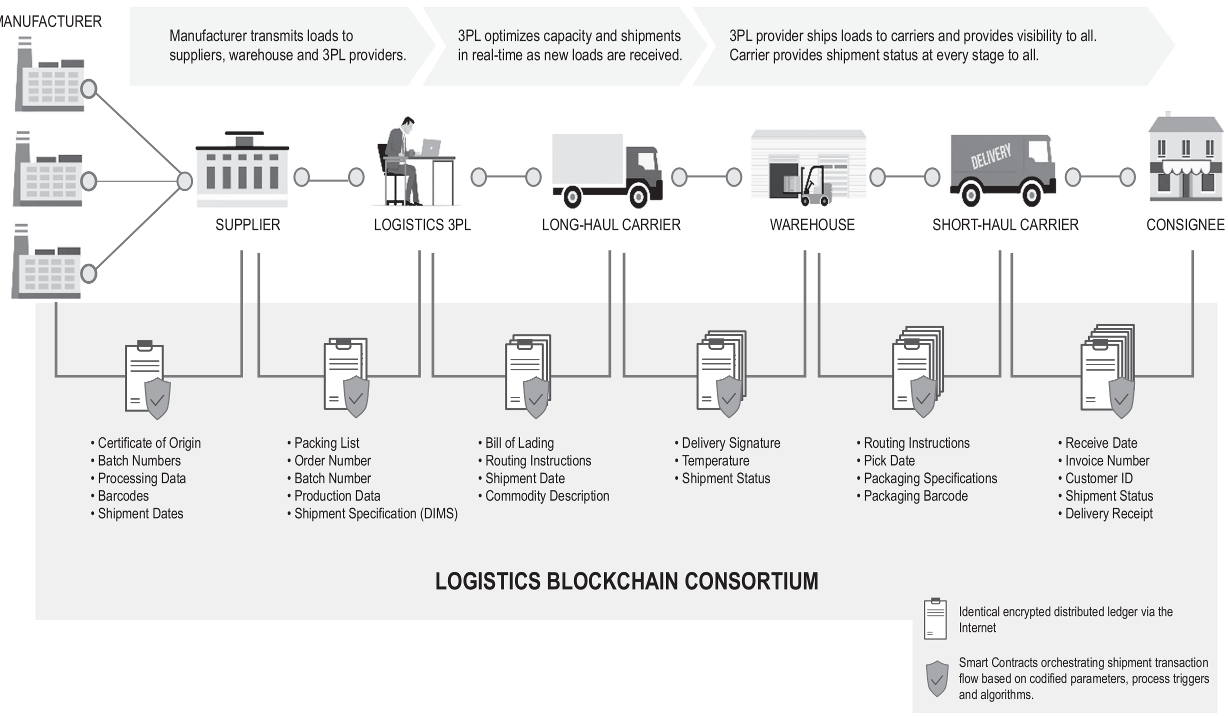


Figure 9.2 Blockchain-based logistics and supply chain operations.

Table 9.2 Blockchain adoption challenges in the supply chain

Challenge	*Description*	*Reference*
Technology	Adopting new technology in an attempt to market oneself as an early adopter without a proper strategy creates many issues.	Saberi et al. (2019), Dobrovnik et al. (2018), Queiroz and Wamba (2019)
Operational issues	Due to multiple entities and many business processes in the supply chain, deploying a consensus mechanism is challenging. As such, *trust, shortage of professionals, anonymity concern, lack of device authenticity, lack of scalability and immutability* are major operational challenges for implementing blockchain in the supply chain.	Mackey et al. (2019),Feng et al. (2018), Wang et al. (2019a), Casino et al. (2019)
Infrastructure	Requires large-scale investment in technological infrastructure.	Queiroz and Wamba (2019), Saberi et al. (2019), Baker and Steiner (2015)
Cost	The high cost is a significant issue due to building technological infrastructure across the supply chain.	Saberi et al. (2019), Kamble (2019), Nikolakis (2018)
Legal implications issues	Lack of business models and best practices for implementing new technologies are major challenges. These include *jurisdiction, contract enforceability, legal practitioners' knowledge, identify theft and liability of customer risk issues*.	Chang et al. (2019), Queiroz et al. (2019), Jacob and Buer (2016)
Implementations	Lack of business model and best practice for implementing the new technology.	Dobrovnik et al. (2018), Saberi et al. (2019), Verhoeven et al. (2018)
Training	Lack of trained people to implement the technology.	Saberi et al. (2019), Francisco and Swanson (2018)
Knowledge and expertise	Lack of knowledge and expertise to encounter troubleshoot issues after implementation of the technology.	Saberi et al. (2019), Verhoeven et al. (2018)
Governance issues	Data integrity and data provenance are key challenges in the blockchain adoption supply chain. These include *compliance policy and guidance, bill of lading, governance procedure establishment, a variation on digital flow and physical flow of goods*.	Casino et al. (2019), Saberi et al. (2019), Mackey et al. (2019), Figorilli et al. (2018), Chang et al. (2019)
Integration	Challenges of integrating sustainable supply chain practice through blockchain technology	Haddud et al. (2017), Saberi et al. (2019)
System deployment	System development is another challenge for blockchain adoption in the supply chain. The challenges include *blockchain structure design, integration with partner, data security and sharing and management disinterest*.	Chang et al. (2019),van Engelenburg et al. (2019), Figorilli et al. (2018)

(*Continued*)

Table 9.2 (Continued)

Challenge	*Description*	*Reference*
Collaboration, communication, and coordination	Lack of collaboration, communication and coordination among the supply chain partners.	Saberi et al. (2019), Verhoeven et al. (2018)
Security	System-related security is one of the big challenges.	Saberi et al. (2019)
Top management support	Lack of top management support and commitment.	Saberi et al. (2019)
Sustainability issues	Challenges of integrating sustainable supply chain practices through blockchain technology. The challenges include *ecologically unfriendly, power consumption, double spending risk and employee ethics*.	Nikolakis et al. (2018), Fu et al. (2018), Pankowska (2019), Saberi et al. (2019), Carter and Rogers (2008)
Awareness of customer	Lack of customer awareness relating to blockchain technology adoption in the supply chain.	Saberi et al. (2019)
Government policy	Lack of government policy.	Saberi et al. (2019)
Ethical and safe practice	Lack of industry involvement in ethical and safe practice.	Saberi et al. (2019)

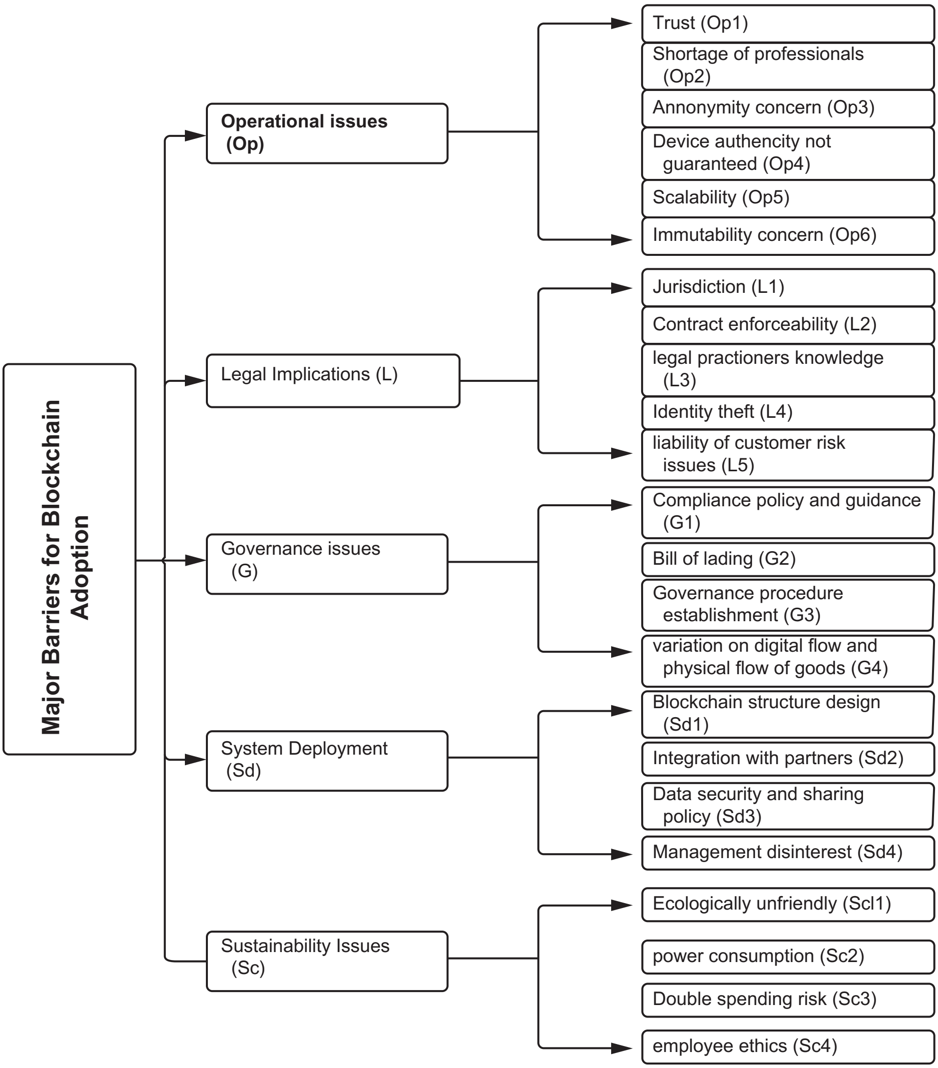
criteria. Decision-makers make a decision by providing quantitative value from a pre-existing numerical scale (1, 2, 3, …, 9) to rank options based on whichever best meets the decision-making criteria (Chang, 1996).

Fuzzy AHP is more applicable in situations when a decision cannot be made precisely as there is more complexity associated with surrounding environments. Experts can make precise decisions when the situation is more known to the expert, but the majority of the times, human judgement is imprecise. Bellman and Zadeh (1970) first introduced fuzzy set theory to more accurately explain qualitative, vague, inconsistent and fuzzy information. This study led Chang (1996) to propose fuzzy extent analysis methodology and all the computational work was conducted through online software. The fuzzy AHP is explained in the following with some results as an example. The pairwise comparison matrix can be expressed as in Figure 9.4. The fuzzy triangular scale and the linguistic terms used for the comparison matrix are presented in Table 9.3.

Elements of a complete pairwise comparison matrix used in the fuzzy AHP method are triangular fuzzy numbers where the first component (l) is the least number, the second component (m) is the mean of numbers and the third component (u) is the maximum number (Ayhan, 2013).

To ensure the reliability of AHP results, the consistency ratio (CR) of pairwise comparison metrics is salient. The CR for each matrix is derived from dividing the consistency index (CI) of each matrix by the random index (RI):

$$CR_g = \frac{CI_g}{RI_g}$$



Major categories are represented in a shorter form for calculation and presentation purpose such as Operational issues - (Op), Legal Implications - (L) and thei respective sub-categories are represented as (Op1 = Trust, Op2= shortage of Professionals, Op3= .... and follows ......)

Figure 9.3 Hierarchical structure of blockchain adoption challenges in the supply chain.

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix}$$

Figure 9.4 A pairwise comparison matrix.

Table 9.3 Fuzzy triangular scale and linguistic terms

Code	*Linguistic variables*	*L*	*M*	*U*
1	Equally important	1	1	1
2	Intermediate value between 1 and 3	1	2	3
3	Slightly important	2	3	4
4	Intermediate value between 3 and 5	3	4	5
5	Important	4	5	6
6	Intermediate value between 5 and 7	5	6	7
7	Strongly important	6	7	8
8	Intermediate value between 7 and 9	7	8	9
9	Extremely important	9	9	9

In Table 9.4, the random indices for fuzzy pairwise comparison matrices were developed, according to Gogus et al. (1997), by initiating 400 random matrices. Only 10% of consistency variations are allowed. The software automatically detects any inconsistency and allows the decision to be modified manually (Radionovs et al., 2016).

The pairwise comparison matrix has been constructed for the main criteria and sub-criteria concerning the main objective. For example (the following example was generated after taking the mean value of triangular fuzzy numbers given to a criterion in respective to others):

$$\text{Operational} = \begin{bmatrix} 1.000, & 1.000, & 1.000 \\ 0.143, & 0.167, & 0.200 \\ 0.200, & 0.289, & 0.500 \\ 0.167, & 0.775, & 4.000 \\ 0.143, & 0.183, & 0.250 \end{bmatrix}$$

$$\text{Shortage of skill professionals} = \begin{bmatrix} 1.000, & 1.000, & 1.000 \\ 5.000, & 5.988, & 6.993 \\ 3.003, & 4.464, & 5.988 \\ 0.200, & 0.867, & 4.000 \\ 5.000, & 5.988, & 6.993 \\ 2.000, & 3.003, & 4.000 \end{bmatrix}$$

Results and discussion

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The results of the software interface are provided next (Table 9.5, Figures 9.5 and 9.6).

From Table 9.6, it is evident that the criterion Op2, Op5, Sd1, G4 and G3 are the top five important factors, and comparing their weights to other differences is quite significant. One major issue requires clarification 0 weight of some criteria. It means, as per experts in comparison to the prioritised 15 criteria, those criteria are not necessary or relevant enough to our main issues. One of the main reasons for adopting Chang's extended analysis is when computing the comparison result, it deploys the intersection operation which allows the fuzzy intersection

Table 9.4 Random index

N	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
RI^g	0	0	0.1796	0.2627	0.3597	0.3818	0.4090	0.4164	0.4348	0.4455	0.4536	0.4776	0.4691	0.4804	0.4880

Table 9.5 Priorities of main criteria with respect to goal

Rank	*Name*	*Weight*
1	Operational issue	0.354
4	Legal implications	0.056
2	Governance issue	0.337
3	System deployment	0.252
5	Sustainability issue	0

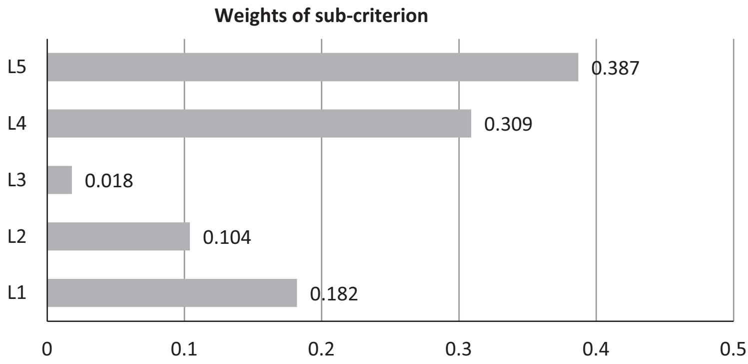

Figure 9.5 Priorities with respect to legal implications.

result to be zero. The representation of the corresponding criteria may raise confusion about their zero weight as to how it is possible that criteria of a decision-making process have no importance. The explanation comes with fuzzy logic in a comparison matrix: if one criterion carries the least weight among others, it also means the criteria have no importance and can be represented with zero importance (Özdağoğlu and Özdağoğlu, 2007). The research objective is based on a topic that ultimately represents an uncertain environment and decision-making with absolute certainty not possible for the decision-makers, which motivated the authors to follow Chang's extended fuzzy AHP method.

Based on the final weight calculation total, 15 challenges have been ranked and found to be more responsible for halting the process of blockchain adoption in the supply chain.

Considering the sub-criteria of our study, we identified Op2 (shortage of professionals) is ranked 1 with an importance weight equal to 15.1158%. We also found that Op5 (scalability issue) is ranked 2, which carries an importance weight equal to 13.275%. Similarly, we identified Sd1 (blockchain structure/design) as ranked 3 with a 9.2988% importance weight. Our findings are consistent with the literature, as authors such as Makhdoom et al. (2019) and Saberi et al. (2019a) asserted that as blockchain adoption in the supply chain is in the infancy stage, the professional shortage and scalability are important challenges to adopt blockchain in the supply chain. The prioritised of 15 challenges with respect to their weight-based rank are presented in Table 9.6.

Blockchain in the global supply chain is in the infancy stage, and most firms are yet to go beyond analyses leading to the adoption phase (Queiroz and Wamba, 2019). Blockchain adoption has gained a relative pace in the global supply chain, focusing on enormous potential over recent years. However, existing literature on the blockchain provides relatively limited priorities

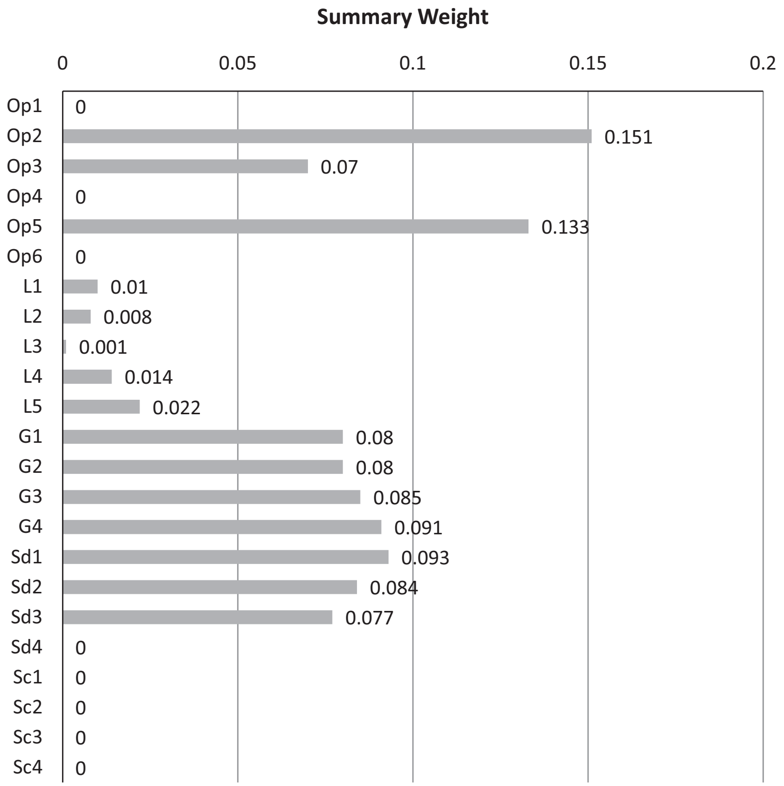

Figure 9.6 Summary of priorities with respect to the objective.

Table 9.6 Prioritised blockchain adoption challenges in the supply chain

Code	*Challenges*	*Weight*	*Rank*
Op2	Shortage of professionals	0.151158	1
Op5	Scalability	0.13275	2
Sd1	Blockchain structure/design	0.092988	3
G4	Variation between digital transaction and physical flow	0.091664	4
G3	Governance procedure	0.085261	5
Sd2	Integration with partners	0.082152	6
G2	Bill of lading	0.080543	7
G1	Compliance policy and guidance	0.079532	8
Sd3	Data security and sharing policy	0.07686	9
Op3	Anonymity concern/data quality not guaranteed	0.070092	10
L5	Liability of customer risk issue	0.021672	11
L4	Identity and information theft	0.017304	12
L1	Jurisdiction	0.010192	13
L2	Contract enforceability	.005824	14
L3	Legal practitioners' insufficient knowledge	.001008	15

on blockchain adoption challenges in the supply chain (Janssen et al., 2020; Saberi et al., 2019b; Biswas and Gupta, 2019; Queiroz and Wamba, 2019). In terms of blockchain adoption challenges in the supply chain, our findings bring important insights by prioritising 5 significant challenges and 15 sub-challenges accordingly to take the adoption decision in the global supply chain. In addition, to overcome such challenges, blockchain technology can bring the most important change and strategies in supply chain design, activities and product flow. In particular, the findings of this study add a useful contribution to the existing body of knowledge in this field.

Conclusion

The emerging technology blockchain is still in its infancy stage. Expert predicts it will serve an essential role in the value creation activities of the global supply chain. However, numerous challenges inhibit blockchain adoption in the global supply chain. This study examines the blockchain adoption challenges in the supply chain. Our study found 23 challenges regarding blockchain adoption, which are classified under five groups: implementation challenges, operational challenges, business process challenges, legal challenges and sustainability challenges. In an effort to prioritise the identified challenges, we find that the shortage of professionals, scalability and system architecture are the top three challenges of blockchain adoption in the supply chain. Supply chain managers needed to take proactive and rapid moves to mitigate the most significant blockchain adoption challenges to improve supply chain operations and transparency, visibility, and sustainability in the global supply chain. This study is expected to add to the existing knowledge and academic literature by extending the insight of blockchain adoption challenges in the supply chain. The proposed model in this chapter may serve as a framework for managers to prioritise blockchain adoption challenges in the supply chain management. The prioritisation of challenges will assist managers in designing effective and efficient strategies to mitigate the most important challenges. Despite the numerous merits of this study, some limitations need to be addressed in future research. This study is based on a literature review and a small number of experts' opinions. Further, empirical study may be conducted by incorporating data from different and many respondents encompassing different supply chain members. Future research may also be conducted to develop a decision model that can determine the most effective and efficient strategies to mitigate blockchain adoption challenges in the global supply chain.

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