Potential of blockchain technology in supply chain management: a literature review

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Abstract

Purpose – The purpose of this paper is to review the existing literature on blockchain technology, present some trends and consider its potential value in supply chain management (SCM).
Design/methodology/approach – Papers that contained the word "blockchain" in their titles, keywords or abstracts were selected for conducting trend analyses.
Findings – The blockchain technology is rapidly making inroads in many industries and there is tremendous potential to eliminate intermediaries and to make SCM more efficient.
Research limitations/implications – This analysis is limited to 299 papers from the EBSCO database through December 2018.
Practical implications – This paper highlights the imperative role of blockchain technology that has created a discourse in the world of innovation and technology. This work will help academics to further the understanding of blockchain technology.
Social implications – Blockchain technology will provide transparency to consumers.
Originality/value – This paper presents the first review of blockchain technology and delves into its value in SCM. This work will help researchers in identifying the areas where blockchain is the most desirable and can be implemented.

Keywords Blockchain, Smart contract, E-commerce, Global sourcing, Supply-chain management, Logistics management, Disruptive technology

Paper type Literature review

Introduction

This paper reviews the existing literature on blockchain technology, present some trends and consider its potential in supply chain management (SCM). Blockchain technology is claimed to be one of the most important and innovative technologies developed in recent years (Peters and Panayi, 2015; Pilkington, 2016; PWC, 2015; Swan, 2015). Blockchain is evolving from a secure monetary transaction system into a part of an ecosystem of emerging technologies that include artificial intelligence (AI), the Internet of Things (IoT), robotics and crowdsourcing, among others. Together, these technologies represent the technical foundation of the future of business activities (Deloitte, 2016; Dorri *et al.*, 2016; Ferrer, 2016; Omohundro, 2014).

The technical foundation of blockchain supports various businesses such as banking, trading, insurance, data protection, voting, intellectual property, identity authentication, leasing and government service (Atzori, 2017; de Meijer, 2016; Hope and Casey, 2015; Liebenau and Elaluf-Calderwood, 2016; Peters and Panayi, 2015; Swan, 2015; Trautman, 2016; Yermack, 2017; Zyskind *et al.*, 2015). The functions of blockchain technology, such as protecting data integrity, instant sharing of the necessary information, as well as programmable and automatic controls of processes, are likely to disrupt the existing ecosystem by eliminating the need for many manual processes and intermediaries. The WEF (2015) has characterized blockchain as one of the six megatrends in computing likely

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to shape the world in the next decade. Blockchain technology is considered to be the biggest innovation in computer technology (Tapscott, 2017).

Blockchain technology helps avoid conflicts that occur when multiple modifications are made simultaneously from different computers within a distributed database (Peters and Panayi, 2015). Distributed databases are comparable to blockchains as both systems rely on multiple computers for operations and for maintenance procedures. Global trade relies on physical documents such as letters of credit (LC) and intermediaries involved in such activities ensure smooth functioning of trade. Blockchain technology is likely to transform the global supply chain platform by eliminating intermediaries/brokers and the process of physical verification of documents. One of the primary objectives of SCM is to reduce risk. Relational risks in collaboration is a major risk where a business partner engages in distorting information for an opportunity (Bettis and Mahajan, 1985; Thomas and Baird, 1990). Logistics services often play a key role in a firm's ability to deliver value to customers (Mentzer *et al.*, 2001). Blockchain technology is expected to provide value to SCM in three areas: smart contracts, supply chain finance, and increased visibility and traceability of a supply chain (Kshetri, 2018).

This paper reviews articles published through the end of December 2018 to identify sectors/industries where blockchain technology has been used or has the potential to be useful. The analysis considered the frequency of keywords used, journals that published such articles, disciplines covering research and industries where it has been adopted or are in the process of being adopted. The remainder of the paper is organized as follows: the second section presents a review of the relevant literature on blockchain technology. The third section discusses the motivation behind this research and presents the key research questions discussed in the study. The fourth section provides analyses and is followed by implications for SCM professionals in the fifth section. The sixth section concludes the discussion.

Literature review

The literature review is divided into six sub-sections. The first talks about the genesis of blockchain technology, the second covers blockchain technology itself. The third sub-section discusses the significance of blockchain technology and the fourth discusses the applications of blockchain technology. The fifth sub-section explains the smart contract and the last sub-section illuminates the key role of blockchain technology in SCM, and its importance and usefulness in business.

Genesis

The first known experiments with Cryptocurrencies occurred in the Netherlands in the mid-1980s. However, Cryptocurrencies became better known with the introduction of bitcoin in 2008. This was the brainchild of someone who published it in the pseudonym of Nakamoto (2008) and has not been identified yet (Fiorillo, 2018). A user wishing to participate in the bitcoin network must download and install the bitcoin core client (Farghaly, 2014). A bitcoin client sets the user's computer up as a node on the network. Network discovery is an important role performed by each node. Finally, each node becomes a block into the public ledger and a series of nodes from blockchain (Meiklejohn *et al.*, 2013).

The data structure of bitcoin's ledger is borrowed with minimal modifications from a paper written by Haber and Stornetta (1997). The origin of blockchain can be traced back to the 1990s when there was a need to time stamp every digital transaction to avoid tampering with documents. Haber and Stornetta (1991) addressed the problem of time stamping of documents by building a "digital notary." Bitcoin borrowed the data structure from Haber, and Stornetta and re-engineered its security properties. Later, Bayer *et al.* (1993) highlighted that links created between documents using hash pointers are simpler and faster to compare with multiple other documents. Incidentally, Benaloh and Mare (1991) independently introduced these same three ideas shortly before the Haber and Stornetta (1997) paper.

Blockchain technology

Blockchain technology distributes the storage, organization and verification of hash pointers to a group of computers as opposed to storing them in a central database of an enterprise resource planning (ERP) system. This mechanism reduces the risk of failure at a single point (Peters and Panayi, 2015). The blockchain functions as a layer supplementing existing ERP software. For example, provenance is a digital enterprise platform that allows businesses to make their products and supply chains more transparent and traceable through blockchain technology since 2013. It helps businesses to be transparent on three levels: business level, product level and item level. Provenance (2015) enables businesses to easily collate data, open data and verify key information on an immutable data ledger. "Provenance has completed a six month pilot for tracking responsible sourcing of tuna in Indonesia via blockchain" (Laaper and Fitzgerald, 2017).

A blockchain is a chain of interconnected encrypted blocks. Creating a block is like writing with a marking pen and distributing the pieces like a jigsaw puzzle, which cannot be altered or deleted without breaking the chain on a network. A blockchain is designed to operate with little human intervention, unlike an ERP or database system that requires intensive human effort (Peters and Panayi, 2015; Swan, 2015). Blockchains have evolved in three phases since 2009 in Phases 1.0, 2.0 and 3.0 (Swan, 2015). Blockchain 1.0 focused on the trading of cryptocurrency. The functions of digital money transfer, remittance and payment comprise a new ecosystem: "internet of money" (Peters and Panayi, 2015). The bitcoin blockchain was the first phase known as distributed open source ledger. "Money is Memory" was a similar idea put forward by Kocherlakota (1998). However, the paper titled "Bitcoin: a peer-to-peer electronic cash system" (Nakamoto, 2008) popularized the term block and its use has been increasing ever since. Blockchain 2.0 involved a similar trading mechanism, but with a much broader scope of financial applications. A new type of application called a "Smart Contract" (Swan, 2015) was introduced in the second generation of blockchain to expand trading from a simple digital currency to a large variety of products. Blockchain-based smart contracts are computing programs operating on a blockchain that autonomously verify, enforce and execute the terms of contracts (Peters and Panayi, 2015; Zhang *et al.*, 2016).

Significance

Blockchain technologies and cryptocurrencies have attracted much attention in recent years (Radziwill, 2018). Blockchain is an emerging digital technology with the potential to push organizations to rethink their strategies and capabilities (Schatsky and Muraskin, 2016). The most significant impact of blockchain technology is within the walls of organizations (Schneider *et al.*, 2016). A blockchain database is an immutable ledger of transactions which is not maintained by a centralized authority and provides proof of transactions without the need for authentication (Swan, 2015).

A blockchain supports several functions such as distributed storage and listings, transactional validity, transactional persistence, transactional anonymity based on multiple networks for transactions (Reid and Harrigan, 2011), transactional privacy and traceability. Moreover, transactions can be validated almost instantly through services such as "proof of service" (Duffield and Diaz, 2015), the "ripple protocol consensus algorithm" (Schwartz *et al.*, 2014) and "proof of stake" (Buterin, 2013). The elimination of a central authority to validate transactions improves efficiencies and reduces transaction costs. Similarly, the transfer of payment between buyer and seller is recorded in a common secure ledger (Hart and Holmstrom, 1986). Honeywell launched its online buying and selling platform for new and used aircraft parts using blockchain technology. Honeywell is the first to leverage a blockchain to build trust between the buyer and seller (Petersson, 2019).

Applications

Smart contracts allow for the encoding of rules and situations that are agreed upon by various trading parties. These contracts autonomously execute pre-specified tasks, or settle a contract, by examining changing conditions in conjunction with the contract's embedded rules. The execution and monitoring of contracts mainly rely on a trusted central authority. Blockchain-based smart contracts decentralize the enforcement power to each node in the network. This function of a blockchain helps to reduce the risk between trading partners (Kiviat, 2015). Venture capital funded startups such as Skuchain, a supply chain firm, are creating blockchain-based products to address inefficiencies in business-to-business trade and supply chain finance (Kiviat, 2015).

Smart contract

The idea of smart contracts was proposed by Szabo (1994). This term was used because the author saw them as analogous to legal contracts with the ability of automated enforcement. Szabo (1994) presented a smart contract as an extension of a digital-cash protocol and also recognized that Byzantine agreements and digital signatures could be used as building blocks of smart contracts. However, this view has been critiqued by Levy (2017). The blockchain network will automatically stop the smart contract from moving along if a violation of the covenant is detected, thereby limiting the potential of any further damage/loss.

Blockchain in supply chain management

The use of blockchain technology outside finance has been largely experimental. Some of the most promising non-finance applications of blockchain technology are expected to include those in SCM, power and food/agriculture. These areas are suitable fits for using blockchain technology and are likely to deliver a return on investment at an early stage of blockchain deployment. For example, dispatching roses from Kenya to Holland reportedly creates a 25-centimeter high pile of paperwork which would be eliminated by this technology (Lehmacher, 2017). A blockchain can make tracking items and transactions in the supply chain radically faster and simpler by an estimated 85 percent when used in conjunction with IoT technology, cutting administrative and logistics timelines in shipping (Laaper and Fitzgerald, 2017). Researchers have noted that blockchain and IoT blend is a powerful combination and is set to transform many industries (Christidis and Devetsikiotis, 2016; Kshetri, 2018).

A likely application of blockchain technology is verifying sustainability. A blockchain can be used in SCM to identify the players performing every action. The blockchain facilitates valid and effective measurement of the outcomes and performance of the key SCM processes. Once the input tracking data are on a blockchain ledger, they are immutable. Other suppliers in the chain can also track shipments, progress along the way and deliveries (Mishra *et al.*, 2018). For example, "Australia's largest 100% family-owned meat processor, Thomas Foods International, and largest independent grocery retailer, Drakes Supermarket have signed on as members of the blockchain-based food ecosystem IBM Food Trust. The two South Australian organizations are the first in Australia to pilot IBM Food Trust using the IBM Blockchain Platform, reducing traceability times from three days to three seconds" (Pauka, 2019). In this way, blockchain produces trust among suppliers. By eliminating intermediaries, the efficiency of auditing can be improved and costs can be lowered. Individual suppliers can perform their own checks and balances on a real-time basis (Koetsier, 2017). The blockchain also provides an accurate method of measuring product quality during transportation. The shipping industry is increasingly looking to streamline global supply processes by implementing the blockchain platform. The reason for this is that 90 percent of goods in global trade are carried by ships and

shipping transactions often involve dozens of people and organizations, generating more than 200 different interactions and communications among them (Allison, 2018).

Most shipping transactions involve sales contracts, charter party agreements, bills of lading, certificates of origin, port documents, LC and many other documents related to a vessel and its cargo. The internet facilitates the digital exchange of documents, but this occurs bilaterally and therefore still causes delays along the supply chain. Moreover, 80 percent of shipping documentation is still in paper from Southurst (2016). Shipping companies using blockchain technology would be able to upload and share documents instantaneously and securely. This would allow every participant to track and manage the shipment's progress and documentation from start to finish, increasing efficiency and transparency, while simultaneously reducing costs and the risk of documents being delayed, misplaced or tampered with (Kshetri, 2018). For example, Zim, an Israeli shipping company, has wrapped up the first pilot of paperless bills of lading based on blockchain technology. The application is free for shippers, importers and traders, and requires no IT or operational changes.

Prior researchers have noted various key objectives of the supply chain. They include cost, quality, speed, dependability, risk reduction (Bettis and Mahajan, 1985; Thomas and Baird, 1990) sustainability (Bowen *et al.*, 2009) and flexibility (Dinnin *et al.*, 2009; Goldbach *et al.*, 2003; Kovacs, 2004; Meyer and Hohmann, 2000; Rao and Holt, 2005; White, 1996). Global supply chains are complex and face multiple uncertainties (Manuj and Mentzer, 2008). The blockchain technology can be deployed without the need for devices to read hardware or having to attach tags to cases or pallets unlike many other IoT systems such as RFID, smart fleet management and intelligent transportation systems.

However, it is not clear which industries have adopted this technology or are moving in that direction. This led to the review of existing academic literature to see the current trends. The next section will describe the research design that was followed for this study.

Research design

From a methodological point of view, literature reviews can be considered content analyses, where quantitative and qualitative aspects are combined to assess structural as well as content criteria (Brewerton and Millward, 2001). The methodology used in this research is based on the work of Seuring and Müller (2008). It consists of five steps:

(1) Defining the boundary conditions: deciding the sources to be used, period to be considered and method used for this study.

(2) Material collection: collecting relevant papers and defining the unit of analysis (i.e., the single paper).

(3) Descriptive analysis: assessing formal aspects of the, e.g., the number of publications per year, background for subsequent theoretical analysis.

(4) Category selection: selecting structural dimensions and related analytic categories to be applied to the collected material. Structural dimensions form the major topics of analysis, which consist of single analytic categories.

(5) Material evaluation: analyzing the material according to the structural dimensions. This should allow the identification of relevant issues and the interpretation of results.

Analysis and discussions

The total number of documents published in peer-reviewed journals, in the English language, that used "blockchain" in their titles, keywords or abstracts in the EBSCO Premium database was 357. However, 58 documents were not research papers (Table I).

Document type	2015	2016	2017	2018	Total
Article	4	23	91	181	299
Magazine-Article	1	5	8	19	33
Editorial			2		2
Interview		2	2	2	6
Letter to the Editor		1	1	1	3
Opinion			2		2
Proceeding			3	4	7
Product Review			1		1
Speech			2		2
Game/Puzzle				1	1
Letter				1	1
Total	5	31	112	209	357

Table I.
Breakdown of document types

These were dropped from further study leaving 299 papers. The growth in research on blockchain technology has been very rapid, from four papers in 2015 to 181 papers in 2018.

Several top-level analyses were done on 299 articles to provide a broader perspective. These articles were published in 166 different journals. The growth in research on blockchain also resulted in a large number of journals publishing the research. Figure 1 shows the growth in the number of journals that began publishing research on this topic. It is interesting to note that 89 journals have published on blockchain for the first time in 2018. Six journals published ten or more papers and only one of them is a business journal. The only business journal was tied at the fourth position with two other non-business journals. These top six journals account for 22 percent of all publications on blockchains. One of the likely reasons for this trend may be that blockchain is a technology and has many other aspects such as legal, security and strategy. Table AI provides the complete list of journals and the number of papers published by them each year.

Approximately, one-fifth of the journals (39/166 = 23%) that published research on blockchain technology were business journals in the Australian Business Deans Council list. These business journals published approximately one-fifth of the papers (66/299 = 22%). Table II shows the details of the 39 business journals which published these 66 papers. With the exception of eleven journals, each published only a single paper. Six "A*" level journals published three papers in 2017, and 2018 each.

Further, the use of keywords in these papers related to SCM was reviewed. An attempt was made to analyze the use of the terms supply chain, logistics, shipping, transport,

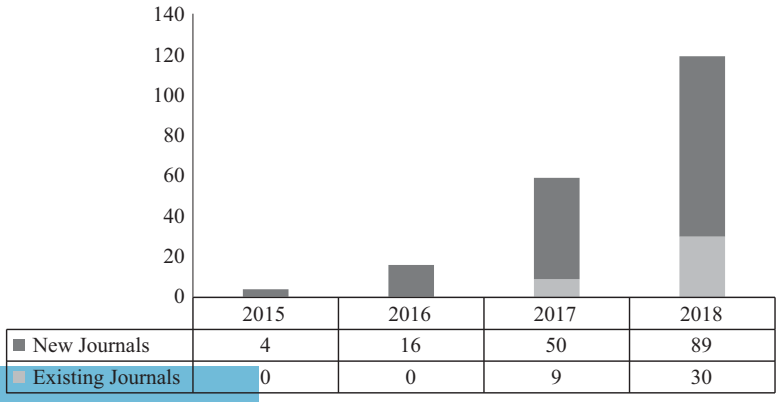


Figure 1.
Growth in the number of journals publishing research on blockchain technology

Category/Name of the journal	2015	2016	2017	2018	Total
A*			3	3	6
Journal of the Association for Information Systems				1	1
Management Science				1	1
Journal of Management Information Systems				1	1
Journal of Management Studies			1		1
Decision Support Systems			1		1
Review of Finance			1		1
A	1	2	8	17	28
Communications of the ACM		2	3	5	10
Business Lawyer			2	1	3
Berkeley Technology Law Journal	1			1	2
International Journal of Information Management				2	2
Journal of Business Ethics				1	1
Journal of Management Inquiry				1	1
Economics Letters				1	1
Energy Policy			1		1
Information Society				1	1
Journal of Information Systems			1		1
International Journal of Production Research				1	1
Third World Quarterly			1		1
Journal of Service Management				1	1
IEEE Transactions on Vehicular Technology				1	1
International Journal of Accounting Information Systems				1	1
B	1		2	5	8
Duke Law Journal	1		1		2
Facilities				1	1
Journal of Economic Surveys				1	1
Fordham Journal of Corporate & Financial Law			1		1
Journal of Marketing Education				1	1
Current Issues in Auditing				1	1
Journal of Corporation Law				1	1
C		3	9	12	24
International Tax Review		2	2	3	7
Journal of Accountancy			2	1	3
Journal of Money Laundering Control		1	1	1	3
Journal of Emerging Technologies in Accounting			2		2
Journal of Risk Management in Financial Institutions				2	2
Business Horizons			1	1	2
Foresight: The International Journal of Applied Forecasting				1	1
Business Law Review				1	1
Journal of Financial Crime				1	1
International Advances in Economic Research			1		1
Journal of Theoretical Accounting Research				1	1
Total	2	5	22	37	66

Table II.
Papers published in ABDC business journals

finance, security, banking and strategy in these papers. About 65 percent of papers (193/299) did not have any of these terms. Only one paper used some of these words for a total of five times in abstract, title or keywords. Table III provides the cumulative frequency of these terms and their locations in these papers.

All the papers contained the term "blockchain" in at least one of the locations. The term appeared 171, 138 and 243 times in titles, keywords and abstracts, respectively. Further, "blockchain" appeared in only one of the locations in 121 papers, in two locations in 103 papers and in all three locations in 75 papers. There is an increasing interest in research on blockchain technology among SCM and logistics management areas. Figure 2 shows the

growth in the number of research papers in these areas during the period studied. There were no papers published containing both SCM and blockchain prior to 2016.

There were 11 papers submitted by institutions which do not contain any authors. The rest of the 288 papers were contributed by 535 authors/co-authors. Table IV provides the breakdown of the number of authors per paper. A few authors have published more than one paper. Therefore, the total of the last column (number of authors = 570) is greater than the total authors 535. There are five authors who have published three papers each, as shown in Table V. No author has published more than three papers on this topic.

These 299 academic papers were presented by 101 publishers. In total, 65 of them published only a single paper, and an additional 17 published just two papers. Only seven publishers issued ten or more papers (Table VI). These seven publishers accounted for 143 papers, approximately 48 percent of the total number of papers published.

The highest number of papers on blockchain was published in the year 2018, indicating that the concept is picking up momentum. This is a new technology. There are some challenges, as is the case with any new technology. Schoenberger (2018) identified five weak links of blockchain. These are reliability of "private" blockchains, transaction fees, energy use, cost of security and regulation. However, energy requirements and the speed of transactions seem to be the biggest challenges. The limitations and challenges need to be explored further. The next section will discuss the implications of blockchain technology for SCM professionals.

Implications for SCM professionals

Supply chains have evolved from networks of OEMs and suppliers to a vast ecosystem of multiple parties trying to coordinate and work together efficiently. From connected

Table III.
Cumulative frequency and the location of the use of terms in papers

	Title	Keyword	Abstract	Total
Shipping	0	0	0	0
Logistics	1	0	3	4
Transport	1	0	4	5
Strategy	2	4	5	11
Finance	1	3	16	20
Supply chain	5	5	11	21
Banking	2	6	17	25
Security	8	13	50	71

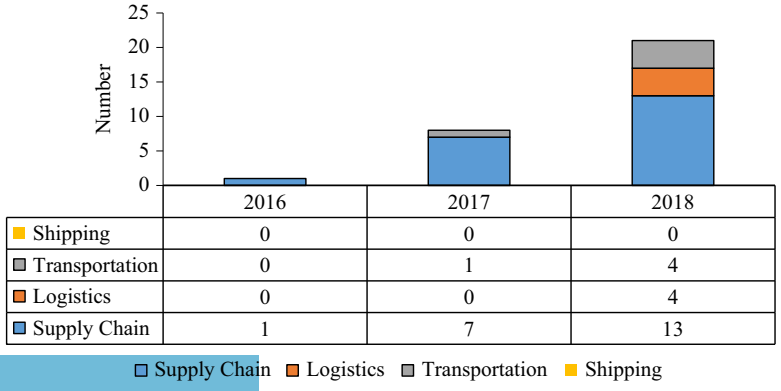


Figure 2.
Growth in the research on blockchain in SCM and logistics management

No. of authors on a paper (a)	Number of papers 2015 (b)	2016 (c)	2017 (d)	2018 (e)	Total (f)	Total No. of contributing authors[a] (g)
0[b]			3	8	11	0
1	3	15	41	81	140	140
2	1	6	29	45	81	162
3		1	12	20	33	99
4		1	4	9	14	56
5			1	9	10	50
6			1	7	8	48
7				1	1	7
8				1	1	8
Grand total	4	23	91	181	299	570[c]

Notes: [a]Total No. of authors (g) = No. of authors on a paper (a) × total no. of papers (f); [b]institutional submissions, i.e., no author; [c]this is not the total of the column (see explanation in the text)

Table IV. Number of authors on a paper

Author	Papers
Irwin, Angela S.M.	Irwin and Milad (2016), Irwin and Turner (2018), Reynolds and Irwin (2017)
Kshetri, Nir	Kshetri (2017a, b, 2018)
Parry, Glenn	Adams *et al.* (2017)
Savelyev, Alexander	Savelyev (2017, 2018a, b)
Vasarhelyi, Miklos A.	Dai and Vasarhelyi (2017), Dai *et al.* (2017), Zhang *et al.* (2018)

Table V. Top authors and their publications

Publisher	2015	2016	2017	2018	Total
Elsevier B.V.		1	9	29	39
Henry Stewart Publications LLP		7	11	8	26
IEEE	2		4	14	20
Wiley-Blackwell		1	12	6	19
Emerald Publishing		2	3	13	18
Taylor & Francis Ltd			2	9	11
Association for Computing Machinery		2	3	5	10
Total	2	13	44	84	143

Table VI. Top publishers by the number of papers published

manufacturing equipment to digital shipping notices and RFID scanning, products are tracked on computerized systems from their earliest origins, often all the way to the recycling bin. The user interface and business processes remain the same. However, information on inventory along the entire supply chain can be shared without the risk of a data breach.

There is an interesting contrast between the use of blockchains in the financial industry and its use in SCM. Bloomberg stated that users in the financial industry could get the same functionalities as from a regular database as well as other benefits (Levine, 2017). As an example, obtaining various approvals and verifications are normal process steps which take time and have risks of frauds. Due to inbuilt security features in blockchain technology, the need for verification is eliminated and the number of process steps reduced, which saves time and makes communication more efficient. However, the technology has a huge potential for use in global supply chains, making them efficient and cost-effective. Using innovation diffusion theory (Rogers, 1962), it can be contended that blockchain technology has a relative advantage in supply chain activities compared to other industries.

Relative advantages can be defined as the perceived benefits of a new technology over previous technologies and the extent to which it is better than the idea it supersedes (Rogers, 1995). As an example, Everledger, an emerging technology enterprise, uses IBM's blockchain platform to track diamonds from mine to store, leaving stolen items and conflict-zone jewels outside the system (Vella, 2018).

One of the main determinants of adopting blockchain in SCM is the current number of players in a global supply chain (Figure 3). Each of the players in a supply chain has specific capabilities and constraints which affects the competitiveness of organizations. The conventional mode of a supply chain system is very time consuming, affecting the overall service delivery process until it reaches the final customer.

Blockchain brings all relevant parties together, which can sometimes be a difficult task, and eliminates the need for some of the players in a chain, thus making supply chains more efficient. For example, a supply chain in the oil industry is reported to have up to 13 layers of suppliers (del Castillo, 2017). The oil trading sector may overtake the financial sector in implementing blockchain technology because firms in the oil sector are under pressure to remain competitive (Acheson, 2017). In January 2018, Maersk and IBM announced the intention to establish a new blockchain platform (Figure 4) to provide more efficient and secure methods for conducting global trade using blockchain technology (Allison, 2018; Chavez-Dreyfuss, 2017). Corporations negotiate procurement discounts based on the total number of purchases, which is hard to track across subsidiaries, business partners and others in a supply chain network. Blockchain makes it possible due to a constantly refreshed digital ledger that incorporates data from all relevant partners. The time-consuming audit without blockchain requires many people while blockchain does this continuously without the need for additional staff and time, reducing the cost of the verification/audit processes.

The main benefit of a blockchain is that all members are integrated into one secure network. The network integration of all major players in blockchain improves the overall service delivery, which benefits both the buyer and the seller. For instance, Ambrosus is a blockchain – powered IoT network for food and pharmaceutical enterprises, enabling secure and frictionless dialogue between sensors, distributed ledgers, and databases to optimize supply chain visibility and quality assurance. The original vision of the technology enterprise was to launch the world's first blockchain-tracked coffee, with the platform connecting stakeholders from farmers through to consumers. This improves the flow of

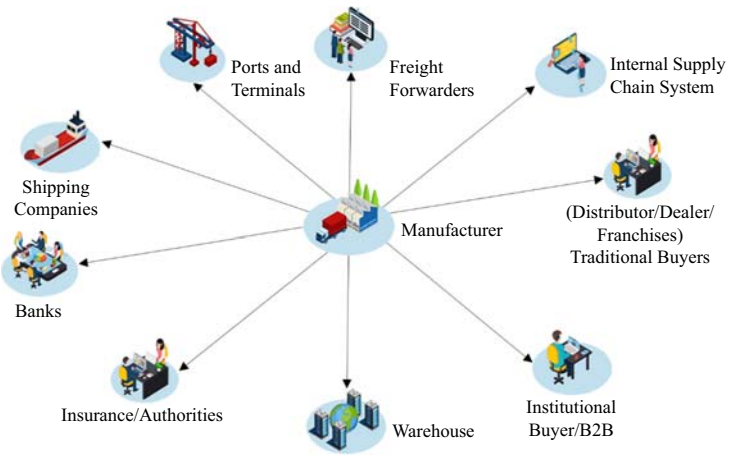
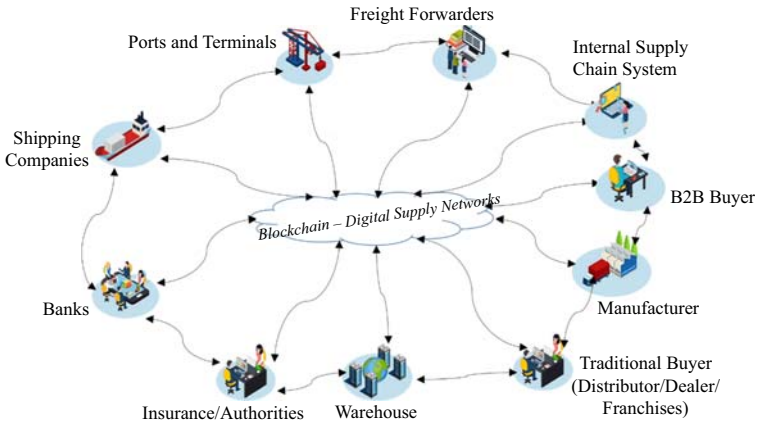


Figure 3.
Conventional supply chain model

Source: A modified version of IBM



Source: A modified version of IBM

Figure 4. Supply chain with blockchain technology

work, increases efficiency and increases the speed of movement of goods. Due to the layer of security provided by blockchain technology, as stated earlier, the cost of reconciliation will also decline. Therefore, the early adopters of this technology will improve their efficiency and are likely to have an edge over their competitors. According to Deloitte (2016), there are some open discussions regarding the implementation of blockchain technology. The factors that may create a hurdle are the awareness and understanding of the technology, organizational culture, cost and efficiency, regulation, and lastly security and privacy that may hinder the implementation of the technology in organizations. However, the potential benefits of blockchain technology in SCM are yet to be measured (Table III and Figure 2). The success of blockchain technology depends on trust, which is the most important factor for its successful implementation. Therefore, blockchain technology needs to be explored on a wider scale. This discussion will be concluded in the next section with some limitations and potential extensions of this research.

Conclusion

This paper is a review of the existing literature on blockchain technology and an exploration of its suitability in SCM. Some of the advantages of using blockchain are data security, reduction in finance and banking risk and the potential to address fraudulent and manipulative activities. There are many projects underway to apply blockchain technology in global logistics by adding value in supply chain transparency and digitalizing administrative operations. For instance, the Blockchain in Transport Alliance started in 2017 and has an annual turnover of more than $1 trillion. Its members include freight, transportation, and logistics organizations, and affiliated industries. The company provides training on blockchain applications and distributed ledger technology and encourages the use and adoption of new solutions. It has acquired 500 members across 25 nations and has become the largest commercial blockchain alliance in the world. Blockchain technology is adaptable and provides better operational efficiency. It tracks ownership throughout the chain and maintains the integrity of quantity and ownership. Most of the significant investors in blockchain startups are in the USA, including Digital Currency Group, Blockchain Capital, Andreessen Horowitz and Union Square Ventures (Werbach, 2018).

Blockchain technology has the potential to improve trust through increased visibility within industries and across organizations. As stated earlier, global trade relies on LC for

importers and exporters in the supply chain industry. Conventionally, LCs are evaluated on the basis of trade documents and not on the delivery or quality of goods. Errors in the compliance requirements often lead to payment disputes and differences of opinion between trading parties. With blockchain, LC can be presented as smart contracts between the financier, buyer and seller. A blockchain smart contract codifies the terms and conditions of trade (Varghese and Goyal, 2017). The value of blockchain technology is expected to be focused on three primary areas: smart contracts, supply chain finance, and increased supply chain visibility and traceability. For instance, Bext360 is a software-as-a-service platform that combines blockchain, AI and machine vision and aims to bring new levels of traceability, transparency and sustainability to the supply chain. Blockchain can also help achieve robust cybersecurity measures. Trust and security can thus be improved with the blockchain. For example, OriginTrail protocol brings trusted data sharing to global supply chains by utilizing blockchain technology. The OriginTrail Decentralized Network is built for data integrity and validation in inter-organizational environments, based on globally recognized standards and powerful graph data structures. OriginTrail is a foundation for the next generation of business applications.

This study does have some limitations. First is the use of a single comprehensive, multidisciplinary database. Another limitation is the use of only a select few keywords. It is possible that a paper was missed because it did not contain "blockchain" in the title, keywords or abstract. The application of blockchain technology in SCM is limited so far. Moreover, its implementation is in a nascent stage. This limits proving the value of blockchain technology in SCM. As stated earlier, this is the first paper to review the literature on this new technology and its usefulness in SCM. This work can be extended in many ways. One possible extension is a controlled study of the benefits of implementing blockchain technology in a supply chain. Another possible extension could be a case study on blockchain in an organization that has implemented it. A further possible extension of this work could be to develop a model of the value of the blockchain in various function and/or industries. A further possible extension of this work could be to develop a model of the value of blockchain technology in various functions and/or industries.

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Appendix

Name of the journal	2015	2016	2017	2018	Total
Journal of Securities Operations & Custody		4	6	3	13
Journal of Payments Strategy & Systems		3	5	3	11
Strategic Change			10	1	11
Communications of the ACM		2	3	5	10
Computer Law & Security Review			2	8	10
IEEE Communications Magazine			4	6	10
Information Services & Use				8	8
International Tax Review		2	2	3	7
CPA Journal			2	4	6
Future Generation Computer Systems				6	6
Journal of Internet Law			2	3	5
Journal of Financial Planning				4	4
Journal of Risk Finance (Emerald Group Publishing Limited)				4	4
Strategic Finance		1	2	1	4
Business Lawyer			2	1	3
CyberPsychology, Behavior & Social Networking				3	3
IEEE Network				3	3
Industrial Management & Data Systems			1	2	3
Intellectual Property & Technology Law Journal		1	1	1	3
Intelligent Systems in Accounting, Finance & Management			1	2	3
Journal of Accountancy			2	1	3
Journal of Money Laundering Control		1	1	1	3
AAII Journal				2	2
Berkeley Technology Law Journal	1			1	2
Bulletin of the Transilvania University of Brasov. Series V: Economic Sciences			1	1	2
Business Horizons			1	1	2
Computer Networks				2	2
Contract Management			1	1	2
Defense Counsel Journal				2	2
Duke Law Journal	1		1		2
Electronic Commerce Research & Applications			1	1	2
IEEE Micro	1			1	2
International Journal of Information Management				2	2
Journal of Emerging Technologies in Accounting			2		2
Journal of Management Analytics				2	2
Journal of Network & Computer Applications				2	2
Journal of Property Management				2	2
Journal of Risk Management in Financial Institutions				2	2
Journal of Systems Architecture				2	2
Journal of the Insurance Institute of India				2	2
NetworkWorld Asia				2	2
Review of Banking & Financial Law		1	1		2
RMA Journal			2		2
Scientific Papers of Silesian University of Technology. Organization & Management			1	1	2
Accounting & Finance				1	1
Accounting & Management Information Systems			1		1
Adhyayan: A Journal of Management Sciences				1	1
Administration & Society				1	1
Amity Global Business Review			1		1

(*continued*)

Table AI. List of journals with the number of papers published on the blockchain technology

Name of the journal	2015	2016	2017	2018	Total
Annals of "Constantin Brancusi" University of Targu-Jiu. Economy Series				1	1
Annals of Financial Economics				1	1
Annals of the University of Oradea, Economic Science Series				1	1
BIT: Banking & Information Technology		1			1
Brazilian Journal of Operations & Production Management				1	1
Business Education Innovation Journal		1			1
Business Law Review				1	1
Business Management/Biznes Upravlenie				1	1
Computer Communications				1	1
Computers & Security				1	1
Current Issues in Auditing				1	1
DealMakers				1	1
Decision Support Systems			1		1
Economic Perspectives			1		1
Economics Letters				1	1
Economy, Culture & History Japan Spotlight Bimonthly				1	1
Ekonomika				1	1
Emerging Markets Finance & Trade				1	1
Energy Policy			1		1
Entrepreneurial Business & Economics Review			1		1
European Company & Financial Law Review				1	1
European Integration Studies			1		1
Facilities				1	1
FAIMA Business & Management Journal				1	1
Finance & Credit				1	1
Finance & Development		1			1
Financial & Credit Activity: Problems of Theory & Practice				1	1
Financial Studies			1		1
Fordham Journal of Corporate & Financial Law			1		1
Foresight: The International Journal of Applied Forecasting				1	1
Global Business & Management Research				1	1
Global Economic Observer			1		1
Global Journal of Enterprise Information System		1			1
Government Information Quarterly			1		1
IEEE Technology & Society Magazine	1				1
IEEE Transactions on Engineering Management				1	1
IEEE Transactions on Knowledge & Data Engineering				1	1
IEEE Transactions on Systems, Man & Cybernetics. Systems				1	1
IEEE Transactions on Vehicular Technology				1	1
IET Communications				1	1
Independent Review				1	1
Informatica Economica				1	1
Information & Communications Technology Law			1		1
Information Society				1	1
InterEULawEast: Journal for International & European Law, Economics & Market Integrations				1	1
Internal Auditing & Risk Management				1	1
International Advances in Economic Research			1		1
International Journal of Accounting Information Systems				1	1
International Journal of Business Insights & Transformation			1		1
International Journal of Global Business				1	1
International Journal of Healthcare Management				1	1
International Journal of Performance Measurement				1	1
International Journal of Production Research				1	1

Table AI. (*continued*)

Name of the journal	2015	2016	2017	2018	Total
International Journal of the Academic Business World		1			1
International Journal of Theoretical & Applied Finance				1	1
International Trade Forum				1	1
Journal of Accounting & Finance				1	1
Journal of Business & Technology Law				1	1
Journal of Business Ethics				1	1
Journal of Corporate Accounting & Finance (Wiley)		1			1
Journal of Corporation Law				1	1
Journal of Economic Surveys				1	1
Journal of Economics & Business				1	1
Journal of Financial Crime				1	1
Journal of Financial Regulation & Compliance			1		1
Journal of Financial Service Professionals				1	1
Journal of Government Financial Management			1		1
Journal of Information Science Theory & Practice (JISTaP)			1		1
Journal of Information Systems			1		1
Journal of Intelligent & Fuzzy Systems				1	1
Journal of International Affairs				1	1
Journal of International Arbitration				1	1
Journal of International Technology & Information Management			1		1
Journal of Investment Compliance (Emerald Group)				1	1
Journal of Korean Society for internet Information			1		1
Journal of Management Information Systems				1	1
Journal of Management Inquiry				1	1
Journal of Management Studies			1		1
Journal of Marketing Education				1	1
Journal of Modern Project Management			1		1
Journal of Organization Design				1	1
Journal of Purchasing & Supply Management			1		1
Journal of Service Management				1	1
Journal of Supply Chain Management Systems				1	1
Journal of Taxation & Regulation of Financial Institutions				1	1
Journal of Taxation of Investments				1	1
Journal of the Association for Information Systems				1	1
Journal of the Australian & New Zealand Institute of Insurance & Finance				1	1
Journal of Theoretical Accounting Research				1	1
Latgale National Economy Research				1	1
Logistics & Transport				1	1
Management (18544223)			1		1
Management Science				1	1
Management Theory & Studies for Rural Business & Infrastructure Development				1	1
Michigan Law Review				1	1
MIS Quarterly Executive				1	1
Network Security				1	1
OECD Observer			1		1
Ovidius University Annals, Series Economic Sciences			1		1
Performance Evaluation		1			1
Policy				1	1
Production & Operations Management				1	1
Real Estate Finance Journal			1		1
Records Management Journal		1			1
Research Technology Management				1	1
Review of Finance			1		1

(*continued*)

Table AI.

Name of the journal	2015	2016	2017	2018	Total
Review of International Business & Strategy				1	1
Robotics & Computer-Integrated Manufacturing				1	1
San Diego Law Review			1		1
Small Business Economics			1		1
Supply Chain Management				1	1
Technology Analysis & Strategic Management				1	1
Telecom Business Review			1		1
Telecommunications Policy			1		1
Third World Quarterly			1		1
University of Pennsylvania Law Review			1		1
World Customs Journal				1	1
Total	4	23	91	181	299

Table AI.

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