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Research Article

Blockchain in Supply Chain Management: Characteristics and Benefits

Eladian Rodrigues[1]
Wagner Lourenzani[1]
Eduardo Satolo[1]

[1] Universidade Estadual Paulista, Tupã, SP, Brazil.

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ABSTRACT

The basis for application of new technologies in organizations is supported by the continuous analysis of data and information from multiple sources. Blockchain is one of the new technologies that, in association with the concepts and principles of Industry 4.0, could generate gains and improvements. Much has been said about the potential of blockchain technology, its benefits, and its disruptive impact in various areas, including supply chain management. In the academic field, however, the development of this topic is in full swing, as a growing number of scientific studies have been published without a theoretical convergence of their foundations, concepts, and authors being noted. Thus, considering the initial stage of the scientific debate of this object of analysis, this research aimed to understand the scenario of the adoption of blockchain in supply chain management based on academic publications evidencing its characteristics and benefits, through a systematic literature review. Due to profound analysis, characteristics and benefits of its application on supply chain management as transparency, confidence, information decentralization, and information security are disclosed in this study.

Keywords: blockchain; supply chain management; systematic literature review; benefits; characteristics

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INTRODUCTION

The application of new technologies in organizations is based on the continuous analysis of data and information from multiple sources, which are intelligently interconnected, so that all internal and external experiences of the organization are coordinated, and their added value is maximized (Roblek, Meško, & Krapež, 2016). In this sense, Industry 4.0 and all associated transformations are continuously promoting the shift from the industrial focus on products to the focus on 'data-driven' products and services that require a strategic positioning of information technology, especially in the area of supply chain management (SCM) (Zhong, Klotz, & Newman, 2017).

Blockchain is one of the new technologies associated with the concepts and principles of Industry 4.0 that generate benefits in dealing with SCM uncertainties and difficulties. It is a transaction system (information exchange) with cryptographic evidence that enables direct interaction between actors involved in the digital network or the chain it refers to (Buterin, 2014; Nakamoto, 2008).

This technology has the function of creating a decentralized and distributed environment, in which digital information on transactions between the parties is accessible to all parties involved and is no longer centralized in a single agent. A simultaneous cryptographic check guarantees the information contained in its linear record with multiple reliable and complete sources (Biktimirov, Domashev, Cherkashin, & Shcherbakov, 2017; Risius & Spohrer, 2017).

Much has been said about the potential of blockchain technology and its benefits to improve a series of business process, providing a very secure chain of information and transactions, but also its effects that can cause disruption in several sectors, changing things to a new reality with the adoption of technology, as shown by a variety of recent systematic literature reviews (SLR), as example of: blockchain in agriculture (Yadav & Singh, 2019), analysis for blockchain solutions in IoT (Conoscenti, Vetrò, & Martin, 2016; Lo et al., 2019), blockchain for cities (Shen & Pena-Mora, 2018), blockchain for big data (Karafiloski & Mishev, 2017), blockchain on service systems (Seebacher & Schüritz, 2017), and multi-agent systems (Calvaresi, Dubovitskaya, Calbimonte, Taveter, & Schumacher, 2018). Thus, considering the initial stage of the scientific debate of this object of analysis and the absence of a wide range of SLR on the issue SCM and blockchain, this research aimed to understand the scenario of the adoption of blockchain in SCM based on academic publications evidencing its characteristics and benefits, through a systematic literature review.

CONCEPTUAL BACKGROUND

Supply chain management (SCM) has several approaches, either as a function, as a philosophy, or even as a discipline. However, fundamental principles permeate all these variants, including information transparency, supplier relationships, customer service, agility, quality, communication, segmentation, and others (Ellram & Cooper, 2014).

The organizations that use SCM adopt a systematic approach to the supply chain that includes a strategic alignment with internal and external synergies and value creation with a focus on customer satisfaction (Mentzer et al., 2001).

Supply chains are globally networked, connecting organizations and customers through a constant flow of information, materials, and capital (Seuring, 2013). In this sense, the SCM processes that permeate the entire corporate structure are supported, recorded, and integrated by an intensive internal flow of information and between the individual links in the chain, usually through information systems (Lambert, Cooper, & Pagh, 1998; Lambert & Enz, 2017).

Hence, the flow of information and relationships in SCM has its challenges and obstacles to overcome, including inaccuracies, distortions, delays, mistrust, and inefficiency. These conditions imply uncoordinated decisions, opportunities for whip effects, failure in information systems, and mistrust between related parties (Cao, Gan, & Thompson, 2013).

In this sense, information technology is of growing importance to SCM. It represents an opportunity to improve competitiveness by implementing physical cyber connectivity between systems, processes, and people in SCM for Industry 4.0 (Hermann, Pentek, & Otto, 2016; Lee, Bagheri, & Kao, 2015; Waller & Fawcett, 2013).

In the pantheon of new technologies incorporated and powered by Industry 4.0, lies blockchain or blockchain technology, referred to as a distributed system of capture and encrypted storage, in a linear, immutable, and non-perishable record, of transactions between agents of a network (Risius & Spohrer, 2017).

Its most famous applications are cryptocurrencies like Bitcoin, which were created in 2008. Blockchain is configured as the basis for the application for these transaction systems. However, the focus of its application goes beyond these operations, and attracts interest from several other areas, as the disruptive potential of blockchain could lead to changes in the business world. Understanding the potential of blockchain and its various applications is still in its early stages (Buterin, 2014; Chen et al., 2017; Nakamoto, 2008).

The exchange of information between two parties connected to the blockchain network is called a transaction, which in turn is recorded in a data set, called a block. This block connects to another already registered block, and all blocks that contain information about all executed transactions are stored simultaneously in the so-called node. The nodes contain the records of all transactions on the blockchain network and confirm the truthfulness of each new transaction with the help of algorithms and encryption. When all transactions are completed, there is a type of consensus between the nodes, and new blocks are connected in a continuous stream, the so-called blockchain, and aligned with the previous blocks. Blockchain concept is presented in Figure 1 to contribute to the comprehension of blockchain functionality.

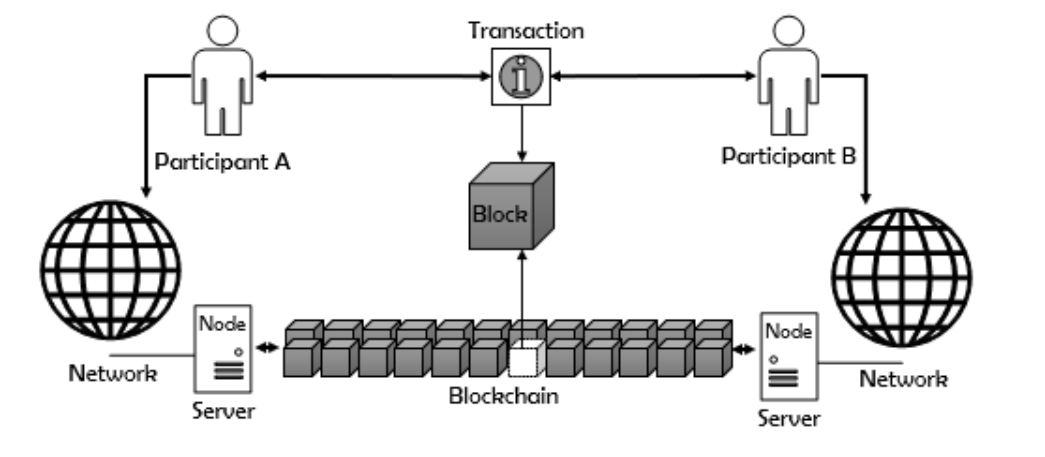

Figure 1. Blockchain concept.
Source: The authors, based on Buterin (2014); Nakamoto (2008); Ølnes, Ubacht, and Janssen (2017).

Blockchain networks can primarily be divided into two types, public and private, with two sub-targets, networks with or without authorization. This classification can be treated as a design option, as defined when setting up the network (Ølnes, Ubacht, & Janssen, 2017). The classification is evidenced in Table 1.

Table 1

Classification of blockchain networks

Type	Permitted	Non-Permitted
Public	Unrestricted access to data or transactions. Restricted participation in consensus mechanisms.	Unrestricted access to data, transactions, or consensus mechanisms.
Private	Restricted access to data or transactions. Participation in the consensus mechanism with the authorization of the network owner.	No access to data, transactions, or consensus mechanisms.

Note. Source: Adapted from (Ølnes et al., 2017).

Technical challenges should, however, be taken into account, as this is a new technology, the use of which is currently being expanded. In general, seven points can be highlighted: information transfer rate, processing latency, size and bandwidth, security if a hacker attack happens on 51% of the network, waste of resources, usability and infrastructure, the multiple chains, rigid forks, and versioning. All of this can create a complex environment to blockchain application in real world, but these are challenges to be overcome (Swan, 2015).

METHODOLOGICAL PROCEDURES

The systematic literature review was carried out with integral participation of all authors in three complementary steps: input, process, and output. The applied method (Figure 2) is the result of the models presented by Webster and Watson (2002), Levy and Ellis (2006), Biolchini, Mian, Natali, Conte and Travassos (2007), and Conforto, Amaral and Silva (2011).

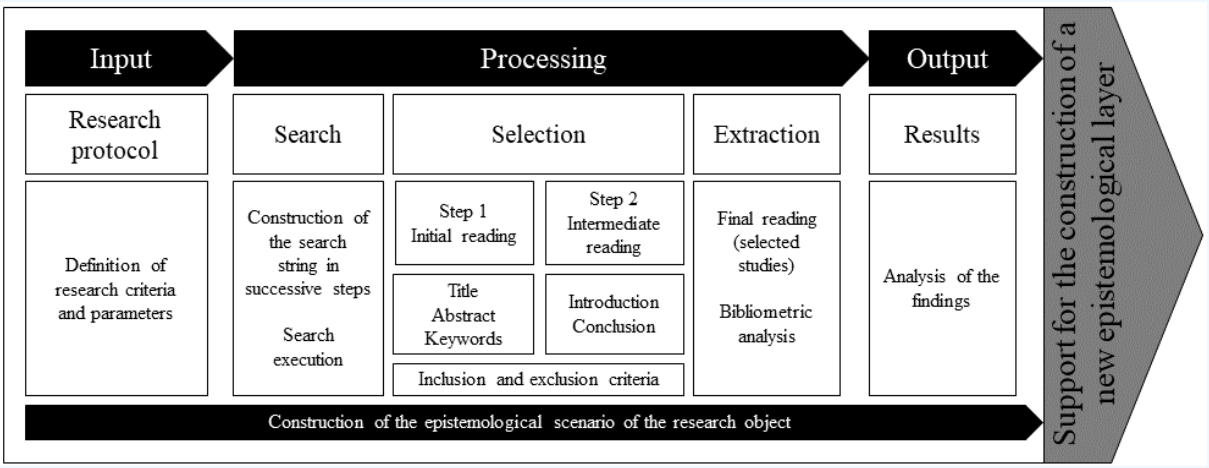

Figure 2. Process of systematic literature review.
Source: Based on Webster and Watson (2002), Levy and Ellis (2006), Biolchini et al. (2007), and Conforto et al. (2011).

Input

In the input stage, the research report is drawn up, which describes the central points. Once evaluated, it is considered a guide to the researcher's entire work execution. The protocol completes the research objective, the key questions, the keywords, the criteria for selecting research sources, the selection of databases, the languages considered, the inclusion and exclusion criteria, the types of study definition, and the key issues of extraction (Conforto et al., 2011). The protocol established for this work is presented in Table 2. The steps and their respective descriptions are revealed in it.

Table 2

Research protocol

Phases	Description
Objective	Understand the scenario of the adoption of blockchain in SCM based on academic publications evidencing its characteristics and benefits, through a systematic literature review
Key issue	What are the relevant publications on blockchain in SCM and its characteristics and benefits?
Keywords	blockchain supply chain management
Criteria for defining sources	Peer-reviewed articles published in journals or conferences between 2008 and 2019
Language	English
Source search method	Scientific databases with access available on the internet
Selected databases	Scopus Science Direct Web of Science
Study inclusion criteria	Blockchain applied to supply chain management

Continues

Table 2 (continued)

Phases	Description
Study exclusion criteria	(a) Blockchain on peripheral themes to supply chain management (b) Not related to blockchain in supply chain management (c) Inability to access the full text
Types of studies considered	Qualitative Quantitative Mixed

Some justifications are necessary to better understand the criteria set out in the previous chart. There have been selected articles, journals, and topics from conferences as sources, because it is understood that the subject being researched is not only relevant but also presents a great range of possibilities of study. To a broader understand and better qualification of the epistemological gap it is important to consider the overall information of the research materials, not focusing only on metrics of citation, review process, or others, but also on other relevant information, even from less formal publication venues as conferences (Vahdati et al., 2021). By that, a variety of topics to be studied relating SCM and blockchain is emerging and being displayed in numerous types of sources that must not be disregarded — as example, relevant publications in conferences during the researched period. To eliminate possible misinterpretations in the qualitative selection analysis, exclusion criteria were defined to complement the inclusion criteria, and to guide the relevance evaluation of the studies: (a) Blockchain in peripheric topics to supply chain management: Outlined in the premises, it will use studies on peripheral topics related to the supply chain and its business processes, with less relevance and causing a deviation from the focus of this study, for example, application in IT systems for industry, or proposals of new models of coding for application in industry; (b) Issues non-related to blockchain in SCM: The premise states that there are studies on blockchain that are applied to other fields of knowledge, specific and/or with too much technical depth, for example, studies that focus on information technology rather than network architecture, IT direct applications, IT information security applications, cryptocurrencies applications, and others; (c) Inability to access the full text: Texts presented in the search results that are not accessible or unavailable due to restrictions as: subscription to the journal, limitation of full access to conference information, or any unknown reason.

Processing

The processing aims to transform the collected data into information for the researcher's analyses and later to support the establishment of a new epistemological layer (Levy & Ellis, 2006). This step is repeated cyclically until the data is saturated to obtain sound information (Conforto et al., 2011). In this work, segregation processing is carried out in three stages — search, selection, and extraction. The result is a conjunction of information for the next step analysis.

Search

In this sub-stage, a previous discussion with all authors' involvement was conducted to construct the search strings. The keywords 'blockchain' and 'supply chain management' were used with the

Boolean operator 'AND.' In addition, the search engine has parameterized the period from January 1, 2008 to April 4, 2019 as the initial filter, considering that in 2008 there was the first disclosure of the blockchain by the Satoshi Nakamoto manifesto, and that the end date of this research was 2019. As can be seen in Table 3, there were 182 search results represented by many types of documents.

Table 3

Stage 1: Search

Date of research	Database	String	Filter 1	Results from database
April 06, 2019	Scopus	'blockchain' AND 'supply chain management'	2008–2019	79
	Science Direct			82
	Web of Science			21
			Total	**182**

Note. Source: Search data.

New filters, which favor the construction of strings and consistent search criteria, have been added. In Filters 2 and 3, the criteria for the definition of the font were taken into account and in Filter 4 the original language of the publications was considered. According to Table 4, 127 works were obtained.

Table 4

Stage 2: Processing

Date of research	Database	String	Filter 1	Filter 2	Filter 3	Filter 4	Results from database
April 06, 2019	Scopus	'blockchain' AND 'supply chain management'	2008 2019	Conference paper	Articles	English	51
	Science Direct			Review articles	Research articles	English	60
	Web of Science			Proceedings paper	Articles	English	16
						Total	**127**

Note. Source: Search data.

The strings resultant from the search parametrizations are evidenced in Table 5. Changes in the parameters of the Boolean operators, and the abbreviations of the database categorization, affected the search results.

Table 5

Search strings

Date	Database	Final string
April 06, 2019	Scopus	TITLE-ABS-KEY (“blockchain” AND “SCM”) AND PUBYEAR > 2008 AND PUBYEAR < 2019 AND (LIMIT-TO (DOCTYPE, “cp”) OR LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (LANGUAGE, “English”))
	Science Direct	TITLE-ABS-KEY (“blockchain” AND “SCM”) AND PUBYEAR > 2008 AND PUBYEAR < 2019 AND (LIMIT-TO (DOCTYPE, “review articles”) OR LIMIT-TO (DOCTYPE, “research articles”)) AND (LIMIT-TO (LANGUAGE, “English”))
	Web of Science	TOPIC: ("blockchain" AND "SCM") Refined by: LANGUAGES: (ENGLISH) AND TIPOS DE DOCUMENTO: (ARTICLE OR PROCEEDINGS PAPER) Time interval: 2008-2019. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI, CCR-EXPANDED, IC

Note. Source: Search data.

In this sense, the following representativeness of the databases is observed compared to the original results: Science Direct with 47.24% of the identified studies, followed by Scopus base with 40.16% and Web of Science with 12.6%, with the lowest representativeness.

Selection

This subsection is conducted with an integral discussion and analysis by all authors and begins with the analysis of the possible duplicated studies found in the various databases examined. Studies that appear more than once in the survey conducted in the databases are defined by duplicates. Nine studies were disregarded in this research.

The work considered valid for analysis therefore comprised a total of 118 studies. In Step 1 of the selection, the title, abstract, and keywords were read. The texts were reclassified, and 71 studies were rejected after the criteria: (a) blockchain on topics peripheral to supply chain management and (b) themes not related to blockchain in supply chain management.

From the first phase of selection, 47 studies were accepted. These studies showed identification with the basic inclusion criterion, the application of blockchain in supply chain management.

In addition, in this sub-step, in Step 2, the introduction and conclusions of the articles were read. Four studies were rejected according to criterion (a) blockchain on peripheral topics to supply chain management. Another 12 studies were excluded according to criterion (c) full text not available. Finally, 31 studies were approved for extraction.

Extraction

In this sub-step, the 31 selected studies were analyzed, which are presented in Table 6.

Table 6

Studies selected for extraction

Code	Title	Author	Year	Type	Origin
1	A blockchain-based supply chain quality management framework	Chen et al.	2017	Conference paper	China
2	A novel blockchain-based product ownership management system (POMS) for anti-counterfeits in the post supply chain	Toyoda, Mathiopoulos, Sasase, and Ohtsuki	2017	Journal article	Japan
3	Blockchain and SCM: Aircrafts' parts' business case	Madhwal and Panfilov	2017	Conference paper	Russia
4	Development of a traceability system for the animal product supply chain based on blockchain technology	Marinello, Atzori, Lisi, Boscaro, and Pezzuolo	2017	Conference paper	Italy
5	Information sharing for SCM based on blockchain technology	Nakasumi	2017	Conference paper	Japan
6	Blockchain's roles in meeting key SCM objectives	Kshetri	2018	Journal article	USA
7	A blockchain aided metric for predictive delivery performance in supply chain management	Meng and Qian	2018	Conference paper	Singapore
8	A blockchain architecture for reducing the bullwhip effect	Van Engelenburg, Janssen and Klievink	2018	Conference paper	Netherlands
9	A fully observable supply chain management system using blockchain and IoT	Naidu, Mudliar, Naik and Bhavathankar	2018	Conference paper	India
10	A study on the transparent price tracing system in SCM based on blockchain	Yoo and Won	2018	Journal article	South Korea
11	Application of RFID combined with blockchain technology in logistics of construction materials	Lanko, Vatin and Kaklauskas	2018	Journal article	Russia
12	Applying blockchain technology: Evidence from Norwegian companies	Gausdal, Czachorowski and Solesvik	2018	Journal article	Norway
13	Big data analytics for logistics and distributions using blockchain	Petroni, Moraes and Gonçalves	2018	Conference paper	Brazil
14	Binding the physical and cyber worlds: A blockchain approach for cargo supply chain security enhancement	Xu et al.	2018	Conference paper	USA
15	Blockchain-based traceability in agri-food SCM: A practical implementation	Caro, Ali, Vecchio and Giaffreda	2018	Conference paper	Italy
16	CoC: A unified distributed ledger based SCM system	Gao, Xu, Chen, Zhao, Lu and Shi	2018	Journal article	USA
17	Distributed ledger technology for document and workflow management in trade and logistics	Wang, Liffman, Karunamoorthy and Abebe	2018	Conference paper	Australia
18	Ensuring performance measurement integrity in logistics using blockchain	Kuhi, Kaare and Koppel	2018	Conference paper	Estonia
19	Future challenges on the use of blockchain for food traceability analysis	Galvez, Mejuto and Simal-Gandara	2018	Journal article	Spain

Continues

Table 6 (Continued)

Code	Title	Author	Year	Type	Origin
20	Governance on the drug supply chain via Gcoin blockchain	Tseng, Liao, Chong and Liao	2018	Journal article	China
21	Improving supply chain resilience with establishing a decentralized information sharing mechanism	Cui and Idota	2018	Conference paper	Japan
22	IoT enabled smart logistics using smart contracts	Arumugam et al.	2018	Conference paper	India
23	Research on agricultural supply chain system with double chain architecture based on blockchain technology	Leng, Bi, Jing, Fu and Van Nieuwenhuyse	2018	Journal article	China
24	Solving the trust issues in the process of transportation of dangerous goods by using blockchain technology	Imeri, Feltus, Khadraoui, Agoulmine and Nicolas	2018	Conference paper	China
25	SCM based on blockchain: A systematic mapping study	Tribis, Bouchti and Bouayad	2018	Journal article	Morocco
26	The impact of the blockchain on the supply chain: a theory-based research framework and a call for action	Treiblmaier	2018	Journal article	Austria
27	A systematic literature review of blockchain-based applications: Current status, classification, and open issues	Casino, Dasaklis and Patsakis	2019	Journal article	Greece
28	Beyond Bitcoin: What blockchain and distributed ledger technologies mean for firms	Hughes, Park, Kietzmann and Archer-Brown	2019	Journal article	UK
29	Blockchain adoption challenges in the supply chain: An empirical investigation of the main drivers in India and the USA	Queiroz and Wamba	2019	Journal article	Brazil
30	Making sense of blockchain technology: How will it transform supply chains?	Wang, Singgih, Wang and Rit	2019	Journal article	UK
31	Tracing manufacturing processes using blockchain-based token compositions	Westerkamp, Victor and Kupper	2019	Journal article	Germany

Note. Source: The author.

The studies selected in the extraction phase were published in 2017 (5), 2018 (21), and 2019 (5). When combined with information on work quantities, type of publication, and year of publication, there is a major presence of articles published in journals and conferences, evidencing a process of maturing the blockchain approach in supply chain management, migrating to an in-depth study, as observed in Figure 3.

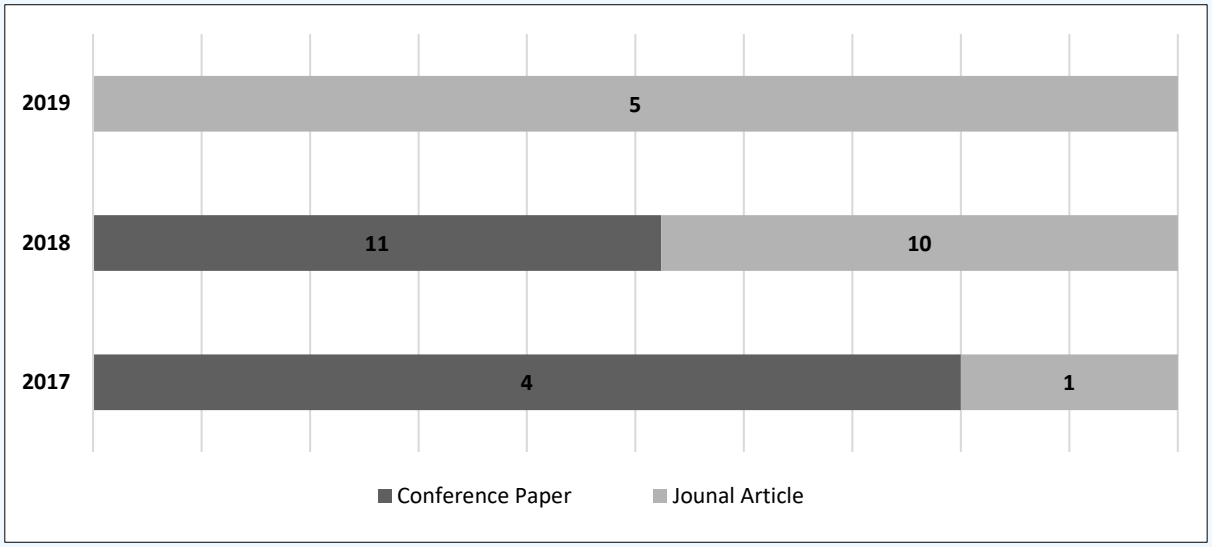

Figure 3. Crossing information from the field of study.
Source: Search data.

Considering the publication scenario, the topic is sprayed across multiple publication sources, generating a low concentration of knowledge by specialty. Table 7 shows the number of articles per publication source with the respective impacting factors and the H index.

Table 7

Number of publications per vehicle, H index, and impact factor

Source	Impact factor	H index	Amount
International Journal of Production Economics	2.48	155	1
TrAC Trends in Analytical Chemistry	2.13	142	1
Supply Chain Management	2.10	98	1
International Journal of Information Management	1.71	91	2
Business Horizons	1.30	67	1
Telematics and Informatics	1.21	48	1
Future Generation Computer Systems	0.84	93	1
International Journal of Environmental Research and Public Health	0.82	78	1
IEEE Access	0.61	56	1
Sustainability	0.55	53	2
Digital Communications and Networks	0.49	13	1
Journal of Computer Science and Technology	0.29	40	1
MATEC Web of Conferences	0.17	18	2
International Conference on Service Operations and Logistics, and Informatics (SOLI 2018)	N/A	N/A	2
Proceedings of Business Modeling and Software Design — 8th International Symposium (BMSD 2018)	N/A	N/A	1

Continues

Table 7 (Continued)

Source	Impact factor	H index	Amount
2017 IEEE 14th International Conference on e-Business Engineering (ICEBE)	N/A	N/A	1
2018 3rd International Conference for Convergence in Technology (I2CT)	N/A	N/A	1
Advances in Production Management Systems. Smart Manufacturing for Industry 4.0	N/A	N/A	1
2018 IEEE International Symposium on Technologies for Homeland Security (HST)	N/A	N/A	1
DAAAM Proceedings	N/A	N/A	1
2018 IoT Vertical and Topical Summit on Agriculture — Tuscany (IoT Tuscany)	N/A	N/A	1
Precision Livestock Farming 2017 — 8th European Conference	N/A	N/A	1
Proceedings of the 27th ACM International Conference on Information and Knowledge Management — CIKM '18	N/A	N/A	1
Proceedings of the 5th Multidisciplinary International Social Networks Conference — MISNC '18	N/A	N/A	1
2017 IEEE 19th Conference on Business Informatics (CBI)	N/A	N/A	1
2018 8th International Conference on Logistics, Informatics and Service Sciences (LISS)	N/A	N/A	1
Proceedings of the 11th International Conference on Security of Information and Networks — SIN '18	N/A	N/A	1

Note. Source: The authors (data collected at https://www.scimagojr.com, retrieved on April 06, 2019).

Output

In the last step, the information collected is analyzed. The correlation between information, its meaning and significance are presented, the current scenario outlined, and possible knowledge gaps identified (Levy & Ellis, 2006). A centralized approach is adopted on the studied concept, transposing the barriers established by the authors, and pointing out a new path to build knowledge (Webster & Watson, 2002). The product of this step is presented in the Analysis and Discussion of Results.

DISCUSSION OF RESULTS

Kshetri (2018) has set goals related to the positive performance of the supply chain and listed six main dimensions: cost, speed, reliability, risk mitigation, sustainability, and flexibility. The author develops the analysis through a multi-case study of the blockchain application in the supply chain on secondary information sources. Meng and Qian (2018) conducted an interdisciplinary study linking information science and business processes, proposing a model for analyzing supply chain management by introducing blockchain into SCM. Hughes et al. (2019) discussed the application of blockchain in the context of using IoT and the establishment of smart contracts, thereby achieving increased transparency and reliability of end-to-end information in the chain. In this sense, for the authors blockchain is characterized as a technology that generally benefits the supply chain and reinforce the characteristic of reliability; however, both demarcate the early stages of research and application of the technology, which constitutes obstacles to its dissemination and feasibility.

Chen et al. (2017) present, as a plausible question, the discussion of the application of blockchain as a solution to the problem of insufficient trust between the participants links in the supply chain and address issues including information asymmetry, the equal distribution of power between stakeholders, and their resulting impact on the quality of products and services throughout the supply chain. Following the same thought, Gausdal et al. (2018) present a study on the application of blockchain in the SCM of the Norwegian maritime industry. The main drivers for the adoption of the technology are explained, among others: cost reduction, level of self-regulation, and a strong flow of information.

Supporting that, Naidu et al. (2018) discuss a proposed decentralized model with continuity in the information chain between the parties involved, using the integration via blockchain and internet of things application (IoT). They highlight the benefits of blockchain application in SCM and its information systems: information decentralization and greater transparency, which can be aligned with Nakasumi (2017), who mentioned using blockchain in the supply chain as a possible solution to some problems, including double marginalization and information asymmetry, and with Van Engelenburg et al. (2018), who presented the advantages and disadvantages of blockchain in the areas of information access and information protection, discussing the technology's impact in reducing information asymmetry in SCM, and highlighting transparency as a positive and contributory feature of blockchain for all actors in the supply chain, regardless of their complexity. By that is possible to highlight the authors emphasizing blockchain benefit to increase transparency and information decentralization and its characteristic of high levels of information security.

The potential impact of the application of technology in supply chain management is due to its complexity in creating a physical cyber-system or large-scale fracture of the current model, which is inhibited by technological deficiencies that are not addressed or effectively addressed in the current scenario. In this sense, Gao et al. (2018) discuss the complexity of SCM in large-scale use, proposing an information system for blockchain-based SCM, in accordance with Petroni et al. (2018) and Queiroz and Wamba (2019), who highlight the growing production of data, following the exchange of information and the deepening of their analyses, and propose using comprehensive data and analysis of the information generated in the blockchain network. The expected results are to be a gain in transparency and information security throughout the supply chain. However, it is factually proven that in-depth studies and applications are still at an early stage and do not provide elements for a critical analysis of their effective contribution to the practical dimension.

It is therefore assumed that the analyzed studies emphasize the benefits of blockchain in the face of supply chain problems, fueling expectations that this technology will improve process and mitigate risks. By that, Cui and Idota (2018) consider these as weaknesses of information systems for SCM: fragmentation, complexity, and geographical dispersion. To solve the pointed issue, it is proposed a reorganization that includes the integration and provision of real-time information to all those involved in the chain, the development of a reliable information system to strengthen the resilience of the supply chain, and the linking of data and information to a new digital SCM model. In consonance with that, Treiblmaier (2018) proposes a framework based on approach

theories that are widely used in SCM and logistics, and that strengthens the characteristics and benefits of reliability and transparency.

However, expectations are created in industry. Leng et al. (2018) developed a study on the agricultural supply chain, positioning blockchain as a support technology, and proposed a structure to meet the demands of agricultural businesses, solving problems including reconciling supply and demand, integrating information, and formalizing relationships and agreements through smart contracts. Tseng et al. (2018) focus on the drug industry and refer to blockchain as an economic and mathematical way of establishing trust between the parts of the chain, reinforcing the need for transparency of the highly regulated product chains. Wang et al. (2019) highlight the benefits of transparency in the supply chain, confidence-building and secure exchange of information, strengthening trust and elimination of chain intermediaries. Nevertheless, challenges have been also identified in blockchain implementation: issues related to trust in technology, people's familiarization with technology, difficulties entering and exchanging data, network issues, and legal issues. But all of those could not surpass the benefits of high information security and transparency, gained after blockchain application in SCM.

In this scenario, it is perceived a prevalence of conceptual models that are mostly far from empirical studies and practical linkages with other technologies. As an example, Caro et al. (2018) propose a decentralized solution for the traceability of the blockchain-based agri-food supply chain, and the application of internet of things for generation and use of data throughout the chain, providing transparency, reliability, the immutability of data, and greater security in auditing, aligning with Marinello et al.'s (2017) perspective. On the other hand, Galvez et al. (2018) analyze the upcoming challenges for blockchain application in food traceability. They propose to use the internet of things in chemical food analyzers as a source of food data for the traceability network and to guarantee the authenticity and safety of food throughout the supply chain. This corroborates the work of Westerkamp et al. (2019), who present a proposal for a traceability system for manufactured products using blockchain tokens, considering components and other elements of the manufacturing process. Its main advantage is the ability to track the product and the transparency of the whole chain, especially for the end consumer.

Considering the logistics and the reliabilities issues in supply chain management, Lanko et al. (2018) discussed an information system with transparency and trust between the parties involved applying blockchain and RFID (radio frequency identification) technology associated with enabling control of many variables of the chain. This study aligns with Toyoda et al. (2017), whose radiofrequency tags are linked to a blockchain network. This approach aims to reduce counterfeiting and risks in the supply chain management, increasing transparency and reliability, which is reinforced by Madhwal and Panfilov's (2017) perspective studying the blockchain applied to the aircraft manufacturers' supply chain management, with a focus on the traceability of spare parts.

In the matter of the reliability, transparency, and information decentralization, Xu et al. (2018) present a digital identity management model that enables effective tracking in supply chain management, ensures the security of cargo information, and generates efficiency gains in logistics

handling. This perspective is corroborated by Yoo and Won (2018), who proposed a supply chain price tracking and monitoring system through use of blockchain technology and smart contracts.

In terms of strengthening the logistics chain in supply chain management, Arumugam et al. (2018) focused the application of blockchain in SCM on increasing efficiency in addressing key supply chain management challenges in terms of transparency, traceability, responsibility, and reliability through using logistics planning systems, the internet of things, automation, and relationships through blockchain contracts. That perspective is supported by Wang et al. (2018), and Kuhi et al. (2018) discussed the application of blockchain in the logistics chain intending to control the flow of information and its granularity. Its approach strengthens the possibility of greater transparency in the chain and guarantees origin and information decentralization, as well as information security. Not distant, Imeri et al. (2018) presented a study on the possible application of blockchain in the logistics chain of the transport of dangerous products, which considers insufficient trust and transparency in the chain and its potential risks.

Considering the nature of this study and its main problem to be solved, despite the importance of analyzing other relevant work, even with the small amount of publications relating RSL, blockchain, and SCM, it is possible to highlight the work of Tribis et al. (2018), who conducted a systematic bibliographic review and presented a general classification of the status of publications related to blockchain applications in the supply chain. It focused on understanding the relationship between technological application and the perspective of publications divided into validation research, evaluation research, proposed solutions, philosophical work, opinion work, and experimentation. In general, technical and regulatory gaps in the adoption of technologies and the predominance of studies in theoretical areas were presented. It is also important to mention Casino et al. (2019), who conducted a systematic review of the literature on blockchain applications in different sectors. They highlight a section for blockchain applications in SCM. However, this study aims from a different perspective to understand blockchain in SCM characteristics and benefits through an SLR. Both demonstrate a scenario where the transparency and reliability are highlighted.

In short, according to the systematic literature review, it stands out as the main characteristics and benefits of blockchain application in supply chain management: transparency, reliability, information decentralization, and information security. In Table 8, the correlation between the characteristics and benefits and the authors is presented.

Table 8

Characteristics and benefits and author correlation

Characteristics and benefits	Author
Transparency	Arumugam et al. (2018); Caro et al. (2018); Cui and Idota (2018); Galvez et al. (2018); Gao et al. (2018); Hughes et al. (2019); Imeri et al. (2018); Kuhi et al. (2018); Lanko et al. (2018); Leng et al. (2018); Madhwal and Panfilov (2017); Marinello et al. (2017); Naidu et al. (2018); Petroni et al. (2018); Toyoda et al. (2017); Treiblmaier (2018); Tribis et al. (2018); Tseng et al. (2018); Van Engelenburg et al. (2018); Wang et al. (2019); Westerkamp et al. (2019); Xu et al. (2018); Yoo and Won (2018)
Reliability	Arumugam et al. (2018); Caro et al. (2018); Cui and Idota (2018); Galvez et al. (2018); Hughes et al. (2019); Kshetri (2018); Kuhi et al. (2018); Lanko et al. (2018); Leng et al. (2018); Marinello et al. (2017); Meng and Qian (2018); Queiroz and Wamba (2019); Treiblmaier (2018); Tribis et al. (2018); Toyoda et al. (2017); Xu et al. (2018); Yoo and Won (2018)
Information decentralization	Caro et al. (2018); Chen et al. (2017); Gao et al. (2018); Gausdal et al. (2018); Galvez et al. (2018); Lanko et al. (2018); Leng et al. (2018); Madhwal and Panfilov (2017); Marinello et al. (2017); Naidu et al. (2018); Nakasumi (2017); Petroni et al. (2018); Queiroz and Wamba (2019); Toyoda et al. (2017); Van Engelenburg et al. (2018); Wang et al. (2018); Wang et al. (2019); Xu et al. (2018); Yoo and Won (2018)
Information security	Caro et al. (2018); Cui and Idota (2018); Gao et al. (2018); Marinello et al. (2017); Petroni et al. (2018); Queiroz and Wamba (2019); Van Engelenburg et al. (2018); Wang et al. (2018); Wang et al. (2019)

Note. Source: The authors.

The discussion previously presented was the result of the effort of the authors to create from the working materials an epistemological scenario and identify the main characteristics and benefits that emerged. Following this line of thought, the process of construction of the discussion in this study was conducted as an interdisciplinary interpretation of the knowledge formed and the elaboration and identification of characteristics and benefits that could only be identified by and interdisciplinary approach in a SLR.

Despite recent research on the application of blockchain in SCM, its potential is yet to be profoundly debated and its practical application yet to be tested. In this matter, the efforts of research should find a fertile and vast field of study. However, the researchers have and additional responsibility to help society build the knowledge on blockchain application to improve entire chains of production and achieve a new level of integration, potentializing its characteristics and benefits, in behalf of the entire society, transforming well institutionalized and expensive services and relations into transparent and reliable ones.

Nevertheless, studying blockchain without reaching for practical tests and applications may create a slow response of the academia and overall society to the potential change provoked by blockchain in supply chain management. In this sense, promoting practical testing and studying in business with already produced models and knowledge on blockchain in SCM by the academia could bring fast track gains to society.

FINAL REMARKS

It is noteworthy that all analyzed studies show that the application of blockchain in supply chain management is still in its infancy. Therefore, as a limitation of this study, the researcher's inability to access the full text of some studies during the selection phase and adopt it as an exclusion criteria may present an opportunity to expand the analysis in further studies.

Furthermore, it was impossible to find a clear approach to introducing blockchain into SCM. Points of convergence were explained that should be better analyzed, searching for the correlation of their concepts to establish a more universal analysis.

Considering all the previous exposure, an extent basis of opportunities for a major analysis of the blockchain adoption in SCM in its varied possibilities demands that researchers focus on each characteristic and benefit and conduct deeper studies that could amplify and bring new knowledge about the subject, eliminating possible epistemological gaps.

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Authors' contributions

1st author: conceptualization (lead), data curation (lead), formal analysis (lead), methodology (lead), resources (lead), writing-original draft (lead), writing-review & editing (equal).

2nd author: conceptualization (supporting), data curation (supporting), methodology (supporting), supervision (lead), writing-review & editing (lead).

3rd author: data curation (supporting), methodology (supporting), validation (supporting), writing-review & editing (lead).

Authors

Eladian Rodrigues*
Universidade Estadual Paulista, Faculdade de Ciências e Engenharia
Rua Domingos da Costa Lopes, n. 780, Jd. Itaipu, 17602-496, Tupã, SP, Brazil
eladian.rodrigues@unesp.br
https://orcid.org/0000-0001-6741-6359

Wagner Lourenzani
Universidade Estadual Paulista, Faculdade de Ciências e Engenharia
Rua Domingos da Costa Lopes, n. 780, Jd. Itaipu, 17602-496, Tupã, SP, Brazil
w.lourenzani@unesp.br
https://orcid.org/0000-0002-0408-9108

Eduardo Satolo
Universidade Estadual Paulista, Faculdade de Ciências e Engenharia
Rua Domingos da Costa Lopes, n. 780, Jd. Itaipu, 17602-496, Tupã, SP, Brazil
eduardo.satolo@unesp.br
https://orcid.org/0000-0002-8176-2423

* Corresponding author

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