Blockchain Technology-based Supply Chain: State-of-the-art and Future Prospects

Youness Tribis, Abdelali El Bouchti, Houssine Bouayad

Abstract*: *Initially developed for Bitcoin cryptocurrency, Blockchain Technology (BCT) is a decentralized transaction managing technology that provides security, anonymity and data integrity in transactions without the need of any trusted third party. The interest in BCT has been grown, as research topic for many fields, such as finance, health, government, agriculture and many particular Supply Chain (SC) industries. However, there is a lack of systematic literature reviews (SLR) on existing research concerning how BCT is well relevant in SC. This paper conducts a systematic review in order to examine all pertinent research on SC based on BCT. The main inspiration for this work was to synthesize existing evidence, classify research tendencies available in the literature, and identify open themes and gaps for development in this discipline. However, 45 primary papers have been extracted from scientific databases. This systematic review provides direction for future research regarding the applications of BCT for SC

Keywords*: *Blockchain technology, supply chain, decentralized ledger, systematic review.

I. INTRODUCTION

According to Swan (2015), the evolution of the BCT was classified in three different phases:

- Blockchain 1.0- Digital Currency. In 2008, using BCT, a distributed digital currency system was created by Satoshi Nakamoto (2008). Based on the decentralized peer-to-peer system design, Bitcoin was particular application of the blockchain technology developed to ensure trust between parties.
- Blockchain 2.0- Smart Contract. In 2013, Vitalik created Ethereum (the second largest digital currency) to extend Bitcoin system to "smart Contracts" applications. Therefore, BCT can process monetary transactions and guarantee that transactions comply with programmable rules in the form of "smart contracts" (Tschorsch and Scheuermann 2016). This technology allows parties who do not entirely trust each other to manage and be in charge of mutual transactions without relying on the services of any trusted intermediary.
- Blockchain 3.0- Decentralized Applications. Blockchain 3.0 has been intended to grasp all other domains beyond currency, finance and markets, such as manufacturing, SCM, pharmaceutical industry, healthcare, government, agricultural industry, energy, education, media, Internet of Things (IoT) and others industry sectors.

In supply chain domain, the SLR conducted on the last few years illustrate the interest on the role of information technologies (IT) implementation for improving the SC performance and combating many SC challenges. Maestrini et al. (2017) argued that ICT adoption is the key tool of any supply chain performance measurement system (SCPMS). Similarly, Zaheer and Trkman (2017) asserted that building trust in the relationship and IT infrastructure capability highly affects the information sharing between SC partners. Nevertheless, Zimmermann et al. (2016) considered the difficulty of establishing trust-based relationships and differences in technology used by supply chain actors as the main barriers to the innovation process. In healthcare industry, Volland et al. (2017) noted that consistent IT systems were the potential enabler for the implementation of logistics concepts in hospitals. In the pharmaceutical industry, Campos et al. (2017) found that the technological practices still rarely implemented on revers logistic and limited to the use of RFID (Radio Frequency IDentification) technology. Giving consideration to agriculture sector, Borodin et al. (2016) focused on uncertainty related to mutual exchange of information and concluded that demand for food security and IT were ones of the extremely topics affected by uncertainty. In supply chain finance, Gelsomino et al. (2016) has highlighted the relevance of exploiting the value of information as practical instrument to achieve meaningful benefits specially on supporting managerial decisions. Barata et al. (2018) have been presented IT as one of the interdependent dimensions of Industry 4.0 that offer the opportunity to adopt mobile technologies in supply chain transformations and providing new SCM solutions. The present sections of the study are organized as shown. In Section 2, we detail the used research methodology. Section 3 presents the results extracted from the collected papers. Section 4 investigates the research examination and responds the research inquiries. Section 5 gives the limitations of this investigation. Section 6 provides the conclusion of the paper and gives recommendations for future research.

II. RESEARCH METHODOLOGY

This state-of-the-art review aims to evaluate the present research papers regarding to BCT used for SC. It covers the literature published from 2016 to 2018 on blockchain application for SC. Therefore, we apply procedures for a SLR defined by Kitchenham and Charters (Kitchenham B 2007) to perform the research methodology.

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The main aim of a SLR is to provide a rigorous method to establish if research evidence exists, quantify and analysis the amount of evidence. However, in this research investigation we give abroad review of a research area in addition assessing the quantity of existing evidence (Petersen et al. 2008). The process for the SLR, presented in Fig. 1, consists of three process steps and outcomes.

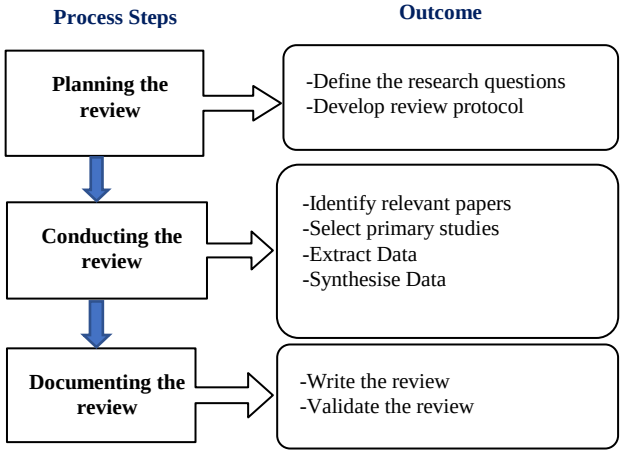

Fig. 1. The Systematic Literature Review Process

A. Research Questions

This study addresses five research inquiries that organize the essential for the overview:

Research question (RQ) 1: What are the research thematics presented in the current research articles on BCT-based SC? We would be able to form a complete understanding and give a general overview the existing literature done on BCT-based SC. RQ2: What is the methodology used in the current research on BCT-based SC? This systematic review allows identifying the different methodologies followed by scholars when conducting this specific issue.

RQ3: What are the existing BCT-based solutions that this technology proposes to eliminate the current SC challenges? BCT is mostly known for its solutions related to finance industry; consequently, it is significant to find the recent benefits and solutions developed by using BCT in SC.

RQ4: What are the existing research gaps in BCT-based SC research? The research gaps identified will assist different scientists as well as experts to emphasis their studies and investigations on parts and sections that necessitate additional exploration. Obtaining research gaps will benefit as well as facilitate to discover and comprehend unanswered research inquiries and questions in the existing BCT application and user for SCM domain.

RQ5: What are the upcoming research objectives for BCT-based SC? Realizing the possible upcoming research targets for BCT is beneficial when deciding where the research on BCT applied on SC should be focused and what concerns must to be explained and answered.

B. Search Process

A search process outlines the procedures that will be applied to carry out a detailed methodical and systematic literature search. A pre-defined process is required to decrease the likelihood of researcher bias (Kitchenham B 2007). This activity involved using a search approach, classifying data sources, choosing research works and investigations to analyze, data examination and analysis as well synthesis. A preliminary search with several combinations of search words until we had attained an appropriate collection of key-words. All terms were joined each other by using ‘‘OR’’ operator and combined with the term ‘‘blockchain’’ by using Boolean ‘‘AND’’. As a final point, we agreed to utilize the words “supply chain” and “blockchain” in the search string, the majority of papers with a BCT application on SC domain were still included. The search protocol was designed and tested before deciding to use the publications from international peer-reviewed journals and conferences. Once carrying out the examination of publications search, we noticed that technical reports, white papers and PhD thesis, had been excluded in our outcomes list. Therefore, we collected Journal Articles, Conference Paper and Book Section that were obtained in the e-database listed in Table I.

Table- I: The e-database used in search process

Online database	Url
ScienceDirect	http://www.sciencedirect.com/
Springer	http://link.springer.com/
IEEE Xplore	http://ieeexplore.ieee.org/
Scopus	http://www.scopus.com/
Elsevier	http://Elsevier.com/
MDP open access journal	http://www.mdpi.com/
AIS Electronic Library (AISeL)	http://aisel.aisnet.org/
ACM Digital Library	https://www.acm.org/

C. Inclusion and Exclusion Criteria

With the aim of selecting and choosing the most relevant papers, inclusion and exclusion criteria were applied in two phases. At the first phase, the selected papers were included based on the analysis of their title and abstract. In this stage, research works and investigations that were not pertinent to the scope of this research subject were rejected. At the second phase, the authors examine the full text of included articles in the first phase and used the following exclusion standards.

Exclusion criteria:

- Articles that were technical reports and PhD thesis.
- Articles lacking full manuscript availability and accessibility.
- Articles where the language was not English.
- Articles that had particular extra significance than BCT applied in supply chain domain.
- Articles where as a minimum one of the search words did not be comprised in the paper title, keywords or abstract of the article.

D. Data extraction

Data extraction form allows collecting the information needed to address the research questions of this study.

The following information, listed in Table II, were extracted from each research work and investigation.

Table- II: Data extraction items

Data item	Description
Title	The title of the full manuscript
Authors	The name of the author(s)
Country	The country of author(s)
Publication information	The name of the publication place
Publication type	The type of publication (conference/workshop/journal)
Publication source	Academia or Industry
Abstract	The abstract of the full manuscript
Investigation purpose	The main purpose of the article
Methods	The methodology used for conducting the study
Research questions	Research questions and inquiries for our article
Investigation results	The fundamental results of the research works and investigations

III. RESULTS

According to the extracted data, the main findings of the search and selection process for our systematic literature review are presented in this section.

A. Outcomes of search and selection process

The essential findings of the search and selection are provided in Fig. 2. Initially, one hundred ninety-seven publications were found when the aimed search process was used to the particular scientific research literature. The principal stage of inclusion and exclusion criteria was belonging to title and abstract. Thus, we retrieved 70 scientific articles. The main motive for the important number of excluded articles (143) was that they were not associated to the principal research subject. For example, many excluded papers focused on digital currency or just on supply chain industries without relationship with blockchain technology, and therefore they did not belong to our study. In the next phase of scientific research article selection, we read entirely the included articles in the first stage. This brought about in the selection of 45 scientific articles that we comprised in our research investigation as primary scientific articles.

B. Publication year

As shown in the Fig. 3, since 2008 when blockchain was created, the researchers interest on blockchain based SC began after 2016 with two papers (4%). In 2017, 19 papers (42%) were published and the majority of the designated artciles, 24 scientific articles (53%), were published and available in the first half of 2018. This proves and validates that the investigated research topic is is a recent and prominent area.

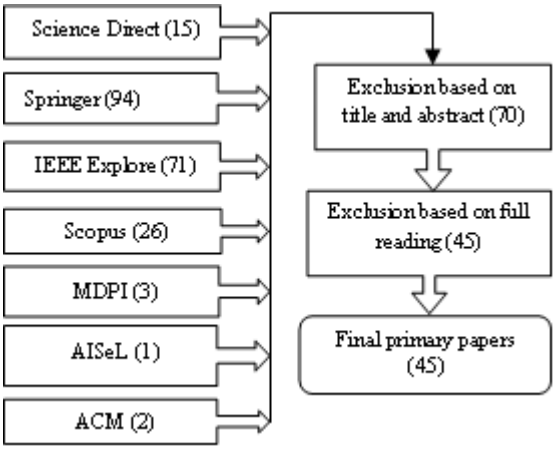

Fig. 2. Search and selection procedure

C. Geographic distribution of publications

The geographical distribution of the selected primary scientific articles is illustrated in Fig. 4. Distributed at 18 different countries, the blockchain technology has achieved large interest all over the place of the globe. The essential volume of scientific articles, 11 (24.44%), were published and available by the academia in the United States. Whereas, China occupied the second place with five papers (11.11%). Switzerland and the other countries had three or less than two published articles.

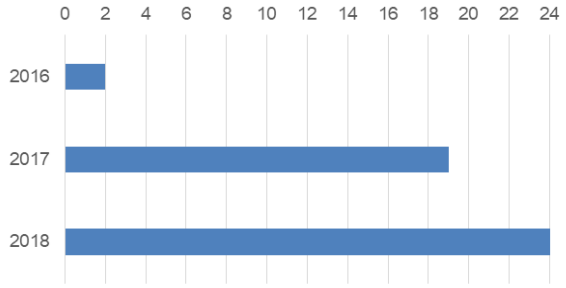

Fig. 3.Publication year of the selected primary artciles

D. Publication type

In this study, the publication types included were journal, conference, book chapter, workshop and symposium. Fig. 5 shows that a large amount of the scientific articles were published and available in international conferences, 16 (35.56%) as well as journal, 15 (33.33%) respectively.

E. Publication channel

The overall list of publication channel of each designated paper was displayed in Table 3. We found 41 publication channels.

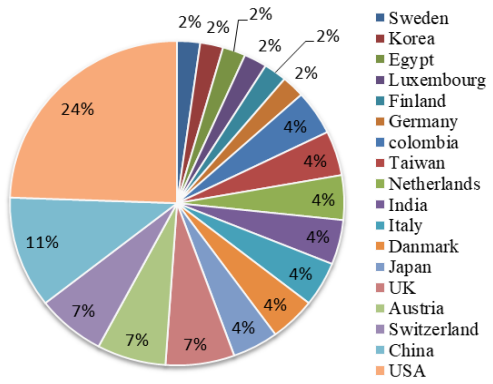

Fig. 4.Geographic distribution of the selected primary articles.

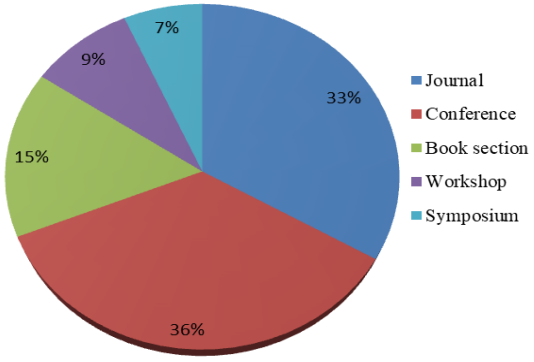

Fig. 5.Publication type.

F. Publication categorization

In this section, a quantitative assessment of the selected primary papers is presented. The publications are classified in two categories: Thematically and methodically. Then, the relevant studies are sorted into an overview.

Thematic categorization

A thematic scope of publications along our review is provided in Fig. 6. In the bounds of the research thematic categorization, authors outline the principal research investigations on 19 research subjects and studies related to some specific SC domains. In addition, authors distinguished one thematic, supply chain traceability that has really been the overall focus of researchers and represents the majority of topics (18 articles, 40%). Over and above, the literature highlight particularly certain distinct supply chain sectors such as food SC (5 articles), pharmaceutical SC (2 articles) and textile supply chain (2 articles). The second relevant SC thematic treated by the primary scientific articles is the SC information security with six papers (13.33%), after that; we found SC finance thematic with three papers (6.67%). Others thematic have two or less than one publication.

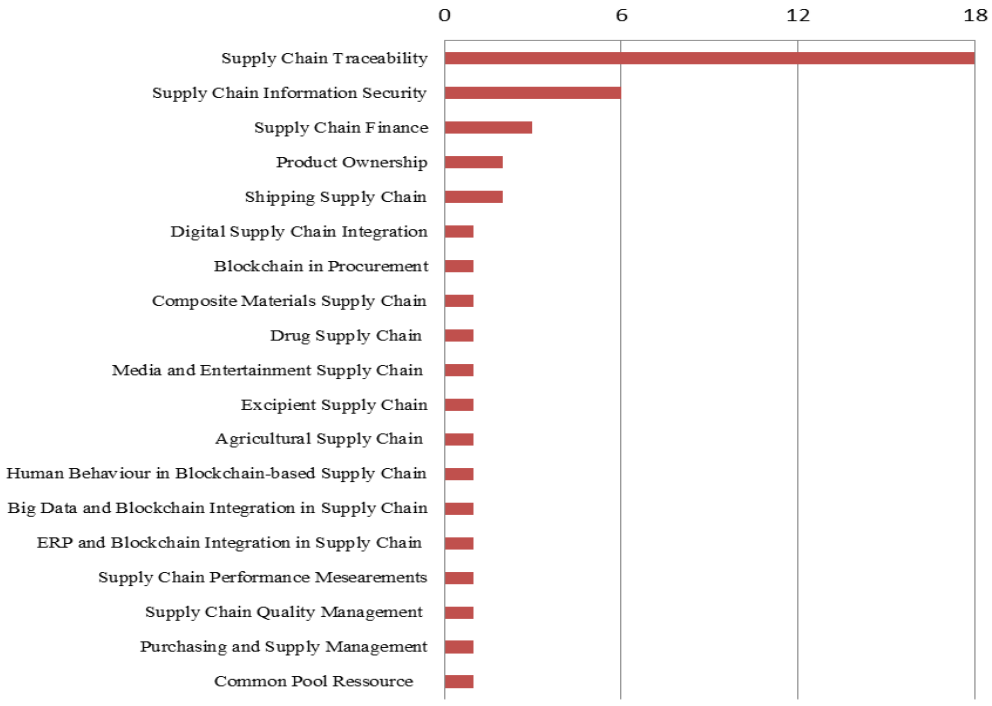

Fig. 6. Thematic categorization of scientific articles

Methodological categorization

The second categorization considered the methodologies used in the reviewed literature (Fig. 7). In the given chart, the shape shows the measurable type of the used procedures and methods. Most of papers have been published as conceptual papers with 37 publications (82.22%); others distributed on 26 publications (57.78%) for theory/conceptual papers and 11 publications (24.44%) as conceptual & simulation articles.

The other methodologies were conducted in few papers; five publications (11.11%) for case study works and three publications (6.67%) for empirical papers.

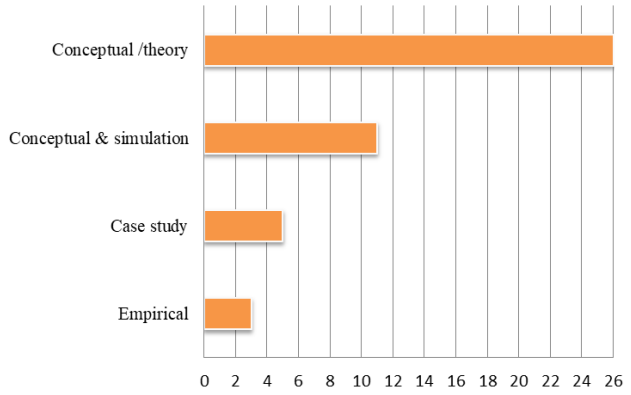

Fig. 7.Methodological categorization of papers

G. Overview of publications

As shown in Table IV, a supply chain topic and methodological and procedural review of entirely literature is presented. We originate that theory and conceptual methodologies were largely applied in SC traceability, SC information security and SCF. Those three research areas introduce the blockchain concept and proposed innovative models and systems based on blockchain. However, the frameworks mostly tested and simulated in lab or in industrial context were in SC traceability. In addition, few themes offered the possibility to apply case study such as SC traceability, Shipping SC, DSC integration and SC performance measurements. Only three research areas were concerned by conducting Empirical research methodology: Supply Chain traceability, SC information security and Shipping SC.

IV. DISCUSSION

The analysis of the results enables us to classify and analyze what have been stressed in previous research works as well as what are the gaps and prospects for future studies and research. There is a trend of increasing attention towards various subjects linked to blockchain research in last 10 years. Particularly, the number of publications for blockchain applications in supply chain has been significantly increased after 2016 (Fig. 3). In this section, authors deliberate and review the findings then response the five principal research inquiries and questions.

RQ1: What are the research thematics investigated in existing research works on BCT-based Supply Chain?

The main findings of this systematic review demonstrated that a large portion of the research works concentrates on design of new framework and models based on blockchain technology concept and its innovative characteristics. However, there is a need field research, since the techniques investigated and proposed frameworks are mostly novel and have usually not yet been implemented in practice. Analyzing the 19 identified research thematic (Fig. 6 and Table IV), certainly there is one main topics stressed in the literature: supply chain traceability with 18 papers (40%). Actually, the blockchain-based traceability was introduced in several industries, specially; the food supply chain (Feng Tian 2017), (Tian 2016), (Tse et al. 2018), (Caro et al. 2018), (Bettín-Díaz et al. 2018), the pharmaceutical supply chain (Bocek et al. 2017), (Archa et al. 2018), the textile supply chain (ElMessiry and ElMessiry 2018), (Agrawal et al. 2018) and Transportation Dangerous Good (Imeri and Khadraoui 2018). The rest of the publication in traceability thematic did not focus on precise SC area; (Wu et al. 2017), (Lu and Xu 2017), (Ciccio et al. 2018),(Alzahrani and Bulusu 2018), (Islam et al. 2018), (Li et al. 2017), (Boehm et al. 2017), (Francisco and Swanson 2018).

RQ2: What are the research works methodologies used in current research on BCT-based SC?

In fact, as seen in Fig. 7 and Table IV, conceptual papers is the research methodology with more entries, which target to suggest original BCT-based structures associated to quite a lot of SC manufacturing. The methodological categorization allowed us to identify that a majority of the papers are mostly proposing new technical solutions and examining their adoption further than assessing and/or validating them in practice. However, many of these framework solutions were tested or simulated under limited environment. We realize that researchers are not interested on conducting Empirical research and case studies rather than focusing on understanding this new blockchain concept and exploring their applications in SC field.

RQ3: What are the current BCT-based solutions that this technology proposes to combat the current SC challenges?

Considering the different SC topics introduced by this study, the Table V reviews the current blockchain based frameworks and model solutions proposed in the literature that will resolve the existing supply chain problems. Therefore, we summarize the main benefits providing by these blockchain-based solutions.

In the SC traceability area, each participant in a supply chain can see in pseudo real-time the development of goods and properties as they proceed over the SC, accepting where a specific container is in transportation. Contributors are also able to establish the status of customs documents, observe lading bills and observe additional documents and data. The passage of novel SC actions and documents is taken in real time. This technology could realize the traceability with trusted information in the whole SC and enhancing the product quality and safety. Furthermore, blockchain technology permits to tackle many types of counterfeit on the Consumer Electronics Supply Chain. In addition, blockchain solution would reduce operational costs

In SC information security, the blockchain application allows managing supply chain information more efficiently and supports the SCM responsibilities for example lading bill, international trade compliance, as well as customs clearance. The new models permit lawful and regulatory decisions in relation to collecting, storing then sharing sensitive documents and data. However, the frequency and efficiency of trades could increase.

In SCF, the novel frameworks could reduce transactions costs in reverse factoring instruments by decreasing the necessity for several mediators. In other hand, one solution will ensure cost-effectively collection of payment and supervision of the transactions between customer and merchandise store.

Remarkably, because the blockchain concept is still in its premature stage, we found few blockchain-based solutions for some specific supply chain areas related to Product Ownership, Procurement, Drug SC, Agricultural SC, Big Data and Blockchain integration in SC, SC Quality Management and Common Pool Ressource (Table 5). Therefore, considering the opportunities offered by the blockchain features in a decentralized environment, the number of solutions based on blockchain for supply chain problems will expected rise in the near future.

RQ4: What are the current studies gaps in BCT-based SC?

In this sub-section, we identified the main research gaps introduced by the literature that needs more research in the future. The first research gap is that important number of scientific papers is published and printed in international conferences, scientific meetings and workshops comparing with the number of publications in high quality journal. For example, In SCF, there are very restricted quantity of published research articles that comes together SCF and BCT. The regulations obstacles are important gap. However, multiple jurisdictions, standards, commercial codes and accounting rules create complexity of implementing BCT-based solutions in order to comply with old laws, regulations and institutions. Financial establishments and experts are invited to afford the authorized and lawful structure and the outline for a procedural and practical framework. In addition, DSC integration necessitates standards for system interoperability, which blockchain technology itself does not provide. Blockchain knows how to transform the system and method of processing dealings and contacts, storing as well as sharing data, but it cannot modify the accounting rules. The difficulty of adoption generate another gap related to the difficulties to convince the SC participants to adhere in this new ecosystem based on blockchain and migrate their traditional systems to the novel one. In the upcoming years, the possible increased size of distributed ledgers and the probable large increase of transactions number, could affect the efficiency of the blockchain and generate problems related to latency, storage and synchronization. For many existing blockchain applications, to ensure the privacy and security of the data stored on the shared ledger, transactions and smart contracts were necessary to associate the known identities. Then, for privacy of the manufacturers, the transparency and anonymity are hard to be simultaneously fulfilled. The growth of the network could significantly rise the need for available energy sources to supply extended hardware computing power and the network transfer infrastructure. Thus, the implementation cost will increase significantly. In addition, some SC actors' in developing countries did not reach the requirement of the high degree of computerization and IT infrastructure needed.

Considerable complexity and uncertainty for members were produced because of the trades and transactions latency that occupy and consume certain time to complete while waiting for every one of participants or contributors update and inform their ledgers.

As any new technology, security and data integrity will be considered as very important gaps. In fact, considering the suggested frameworks, the efficiency of information SC Security System was not evaluated in manufacturing environment.

RQ5: What are the directions of the upcoming research studies for BCT-based SC?

Stressing evidences collected from the data extraction process, we identified two main future research directions for SCM based on BCT related to technological and non-technological challenges. The first future research direction was concerning the technological aspect. Research could focus on the opportunities of integrating others ICT with Blockchain for instance AI, IoT, big data analytics as well as cloud applications that can accelerate and simplify digital supply chain integration. Also, the problem of how to migrate current electronic records into the new advanced blockchain structure needs additional research and development. As well, to improve the security and privacy in accessing cloud databases for customers, stores and financial supervisory party, future studies should consider a cost-effective method. We believe that future research will also address the technical gaps related to scalability, size, security and data integrity energy efficiency. Similarly, we accept as true that upcoming studies will emphasis on the evaluation of the designed blockchain frameworks in operational environment with the aim the create systems for application industrial context. As cited above, the second future research direction were related to non-technological challenges associated to exterior elements for instance rule and guideline, company culture, in addition to social acceptance. However, we accept as true that upcoming studies will include the investigation of the impact of these external factors in blockchain adoption. In addition, blockchain adoption will activate the necessity to carry out additional studies on the impact of the type of product or service for end user adoption. New research should be conducted on the blockchain impact on the intra-company synergies between manufacturing, marketing, and finance. Other challenge related to types of blockchain innovations that should be designed in concert with supply chain actors, will be a topic for research. In the literature, Supply Chain traceability has received a large interest. Therefore, traceability will be always an attractive topic for research.

V. LIMITATIONS OF THE STUDY

To consider the validity of our systematic review, there are some limits associated to publication bias, selection bias, imprecision in data extraction, as well as categorization bias. The publication bias is related to the issue that is probable that certain appropriate research works and investigations were not selected all over the searching procedure. We are not able ensure that entirely pertinent principal research works were designated and chosen.

BCT is an original subject in SC industry in addition to academia. It is conceivable that certain research works and examinations accomplished in the industry sector were published and available as white articles or technical reports. Selection bias is associated to the misapprehension of the standards and conditions applied to choose the scientific papers. We mitigated this problem by conducting a model exploration with diverse key-words to guarantee that many papers were encompassed in this study. To guarantee that all designated and chosen articles were relevant for our research theme then could responded the identified research inquiries RQs; inclusion and exclusion criteria were more precise and correct. Nevertheless, there is one limitation related to the search string which encompassed merely the terms "blockchain" and "supply chain". There is a likelihood that not all the research articles and publications regarding to blockchain and supply chain were obtained because of our search procedure. Indeed, many researches related to blockchain focus to some areas such as digital currency and IoT. Nonetheless, we aim to map out precisely the blockchain application in supply chain domain and excluding the other blockchain application domains. Misclassification in data extraction is associated to the possibility and pitfall that critic and reviewers differed when mined data and information. To mitigate this limit, three authors participate in the paper selection process and discuss the opportunities of including or excluding the paper.

VI. CONCLUSION

Actually, the current research works conducted in the BCT; lacked of systematic analysis regarding the BCT application in SC. The major aim of this SLR is to analyze the current research works on the BCT-based SC. From 45 extracted primary studies, published in the period between 2016 and 2018, the results prove that more than 40% of the papers focus on BCT-based SC traceability. The remaining papers assess new BCT-based SC thematics that need much more exploration such as SC Information Security (13%) and BCT driven SC Finance (6.67%). In addition, more than 82% of the selected studies focusing on proposing new BCT-based frameworks that will resolve the currents SC problems. However, many of the suggested frameworks-based solutions were not tested or evaluated on the real industrial environment.

Based on the current research status, this systematic review points out some recommendations on future research directions as following:

- More focusing on the opportunities of integrating others ICT with BCT for instance Artificial Intelligence (AI), cloud applications as well as Internet of Thing (IoT).
- Studying the problem of how to migrate from current SCM systems into the new advanced BCT structures.
- Conducting studies on the security and privacy in accessing cloud databases for customers, stores and financial supervisory party, future studies should consider a cost-effective method.
- Addressing the critical technical gaps related to scalability, size, security and data integrity energy efficiency.
- Evaluation and experimentation of the designed BCT frameworks in operational environment with the essential aim to create systems for application industrial context. We notice that industrial experiences are rare in the literature and existing e-database.
- Investigation of the impact of non-technological challenges regarding to outside elements for instance rule and guideline, company culture, and social acceptance regarding the blockchain adoption in the SC context.
- Development of new BCT-based solution for SC traceability challenges.
- We believe that this systematic literature review will strongly contribute to the research community investigations in this prominent area.

Table- III: Publication channels

Publication channel	Author
International Journal of Information Management	N. Kshetri 2017
International Symposium on Business Modeling and Software Design	Engelenburg et al 2018 Ciccio et al 2018
IEEE International Conference on e-Business Engineering	Chen et al 2017
Advances in Intelligent Systems and Computing	Chang et al 2018
Information (Switzerland)	Wu et al 2017
IEEE Access	Toyoda et al 2017
International Conference on Services Systems and Services Management	Tian 2017 Tian 2016
IEEE Software	Lu et Xu 2017
Springer, Cham	Kharlamov and Parry 2018 Hofmann et al 2018
Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	Rubio et al 2018
Workshop on Cryptocurrencies and Blockchains for Distributed Systems	Alzahrani and Bulusu 2018
SMPTE Annual Technical Conference and Exhibition	Wong and Obermeier 2017
IEEE International Conference on Industrial Engineering and Engineering Management	Tse et al 2018
International Conference on Blockchain	ElMessiry M and ElMessiry A 2018

Elsevier	Banerjee 2018
International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob)	Chen et al 2017
Springer Singapore	Agrawal et al 2018
IoT Vertical and Topical Summit on Agriculture - Tuscany (IOT Tuscany)	Caro et al 2018
Telecommunications Policy	Kshetri 2017
IM - IFIP/IEEE International Symposium on Integrated Network and Service Management	Bocek et al 2017
Journal of Computer Science and Technology	Gao et al 2018
International Conference on Computer Communication and Networks	Xu et al 2017
Journal of Intelligent Information Systems	Engelenburg, et al 2017
Hawaii International Conference on System Sciences	Korpela,et al 2017
IEEE International Conference on Applied System Invention	Mondragon et al 2018
International Journal of Environmental Research and Public Health	Tseng et al 2018
International Workshop on Information Security Applications	Boehm et al 2017
International Conference on Dynamics in Logistics	Loklindt et al 2018
IEEE Conference on Business Informatics, CBI	Nakasumi, 2017
ACM Conference on Supporting Groupwork	Jabbar and Bjørn 2018
International Conference on Computational Science and Its Applications	Bettín-Díaz et al 2018
IEEE	Islam et al 2018
IEEE International Conference on Distributed Computing Systems Workshops	Li, et al 2017
Journal of Purchasing and Supply Management	Foerstl,et al 2017
Future Generation Computer Systems	Leng et al 2018
IEEE International Workshops on Foundations and Applications of Self* Systems (FAS*W)	Kurka, et Pitt 2017
Palgrave Macmillan, Cham	Nicoletti, 2018
IFIP International Conference on New Technologies, Mobility and Security	Imeri et Khadraoui 2018
Logistics (MDPI)	Francisco,et Swanson 2018
Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST	Archa et al 2017
Journal of Excipients and Food Chemicals	Apte,et Petrovsky 2016

Table- IV: Overview of publications

SC Thematic	Conceptual /theory	Conceptual and simulation	Case study	Empirical
SC traceability	Tian 2017 Tian 2016 Agrawal et al 2018 Boehm et al 2017 Bettín-Díaz et al 2018 Li et al 2017 Imeri and Khadraoui 2018 Francisco and Swanson 2018 Archa et al 2017	Wu et al 2017 Alzahrani and Bulusu 2018 ElMessiry M and ElMessiry A 2018 Caro et al 2018 Ciccio et al 2018 Islam et al 2018	Lu et Xu 2017 Bocek et al 2017	Tse et al 2018
SC information security	Xu et al 2017 Engelenburg, et al 2017 Nakasumi 2017 Engelenburg, et al 2018	Gao et al 2018		Kshetri 2017
SC Finance	Hofmann et al 2018 Hofmann et al 2018	Chen et al 2017		
Product Ownership	Chang et al 2018	Toyoda et al 2017		
Shipping SC			Loklindt et al 2018	Jabbar and Bjørn 2018
DSC integration			Korpela et al 2017	
Blockchain in Procurement	Nicoletti 2018			
Composite materials SC	Mondragon et al 2018			
Drug supply chain	Tseng et al 2018			
Media and entertainment SC	Wong and Obermeier 2017			
Excipient SC	Apte and Petrovsky			
Agricultural SC		Leng et al 2018		
Human Behavior in Blockchain-based SC	Kharlamov and Parry 2018			
Big Data and Blockchain integration in SC	Rubio et al 2018			
ERP and Blockchain integration in SC	Banerjee 2018			
SC performance measurements			N. Kshetri 2017	
SC quality management	Chen et al 2017			
Purchasing and supply management	Foerstl et al 2017			
Common Pool Resource		Kurka and Pitt 2017		

Table- V: Blockchain-based frameworks solutions

SC Thematic	Author Year	Framework/model	ICT used	Blockchain Benefits
SC Traceability	Tian 2016	Agri-food SC traceability system	Blockchain & RFID	-Realize the traceability with trusted information in the whole agri-food SC -Enhancing the food quality and safety
	Tian 2017	Food SC traceability system	Blockchain & IoT	Deliver real-time food tracing to all SC members with openness, transparency, neutrality, reliability and security
	Boehm et al 2017	blockchain-based tracking of products	NFC tags	-Capture a product's provenance including any changes holistically. -Combat many types of counterfeit on the Consumer Electronics Supply Chain
	Li 2017	Hybrid P2P physical distribution (HP3D) framework	Blockchain & Hybrid P2P network	- Tracks the pseudo real-time status of the shipment making the physical distribution process completely transparent to the stakeholders.
	Imeri and Khadraoui 2018	decentralized approach for sharing information in TDG	Blockchain	Ensures a Security and Traceability of Shared Information in the Transportation of Dangerous Goods
	Archa 2018	Trace and track pharma SC system	Blockchain & IoT framework	-Assure immutable record of drugs & transactions
	Wu et al 2017	Online shipment tracking Framework	Blockchain	deliver validated, pseudo real-time shipment tracking during the distribution phase
	Alzahrani and Bulusu 2018	Block-Supply Chain	NFC and Blockchain	Track-and-trace products and detect modification,cloning, and tagre application attacks
	ElMessiry M and ElMessiry	blockchain-based framework for textile quality improvement	Blockchain	Improve the traceability, transparency and quality of the textile production and end product.
	Caro et al 2018	AgriBlockIoT blockchain-based traceability solution	Blockchain	Achieve traceability in Agri-Food supply chain management using two different blockchain implementations, Hyperledger Sawtooth and Ethereum
	Islam et al 2018	(integrated circuits) IC traceability scheme	Blockchain and PUFs (physically unclonable function)	Authenticate, track, trace, analyze, and provision chips during their entire life cycle
	Bocek 2017	Modum.io AG pharma SC Architecture	Blockchain & IoT sensors	-Assert data immutability and public accessibility of temperature records. -Reduce operational costs
	Tse 2018	Decentralized Food Supply Chain Authentication Model	Blockchain	-Help government to track, monitor and audit the food supply chain -Helping manufacturers to record the transactions in authenticity - Improve the efficiency of food supply chain's processing
SC information security	Xu et al 2017	CoC (supply chain on blockchain) system based on hybrid decentralized ledger	Blockchain	- Prevent unauthorized access to data stored on the ledger. - Allows managing supply chain information more efficiently without compromising desirable features of decentralized ledger.
	Gao et al 2018	CoC (supply chain on blockchain) System based on a hybrid decentralized ledger with two step block construction mechanism	Blockchain	-Assure cargo tracing capability, - Support the SCM tasks (bill of lading, international trade compliance, and customs clearance.
	Engelenburg, et al 2017	Software architecture for B-to-G information sharing	Blockchain	- Enables government organizations to receive more information used for better and more focused inspections. - Contributes to public safety and security
	Nakasumi 2017	Blockchain scheme for information sharing	Blockchain & homomorphic encryption solution	- Allow companies to utilize data without being overly concerned about properly securing them - Permit legal and regulatory decisions about collecting, storing and sharing sensitive data
	Engelenburg, et al 2018	A Blockchain Architecture for Reducing the Bullwhip Effect	Blockchain	-Allow parties to balance their need for inventory management with their need for flexibility for changing partners -Assure sensitive data security

Supply Chain Finance	Hofmann 2018	-Simplified post-trade clearing and settlement services in the reverse securitisation model	Blockchain	- Reduce transactions costs in reverse factoring instruments by reducing the need for multiple intermediaries
	Chen 2017	Blockchain-based Payment Collection Supervision System (BPCSS)	Blockchain & Cloud Databases	Ensure Cost-effectively collection of payment and Supervision of the transactions between customer and merchandise store
Product Ownership	Chang et al 2018	blockchain based product record system	lockchain	-Assure product's quality after products were transported through the whole supply chain. -recorded and traced back events occurred during transportation or after product was sold
	Toyoda 2017	Product Ownership Management System model	Blockchain & RFID	- Reject the purchase of counterfeits even with genuine RFID tag information if the seller does not possess their ownership
Blockchain in Procurement	Nicoletti 2018	-Blockchain-based Procurement model - Blockchain-based Procurement finance model	Blockchain & ICT of Industry 4.0	- Reducing or eliminating bureaucracy, distrust - Ensure transparency and security of commercial transactions among companies and financial institutions.
Drug supply chain	Tseng et al 2018	Gcoin blockchain system	lockchain	-Create transparent drug transaction data - ensure Governance on the Drug Supply Chain
Agricultural SC	Leng 2018	Agricultural supply chain system based on double chain architecture	Blockchain	- Assure the openness and security of transaction information and the privacy of enterprise information, - Enhance the credibility of the public service platform and the overall efficiency of the system
Big Data and Blockchain integration in SC	Rubio et al 2018	decentralized chain archetype	Big Data and Blockchain	Manage the Big Data from the application of Blockchain technologies
SC Quality Management	Si Chen 2017	Blockchain-based SC Quality Management framework	Blockchain & IoT sensors	- Improve the supply chain quality management - Provide a theoretical basis to intelligent quality management of supply chain
Common Pool Ressource	Kurka and Pitt 2017	Smart-CPR system model	Blockchain	Assure the distribution of collective resources efficiently

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