# Towards More Sustainability: A Literature Review Where Bioeconomy Meets Blockchain

Sven Willrich[1], Felix Melcher[1], Tim Straub[1] and Christof Weinhardt[2]
[1]*FZI Forschungszentrum Informatik, Haid-und-Neu-Straße 10-14, 76131 Karlsruhe, Germany*
[2]*Karlsruhe Institute of Technology, Karlsruhe, Germany*

Keywords: Bioeconomy, Natural Resources, Sustainability, Blockchain, Literature Review.

Abstract: On the one hand, society has gradually grown awareness and importance of sustainability and natural resources. On the other hand, blockchain technology gains increasingly interest and the impacts may have not completely examined ecological, economical, and social. To present the state-of-the-art and hot topics within bioeconomy and blockchain, we reviewed them equally and outlined future research threads. Based on a systematic literature review combined with text mining and clustering, to enhance our data collection phase, we describe a dedicated research thread and end up with real-word and possibly future-potential implications driven by blockchain technology. Overall, this review gives important insights on how blockchain was and could be engaged to add value towards sustainability at bioeconomy and natural resources.

## 1 INTRODUCTION

Bioeconomy brings natural resources and economy together. It means being in exchange with natural resources in a sustainable and responsible way while using biological resources to undertake economic activities (McCormick and Kautto, 2013). While doing so, we consider scarce fossil natural resources and general implications towards the climate change. This kind of economy is trying to create a knowledge-based production and usage of natural resources with the goal of developing new products, procedures, and services in all economic branches, with the focus of providing a sustainable economy (Bioökonomierat, 2017). At the same time, with corporate social responsibility (Orlitzky, Schmidt and Rynes, 2003) and corporate sustainability (Gómez and Medel-González, 2015) organizations are getting sensitized and are taking such thoughts into the design and distribution of products or services. Many researchers agree upon the explicitly growing world population cannot continue on the way they are currently in exchange with natural resources and that new sustainable ways to behave commercially are sought after. It gradually becomes more and more important to establish and to ensure a good governance to natural resources (Devaney, Henchion and Regan, 2017). Hence, the topic around bioeconomy is also touched politically, there are activities involved such as participation and citizen science. As bioeconomy normally includes a multitude of ecological, economic and social parties with his own interests, the cross-industries may consist of complex supply chains. With blockchain has been arising, there is a promising candidate to challenge uses cases where trust between parties could be (is) an obstacle. Theoretically, neither intermediaries are required nor parties are enforced to trust somebody blindly in case of an association (Nguyen, 2016) as they now are able to get into business in a peer-to-peer topology.

In this contribution, we present a structured literature review based on a text mining classification approach (Yang, Zhang and Yan, 2017) (Yang and Hong, 2017). We use this procedure to cluster and classify the literature results of the topic-related search queries. Lastly, we discuss every auto-generated cluster separately and go into depth, respectively.

## 2 LITERATURE REVIEW

In this paper, we want to analyze the state-of-the-art in the field of bioeconomy and blockchain to suppose possible future research threads. To do so in a clear and structured way, we follow the guidelines from Webster and Watson (Webster and Watson, 2002) and in particular use a proven approach (vom Brocke *et al.*, 2009). This method is a framework organized



Willrich, S., Melcher, F., Straub, T. and Weinhardt, C.
Towards More Sustainability: A Literature Review Where Bioeconomy Meets Blockchain.
DOI: 10.5220/0007786301070114
In *Proceedings of the 16th International Joint Conference on e-Business and Telecommunications (ICETE 2019)*, pages 107-114
ISBN: 978-989-758-378-0

in five phases. Each of the following sections represent one of these five phases.

## 2.1 Definition of Research Scope

To define the scope of our research, we use the taxonomy described by Cooper (Cooper, 1988).

The focus (1) of our literature review is to find related practices and/or applications where distributed ledger technologies (DLT) aka blockchain are used in the field of bioeconomy. Because the combination of bioeconomy / managing natural resources with the technology of distributed ledgers is not widely discussed, our goal (2) is to identify the central issues within this field. The structure of this review is organized (3) in a conceptual way. Written with an espousal perspective (4), since we are convinced the examination of distributed ledger technologies is not sufficient. Especially with respect to the context of bioeconomy and a ledger with a distributed infrastructure, that could fit in the field of communal used natural resources. We address a specialized audience (5) with this review, because the terms and concepts, especially in the scope of DLT, need a deep understanding of cryptography, distributed databases, and knowledge about the patterns of communication within computer networks. Lastly, since we ask several academic databases with the same key words in a breadth-oriented search, the review reaches a representative coverage (6) of the topics.

## 2.2 Conceptualization of Topic

In the second phase (vom Brocke *et al.*, 2009) we describe the basic concepts and terms to put an overview about the contextual definitions needed to understand the basics of our research area helping us to find new keywords for our literature search.

**Bioeconomy** is the knowledge-based production and usage of natural resources, to create new products, procedures, and services in all economic branches, with the focus of providing a sustainable economy (Bioökonomierat, 2017). Goals of bioeconomy are, e.g., to change from fossil fuels as the economic engine to an efficient economy based on sustainable energy. In total, the topic spans from encouraging consumer to be part in a bioeconomy value chain of sustainable consumption until the protection of the climate (McCormick and Kautto, 2013). It embraces political and society topics alike, and range from participation and citizenship to democratic and liberation approaches. It has the claim to include everyone, because every individual has an effect on it and the bioeconomy affects everyone.

The rise of **Blockchain / Distributed Ledger Technologies** has most probably begun when Satoshi Nakamoto[1] had published his understanding of the blockchain technology in 2008 (Nakamoto, 2008). In this connection, blockchain can be understood as one potential implementation of a DLT (Cachin, 2016). As conceptualized, the potentials come from its distributed and decentralized structure – resulting in the missing necessity of any intermediary. Since every central unit, e.g. technical, organizational, or human agent can be supposed to be a black box. Where the missing trust can become a problem, blockchain provides an alternative way to interact without it (Hawlitschek, Notheisen and Teubner, 2018). Hence, intermediaries might no longer be a vital or indispensable part of transactions. Through its public ledger and its consensus mechanism, the transactions made on a blockchain are persistent in a transparent, immutable, and traceable way (Nakamoto, 2008) and consequently protected from deletion, tampering, and revision (Iansiti and Lakhani, 2017).

Furthermore, DLTs may have the ability to trigger transactions automatically. With that feature, referred to as *Smart Contracts*, DLTs are empowered to execute programs at specific (time) events (Buterin and others, 2014). The execution takes place as soon as the event has occurred. These smart contracts also enable a blockchain-based governance through the concept of decentralized autonomous organizations (DAO) (Reijers, O'Brolcháin and Haynes, 2016b). The main purpose of a DAO is the decentralized governance of "computerized rules and contracts" (Chohan, 2017) in a transparent manner. We argue that this kind of governance can be a promising candidate for satisfying participatory requirements needed for an effective bioeconomy.

## 2.3 Literature Search (Data Collection)

In this section, we have documented our literature search. The research fields we target are relatively new, that is why we do not set any boundaries such as specific journals or conferences. At the end of this section and with this information in mind, we want to identify journals and conferences that cover our research topics blockchain and bioeconomy most suitable.

[1] A person or a group of people.

For the field of bioeconomy, several synonyms are existing while each meaning slightly differ. Therefore, we have used the three most common terms for this, i.e., bioeconomy, bioeconomics, bioeconomic. In addition, DLT is not widely used in publications, mostly the authors refer to blockchain and use this term as the generalized name for the technology. As a result, our first search query was (blockchain AND (bioeconomy OR bioeconomics OR bioeconomic))[2].

In behalf of a comprehensive understanding of our data collection phase, we explain the procedure in more detail: We used a tool that calls the application programming interfaces (APIs) of research databases. These are IEEE, Springer Link, Elsevier, Crossref and arXiv as they provide a convenient way to receive machine-readable data for further analyses. The data collection process consisted of three steps. In the first step, we sent search query requests to the APIs. In the second step, the query results got cleansing, which consists of identifying and cleaning up duplicates, removing papers not written in English (for better text mining results), and information aggregation due to different results emerged by different databases for the same publication. In the final step, we saved the results in a file-based database.

Our literature search took place in the period from May to July of 2018. According to scope definitions (Cooper, 1988), the final search (including the total count) phrases to build our document corpus are the following: Blockchain Democracy (5.879), Blockchain Government (11.010), Blockchain Sustainability (10.188), Blockchain (4.738), Decentralized Autonomous Organization (19.549), Distributed Ledger Technology (21.249), Natural Resource Blockchain (13.109).

## 2.4 Literature Analysis and Synthesis

This section describes how we have analyzed the (meta) data within the document corpus and shows up some data insights. The next step in our analysis was to cluster the publications with basic algorithms of natural language processing (NLP) (Manning and Schütze, 1999).

We have used the abstracts and titles to build a bag of words corpus where we, have removed common and field-specific stop words, and stemmed the sentences to tokens. After that, we have calculated the Term Frequency – Inversed Document Frequency (TF-IDF) weight[3]. Next, to find overlapping research fields and to identify often-covered fields within our topics, we have clustered the TF-IDF of each document. This procedure is partly based on an existing contribution on how performing literature review by text mining (Yang, Zhang and Yan, 2017) (Yang and Hong, 2017). To conduct our clustering, we have applied K-Mean[4] to identify groups in our dataset. To determine the optimal number of clusters, we have used the common method in unsupervised learning, the elbow method. To find the best k, we have calculated the distortion score (sum of squared errors) for a different number of k, in our case 1-10, as we have sought for the smallest k with a low score. The basis for our clustering is the TF-IDF matrix

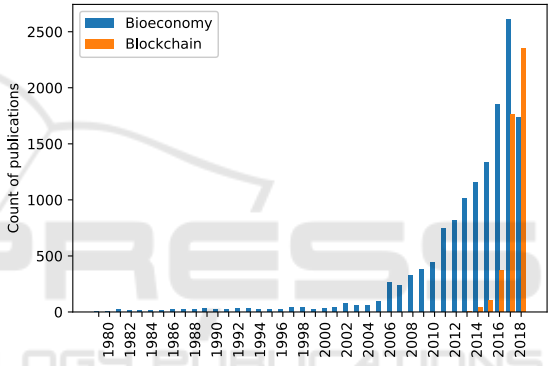


Figure 1: Publications per year.

containing all tri-gram tokens in our corpus. We reduced the corpus size before the clustering by filtering out all data records without an abstract and with less than two citations.Finally, after we have reached our clusters, we have classified them manually based on the top terms.

One result of the metadata analysis is an overview about the publication rate over time in research for our topics (Figure 1). This chart gives insights that the research field around blockchain technology and bioeconomy is continuously rising in the past years. Developed in 2009, Bitcoin (and therefore the blockchain) is not widely mentioned in any publications before 2014. While bioecnomy has been

[2] An iterative process has led to an optimized query that differs from our final search query yielding meaningful results with respect to our research area, e.g., our first query for bioeconomy had led to deep biology research that are generally out of the scope of our review.

[3] The TF-IDF is a statistical method used to evaluate how important a word is within a document compared to the whole corpus.

[4] The k-means algorithm groups data by separating the samples in n clusters of equal variance, trying to minimizing the sum-of-squares.

a research objective for over the last decades. The publication date analysis makes visible that since 2007 the count of released publications is soaring. This explains that this topic is also becoming more relevant in research in the recent years. The container type [5] shows us that there are already popular conferences and workshops explicitly concerned to DLTs and blockchains, although it is only one decade old, there are already 200 papers each year since 2016 and over 1500 each year since 2017. The "Journal of Bioeconomics" is the most popular under all containers in the field of bioeconomy

The following sections are descriptions of the most cited publications within each of the four clusters the k-means algorithm has calculated. The results of the cluster analysis are available in a GitHub repository[6].

**Supply Chain Management** (SCM) is one of the possible use cases in DLT sector and one of our clusters. The SCM is an often-discussed application type in the field of Distributed Ledgers (Iansiti and Lakhani, 2017). Is useful to identify actors who are involved in (Toyoda *et al.*, 2017) to optimize. The rise of a connected industry i.e. through the Internet of the Things (IoT) takes a supporting role in a digital SCM (Haddud *et al.*, 2017; Kshetri, 2018). We analyzed a papers for real-time information sharing during the distribution phase of a product (Nakasumi, 2017) to optimize the workflows to increase the transparency between parties. To secure the post supply chain, some IEEE members (Toyoda *et al.*, 2017) proposed a Product Ownership Management System (POMS) based on a distributed ledger. Martin Holland et al. describe a blockchain based digital rights management system to secure the copyrights of, especially safety-critical, products (Holland, Nigischer and Stjepandic, 2017). Another example to avoid counterfeiting with a blockchain to fight against an international fake medicine market was examined (Mackey and Nayyar, 2017). A more complex analysis of the healthcare market and the possible adoption is described in (Clauson *et al.*, 2018). Feng Tian (Tian, 2016) addresses the agrifood supply chain in Chinas constantly growing economy. They developed a system, which covers the whole process of information retrieval and management in a agrifood supply chain, which includes the monitoring, tracing and traceability management for the quality and safety "from farm to fork" (Tian, 2016). They argue that China loses every year 170 billion Renminbi (RMB) in the agriculture industry because of quality problems and losses in supply chains (Chen *et al.*, 2017). There problems are avoided that traditional centralized trust mechanism cannot solve.

While looking at SCM, the blockchain was used to the management of energy. With microgrid energy markets (Mengelkamp, Notheisen, *et al.*, 2018), (Mengelkamp, Gärttner, *et al.*, 2018), (Zhumabekuly Aitzhan and Svetinovic, 2016), the trading between self-producer and consumer (i.e., prosumers) in a peer-to-peer network is understood.

To build the bridge between bioeconomy and blockchain from the energy application's point of view, the blockchain is effectively applicable whenever the existence for central actors should be vanished. If we argue from the natural resource management perspective of the forest, it is desirable to merge small forests together (Bundesministerium für Ernährung und Landwirtschaft (BMEL), 2008). This way, decentralized coordination purposes with partners on eye level can leverage the emergence of such associations in a transparent and efficient way.

**Blockchain Protocol** is the biggest cluster, mainly focused on the Bitcoin design, outlining the fields of security, privacy, smart contracts, the decentralized architecture and possible on-chain applications. In a historical overview (Bonneau *et al.*, 2015), they describe the origin of the first cryptocurrencies. They also give an exhaustive technical overview about the Bitcoin design decisions including the Bitcoin Improvement Proposals (BIPs), developer mailing lists, trying to cover the current specifications, which has continuously refined since the release of the original Bitcoin white paper (Nakamoto, 2008). A selection of the specifications they describe are the transactions, consensus, block confirmation, (incentivized) mining and the impact on the consensus. Further, they discuss the client-side security, anonymity, modification of the protocol and alternative consensus algorithms. This work is highly recommendable to get a widely overview about the Bitcoin protocol. In a more on the peer-to-peer network focused paper (Decker and Wattenhofer, 2013) the information propagation between the nodes is researched. They investigated the methods used to broadcast the transactions and blocks through the network and verify the aspect that a delay in this

[5] Generic field for journals, conferences, workshops etc.

[6] Find repository https://github.com/melcherf/literarure-review_bioeconomy-blockchain at the commit id: 64bf59d9dccf980f6b873e96b04510e914e3f916

broadcasting could result in a fork[7] of the blockchain. They also address possible improvements and emphasize several challenges towards architectural limitations. Non-determinism might be a problem.
Also described in this cluster are the Smart contracts, the decentralized applications running on a blockchain. They are applicable in several domains, e.g., crowdfunding, financial services, identity management, and gambling. It touches topics like cryptography, consensus algorithms, and programming languages until governance, finance, and law (Buterin and others, 2014). To use the benefits of blockchain without cryptographic knowledge, a cryptographic protocol allows programmers to write private smart contracts in an intuitive manner (Kosba *et al.*, 2016). Further research concentrates on how making smart contracts to be smarter and more secure. During the investigation of security aspects, they have revealed problems that may be utilized by adversaries to gain profit and have argued how such vulnerabilities could be reduced and security be increased (Luu *et al.*, 2016a). One task they describe is to enhance the security within contracts; another task is to make the input more trustworthy. Concerning this matter, thoughts have given to trustworthy data feeds acting as a bridge between blockchain and non-blockchain applications. Following this, a blockchain application to ask HTTPS-enabled websites was developed and serves as a source-authenticated data to relying smart contracts (Zhang *et al.*, 2016).

Not just offline existing parties are able to collaboration, coordination or cooperation across organizations over the bitcoin protocol, but also digital ones, i.e., a decentralized autonomous organization (Luu *et al.*, 2016b). DAOs are organizations based on smart contracts (Swan, 2015). When such DAOs are organized in business networks, cross organization collaboration gets possible (Norta, 2016). To take decisions democratically, mechanisms to organize and conduct elections are required, thus another research team tackles voting realized by dedicated blockchains or smart contracts (Yavuz *et al.*, 2018a). To handle a digital organization adequately, every-day and strategic decisions are required in a recurring manner. On the question of how such voting systems are possible, a simple implementation is made (Yavuz *et al.*, 2018b).

These findings address the challenges of Bioeconomy. As already introduced, bioeconomy implies the involvement of various parties working together in, i.e., supply chains or associations where previously independent organizations are merged. Smart Contracts may help to set up an (decentralized autonomous) collaboration, to organize it and to make processes / decisions more efficient and timesaving.
**Governance**, the process of governing (Bevir, 2012). To manage (social) systems and/or organizations, we undertake several tasks to hold it healthy and make it work. In literature, the implications of blockchain governance are discussed, i.e., how owners and managers of public companies are affected during tasks around corporate governance (Yermack, 2017). In this way, blockchain implications range from technical to economic and strategic areas and may trigger a need for institutional changes where operative and organizational processes is affected. For example, the information stewardship changes while data is stored in the blockchain (Ølnes, Ubacht and Janssen, 2017), apart from that it faces corruption and wrongdoing perpetrated by frauds (de Souza, Luciano and Wiedenhöft, 2018) through the aid of transparency, immutability, and traceability. To understand blockchain not just as a technology enabler, but also as a possible next step towards institutional evolution, decentralized, democratic, and self-organized ideas come in (Davidson, De Filippi and Potts, 2018). Banking is one of the most popular domains in that blockchain-driven disruptions arise, including how banks work as organizations too, i.e., such a conventional and centralized hierarchical organization is discussed to be shifted into those democratic, decentralized, and self-organized ones (MacDonald, Allen and Potts, 2016). When considering social and society aspects, various governance models can be taken into account, hereof researchers have examined the interaction between blockchain and social contract theories (Reijers, O'Brolcháin and Haynes, 2016a). Another example was given by a libertarian viewpoint with its remarkable resemblance to blockchain properties as both bypass central authority and provide anonymity (Huckle and White, 2016), but coordination and reaching consensus could become more complex (Shermin, 2017).

Bioeconomy may benefit from those blockchain-driven developments as it also affects participation, citizen science, governance, cross-industrial areas,

[7] A fork is a split of the blockchain in two separated ledgers with the same history but a different protocol for the future and is mostly unintended.

and SCM. Especially natural resources touch every individual alike and are hence worth considering in a democratic and representative way.

**Decentralized Networks** depicted in this chapter are dealing with the papers in the cluster about mulit-agent systems (MAS), the self-organization of vehicles and robotic automation and wireless sensor networks. In a vision of an effective bioeconomy future, intelligent agents will do the work. Often referred to as self-organized systems, MAS has many similarities with a blockchain. To mention one, they both need a distributed consensus algorithm to ensure the integrity of the data send between their nodes or agents (Saber, Fax and Murray, 2007). One popular paper we discovered is about a theoretical framework to analyze consensus algorithms in MAS with fixed or dynamic network topology (Saber, Fax and Murray, 2007). The scope of the framework is about the information flow, the robustness when network nodes fail, delays in time and shows the possible guarantee of performance with different consensus algorithms. In another paper (Willke, Tientrakool and Maxemchuk, 2009), they surveyed inter-vehicle communication (IVC) protocols and applications of the last decade to classify them, depending on their information propagation and consensus into four types: General, Safety, group planning and individual planning & regulation. Consensus algorithms for a decentralized control of communicating-agent systems are also discussed and analyzed (Xie and Wang, 2005). Also the connectivity and coverage in wireless sensor networks, used in military, industry, agriculture, urban management, and their impact on the quality of service is discussed (Zhu *et al.*, 2012). They examine current research results, solutions and problems with focus on energy efficiency. To ensure the authenticity and integrity of the data gathered by sensors a blockchain could be a possible solution. In our research field, MAS as well as wireless sensor networks and the automation of processes could have a huge impact on the development of an autonomous organized bioeconomy.

# 3 RESEARCH AGENDA

In our structured literature review, we have examined the state-of-the-art and most cited literature towards the concepts of bioeconomy and blockchain found with our keyword-driven approach. All in one, we have identified several dedicated research threads by our clustering approach. We describe each separately and conclude each with relevant implications between bioeconomy challenges and blockchain solutions. Since there was no cluster dedicated explicitly to bioeconomy and blockchain, it seems worth to higher research efforts in this domain. Literature have focused on supply chain management, government and application development with smart contracts on public domains or where companies come together to work in an association with no longer need for an intermediate. Especially the topic around supply chain management and government arises as a promising candidate to enhance bioeconomy-oriented activities since transparency, immutability and – in general – the benefits of digitalization are driver to revolutionize collaboration. Looking at resource management, many efforts have flowed into energy tasks such as Energy Internet, but natural resources have not been an objective of research so far.

As for all publications to blockchain, it is true that they are not the solution for all problems we are currently facing and a requirement-driven approach is advisable. Despite the benefits of blockchain, the underlying question is related to trust (Beck *et al.*, 2016), i.e., is there any trust problem justifying the blockchain application or can we meet our requirements with a central and trustable party too? Based on the review's findings and the contemporary challenges in the field of bioeconomy, blockchain and its beneficial features are worth considering. Especially when taking into account that DLT is in an early state and scientifically not examined completely, the impact is not sufficiently clear.

Therefore, further research may address the whole system bioeconomy is embraced by. In particular, including the society and all relevant stakeholder to socialize the process of natural resources decision-making by an appropriate blockchain design. Care for transparency on society-affecting decisions and provide a basis for natural resource governance in a democratic manner and for the benefit of climate and according to the Sustainable Development Goals (SDGs) (Group *et al.*, 2015).

# 4 CONCLUSIONS

We have made a contribution embracing two high-rated and important topics, i.e., to what extent have researchers examined how blockchain can support sustainability towards natural resources within the bioeconomy. In order to approach the topic, we have conducted a systematic review by hybridization of the proposed literature review process (vom Brocke *et al.*, 2009) and state-of-the-art text mining procedures to receive clusters to be examined. We argue for this

methodology as it allows reaching the cluster emergence automatically and enables us to divide the whole topic into dedicated areas that we have called research threads – all of these in a deterministic, replicable, and justified way. We have described each cluster by reviewing the state-of-the-art (backwards) and with discussion of possible implications, potentials and challenges in the field of bioeconomy and blockchain (forward).

Further, our literature review demonstrates that both bioeconomy and blockchain in combination are a promising candidate to become an emerging interdisciplinary research field. Driven by this anticipation, challenges the bioeconomy is contemporary faced with and the solutions the blockchain technology provides – this review shows a growing activity and attention in both of them fields.

# REFERENCES


Beck, R. *et al.* (2016) 'Blockchain - The Gateway to trust-free cryptographic Transactions', in *Twenty-Fourth European Conference on Information Systems (ECIS)*.

Bevir, M. (2012) *Governance: A very short introduction*. OUP Oxford.

Bioökonomierat (2017) 'Was ist Bioökonomie?'

Bonneau, J. *et al.* (2015) 'SoK: Research perspectives and challenges for bitcoin and cryptocurrencies', *Proceedings - IEEE Symposium on Security and Privacy*, 2015-July, pp. 104–121.

vom Brocke, J. *et al.* (2009) 'Reconstructing the Giant: On the Importance of Rigour in Documenting the Literature Search Process', in *Information systems in a globalising world : challenges, ethics and practices ; ECIS 2009, 17th European Conference on Information Systems*, pp. 2206–2217.

Bundesministerium für Ernährung und Landwirtschaft (BMEL) (2008) *Waldstrategie 2020*.

Buterin, V. and others (2014) 'A next-generation smart contract and decentralized application platform', *white paper*.

Cachin, C. (2016) 'Architecture of the hyperledger blockchain fabric', in *Workshop on Distributed Cryptocurrencies and Consensus Ledgers*.

Chen, S. *et al.* (2017) 'A Blockchain-Based Supply Chain Quality Management Framework', *2017 IEEE 14th International Conference on e-Business Engineering (ICEBE)*, pp. 172–176.

Chohan, U. (2017) 'The Decentralized Autonomous Organization and Governance Issues', *Ssrn*.

Clauson, K. A. *et al.* (2018) 'Leveraging Blockchain Technology to Enhance Supply Chain Management in Healthcare':, *Blockchain in Healthcare Today*, pp. 1–12.

Cooper, H. M. (1988) 'Organizing Knowledge Syntheses: A Taxonomy of Literature Reviews', *Knowledge in Society*.

Davidson, S., De Filippi, P. and Potts, J. (2018) 'Blockchains and the economic institutions of capitalism', *Journal of Institutional Economics*, 14(4), pp. 639–658.

Decker, C. and Wattenhofer, R. (2013) 'Information propagation in the Bitcoin network', in *IEEE P2P 2013 Proceedings*, pp. 1–10.

Devaney, L., Henchion, M. and Regan, Á. (2017) 'Good Governance in the Bioeconomy', *EuroChoices*, 16(2), pp. 41–46.

Gómez, J. M. and Medel-González, F. (2015) 'Integrating IT-for-Green project through web services with the system of sustainability performance evaluation', *INFORMATIK 2015*. Gesellschaft für Informatik eV.

Group, O. W. *et al.* (2015) 'Sustainable Development Goals and targets', *United Nations*.

Haddud, A. *et al.* (2017) 'Examining potential benefits and challenges associated with the Internet of Things integration in supply chains', *Journal of Manufacturing Technology Management*, 28(8), pp. 1055–1085.

Hawlitschek, F., Notheisen, B. and Teubner, T. (2018) 'The limits of trust-free systems: A literature review on blockchain technology and trust in the sharing economy', *Electronic Commerce Research and Applications*, 29, pp. 50–63.

Holland, M., Nigischer, C. and Stjepandic, J. (2017) 'Copyright protection in additive manufacturing with blockchain approach', *Advances in Transdisciplinary Engineering*, 5, pp. 914–921.

Huckle, S. and White, M. (2016) 'Socialism and the Blockchain', *Future Internet*, 8(4), p. 49.

Iansiti, M. and Lakhani, K. R. (2017) 'The truth about blockchain', *Harvard Business Review*, 95(1), pp. 118–127.

Kosba, A. *et al.* (2016) 'Hawk: The Blockchain Model of Cryptography and Privacy-Preserving Smart Contracts', in *2016 IEEE Symposium on Security and Privacy (SP)*. IEEE, pp. 839–858.

Kshetri, N. (2018) '1 Blockchain's roles in meeting key supply chain management objectives', *International Journal of Information Management*. Elsevier, 39(December 2017), pp. 80–89.

Luu, L. *et al.* (2016a) 'Making Smart Contracts Smarter', in *Proceedings of the 2016 ACM SIGSAC Conference on Computer and Communications Security - CCS'16*. New York, New York, USA: ACM Press, pp. 254–269.

Luu, L. *et al.* (2016b) 'Making Smart Contracts Smarter', in *Proceedings of the 2016 ACM SIGSAC Conference on Computer and Communications Security - CCS'16*. New York, New York, USA: ACM Press, pp. 254–269.

MacDonald, T. J., Allen, D. W. E. and Potts, J. (2016) 'Blockchains and the Boundaries of Self-Organized Economies: Predictions for the Future of Banking', in, pp. 279–296.

Mackey, T. K. and Nayyar, G. (2017) 'A review of existing and emerging digital technologies to combat the global

trade in fake medicines', *Expert Opinion on Drug Safety*. Taylor & Francis, 16(5), pp. 587–602.

Manning, C. D. and Schütze, H. (1999) *Foundations of Statistical Natural Language Processing*. Cambridge, MA, USA: MIT Press.

McCormick, K. and Kautto, N. (2013) 'The Bioeconomy in Europe: An Overview', *Sustainability*, 5(6), pp. 2589–2608.

Mengelkamp, E., Notheisen, B., *et al.* (2018) 'A blockchain-based smart grid: towards sustainable local energy markets', *Computer Science - Research and Development*, 33(1–2), pp. 207–214.

Mengelkamp, E., Gärttner, J., *et al.* (2018) 'Designing microgrid energy markets', *Applied Energy*, 210, pp. 870–880.

Nakamoto, S. (2008) 'Bitcoin', *A peer-to-peer electronic cash system*.

Nakasumi, M. (2017) 'Information sharing for supply chain management based on block chain technology', *Proceedings - 2017 IEEE 19th Conference on Business Informatics, CBI 2017*, 1, pp. 140–149.

Nguyen, Q. K. (2016) 'Blockchain - A Financial Technology for Future Sustainable Development', in *2016 3rd International Conference on Green Technology and Sustainable Development (GTSD)*. IEEE, pp. 51–54.

Norta, A. (2016) 'Establishing Distributed Governance Infrastructures for Enacting Cross-Organization Collaborations', in, pp. 24–35.

Ølnes, S., Ubacht, J. and Janssen, M. (2017) 'Blockchain in government: Benefits and implications of distributed ledger technology for information sharing', *Government Information Quarterly*, 34(3), pp. 355–364.

Orlitzky, M., Schmidt, F. L. and Rynes, S. L. (2003) 'Corporate Social and Financial Performance', *Organization Studies*.

Reijers, W., O'Brolcháin, F. and Haynes, P. (2016a) 'Governance in Blockchain Technologies & Social Contract Theories', *Ledger*. Cham: Springer International Publishing, 1, pp. 134–151.

Reijers, W., O'Brolcháin, F. and Haynes, P. (2016b) 'Governance in Blockchain Technologies & Social Contract Theories', *Ledger*. Cham: Springer International Publishing, 1, pp. 134–151.

Saber, R. O., Fax, J. a and Murray, R. M. (2007) 'Consensus and Cooperation in Multi-Agent Networked Systems', *Proceedings of IEEE*, 95(1), pp. 215–233.

Shermin, V. (2017) 'Disrupting governance with blockchains and smart contracts', *Strategic Change*, 26(5), pp. 499–509.

de Souza, R. C., Luciano, E. M. and Wiedenhöft, G. C. (2018) 'The uses of the blockchain smart contracts to reduce the levels of corruption', in *Proceedings of the 19th Annual International Conference on Digital Government Research Governance in the Data Age - dgo '18*. New York, New York, USA: ACM Press, pp. 1–2.

Swan, M. (2015) 'Blockchain Thinking : the Brain as a Decentralized Autonomous Corporation [Commentary]', *IEEE Technology and Society Magazine*.

Tian, F. (2016) 'An Agri-food Supply Chain Traceability System for China Based on RFID & Blockchain Technology', *2016 13th International Conference on Service Systems and Service Management (ICSSSM)*, pp. 1–6.

Toyoda, K. *et al.* (2017) 'A Novel Blockchain-Based Product Ownership Management System (POMS) for Anti-Counterfeits in the Post Supply Chain', *IEEE Access*, 5, pp. 17465–17477.

Webster, J. and Watson, R. T. (2002) 'Analyzing the Past to Prepare for the Future: Writing a Literature Review.', *MIS Quarterly*.

Willke, T., Tientrakool, P. and Maxemchuk, N. (2009) 'A survey of inter-vehicle communication protocols and their applications', *IEEE Communications Surveys & Tutorials*, 11(2), pp. 3–20.

Xie, G. and Wang, L. (2005) 'Consensus Control for a class of Networks of Dynamic Agents: Fixed Topology', in *Proceedings of the 44th IEEE Conference on Decision and Control*, pp. 96–101.

Yang, D. and Hong, J. (2017) 'Performing literature review using text mining, Part II: Expanding domain knowledge with abbreviation identification', in *2017 IEEE International Conference on Big Data (Big Data)*. IEEE, pp. 3297–3301.

Yang, D., Zhang, A. N. and Yan, W. (2017) 'Performing literature review using text mining, Part I: Retrieving technology infrastructure using Google Scholar and APIs', in *2017 IEEE International Conference on Big Data (Big Data)*. IEEE, pp. 3290–3296.

Yavuz, E. *et al.* (2018a) 'Towards secure e-voting using ethereum blockchain', in *2018 6th International Symposium on Digital Forensic and Security (ISDFS)*. IEEE, pp. 1–7.

Yavuz, E. *et al.* (2018b) 'Towards secure e-voting using ethereum blockchain', in *2018 6th International Symposium on Digital Forensic and Security (ISDFS)*. IEEE, pp. 1–7.

Yermack, D. (2017) 'Corporate governance and blockchains', *Review of Finance*.

Zhang, F. *et al.* (2016) 'Town Crier', in *Proceedings of the 2016 ACM SIGSAC Conference on Computer and Communications Security - CCS'16*. New York, New York, USA: ACM Press, pp. 270–282.

Zhu, C. *et al.* (2012) 'A survey on coverage and connectivity issues in wireless sensor networks', *Journal of Network and Computer Applications*. Elsevier, 35(2), pp. 619–632.

Zhumabekuly Aitzhan, N. and Svetinovic, D. (2016) 'Security and Privacy in Decentralized Energy Trading through Multi-signatures, Blockchain and Anonymous Messaging Streams', *IEEE Transactions on Dependable and Secure Computing*, pp. 1–1.