The State of Play of Blockchain Technology in the Financial Services Sector: A Systematic Literature Review

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Abstract
The modern trends of digitalization have completely transformed and reshaped business practices, whole businesses, and even a number of industries. Blockchain technology is believed to be the latest advancement in industries such as the financial sector, where trust is of prime significance. Blockchain technology is a decentralized and coded security system which provides the capability for new digital services and platforms to be created through this emerging technology. This research presents a systematic review of scholarly articles on blockchain technology in the financial sector. We commenced by considering 227 articles and subsequently filtered this list down to 87 articles. From this, we present a classification framework that has three dimensions: blockchain-enabled financial benefits, challenges, and functionality. This research identifies implications for future research and practice within the blockchain paradigm.

Keywords—Blockchain technology, blockchain benefits, blockchain challenges, blockchain functionality, financial technologies.

Introduction

Blockchain technology is a financial technology (FinTech) which is first developed as the distributed ledgers for bitcoin. For some time, blockchain technology was overshadowed by the bitcoin phenomenon, but in current years it has started to attract attention in its own right and is becoming a core technology in the FinTech family (Du et al., 2019). Many experts and academic researchers have realized that the impacts of blockchain extend beyond bitcoin and even beyond the financial industry to drive change in many businesses (Ølnes et al., 2017). Blockchain is one of the most promising advanced technologies in the overall FinTech field (Du et al., 2019). While it was first designed to serve as a distributed ledger for tracking bitcoin transactions, blockchain's potential extends beyond bitcoin. Indeed it can change many business operations in both financial and other commercial domains (Kshetri, 2018; Underwood, 2016). A blockchain is a chain of data blocks each of which is created to record transactions. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data (Du et al., 2019).

While blockchain are now playing a significant role in financial innovations and is the backbone technology that is driving the Fintech revolution, the predominant usage of blockchain thus far has been in the area of payments. Payment instruments and payment systems have been developing and changing as a result of new advancements in technology and business processes, and the rapidly-increasing demands of consumers. The main objective of any payment system is safe and smart transactions (Ali et al., 2014; Kshetri, 2018). The development of digital currencies or cryptocurrencies using blockchain technology is the latest revolution in the domain of money transfer. Cryptocurrencies utilize decentralized peer-to-peer (P2P) networks, encryption techniques, cryptography and a public key infrastructure (PKI) in which pairs of public and private keys are used to secure transfer of data (Abramova & Böhme, 2016). A further application for blockchain technology is that of the autonomous, self-governing and self-regulating infrastructure which is designed to facilitate a distributed autonomous organization (Peters & Panayi, 2015; Beck et al., 2016; Chapron, 2017; Wörner et al., 2016). Once fully realized, these distributed autonomous organizations, the archetype of distributed organizing, are expected to be fluid and digital in nature—without offices, managers, contracts, policies or payrolls, and without centralized strategic agendas (Barrett et al., 2016).

As far as technical aspects and shortcomings of blockchain technology are concerned, the phenomenon of decentralized currencies has already stimulated academic research (Andrychowicz et al., 2015; Decker & Wattenhofer, 2013; Vasek et al., 2014). This research has prompted amendments and expansion (Barber et al., 2012; Ben Sasson et al., 2014) of regulatory status and measures (Christopher, 2014; Stokes, 2012; Tu & Meredith 2015) and economic analysis (Becker et al., 2013; Hileman, 2015; Mai et al., 2015). The concept of decentralized trust facilitates an alternative solution to traditional client-server architecture. The data and the actions do not need to be processed by the mediation of the central authority which is consequently not required for the alternative system. The result is that the transactions become irreversible and the cost of transactions is also reduced. Indeed, the requirement for trustworthy governments, private firms, mediators and counter parties is also eliminated because trust is now placed in the protocols and the infrastructure (Karafiloski & Mishev, 2017).

Blockchain technologies are identified as the significant technical innovation in the digitalization of asset ownership. Besides providing a secure audit trail that cannot be corrupted, the blockchain has been described as a multipurpose programmable platform for managing ownership and contracts (Mattila, 2016; Lindman et al., 2017). Blockchain can be described as a decentralized, transactional database technology that facilitates validated, tamper-resistant transactions that are consistent across a large number of network participants called nodes (Glaser, 2017; Beck et al., 2018). Blockchain can be characterized as a class of technologies (distributed ledger technologies) that give users confidence that archived information (e.g., a certificate) has not been altered either accidently or deliberately (Beck et al., 2018). Research suggests that blockchain has the capacity to reduce uncertainty, insecurity, and ambiguity in transactions by providing full transactional disclosure and by producing a single truth for all network participants (Beck et al., 2016; Nærland et al., 2017).

The latest advancements in the distributed transaction are mainly facilitated by the blockchain and fundamentally-distributed database technology (Lindman et al., 2017). Blockchain technology can build financial tools such as payments, smart contracts and trading records, and reduce undesirable dealings and their subsequent impact (Queiroza & Wamba, 2019). Furthermore, legal and public records, including voting or court records, are also considered potential use-cases in this technology (Hughes et al., 2019). Blockchain can serve as a transactional mechanism for 'sharing economic' services (Mainelli & Smith, 2015) as it solves the challenge of the trusted recording of large-scale P2P activities. Blockchains are expected to fundamentally transform economies and societies by lowering transaction costs and reducing the need for trusted third parties (Clemons et al., 2017; Iansiti & Lakhani, 2017). The importance of such a transactional mechanism increases with the emerging 'Programmable World', where an increasing number of physical objects (the Internet of Things) become programmable and connected to the Internet.

The potential of blockchains to transform markets and societies has motivated public and private organizations to make significant investments in the development of applications that use the blockchain technology (Rossi et al., 2019). Furthermore, blockchain technology has versatile uses beyond recording financial transactions. Blockchain's can be used for storing medical records, concluding binding agreements, tracking the flow of goods, storing personal credit records, tracking the provenance of artwork, verifying payments through a supply chain, and much more (Milic, 2019). When it comes to blockchain technology market size, a recent report suggests that it will reach $7.59 billion by 2024. That's a compound annual growth rate of 37.4%. Such rapid market growth is explained by an increasing demand for this technology across all industries, from financial services, through consumer and industrial goods, all the way to media, telecom, transport, healthcare, and public services (Grand View Research, 2019). As a result of that, blockchain technology has spread to other sectors such as manufacturing (17.6% of the market share), distribution and services (14.6%), public sector (4.2%), and infrastructure (3.1%). Nearly every industry is exploring the use of blockchain technology to a significant extent (Budman et al., 2019). According to research conducted by Pawczuk et al. (2018), the blockchain is a priority investment for many companies. Thirty-nine percent of respondents reported that their organizations would invest in excess of $5 million in the technology in the coming year. Collectively, important actors agree that blockchain could impact many aspects of our societies, including environmental sustainability (Chapron, 2017), healthcare (Gammon, 2018) and social networks (Ciriello et al., 2018).

While there is much in the form of grey literature regarding blockchain technology (Brandão et al., 2018), we argue that the state-of-the-art of blockchain-enabled benefits, challenges, and functions has received limited attention in the form of rigorous and empirical academic studies. Zheng et al. (2016) and Casino et al. (2019) state that the functions of blockchain's are not covered to their full extent. However, there are reviews focused on the specific roles of blockchain including the development of decentralized and data-intensive applications (Casino et al., 2019), and managing big data in a decentralized fashion (Karafiloski and Mishev, 2017). Other reviews focus on security issues of the blockchain (Khan & Salah, 2017; Li et al., 2017; Meng et al., 2018) and on its potential to enable trust and decentralization in service systems (Seebacher et al., 2017) and P2P platforms (Hawlitschek et al., 2018). Some technical aspects of the blockchain design such as its consensus protocol (Sankar et al., 2017), and other technical characteristics such as its usability, data integrity, and scalability have also been studied (Yli-Huumo et al., 2016). Moreover, there are other studies that have focused largely on the currency application aspects of blockchains and the related security and privacy challenges (Bonneau et al., 2015; Mukhopadhyay et al., 2016; Khalilov & Levi, 2018; Conti et al., 2018). Clearly there are many areas that have the potential to be studied and explored further and a systematic review of the current blockchain-enabled state-of-the-art benefits, challenges, and functions (Beck et al., 2018) in particular for the financial sector will help identify these gaps.

Overall, there is a lack of major academic studies and publications in this emerging field, despite the potential implications of this technology (Yli-Huumo et al., 2016). As per Elsevier's Scopus database, the keyword 'blockchain' brings about only 331 documents (05.03.2018). Interestingly, three-quarters of these articles were written in 2016. Moreover, since a finance or business-related theme is emphasized by only 2.5 percent of these articles, an urgent need exists for supplementary research to be carried out in this domain (Yli-Huumo et al., 2016).

On the basis of our existing literature review, it appears that research gaps exit in the modern tools associated with blockchain technology (Lindman et al., 2017). That is, both the practical and theoretical views of blockchain technology need additional research studies (Du et al., 2019). The essentially decentralized nature of these payment systems and platforms are linked to a number of critical challenges (Lindman et al., 2017). For instance, how both privacy and trust can be assured in such a platform-mediated network, and how to determine and reduce the risks and challenges. Beneficial, reliable and more efficient services for consumers can only be realized with a better understanding of these challenges and subsequent benefits (Lindman et al., 2017).

This paper explores opportunities where the deployment and use of blockchain technology is likely to transform, in particular, the financial sector. It addresses the background of blockchain technology and research methodologies; and a research classification framework is developed and proposed on the basis of our findings.

Blockchain Technology Background

Blockchain Technology Definition

The blockchain is essentially a decentralized ledger that maintains transaction records on many computers simultaneously. Most cryptocurrencies use blockchain technology to record payment transactions. The Bitcoin network was developed with the blockchain technology as its underlying infrastructure (Abramova & Böhme, 2016).

The advent of the blockchain has brought along with it a number of components and analogous terminologies that often cloud and confuse the discussion surrounding the technology and its implementation. Amongst them are the descriptions related to the grouping and publishing of transactions into distinct data structures called blocks that are cryptographically linked (chained) together and distributed in a peer-to-peer network to prevent tampering of previously published transactions (Beck et al., 2018). The transactions that are added to blocks must be validated by the nodes (miners) with consensus models determining which node gets the privilege of publishing the next block. Blocks can also support highly expressive, native smart contract capabilities through a collection of code and data that is deployed using cryptographically signed transactions on the blockchain network (e.g., Ethereum's smart contracts, Hyperledger Fabric's chaincode).

The first blockchain was described and implemented by the pseudonym Satoshi Nakamoto (The Economist, 2015). Nakamoto published his blockchain description in the paper 'Bitcoin in 2008: A Peer-to-Peer Electronic Cash System' which set out the architecture for a decentralized, trust-less payment system. Bitcoin operates on blockchain technology (Seebacher & Schüritz, 2017), and this blockchain is built upon cryptographic technology (Pilkington, 2015). This blockchain technology is a sequential distributed database where a public ledger is used to store a complete transaction history in a (block) chain (Van Alstyne, 2014; Böhme et al., 2015; Zhao et al., 2016; Tama et al., 2017). The Bitcoin blockchain records all Bitcoin transactions and all allied information (Bradberry, 2015). Indeed, the blockchain is a distributed public ledger comprising a complete, immutable record of all executed transactions (Karafiloski & Mishev, 2017). Whist blockchains and cryptocurrencies have been generally associated with each other, the blockchain technology has also recently become of significant interest to researchers and it is argued to be an even more revolutionizing phenomenon over and above its use in Bitcoin (Zhao et al., 2016) (see Figure 1).

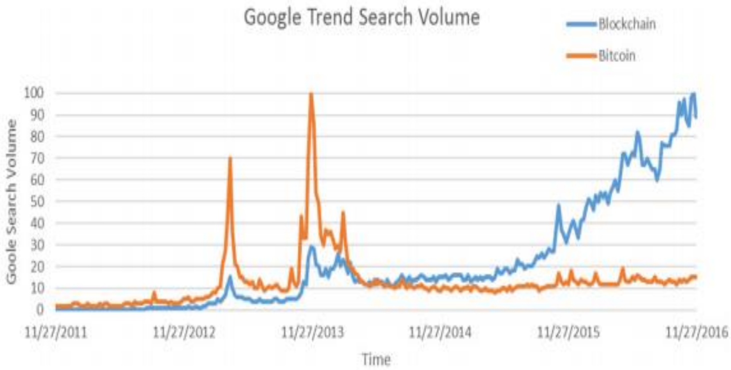

Figure 1. Google trend search volume (Zhao et al., 2016)

Within the blockchain, the security and validity of all transactions are ensured through all nodes within the P2P network holding a full record of the blockchain. Therefore, any successful attack to fraudulently alter the blockchain must target all copies of the blockchain across the total network – and this is considered infeasible (Seebacher & Schüritz, 2017). New blocks containing new transactions are only accepted into the blockchain after agreed verification protocols have been followed. In the Bitcoin example, this protocol is called 'proof-of-work' and this is the only way that new transactions may be added (Nakamoto, 2008; Seebacher & Schüritz, 2017).

Blockchain is both an economic and a technical transformation (Böhme et al., 2015; Zyskind et al., 2015; Liebenau & Elaluf-Calderwood, 2016; Zhao, et al., 2016). As a technical transformation, the blockchain is a new form of database system—particularly for decentralized environments of inadequate trust. As an economic innovation, blockchain offers tools to any problem domain where a dependable record of transactions is needed, and where parties—whether machines or humans—cannot be fully trusted (Lindman et al., 2017).

Based on the earlier discussion, the following definition for a blockchain is developed: A blockchain is a distributed database model reliant on a P2P network. It encompasses a sequence of blocks, with time-stamped transactions that are confirmed by the network community and are secured by public-key infrastructure (PKI). Within the blockchain, an element cannot be changed once it becomes part of that blockchain. As a result, a blockchain provides an indisputable record of previous actions.

Blockchain Technology Characteristics

The two main principle characteristics to be identified when examining blockchain technology are *trust* and *decentralization* (Seebacher & Schüritz, 2017; Tama et al., 2017) (see Figure 2). Accordingly, both these blockchain technology characteristics are addressed next.

Trust

The noteworthy feature of the blockchain is hidden in its decentralized approach (Seebacher & Schüritz, 2017). Specifically, there is no dependence on a third party by the users in securing one's transactions and assets since the network is protected by the proof-of-work protocol, thereby eliminating the need to trust any middleman for verifying and recording transactions (Böhme et al., 2015; Crosby et al., 2016). The entire blockchain code is open source and is available for anyone to view, thus removing any possibility of backdoors being built into the system. This ensures that individuals can act as their own bank and control decisions in ensuring their capital is safe. This is contrasted with the traditional banking environment, where the bank is responsible for customers' money (Hull et al., 2016; Ølnes, 2016). There are a few terms that clearly explain the trust in blockchain technology (see Figure 2), for instance, public and shared interaction (Bonneau et al., 2015; Beck et al., 2016; Sun et al., 2016; Cai & Zhu, 2016); peer verification of transactions (Garman et al., 2014; Tschorsch & Scheuermann, 2016; Kosba et al., 2016; Eyal et al., 2016); low friction in providing information (Böhme et al., 2015; Beck et al., 2016; Sun et al., 2016); and security through cryptography (Zyskind et al., 2015; Xu, 2016; Sun et al., 2016).

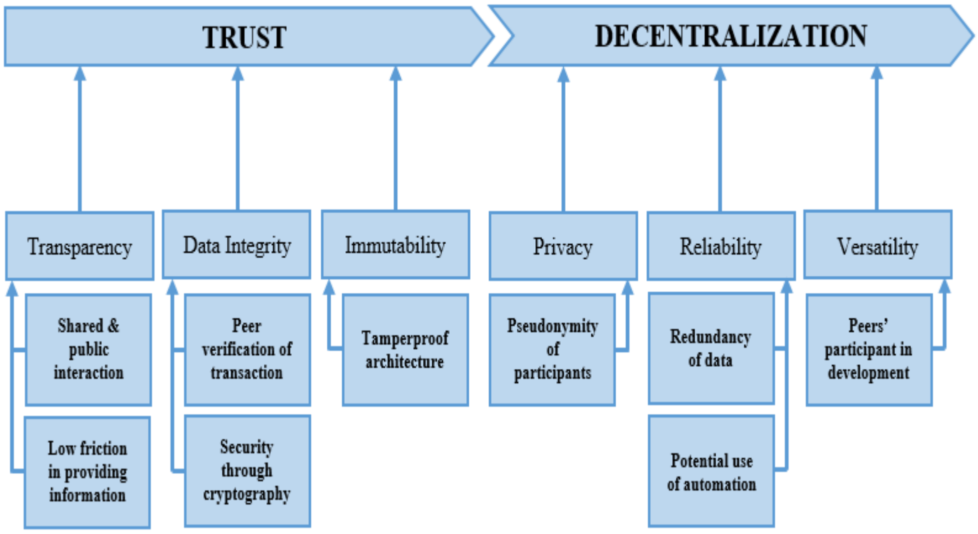

Figure 2. Blockchain technology characteristics (Seebacher & Schüritz, 2017)

Decentralization

One of the key attributes of blockchain technology is decentralization, through which censorship resistance and immutability are realized (Seebacher & Schüritz, 2017). Among its salient features, a blockchain provides a platform where reliance on a centralized third party for the safety of one's assets is no longer required (Tama et al., 2017). A government or hacker cannot infiltrate the centralized ledger for personal use because of the distributed and decentralized nature of the blockchain. Proof-of-work solves complicated mathematical issues with the help of computing power. In addition, proof of work is the well-known consensus system currently employed to harmonize hundreds of thousands of decentralized nodes. As a result, there is surety about safety of assets; and any arbitrary dilution of money supply is prevented (Seebacher & Schüritz, 2017). A few significant terms clearly explain the decentralization in blockchain technology, for example, pseudonymity of participants (Garman et al., 2014; Bonneau et al., 2015; Zyskind et al., 2015); the potential use of automation (Guo & Liang, 2016; Xu, 2016); redundancy of data (Beck et al., 2016; Hull et al., 2016); and peers' participation in development 'versatility' (Xu, 2016; Zhao et al., 2016).

Blockchain Technology Categories

The three general classifications of blockchains are public, consortium and private (Mattila, 2016; Xu et al., 2016; Sankar et al., 2017).

Within the *public blockchain* is concerned, every party has equal rights and privileges—that is, there is no centralized authority (Guo & Liang, 2016; Xu et al., 2016; Sankar et al., 2017). At this point, everyone has the authority to enter or exit. This particular category is free for all and a transaction can be validated by anyone, for example, Bitcoin (Guo & Liang, 2016).

In the *consortium blockchain*, transactions cannot be validated by everyone (Guo & Liang, 2016; Xu et al., 2016). Validation of transactions is confined to only a few key members (Zheng et al., 2016). The rest have the option to validate, however, these nominated people must reach an agreement prior to implementation. The *private blockchain* follows a centralized configuration (Guo & Liang, 2016). A single entity is authorized for decision-making with the command and control of the validation process (Xu et al., 2016). The centralized head will ensure that the consensus that is followed is the one proposed (Zheng et al., 2016). This is akin to having a centralized body such as governments in different nations.

Table 1 provides a comparison between the three general classifications of blockchain technology (public, consortium, and private).

Table 1. Categories of blockchain technology

Property	Public blockchain	Consortium blockchain	Private blockchain
Degree of centralization	Decentralized	Multi-Centralized	Centralized
Participants	Anyone can freely participate and leave	Specific group of people who agree to enter an alliance	Central controller decides members who can participate
Credit mechanism	Proof of work	Collective endorsement	Self-endorsement
Bookkeeper	All participants	Participants decide in negotiation	Self-determined
Incentive mechanism	Needed	Optional	Not needed
Prominent advantage	Self-established credit	Efficiency and cost optimization	Transparency and traceability
Typical application scenario	Bitcoin	Clearing	Audits
Load capacity	3–20 times/second	1000–10000 times/second	======
Consensus process	Permission-less	Permissioned	Permissioned
Efficiency	Low	High	High

(Source: Guo & Liang, 2016; Zheng et al., 2016; Xu et al., 2016; Poon & Dryja, 2016)

Impact of Blockchain Technology on the Financial Sector

For financial service providers, a concerning situation has developed as a result of increased regulation and lack of economic growth since 2008, and the ensuing financial crisis. Consequently, advanced technologies are continuously being employed by the financial sector as these technologies tend to assist in improving transparency and enhancing security, thus resulting in cost saving and efficiency (Schneider et al., 2016). Blockchain have attracted attention in recent years because they have the potential to facilitate the automation and streamlining of processes, eliminate manual back office labour, reduce time, enhance transparency and improve security (Walker et al., 2016).

Trust has remained a main challenge in the establishment of digital payments (Tsiakis & Sthephanides, 2005; Shaw, 2014; Yan & Yang, 2015). Particular research concerning Mobile payment has argued the need for trusted service managers involved in handling the authentication, authorization and account settlement (Ondrus & Pigneur, 2009), with a special focus on the effects of direct and indirect network. Based on P2P networks, distributed transaction platforms provide a solution to this challenge with the help of radical decentralization. These are known as 'cryptocurrencies' or 'decentralized digital currencies' and decentralized consensus systems (Glaser & Bezzenberger, 2015).

The growth and the effects of new payment platforms can better be understood through the information systems (ISs) studies on open platforms (Aksulu & Wade, 2010; Ghazawneh & Henfridsson, 2013). These studies offer approaches for enhancing third party participation (Tiwana et al., 2010). The governance of open source development communities has also been discussed in earlier research (Nyman, 2015; Lindman et al., 2017). Governance in this context focuses upon how to acquire the direction, coordination and control of partially or completely autonomous individuals and organizations (Markus, 2007). Governance has been addressed by the open source research in three different ways: (1) several enticements for autonomous developers to take part in open efforts (Lerner & Tirole, 2002; Von Krogh et al., 2012); (2) maintaining support for essential coordination activities (Crowston et al., 2005; Lindman et al., 2017); and (3) developing a culture that welcomes open contributions (Markus, 2007).

While still an emerging technology, distributed payment platforms are close to gaining widespread recognition. For instance, Japan was reflecting on the legal implications in 2016 as a result of Bitcoin and other cryptocurrencies being treated as currencies (Lindman et al., 2017).

There are generally unresolved questions regarding payment platforms and digital payments, for example, payment ecosystems and trust issues. In addition, a new set of unaddressed research challenges have emerged because of the decentralized nature of blockchain technology wherein different services and platforms are designed, developed and ultimately used.

New digital payment systems are being launched specifically to cater for the need for banking services; and the new systems do not currently handle the previously non-existent needs. As per the findings of previous studies, competing with well-known prevailing trends within the banking sector—which is heavily regulated by rules and regulations—has become extremely difficult, (Dahlberg et al., 2008; Reuver et al., 2015). According to Reuver et al. (2015), a remarkable historical example from an institutional environment has been presented: new payment systems by using blockchain technology were not only meant to reduce cash payments, but the banks also view this setup as a safe and secure method of handling consumer payments. Moreover, mobile operators aspire to benefit from increased revenue by using SIM cards for payer identification. Negotiations on pricing, openness, etc. of the platform strategy were directly affected by the conflicting goals. Consequently, a challenging battle is being faced by the new digital payment platforms using blockchain technology in the heavily-regulated financial sector (Lindman et al., 2017).

Research Methodology

Due to the number of rapidly emerging financial publications, investigating relevant articles for evidence-based practice is not a manageable task for financial experts (Bastian et al., 2010). Furthermore, financial experts should show caution in their decision-making based on certain studies which may be inconclusive due to certain biases in these studies (Abbas et al., 2008). These experts must seek strong facts from the research so that evidence-based practice can be followed. Subsequently, systematic reviews are promoted in this connection as one of the strongest areas of evidence-based financial practice (Evans, 2003). Consequently, systematic studies are found applicable since the summarized research implications that emerge on a given topic are considered to be reliable and valid in comparison to controlled trials or case studies.

Through systematic reviews, the researcher is able to ascertain, assess, understand and produce the available research, and to reach logical conclusions based on the findings of the reviews (Victor, 2008; Dikert et al., 2016). Provision of evidence in a clear manner aimed at improving the consistency and validity of the research findings is a key objective of the systematic review (Coren & Fisher, 2006; Kitchenham & Charters, 2007). A staged process is followed when embarking on a systematic review: review scope is defined initially and questions and protocol are scrutinized; the evidence is then selected; and, subsequently, the researchers perform a quality appraisal of evidence, data acquisition and synthesis (Petticrew & Roberts, 2006).

While performing a systematic literature review, the guidelines are significant in encouraging researchers (Kitchenham & Charters, 2007). The guidelines and the procedures described by Tranfield et al. (2003), Kitchenham and Charters (2007) and Ali et al. (2018) are followed in the systematic review presented in this study. Planning, execution and reporting are the three phases used in this research study. Figure 3 illustrates the steps followed during each phase.

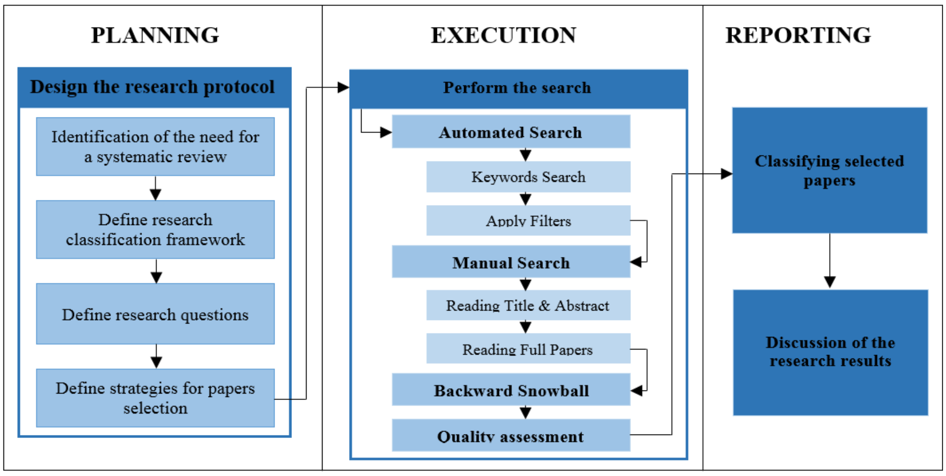

Figure 3. Research systematic review process
(Adapted from Tranfield et al., 2003; Kitchenham & Charters, 2007; Ali et al., 2018)

Planning Phase

The *identification* of the need for a systematic review is the first step. As already discussed, although the research in use of blockchain technology in the financial sector is relatively limited in the literature, there is no review encapsulating all the studies that explore blockchain technology in the financial sector to provide a better understanding of this essential research area.

The *development* of the research review protocol is the second step. The existing blockchain-enabled financial research can be better understood through this systematic review protocol. To perform a systematic review within the relevant journal articles for research on blockchain technology in the financial sector, experts have developed a review protocol to explain a research classification framework initially developed by Ngai and Wat (2002). Blockchain is a comparatively new, complex and unique experience. Consequently, this review study has adjusted the classification scheme of Yang and Tate (2012).

Benefits, challenges and functions are the three dimensions of the classification framework. We shall incorporate specific categories within each dimension. Our final research framework (see Figure 4) consists of blockchain-enabled financial benefits encompassing advantages to people, organizations, technology, economics and policy. Blockchain-enabled financial challenges comprise financial, regulation, operational and adoption challenges. Finally, blockchain-enabled financial functions include point-to-point transmission, data ownership, data sharing, data protection and distributed innovations.

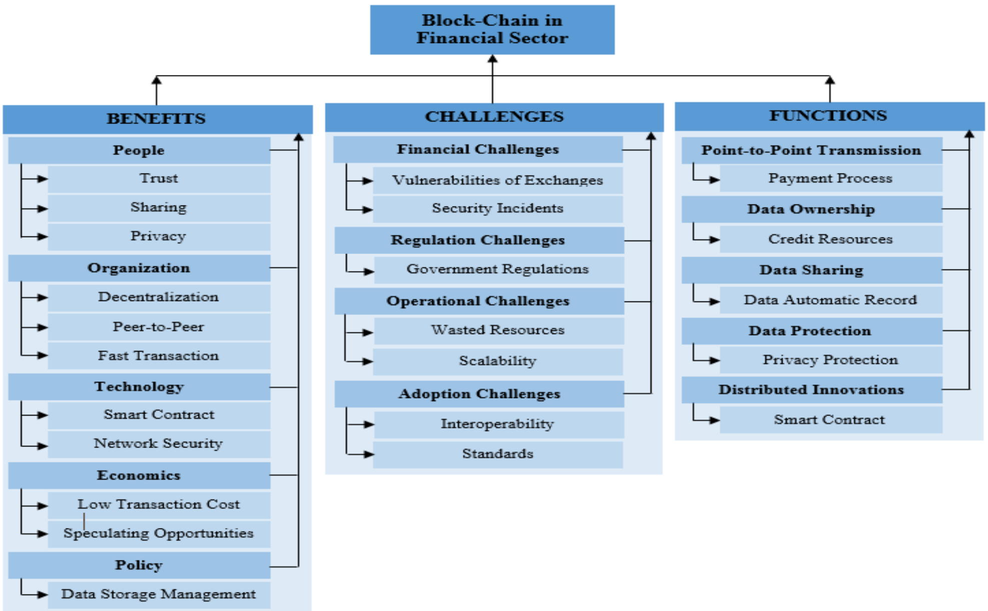

Figure 4. Research classification framework
(Developed from Yang & Tate, 2012)

As shown in Figure 4, the nature of blockchain research, the literature review, the study performed by Barki et al., (1993) and the existing classification schemes of ISs (Alavi & Carlson, 1992; Ngai & Wat, 2002) have helped develop the research classification framework. The following sections will explain the classification framework dimensions and their categories.

Benefits dimension

People, organization, technology, economics, and policy are the five different categories of this dimension. The topics of trust, sharing and privacy are collected under the people's benefits category. In addition, the category of benefit to organization has topics on decentralization, fast transaction and peer-to-peer. The technological benefits category comprises literature on network security and smart contracts. The category financial advantages cover speculating opportunities and the literature on low transaction cost. Last of all, the literature on data storage management is included in the category of policy-related benefit.

Challenges dimension

Financial, regulation, operational and adoption aspects comprise this dimension. Security incidents and literature concerning weaknesses of exchanges fall under financial challenges. The literature relating to the lack of universal regulation of the blockchain falls under regulation challenges. Moreover, literature on wasted resources and scalability comes under operational challenges. Last of all, the literature on interoperability and standards encompasses adoption-related challenges.

Functions dimension

The point-to-point transmission, data ownership, data sharing, data protection, and distributed innovations are among the categories of this dimension. The literature on payment processes is covered in the point-to-point transmission. The literature on credit resources is included in the data ownership. The literature on data automatic recording comes under data sharing. The literature on privacy protection forms part of data protection, and, as a final point, distributed innovations entail information about smart contracts.

The third step in the planning phase is *the definition of the research questions*. It is a critical step in every systematic review. By answering the research questions, the literature review essentially accomplishes the objectives. The research questions emanating from the present systematic review are stated below:

- What are the tangible and expected benefits of the implementation of blockchain technology for the financial sector?
- What are the critical challenges faced in the implementation of blockchain technology in the financial sector?
- What are the current and common areas of blockchain-enabled financial sector functions?
- What are the results of previous studies and their implications in guiding the forthcoming investigation?

The *definition of the strategies for the selection of papers* is the fourth step in the planning phase. In this step, researchers have adopted a combined search method. This combined search method covers a broad automated search of online databases, manual review, and the backward snowball technique.

The selection of the most suitable digital sources forms part of the broad automated search technique (Golder et al., 2014). The digital sources that were selected for this systematic review are the digital libraries of: Science Direct, Emerald, Scopus, ACM Digital, IEEE, and AIS e-library. In addition, significant filtering tools were applied to restrict the desirable research results (Aleixandre-Benavent et al., 2011).

Analyzing the abstract and the title of the research initially was part of the broad manual review (Golder et al., 2014; Higgins & Green, 2011; Pucher, 2013). Subsequently, researchers scrutinized the full articles to filter out inappropriate articles (Hu & Bai, 2014; Pucher, 2013; Shea et al., 2007).

To uncover articles unable to be located from the first method, the researchers employed the backward snowball technique. Using the reference list to find new articles for inclusion is known as the backward snowballing technique (Wohlin, 2014). In this step, the method involves using the reference list, as well as eliminating articles not meeting the basic criteria, for example, language, publication year and type of publication. Dismissal of the previously-scrutinized articles from the list is the next step. Upon their removal, the remaining articles become strong contestants for inclusion. These steps in the backward snowballing ensure that the research scholar has extracted the maximum information from the article under investigation and if an existing article becomes devoid of providing any information required by the scholar, then he/she can consult other sources (if desired) (Webster & Watson, 2002; Wohlin, 2014). The likelihood that the systematic review covers significant articles is increased by the amalgamation of the two techniques.

Execution Phase

In the execution phase, the selection strategies are applied to help filter the overall publication results down to achieve the selection of relevant articles. As summarized below, six techniques are followed in this systematic review research.

- The resolve of search terms is a repetitive process, where we set off with the different search terms that are used for trial searches (Golder et al., 2014; Hu & Bai, 2014; Higgins & Green, 2011). When the initial set of already-known articles is obtained, then the procedure for determining search terms comes to an end. Using sophisticated search strings, together with relevant Boolean operators and all the aforementioned online databases, can assist us in this regard. The '*Blockchain*' and '*Finance Sector*' is the search string used in the existing literature.

- Researchers applied the filters for each database to limit the desirable research results (Aleixandre-Benavent et al., 2011). As it is already known that a large number of articles were produced from the initial search, the number of articles was then narrowed down based on the type of document, selected year of publication and research area.
- To reject the irrelevant articles from search results, the researchers manually checked all the search results to confirm the relevancy and the correctness of the title and the abstract of the articles (Golder et al., 2014; Higgins & Green, 2011; Pucher, 2013).
- The researchers examined the complete articles to identify relevant information (Hu & Bai, 2014; Pucher, 2013; Shea et al., 2007).
- To find articles that were not recognized from the first method, researchers employed the backward snowball technique (Hu & Bai, 2014; Spanos & Angelis, 2016).
- Ultimately, researchers defined the quality assessment criteria, so that the accomplishment of an acceptable level of quality could be assured (Hu & Bai, 2014; Spanos & Angelis, 2016). Moreover, they established a high-quality checklist to evaluate whether or not an article should be included in the research. The assessment questions adopted from Kitchenham (2004), Petticrew and Roberts (2008) and Spanos and Angelis (2016) made up the check list. In addition, the research objective, clear statement of the research problem, the description and availability of data, description of the methodology implemented, presentation of the research results and applicability of the research findings to answer the research question are among the factors included in the checklist. The final review comprised articles fulfilling all these conditions. Table 2 illustrates complete details of the systematic review results.

Table 2. Search results

Databases	**Automated Search Method**		**Manual Search Method**		**Backward Snowball**	**Final Results**
	1st Strategy Keywords Results	2nd Strategy Apply Filter	3rd Strategy Reading Title and Abstract	4th Strategy Reading Full Articles	5th Strategy Backward Snowball Technique	6th Strategy Quality Assessment
Science Direct	356	66	40	23	25	24
Emerald	194	61	38	20	23	19
Scopus	69	34	16	10	14	14
ACM Digital	43	38	22	12	15	15
IEEE	64	12	12	10	11	11
AIS	23	16	9	4	4	4
Total	**749**	**227**	**137**	**79**	**92**	**87**

This systematic review search was conducted from December 2017 until June 2018 and followed the protocol as discussed in the planning phase. The initial keyword search resulted in 749 articles. After applying all the steps reported earlier, 87 articles were finally chosen for further investigation and reporting.

Reporting Phase

After the development of the review protocol, all the predefined steps of the systematic review were executed. In Table 2, the steps leading to the final number of selected articles of this systematic review are illustrated. Specifically, after the initial search (keywords) process, 749 articles were found. The researchers then applied database filters (tools) to reduce the initial search results. As a result of this procedure, 522 articles were removed, and the number of remaining articles was 227. After reading titles and abstracts of the candidate articles to identifying irrelevant articles or duplicates, 90 articles were removed, and the number of remaining articles was 137. Next, after reading full articles, 58 irrelevant articles were removed. The final number of selected articles resulting from the search was 79.

The backward snowball technique was subsequently applied and from the reading of the references, 13 more articles were added, and the number increased to 92 articles. Finally, after checking the quality assessment criteria, 5 articles were removed, reducing the number of articles to 87. Consequently, the final number of articles after the entire study selection process was 87.

Research Results and Classification of Papers

The findings of a detailed review of blockchain technology enabled financial sector related articles to be put forward and examined. The categorization framework was applied by considering three components: blockchain-enabled financial benefits, challenges, and functions. The selected articles for this research study are outlined in Table 3, based on the categorization framework.

Table 3. Classification of accepted articles

Dimension	Category	Type	Reference
BENEFITS	**People**	Trust	Shaw (2014); Yan and Yang (2015); Zyskind et al. (2015); Cai and Zhu (2016); Zhao et al. (2016); Deshpande et al. (2017); Karafiloski and Mishev (2017); Du et al. (2019).
		Sharing	Mainelli and Smith (2015); Zyskind et al. (2015); Zhao et al. (2016); Shackelford and Myers (2016).

Dimension	Category	Type	Reference
		Privacy	Schwab et al. (2011); Zyskind et al. (2015); Zhao et al. (2016); Zhu and Zhou (2016); Shackelford and Myers (2016); Zheng et al. (2016).
	Organization	Decentralization	Barber et al. (2012); Ali et al. (2014); Böhme et al. (2015); Zohar (2015); Abramova and Böhme (2016); Krombholz et al. (2016); Lindman et al. (2017); Seebacher and Schüritz (2017).
		Peer-to-Peer	Mainelli and Smith (2015); Abramova and Böhme (2016).
		Fast transaction	Zohar (2015); Guo & Liang (2016); Lindman et al. (2017).
	Technology	Smart contract	Van Alstyne (2014); Gao et al. (2015); Zhao et al. (2016); Pinna and Ruttenberg (2016); Mainelli (2017); Kenzevic (2018).
		Network security	Van Alstyne (2014); Gao et al. (2015); Axon (2015); Abramova and Böhme (2016); Malinova and Park (2016); Mills et al. (2016); Mainelli and Gupta (2016); Noyes (2016); Zheng et al. (2016); Xu (2016); Mainelli (2017).
	Economics	Low transaction fees	Barber et al. (2012); Ali et al. (2014); Beer and Weber (2014); Van Alstyne (2014); Böhme et al. (2015); Zohar (2015); Möser and Böhme (2015); Gao et al. (2015); Zhu and Zhou (2016); Abramova and Böhme (2016); Karafiloski and Mishev (2017); Li and Wang (2017).
		Speculating opportunities	Glaser et al. (2014); Böhme et al. (2015); Hur et al. (2015); Abramova and Böhme (2016); Tapscott and Tapscott (2016); Mills et al. (2016); Government Office for Science (2016); EMCompass (2017); Kenzevic (2018); Beck et al., (2018); Du et al. (2019).
	Policy	Data storage management	Ateniese et al. (2014); Vorick and Champine, (2014); Zyskind, et al. (2015); Bocovich et al. (2015); Conoscenti et al. (2016); Cram et al. (2019).
CHALLENGES	**Financial Challenges**	Vulnerabilities of Exchanges	Karame et al. (2012); Moore and Christin (2013); Eyal and Sirer (2014); Möser et al. (2014); Böhme et al. (2015).
		Security Incidents	Brezo and Bringas (2012); Moore and Christin (2013); Möser et al. (2014); Böhme et al. (2015); Grant and Hogan (2015); Vasek et al. (2016).
	Regulation Challenges	Government regulations	Grinderg (2011); Reid and Harrigan (2013); Trautman (2014); De Filippi (2014); Guadamuz (2015); Perez (2015); Guo & Liang (2016); Nguyen (2016); Patrick (2016); Peter (2017); Yin et al. (2019).
	Operational Challenges	Wasted resources	Swan (2015); Yli-Huumo et al. (2016); Cocco et al. (2017); Weber et al. (2017); Mendling et al. (2018).
		Scalability	Barber et al. (2012); Zyskind et al. (2015); Conoscenti et al. (2016); Yli-Huumo et al. (2016); Zheng et al. (2016); Chanson et al. (2019).
	Adoption Challenges	Interoperability	DeSalvo and Galvez (2015); Lewis et al. (2017).
		Standards	Guo and Liang (2016); Lewis et al. (2017); Rossi et al. (2019).
FUNCTIONS	**Point-to-Point Transmission**	Payment process	Abramova and Böhme (2016); China International Capital Corporation (2016); Guo and Liang (2016); Zheng et al. (2016); Xu et al. (2016); Poon and Dryja (2016); Lindman et al. (2017); Kenzevic (2018).
	Data Ownership	Credit resources	Zyskind et al. (2015); Xu et al. (2016); Poon and Dryja (2016); Mattila (2016); Lindman et al. (2017); Davidson et al. (2018).
	Data Sharing	Data automatic record	Mainelli and Smith (2015); Zhao et al. (2016); Tapscott and Tapscott (2016); Rizzo (2016); Price (2017).
	Data Protection	Privacy protection	Lazarovich (2015); Zyskind et al. (2015); Zhao et al. (2016); Zheng et al. (2016); Seebacher and Schüritz (2017).
	Distributed Innovations	Smart contract	Böhme et al. (2015); Zyskind et al. (2015); Liebenau and Elaluf-Calderwood (2016); Zhao, et al. (2016); Pinna and Ruttenberg (2016); McKinsey (2016); Guo and Liang (2016); Walker et al. (2016); Lindman et al. (2017); Tapsocott and Tapscott (2017); Block et al. (2018); Kenzevic (2018); Davidson et al. (2018).

Figure 5 illustrates the overall number of selected articles across the years that we scanned in this research review. It is evident that the number of publications related to blockchain technology has increased significantly since the technology first appeared in 2008. It is also worth mentioning that blockchain technology has fascinated researchers as this innovation brings the possibility of cooperatively producing and maintaining transactions in the network. We established that the highest number of articles was published in 2016 with 29 articles; and the lowest number of articles was published in 2013 with only 2 articles (see Figure 5).

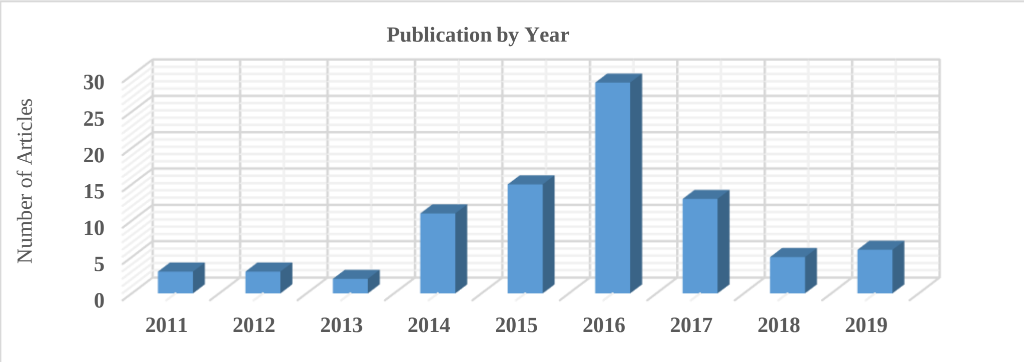

Figure 5. Publications by year

Figure 6 demonstrates the distribution of the selected articles by database sources. We identified 24 articles in the Science Direct database, followed by 19 articles from Emerald database, 15 articles from ACM Digital database, and another 14 articles from Scopus database. Also, about 11 articles from IEEE database. Finally, only 4 articles appeared from AIS e-library (See Figure 6).

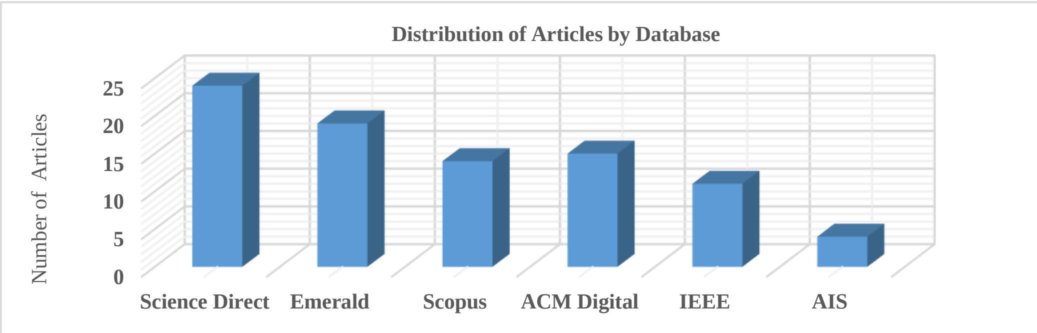

Figure 6. Distribution of articles by database sources

Figure 7 demonstrates the type of articles selected for inclusion in this study. We established that the highest number of articles were journal articles (with 46 articles), and there was only one workshop paper (see Figure 7).

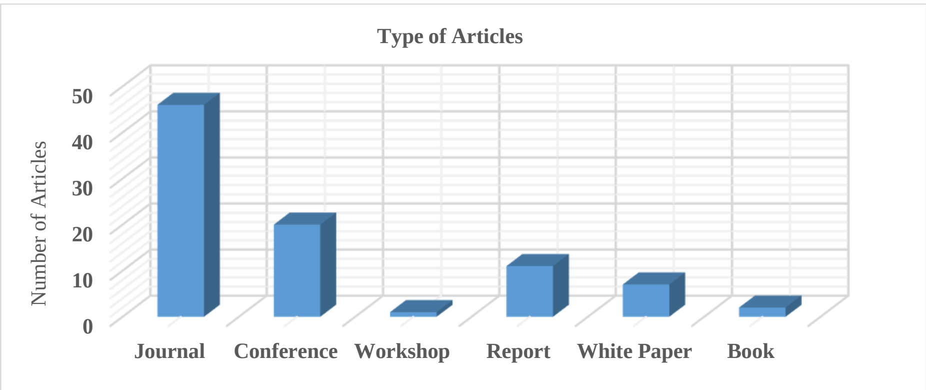

Figure 7. Type of articles

We classified the topics into three dimensions: blockchain-enabled financial sector benefits; challenges; and functions. Figure 8 illustrates the number of articles that were published each year related to each dimension in the research classification framework. We also determined the total number of articles published for blockchain-enabled financial sector benefits (n=46); blockchain-enabled financial sector challenges (n=34); and blockchain-enabled financial sector functions (n=27). The distribution of the topics per year is shown in Figure 8. In our next section, we present research discussions stemming from our findings.

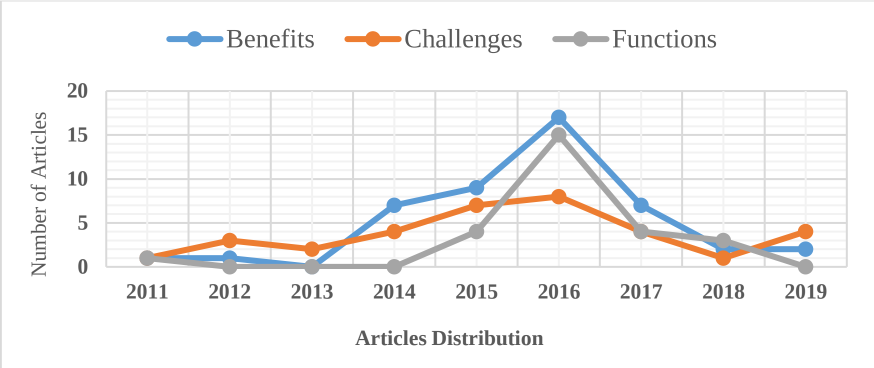

Figure 8. Distributions of research articles

Research Proposition

This section discusses the benefits, challenges, and functions of blockchain technology-based systems that need further consideration, analysis and research—particularly in the financial sector. As blockchain technology development and applications cover a wide range of areas, future research directions can be diverse. To maximize the benefits of the blockchain systems for decision-making in the financial sector, three research propositions are offered that are based on the following areas: blockchain enabled financial sector benefits, blockchain enabled financial sector challenges, and blockchain enabled financial sector functions.

Blockchain Enabled Financial Sector Benefits

Blockchain technology is expected to bring significant benefits to consumers, to the current banking systems, and to society in general. Beyond the security implications and increased transparency of transactions for all parties, either institutions or customers, it can have a beneficial impact on pricing and costs in the market (Glaser et al., 2014; Hur et al., 2015). Such benefits can be identified, simulated and analyzed as the technology evolves and matures. Blockchain also provides the opportunity to maintain secure payment histories of the customers across different banks in different regions and thus reduce the risk of fraud (Zohar, 2015; Gao et al., 2015; Lindman et al., 2017). Other benefits include greater transparency, improved traceability, and increased speed of transactions. All benefits require in-depth study and empirical evaluations for different use cases and applications. Consequently, the following proposition is offered:

Proposition 1. *Measuring the benefits of blockchain technology and its impact on the financial sector is very difficult. Therefore, there is a need to develop theoretically sound and practically feasible blockchain technology impact indicators that relate to people, organizations, technology, economics, and policy to measure its benefits.*

Figure 9 sets out the distribution of blockchain enabled financial sector benefit articles in relation to people, organization, technology, economics and policy, and shows that the highest number of current publications related to the benefits to the economy (21 articles). The lowest number of publications concerns issues relating to the benefits to policy (6 articles). The following sections provide a detailed discussion about the benefits to people, organization, technology, policy and economics.

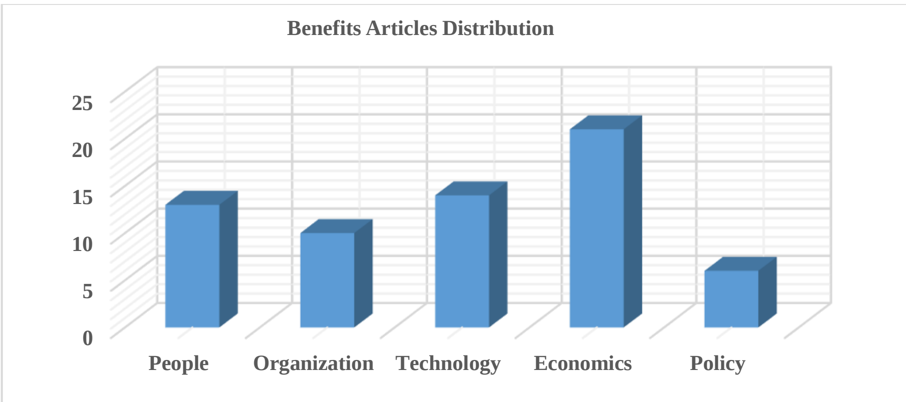

Figure 9. Distribution of blockchain enabled financial sector benefit articles

People

As far as the cyber world is concerned, transactions take place among unknown people. The cyberspace field is using the reputation system. Through the use of this system, people are able to evaluate the reliability of a potential seller (Cai & Zhu, 2016). Furthermore, the amount of data globally is rapidly increasing (Zyskind et al., 2015). In the Big Data era, data is continuously being gathered and evaluated, which results in revolution and financial prosperity (Zyskind et al., 2015). Different organizations are using the data to personalize services, predict future trends and improve corporate decision-making processes. The most precious asset of our economy is the data (Schwab et al., 2011).

Blockchain has captured the attention of people from many industries such as property management, auditing, and copyright protection; however, the leading application area of the technology is now none other than the financial sector (Zhao et al., 2016; Zhu & Zhou, 2016). As part of human society, research on blockchain technology is projected to address the issues of sharing (Mainelli & Smith, 2015; Zhao et al., 2016), trust (Shaw, 2014; Yan & Yang, 2015), and privacy (Schwab et al., 2011; Zhao et al., 2016; Zheng et al., 2016). A key feature that the blockchain can offer for a transaction is trust. Thus, people may be able to share information without compromising confidentiality with the help of new trust mechanisms (Karafiloski & Mishev, 2017).

Trust in transactions can be improved without interference from a third-party as a result of the blockchain (Deshpande et al., 2017). Consequently, end-users themselves have control over their own transactions and data, as the centralized database is not storing data which is prone to being hacked (Shackelford & Myers, 2016). A decentralized personal data management system assuring the ownership of data was proposed by Zyskind et al. (2015). In this setup, data transparency, the ability to audit, and finely administered access controls can be used to protect private and personal data.

Organization

Core to blockchain technology is that a business community can be P2P and decentralized (Barber et al., 2012; Mainelli & Smith, 2015; Abramova & Böhme, 2016; Lindman et al., 2017; Seebacher & Schüritz, 2017). Moreover, there also can be fast transactions (Zohar, 2015; Gao et al., 2015; Lindman et al., 2017). The Bitcoin system is an example of a decentralized organization, where no central authority exits to handle the issue (Ali et al., 2014; Böhme et al., 2015; Krombholz et al., 2016; Zohar, 2015). There are usually P2P relationships amongst the nodes in the blockchain system (Abramova & Böhme, 2016).

Technology

The network security (Abramova & Böhme, 2016; Malinova & Park, 2016) and smart contract (Knezevic, 2018; Zhao et al., 2016; Pinna & Ruttenberg, 2016) are the technical tools fundamental to the blockchain system. As far as the smart contract is concerned, the auto execution of code enables the organization to be self-sufficient. Network security is the core component of this feature, where people can trust the system for business transactions (Gao et al., 2015; Van Alstyne, 2014). According to a research by Xu (2016), the security mechanism based on distributed consensus and public ledger is one of the fundamental attributes of the blockchain. The author describes the bad practices and types of fraud which blockchain technology can prevent. The author defines threats to the blockchain while also recommending appropriate defensive measures to fight against such threats and dangers.

Because of its distributed nature and the absence of a central point of failure, the flexibility of systems and data storage can be enhanced with blockchain technology (Mills et al., 2016). Research conducted by Mainelli (2017) expounded the opportunities offered by this type of technology. The author pointed out that in the event of failure, everyone can retain their own copy of data and transactions since blockchain technology is not centralized. This form of resilience and security provides the opportunity to create new identity systems where users own the data which remains universally consistent and cannot be destroyed (Mainelli & Gupta, 2016).

Blockchain can potentially help to improve the security in distributed networks. Noyes (2016) proposed a novel anti-malware environment named BitAV from which users can distribute the virus patterns on the blockchain. This research showed that BitAV can enhance the fault reliability to improve the scanning speed. The reliability of security infrastructure can also be improved due to this blockchain technology. For example, conventional public key infrastructures (PKIs) are often susceptible to single point of failure due to hardware and software flaws or malicious attacks (Zheng et al., 2016). As demonstrated by Axon (2015), blockchain can be used to construct a privacy-aware PKI, while simultaneously improving the reliability of conventional PKIs.

Economics

As per the economic cost-benefit analysis, potential reasons for interest in the blockchain are speculation opportunities (Glaser et al., 2014; Hur et al., 2015) and seemingly low transaction costs (Barber et al., 2012; Ali et al., 2014; Böhme et al., 2015; Zohar, 2015; Gao et al., 2015; Van Alstyne, 2014; Beer & Weber, 2014; Zhu & Zhou, 2016; Karafiloski & Mishev, 2017; Li & Wang, 2017; Kenzevic, 2018). Theoretically, fees are discretionary and paid out to a successful miner. However, on the practical side, the blockchain transactions are charged a fee, which can be explained by a default value arranged in the usual client software (Möser & Böhme, 2015; Abramova & Böhme, 2016). Compared to traditional payment options, Bitcoin fees are typically lower than the charges levelled at individuals when making international payments and transfers, however cost savings in case of local retail purchases are not always apparent (Böhme et al., 2015; Van Alstyne, 2014).

An opportunity for trading and contemplating activity on exchange markets is offered by the variable exchange rates between sanctioned currencies and the Bitcoin (Abramova & Böhme, 2016). By exploiting the price volatility, many users are acquiring Bitcoins simply to hold them until there is an escalation of the exchange rates (Böhme et al., 2015). Consequently, the debate continues about the status of Bitcoin as merely an investment tool (store-of-value) or a digital currency (means of exchange)

(Glaser et al., 2014; Hur et al., 2015). In addition to enabling the development of markets and products that were earlier unprofitable or unavailable, blockchain is a disruptive technology offering the likelihood of reengineering economic models (EMCompass, 2017).

New business models could be enabled with the implementation of the blockchain. The P2P transactions could take advantage of the transfer of assets without involving a third party and, therefore assist in the development of the 'sharing economy' (Tapscott & Tapscott, 2016). Through the establishment of new types of financial institutions, new entrants (for example, the unbanked) could participate in economic activities from which they are currently denied (Mills et al., 2016; Tapscott & Tapscott, 2016; Government Office for Science, 2016).

Policy
The main policy components underlying the blockchain system include management of access policies and references to users' data (Zyskind et al., 2015), management of data storage contracts (Vorick & Champine, 2014), management of document storage contracts (Bocovich et al., 2015), management of metadata of data kept in a storage systems (Conoscenti et al., 2016; Cram et al., 2019), automatic compensation to clients of a storage server in the case of stored data being lost (Ateniese et al., 2014), and an immutable log when storing metadata of messages of decentralized applications (Conoscenti et al., 2016).

Blockchain Enabled Financial Sector Challenges
There are some significant challenges that blockchain technology needs to overcome before it becomes mainstream in the financial sector. These challenges include scalability (Conoscenti et al., 2016; Yli-Huumo et al., 2016), total time for the verification of the transactions (latency) (Moore & Christin 2013), security (Karame et al., 2012; Eyal & Sirer, 2014), meeting regulatory challenges (Reid & Harrigan, 2013; Trautman, 2014), and transaction cost (Moore & Christin, 2013). Consequently, the following proposition is offered:

Proposition 2. *There are a set of critical financial, regulation, operational, and adoption challenges that will significantly affect blockchain's success in the financial sector.*

Figure 10 sets out the distribution of articles on blockchain enabled financial sector challenges in relation to financial, regulatory, operational and adoption challenges; and shows that the highest number of current publications is within the operational challenges (11 articles). The lowest number of publications is within the adoption challenges (5 articles). The following sections will discuss the findings and challenges relating to financial, regulation, operational and adoption aspects.

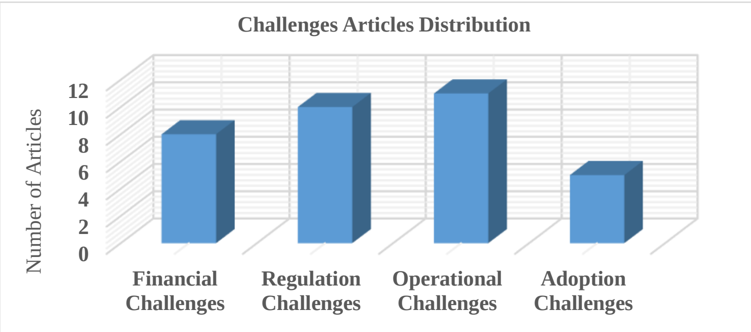

Figure 10. Distribution of articles relating to blockchain enabled financial sector challenges

Financial challenges
The remote wallets, currency exchanges or transaction tools that shield activity on the internet to render them untraceable are examples of third-party financial mediators in the blockchain ecosystem (Moore & Christin 2013). In research conducted by Möser et al. (2014) they identify that with the blockchain 'Bitcoin' as a global Internet currency, involvement of some mediators is essential. The interested individuals cannot buy Bitcoins in the absence of exchanges serving as a platform for the buyers and the sellers. Because of potential security vulnerabilities of systems, the mediators unavoidably represent their clients to mitigate risk (Karame et al., 2012; Eyal & Sirer, 2014). For instance, after losing about 754,000 of its customers' bitcoins after a massive hack, the largest bitcoin exchange—Mt. Gox—closed its business in 2014 (Böhme et al., 2015). Furthermore, bitcoins could be lost due to a user's own unplanned actions, for example, typos in forgotten passwords, transactions or security defects of devices used (Brezo & Bringas, 2012; Grant & Hogan, 2015; Vasek et al., 2016).

Regulation challenges
The technology revolution is followed by the regulatory entities, which is certainly the case with blockchain (Peter, 2017). The blockchain transactions is giving rise to new services, however, laws are absent in regulating transactions (Trautman, 2014; De Filippi, 2014). Even though auditability and transparency are promised benefits of blockchain, developing new regulations for blockchain might meet the needs of highly-regulated industries (Guo & Liang, 2016; Nguyen, 2016). There is a need to reshape the information-sharing regulations for encouraging companies to adopt the technology, as well as their

customers and their investors. Governments should introduce laws that encompass the smart contracts of the blockchain (Peter, 2017; Yin et al., 2019).

One of the key concerns for start-ups and banks investigating the distributed ledgers is the regulation scope (Grinberg, 2011; Reid & Harrigan 2013). Blockchain technology is still in the process of being fully understood by regulators (Peter, 2017). Blockchain technology has many attractions to the regulations since they are looking to improve the robustness of financial sector infrastructures. However, some questions exist about jurisdictional and legal issues (Guadamuz, 2015).

A reactive behavior tends to be displayed by regulators, with no proactive guidance (Patrick, 2016). In 2014, regulators were of the view that new risks would be also observed with any new innovation; however, the cryptocurrencies and shared ledgers represent a cheap and efficient global payments infrastructure, the use of which should not be overregulated at this time (Patrick, 2016). Since blockchain technology will develop market infrastructure, regulators have begun considering potential benefits that could be realized with its adoption and, subsequently, could result in enhanced market infrastructure. Banking supervision is known as the other benefit consequent to the use of blockchain technology: if blockchain technology works as it is anticipated, regulators could move out stress test on the banks without having to rely on the banks to provide them with the data. The authorities concerned have passed this regulation after more than 70 potential risks of Bitcoin influencing users' financial integrity and market participants were found by The European Commission (Perez, 2015).

Regulations could influence the extent to which the technology could be developed. Consequently, there should be a need to balance against the stifling of innovation with the acknowledgement that it is unlikely the technology will deliberately contribute to systemic risks in this regard (Peter, 2017).

Operational challenges

Today, sustainable development, the effects of greenhouse gases and climate change are among the major issues facing society; and many organizations such as financial institutions are seriously looking to save money and reduce their carbon footprint (Cocco et al., 2017). However, the consensus mechanism in blockchain's can be the reason for wasted resources, particularly electricity, in which nodes wanting to add new transactions/blocks constantly compete in a race to mine the next block for a high reward (Swan, 2015). In a practical study, Weber et al. (2017) found that uncles (forks of length 1) formed almost 10% of announced new blocks on the Ethereum network. This phenomenon can be observed as inefficient, but it is also a small sign of the huge replication of effort in proof-of-work mechanisms (Mendling et al., 2018; Weber et al., 2017). Longer forks (as a maximum of length 3) were particularly occasional; hence, in a well-connected network, accidental forking seems questionable, however, it could take place if larger nations were cut off permanently or temporarily (Andersen & Bogusz, 2019). The proof-of-stake being a substitute to the proof-of-work has been discussed to a small degree (Yli-Huumo et al., 2016). Extremely low assumptions in trusting other participants are made by proof-of-work. There is a challenge to design more efficient protocols (for example, Proof-of-Stake), without compromising these suppositions (Yli-Huumo et al., 2016). Studies which focused on wasted resources were inadequate (Swan, 2015). Research conducted by Yli-Huumo et al. (2016) found that the wasted of resources and of computational power have been explored in Bitcoin mining. One of the key attributes in blockchain is computational power, which requires more consideration. With increasing complexity, more computational power is required by the blockchain. The Proof-of-Work concept is a rather new idea, which is the reason why it must be studied more to ensure that it can work in large-scale blockchain environments. The issue with wasted resources needs resolution so that mining in blockchain becomes more efficient.

The scalability issue is the other challenge regarding the operational success of blockchains (Conoscenti et al., 2016; Yli-Huumo et al., 2016; Chanson et al., 2019). As per the research, the increasing number of transactions and data stored permanently on every Bitcoin node are the cause of the scalability issue (Zheng et al., 2016). According to research conducted by Zyskind et al. (2015), increasing volumes of transactions cannot be scaled and handled by the blockchain. Therefore, they suggest that rather than handling the data by a single node, a small subset should be responsible for different groups of data. In other research conducted by Barber et al. (2012), they point out that scalability is an issue caused by the need for every node of the blockchain to verify each block.

According to our assumptions, wasted resources would have remained a key area of concern in the overall research domain. There is a direct impact on all these issues and shortcomings as a result of an increase in the size of blockchain. Research in this area is ongoing and yet to gain maturity given the relative novelty of the technology.

Adoption challenges

In the financial sector, the ability of different software applications and information technology-based systems to collaborate, share and use the information/data is referred to as interoperability (DeSalvo & Galvez, 2015). Existing companies will face challenges related to interoperability of blockchain platforms with their current internal systems. Externally, it remains to be seen how blockchain from multiple businesses might operate with each other (Lewis et al., 2017).

Blockchain technology is a key area of concern for various companies, and authoritative standards should be employed to test security matters (Guo & Liang, 2016; Rossi et al., 2019). Lately, the International Organization for Standardization (IOS) received a request from Standards Australia to develop global standards for blockchain technology. For interbank applications, the R3 blockchain association aims to shape industry standards. A similar group called Interbank Market Technology

Standards Workgroup was also established in China in August 2016. This working group is conducting prospective research on the market of blockchain technology between banks, regulations, and legal frameworks (Guo & Liang, 2016). Blockchain network designs are not standardized yet, and this can result in serious problems in implementation. Many different international and national organizations are attempting to create generally-accepted technical standards (Lewis et al., 2017).

Blockchain Enabled Financial Sector Functions

More recently, international associations, including the United Nations (UN) and the International Monetary Fund (IMF), as well as developed countries such as the US, Britain and Japan, have paid close attention to the growth of blockchain and discerned various applications in different sectors (Guo & Liang, 2016). According to the claims by some researchers, blockchain have the potential to reshape the banking domain (Peters & Panayi, 2015; Morini, 2016). No central storage and permissions are needed for blockchain, resulting in major disruptions in the financial sector—particularly in payment clearing. Various global financial institutions have been framing ideas using blockchain technology since 2015 (Guo & Liang, 2016). Similarly, there has been widespread optimism regarding blockchain adoption in the banking sector. A survey conducted by McKinsey in May 2016 with global banking executives revealed that blockchain applications will have a considerable impact within 3 years and was under-considered by half of the executives, and according to some researches, blockchain applications will have a considerable impact within 18 months (McKinsey, 2016). As per the prediction of another survey of 200 global banks, almost 15% of banks intend to extensively implement blockchain technology. In addition, IBM was of the view that commercial blockchain would be owned by 66% of the banks within 4 years (Fortune, 2016). Therefore, the following proposition is offered:

Proposition 3. *There is a necessity to fully understand the functionality of blockchain that relates to P2P transmission, data ownership, data sharing, data protection, and distributed innovations and its implications for research and practice in the financial sector.*

Figure 11 sets out the distribution of blockchain enabled financial sector function articles in relation to point-to-point (P2P) transmission, data ownership, data sharing, data protection, and distributed innovations and shows that the highest number of current publications is within the domain of distributed innovations (13 articles). The lowest number of publications is within the domain of data sharing with only 5 articles. An in-depth discussion of findings associated with functionality of blockchain technology in the financial sector in relation to P2P transmission, data ownership, data sharing, data protection, and distributed innovations is provided next.

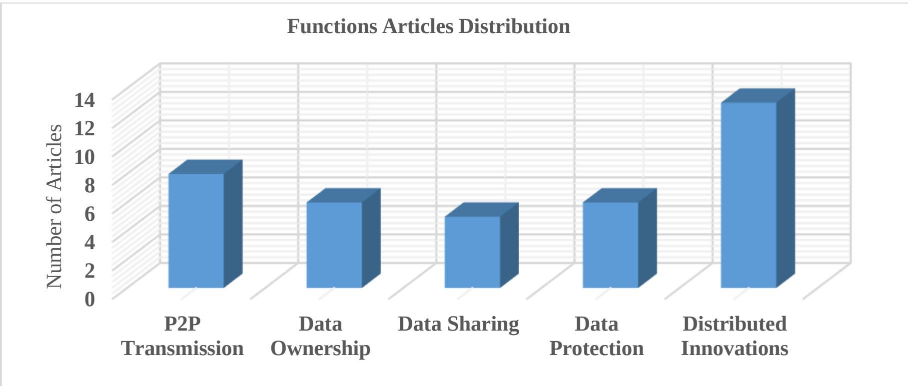

Figure 11. Distribution of articles addressing blockchain enabled financial sector functions

Point-to-point (P2P) transmission

The processing by intermediary clearing firms is often required in interbank payments, which involves transaction reconciliation, bookkeeping, and payment initiation and balance reconciliation. Consequently, the process becomes costly and complicated. In terms of cross-border payments, where the clearing procedures are different for each country, it takes typically 3 days for a remittance to arrive. This is indicative of the huge volume of occupied funds and the low efficiency (China International Capital Corporation, 2016) and lack of alternative mechanisms. The blockchain technology can also implement the P2P payment, hence, the intermediary link is removed and will enhance service efficiency besides reducing the transaction costs (Zheng et al., 2016; Xu et al., 2016; Poon & Dryja, 2016; Lindman et al., 2017; Kenzevic, 2018). This will also enable banks to meet the requirements of fast and convenient payment clearing services for cross-border business activities (Abramova & Böhme, 2016). In addition, research conducted by Guo and Liang (2016) suggests that the payment clearing system can be an appropriate platform for blockchain application. Blockchain technology can be used to solve issues such as lack of mutual trust, high transaction cost and fraud.

Establishing data ownership

A substantial amount of valuable data is generated on the Internet by every individual, which is extremely valuable as proof of the credit situation. However, large Internet companies tend to control this data. Therefore, individuals fail to establish ownership and control over their own data. Moreover, to protect user privacy, achieving data flow between these companies is challenging, which in turn results in the data islands. Blockchain technology is a potentially viable solution to these challenges by providing consistent and legitimate information (Zyskind et al., 2015; Mattila, 2016; Lindman et al., 2017; Davidson et al., 2018). This can also ensure that the information is genuine and reliable (Zyskind et al., 2015), while minimizing the costs of data acquisition by credit agencies (Xu et al., 2016; Poon & Dryja, 2016). Using blockchain technology, big data can become credit resources with clear personal ownership, and even establish the foundation of future credit systems (Mattila, 2016).

Promoting data sharing
The automatic recording of big data can be realized through blockchain (Tapscott & Tapscott, 2016). It also has the potential to store and share encrypted forms of the customer's credit status within institutions (Mainelli & Smith, 2015; Zhao et al., 2016). Researchers have proposed the following blockchain credit solution: banks should store customer information in their own database during the "know your customer" process and, subsequently, encryption technology is employed to upload summary information to store the data in the blockchain (Price, 2017). Upon having query requests, a notification can be sent to the original data provider using the blockchain. Thus, external big data can be searched by all the parties with no exposure of their core business data (Rizzo, 2016).

Data protection
Research on information privacy concerns is clearly of importance to IS researchers, and typically seeks to explain differences in levels of privacy concern or to explore the effects of privacy concerns on various dependent variables, such as the willingness to provide personal information or the willingness to transact online (Bélanger & Crossler, 2011). A research study conducted by Lazarovich (2015) developed an application that offers privacy protection and data protection. This platform has parallels with the Bitcoin's blockchain (Zheng et al., 2016; Zhao et al., 2016). Owing to its decentralized nature, it can be used by real applications for different service providers. Research conducted by Zyskind et al. (2015) recommended a decentralized privacy system utilizing the blockchain for safety of personal data. The research uses blockchain as a database to make this kind of protection possible. The user inputs his/her data in the blockchain, and the companies seeking the required information can use it without storing the private information. At this point, the role of a third party is diminished, and users always receive the log history describing the use of their information (Seebacher & Schüritz, 2017). The smart solution enables the user to manage his/her private information and stops the data from being accessed by unauthorized entities. Moreover, to safely distribute sensitive data in a decentralized manner, researchers have proposed a similar system based on blockchain technology (Zheng et al., 2016).

Distributed innovations in financial transactions
Manual inspections and paper-based transactions are included in the finance supply chain (Guo & Liang, 2016). The presence of many mediators, high costs, high risk of illegal transactions and inefficiencies are characteristic of this process. Using smart contracts to modernize the conventional paperwork processes, manual interventions can be radically reduced by the blockchain technology (Pinna & Ruttenberg, 2016; Tappsocott & Tapscott, 2017; Kenzevic, 2018). Consequently, efficiency of the finance supply-chain would be improved, and manual operational risks will be mitigated (Walker et al., 2016; Davidson et al., 2018). With the supplier, buyer and bank as the main business parties, the sharing of contractual information on a decentralized distributed ledger and smart contracts can ensure that payments are made automatically once a predetermined time and result is reached (Lindman et al., 2017).

Generally, trade financing enterprises and banks can reduce expenditure by employing the functionality of blockchain technology in the finance sector (Block et al., 2018; Kenzevic, 2018). According to calculations by McKinsey (2016), blockchain technology can enable banks to reduce operational costs by US $13.5 to 15 billion on a yearly basis while mitigating the cost of risk by US $1.1 to 1.6 billion annually. In addition, both trading parties will be able to reduce their cost of capital by US $1.1 to 1.3 billion annually, and yearly operational costs by US $1.6 to 2.1 billion. In addition, a smoother flow of overall trade financing is ensured by the transaction efficiency boosting the income of the overall trade chain. Eventually, use of the blockchain could result in a new form of digital disruption and financial transformation (Böhme et al., 2015; Zyskind et al., 2015; Liebenau & Elaluf-Calderwood, 2016; Zhao, et al., 2016).

Implications to Theory, Practice and Future Research

We draw out several key implications from the findings of our systematic review for future research surrounding blockchain technology in the financial sector.

Implications to theory
This paper strives to close the current research gap pertaining to potential implications of the blockchain for the financial services sector by presenting a framework built on three factors, namely benefits, challenges and functions. These were used to derive research questions that are theory-based as well as relevant for the industry. Based on this foundational information this paper initiated and stimulated an academic discussion on the potential impact of the blockchain and introduced a framework for theory development together with several research questions. The paper built on previous theories that are

frequently used in technology research and showed how they can be adapted to blockchain-related questions. These theories can serve as a basis for developing future theories as the technology matures and modified accordingly.

Implications to research

The key implications to research from our findings in this systematic literature review include issues related to blockchains that need further empirical study such as fast transaction, data sharing, wasted resources, scalability, and data protection. Current research in blockchain and, in particular as it relates to the financial sector, is concentrated in the area of associated services that make relevant information accessible in less time (fast transaction) (Zohar, 2015; Guo & Liang, 2016; Lindman et al., 2017; Kenzevic, 2018). This has the potential to reduce transaction fees while expanding the scope and flexibility of IT services to the financial sector (Gao et al., 2015; Zhu & Zhou, 2016; Karafiloski & Mishev, 2017; Li & Wang, 2017). Moreover, another huge incentive for the adoption of blockchain technology within the financial sector is data ownership (Zyskind et al., 2015; Xu et al., 2016; Lindman et al., 2017; Davidson et al., 2018). Using blockchain technology, big data can become credit resources with clear personal ownership, and even establish the foundation of future credit systems (Mattila, 2016). Data protection is clearly of importance to information systems researchers, and typically seeks to explain differences in levels of privacy concern (Lazarovich, 2015; Zhao et al., 2016; Seebacher & Schüritz, 2017). A research study conducted by Lazarovich (2015) developed an application that offers privacy protection and data protection. This platform has parallels with the Bitcoin's blockchain (Zhao et al., 2016). Another research study conducted by Zheng et al. (2016) identifies a smart solution that enables the user to manage the private information and prevents the data from being accessed by unauthorized entities.

Wasted resources and scalability are two of the most discussed operational challenges in blockchain, not just in the financial sector but across all other industries (Yli-Huumo et al., 2016; Lewis et al., 2017; Chanson et al., 2019). Research conducted by Yli-Huumo et al. (2016) found out that wasted resources and computational power have been the main drawbacks in Bitcoin mining. One of the key demands in blockchain processing is computational power, and its effective and efficient use requires further analysis and consideration. With increasing computation, more processing power is required by the blockchain. The Proof-of-Work consensus algorithm in the context of its use in blockchains is a relatively new innovation and requires further experimentation and refinement if it is to be made to work in large-scale blockchain environments. The issue with wasted resources needs to be solved in order to have more efficient mining in blockchain. The scalability issue is another operational challenge that can impact on the success of blockchain adoption. According to research conducted by Barber et al. (2012), scalability is an issue because of the need to verify each block by every node of the blockchain. These research considerations suggest some specific future research possibilities, and these are discussed next.

Future Research Directions

As a research area, functionality of blockchain technology in the financial sector is an emerging topic. Although the research on the use of blockchain technology in the financial sector is growing, this is the first attempt towards a synthesis of the existing research findings based on a systematic review. According to our review strategy, only 87 articles have been selected in our study, among which the significant number of publications occur in 2014-2017 and fewer publications occur in 2011-2013 (see Figure 5). The overall theme of the publications in 2014-2017 represented realization of benefits and challenges with specific blockchain functionality in the financial sector. There is a lack of theoretical orientation and longitudinal study of the overall value of blockchain to the financial sector, demonstrating the lack of maturity in this research area. Nevertheless, a positive finding is the uniform distribution of research articles that are published in IS and business journals (see Figure 6).

An analysis of the research topics according to the classification framework as illustrated in Figure 8 showcases the expanding research interest in the area of benefits presented by blockchain technology in the financial sector. However, there is a reduced interest in studies surrounding blockchain functionality in financial applications. This might imply that the key technological and management issues have been addressed as the blockchain technology has evolved. Therefore, studies associated with the benefits from using blockchain technology might seek more generic benefits rather than specific blockchain functions. This is a promising development that provides a positive roadmap for future research work. This systematic review paper has attempted to offer an overview of some significant key dynamics with blockchain technology that can be of interest to social and finance consultants. This technology is still in its early stages, but it is apparent that there are possibly empowering uses of it in certain contexts. A good starting point to explore blockchain would be to build new research into the following:

- The benefits and challenges for the blockchain system's use from a financial technology and systems perspective. This includes its use within a payment system and banking facility. This can be completed with studies on the extent to which blockchain-based property title systems have the potential to open up normal bank financing to people who cannot access credit from financial organizations.
- Blockchain technology applications, in particular for the financial sector, are still in their infancy. There is a call for researchers to investigate and develop more prototypes to deepen the understanding of the technology in relation to its application in the financial sector. There are many frameworks, concepts and models, such as those suggested by Mamoshina et al. (2017), and these need to be tested and implemented to evaluate their strengths and weaknesses.
- There is a need for open standards to guarantee interoperability between different blockchain products. To date, the main aim has been to focus on the functionality of blockchain prototypes for proof of concepts. However, the open standards for interoperability need to be defined for the adoption and implementation of the blockchain in the financial

sector. It is necessary, at this stage in the life of the technology, for researchers to start looking into interoperability issues and the process of standardization.

- The challenges of interoperability, scalability, data security, data privacy and speed that characterize blockchain financial applications are all open research issues that require further investigation to increase stakeholders' confidence in the use of this type of technology, and to foster its adoption for the financial sector in particular. In fact, to implement trust-free sharing services in the financial sector, it is necessary to consider security aspects (such as confidentiality, availability, and integrity) which represent one of the principal characteristics of blockchain-based technology. This is because a blockchain is a decentralized protocol where all information is confidential and the availability of data does not rely on any third parties. Moreover, integrity is ensured since this technology can be regarded as a distributed file system where participants keep copies of files and agree to changes by consensus.
- There is the potential for blockchain technology to create an infrastructure to implement 'new social contracts for sustainability', contributing to the promotion of the transition to sustainable development. Blockchain system provides a foundation for the transactions of the data that does not require any centralized function and that supports links among the clients for resolving issues (Faber & Hadders, 2016). As a result of that, blockchain overcomes the current business model, which is principally managed by old mainstream bureaucratic structures and organizations that include political loyalties, banks and local governments. Consequence, if blockchain-based solutions are to be used by an increasingly larger number of people and the volume of transactions increases exponentially, more research on wasted resources needs to be conducted to ensure scalability and sustainability.
- In general, there is very limited research related to supply chain finance (Wang et al., 2019; Caniato et al., 2016; Carter et al., 2015). In particular, there is no reliable research which can describe the relationship between blockchain technology and supply chain finance. As such, blockchain diffusion into supply chain systems provides fertile ground for future research. Examining this emerging phenomenon would offer valuable insights as to how blockchain supports financial collaboration across supply chain stages—and not only bilateral financial settlements. More importantly, it will allow us to interrogate the economic value of the blockchain and see whether it affects the profitability of the business.

Based on our findings, there remains many avenues for researchers to explore, particularly technology-related research related to scalability and interoperability, and sociotechnical research related to the development and implications of the blockchain for individuals, organizations and society. While much of the research currently focuses on technical improvements, models, architectures and use cases, implications of the technology on society and changes likely to be brought about by the many proposed use cases to current business models need to be examined as well.

Implications to practice

This research offers the following key implications to practice in order to enable increasing adoption and use of blockchain-based financial solutions.

For financial organizations to adopt and use blockchain technology throughout the financial sector it is necessary to collaborate together through the blockchain consortium (Sankar et al., 2017; Yoo, 2017). With a view to the decentralization of the current financial system, it is very likely that it will take a long time for blockchain to be adopted and used throughout the banking industry because changes in financial systems and transformation of the system of financial organizations must be generally delivered in parallel.

In the case of interbank payment, the move to introduce a closed distributed ledger that does not go through the central bank is accelerating. In international financial transactions, the closed distributed ledger service, including banks and customers, is evolving in the international payment service. Blockchain technology, based on the origins of the distributed ledger introduced by Bitcoin, is already evolving as a new flow of finance. As the introduction of distributed ledgers focused on financial organizations is widespread, closed distributed ledger technology is predicted to be a pioneer in the future innovation of finance in terms of reliability, stability and efficiency (Yoo, 2017).

As technology evolves, the needs of consumer and related environments change. At the same time, there is an increasing opportunity for individuals to be compromised by information such as hacking, and there is a strong need for blockchain technology because of the efforts of organizations that are trying to defend against hacking. To promote market movements, the government and related organizations should recognize and support the power of blockchain in individual and business transactions, public services, etc., through the development of original technologies and expanding knowledge regarding best practices.

Research Limitation

There are two major research limitations associated with this paper.

Firstly, the fundamental operating principle of a blockchain was introduced about a decade ago. The initial interest in the early blockchain was largely limited to the computer science area, to which the blockchain represented a new arrangement of long-term, pre-existing computer science theory (i.e. hashing, linked lists of data, and public key cryptography). Some several years passed before other industry and academic communities were sparked to consider the blockchain concept. Since then, much interest has been generated, but research topics are still considered scattered and research approaches are still maturing and many lack rigor (Trieblmaier, 2019). It is also widely accepted that the emergence of blockchain publications in leading academic journals has shown a substantial time lag in comparison to industry adoption (Trieblmaier, 2019). In overall terms, there is a real lack of research studies in relation to blockchain in general, and in particular to the financial sector – and this produces a significant limitation to a systematic literature review.

Secondly, the Research Methodology of this paper describes that a systemic review of the available literature has been conducted. Through a systemic review, the research is able to ascertain, assess, understand, and produce the available research, and reach logical conclusions based on the findings of the review (Victor, 2008; Dikert et al., 2016). Within this systemic review approach, this paper has adapted the three phase protocol (planning, execution, reporting) of Tranfield et al. (2003), Kitchenham and Charters (2007). This systemic review approach certainly delivers the fundamental goal of a literature review that adds value to a discipline/sector discussion, rather than only providing an overviews of individual papers. Our adapted approach, however, does have a limitation in that the publishing journals of reviews papers were not classified. The addition of this information would add depth to the value contributed by the systemic review.

Conclusion

The extant literature focusing on blockchain technology has been checked, reviewed and discussed. A number of articles were chosen from the online database and classified into several different areas. This systematic review paper offers an understanding of the current blockchain research and its practical implementation and implications for the financial sector.

The blockchain technology is predicted to play a significant role in the future directions of the financial sector. Firstly, users would be able to better manage their transactions and data in many areas. Execution of transactions would be ensured in all respects without the involvement of a third party. The financial sector would thus be able to determine the smart solutions for managing their data according to their needs on a P2P network. Blockchain technology could revolutionize the surrounding ecosystem of financial tools. It can more effective and efficiently contribute to user authentication, automatic encryption on data and recording data access histories. However, a number of challenges still persist, for instance, standards, scalability, interoperability, security incidents, and wasted resources. In addition, blockchain applications offer solutions for the complete replacement of existing systems. Therefore, the transition will not be rapid or straightforward. However, blockchain development is still in the early stages and these obstacles will eventually be overcome, thus opening the way for many exciting possibilities.

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