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A Systematic Review of Blockchain Research and Applications in Business

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Abstract

Blockchain, well-known as the Distributed Ledger Technology (DLT) behind cryptocurrencies such as Bitcoin, has attracted plenty of attention from both practitioners and academics and has begun to revolutionize the way businesses handle their day-to-day operations. DLT leads to many interesting new research topics in different business fields. In this study, we applied the systematic mapping method to review existing articles related to blockchain applications and research in different business areas (accounting, finance and banking, information systems, marketing and supply chain). Our goal is to understand the current applications and research status related to blockchain, so that we can identify research gaps and better directions for future research. Following the recommended steps of the systematic mapping method, we extracted fifty primary papers from several scientific databases. Our findings suggest that despite the attention received, blockchain research still has a long way to go. Several future research directions are discussed.

Introduction

Blockchain is revolutionizing the way businesses handle their day-to-day operations. Most businesses rely on *centralized* transaction systems where the information is controlled by third-party organizations, instead of the specific entities involved in the transaction. Blockchain provides a *decentralized* platform where transactions can take place without the control and involvement of third parties. It is an open, distributed database where different participating computers (or nodes) validate the transaction which then gets added to a continuously growing list of the ledger (Iansiti & Karim, 2017). The validated information is available to every node, which adds to the transparency of the transactions conducted.

A main application of blockchain is cryptocurrency which eliminates the problem of double spending the same currency and increases the transaction security with the use of hash numbers, timestamp, and append-only decentralized system (Miraz & Ali, 2018). However, blockchain can be applied to different business sectors due to its security, reliability, transparency, traceability, inherent data provenance and immutability; it may also create new possibilities and applications in business.

Like other emerging technology in its nascent stage, blockchain has limitations that need to be addressed before having a major impact on business. For example, since nodes in the blockchain network can be anywhere in the world, complex jurisdictional issues may arise. In addition, every transaction requires peer-to-peer verification, which can become time-consuming with more data added. As a result, blockchain might be unsuitable for transactions where speed is of the essence.

Blockchain has received and is likely to continue receiving attention from researchers and practitioners. It is important to synthesize existing progress related to blockchain applications and research in business, in order to identify places needing future attention. Specifically, this paper seeks to understand the following two research questions (RQs):

> *RQ1: What are the applications that have been developed using blockchain technology in different business areas (i.e., accounting, finance and banking, information systems, marketing and supply chain)?*
>
> *RQ2: What is the current status of existing blockchain research in business?*

Understanding the above research questions help researchers and practitioners develop an overall understanding of existing blockchain applications and research done by different disciplines and point out places that need more future attention. To address the above research questions, a systematic mapping study is conducted in which 50 articles about blockchain are extracted from scientific databases. Several research gaps are identified, and future research directions are pointed out.

The rest of the paper is organized as follows. The research methodology is first introduced. Then we discuss the application of blockchain in five business areas (e.g., accounting, finance and banking, information

systems, marketing, and supply chain management); for each business area, we discuss the impacts of blockchain, early adopters, as well as implementation challenges and concerns. After that, we present a set of figures showing the status of existing blockchain research in business. In the end, we discuss research gaps identified from our review and point out several future research directions.

Research Methodology

The systematic mapping method

We adopted the systematic mapping study (or scoping study) as described by Kitchenham and Charters (2007) and Petersen et al. (2008) to identify, review, and summarize relevant research papers. The systematic mapping method is appropriate for this paper because our goal is to identify and map existing research and application of blockchain in different business areas (i.e., accounting, finance and banking, information systems, marketing and supply chain) and to identify possible research gaps. The systematic mapping method (Petersen et al. 2008) as well as our application in this paper is summarized in Table 1.

Table 1 Summary of Systematic Mapping Steps used in this paper

Steps	The application in our paper
Defining research questions	We defined our research protocol and narrowed research questions down to the two research questions mentioned earlier.
Searching for relevant papers	We used search strings related to blockchain and business areas to search scientific databases including Springer Link, EBSCO, ScienceDirect, and JSTOR. The papers we chose mainly focused on peer-reviewed, high quality research that was published in books, journals, conferences, workshop, and symposium. 97 papers were identified.
Screening of papers	• The first stage of inclusion and exclusion is based on the relevance of the titles of the selected papers to our research questions; we also excluded the following types of papers: papers in a language other than English, duplicate papers, and posters. After first stage screening, 60 papers were kept. • In the second stage of screening, we read the abstract to see if they focused on blockchain in business areas to decide whether the papers could made to the next step. 10 papers were excluded because they focused mostly on the technical workings behind blockchain or did not provide any actual or clear research findings or evidence. This resulted in the selection of 50 paper[1] which we included in our research as primary papers.
Keywording	We read all papers and identified the keywords and concepts related to different business areas to develop a higher level of understanding of the papers. After that, we formed clusters and categories for each of the business area.
Data extraction and mapping process	We created a data extraction form (Table 2) to collect the information needed to address our research questions. The extracted data were in excel to make it easy to organize and analyze the retrieved information.

Table 2. Data Extraction Items

Title	Title of the paper
Authors' name	Name of the author(s)
Publication information	Name of the publication place
Publication type	Conference, book, journal, working papers, thesis/dissertation, industry article/ magazines
Publication source	Industry or Academia

[1] A complete list of selected papers is available upon request.

Abstract	Abstract of the selected paper
Study aim	Aim of the selected paper
Field	Business area(s) focused in the paper
Study findings	Major findings of the selected paper

Research Findings and Discussion

RQ1: Applications of Blockchain in Business Areas

In the following, we discuss existing applications of blockchain technology in each of the business areas. For each business area, we will discuss the impacts of blockchain, early adopters as well as implementation concerns and challenges.

Applications of Blockchain in Accounting

Blockchain could make drastic changes in the field of accounting where constant records are kept regarding the various transactions made. The accounting area mostly focuses on accurately measuring as well as communicating financial information that the business needs to keep track of. Its major functions include record keeping, setting standards, proper application of complex rules and logic. Most of the ledgers kept in accounting are centrally controlled and follow certain methods to function properly.

With blockchain, the whole concept of how to do accounting will change. Blockchain is not a method to do the accounting processes but rather the platform on which you could perform such processes. With blockchain, control over records would be de-centralized in a manner that it would be consensus-driven (Bansal, et al. 2018). This means that the trust lies in the system and transactions would be more secure as past records cannot be changed without a consensus decision from all the parties involved. Since the records are permanent, this eliminates the chances of financial crimes which has been a problem faced by the accounting field (Piscini et al. 2017). Blockchain reduces the cost incurred in order to maintain and reconcile different ledgers. The history and ownership of assets will have absolute certainty; it replaces redundant work like bookkeeping and reconciliation so that accountants can focus on more important value-adding matters. With the help of blockchain, a faster accounting system can be formed, which will have fewer chances of corruption while constantly updating and modifying the records.

Blockchain ensures traceable audit trails, automated accounting and reconciliations, tracking of ownership of assets, and authentication of transactions by providing the source for verification. Accounting is based on the historical value of data and with blockchain; the data can be updated instantly without any security risk for modification. Blockchain is a distributed decentralized ledger technology which makes it difficult to break into as it is difficult to hack all the nodes in the network. This maintains a highly secured environment for performing different accounting functions. Blockchain allows real-time accounting system which enables real-time updating of transactions and eliminates the need for reconciliation (Potekhina & Riumkin, 2017). One of the features of blockchain is that the blocks are digital and time-stamped with cryptographic hash which creates a more authenticated and reliable transaction. Blocks in Blockchain are immutable and cannot be altered even by the system administrator which ensures greater data security.

Today accounting is referred to as quadruple entry bookkeeping, where double-entry is performed by a company where the two sets of entries are equal in value. Blockchain alters the current method in use as entries could be made directly on the blockchain (ICAEW, 2018). This new accounting that emerges from the use of blockchain in the field is called 'Triple Entry Accounting System.' In triple entry accounting, all the transactions are cryptographically checked and sealed, they occur simultaneously in the same distributed ledger, creating an interlocked and chained system of accounting records. It is called triple accounting bookkeeping because it includes three entries (the debit, the credit, and the cryptographic signature of the transaction) and three parties (the buyer, the seller, and the blockchain network). In this system, the transactions are cryptographically sealed which makes manipulating or destroying them practically impossible. This system possesses features including smart contracts, distributed ledger, double entry, cryptography, tamper-proof record, validated and secured agreements (Hambiralovic & Karlsson, 2018).

Earlier adopters of blockchain in accounting include the following companies:

- Ernst & Young first accepted Bitcoin as a method of payment. They launched pilot program "Blockchain Analyzer" that facilitate audit teams to review and analysis transactions on the blockchain, perform automated audit tests of assets, liabilities, equity and smart contracts.
- Deloitte developed client specific application using blockchain, they established a development team called Rubix that developed applications such as PermaRec. The application is a triple-entry accounting system that allows Deloitte to record transactions between their clients and quickly audit them (Andersen, 2016).
- KPMG launched the "Digital Ledger Services" program to help financial services companies investigate blockchain applications. "Blockchain Nodes" initiative was created by partnering with Microsoft, so as to identify new applications and usage for blockchain technology (Dai & Vasarhelyi, 2017).

Although blockchain provides many benefits to the field of accounting, it does possess certain implementation challenges. The high dependency of blockchain on the internet could hamper the smooth functioning of the system in case of an internet outage or improper infrastructure. Accounting largely depends on regulations and for blockchain to be properly implemented in accounting, there must be proper regulation in place. It should also have a flexible process so that any changes in regulation could be adopted quickly. For blockchain to be effective, it must be adopted on large scale by corporations or else it will be very limited (Mylaavaram & Mishra, 2018).

Applications of Blockchain in Finance and Banking

Financial and banking institutions process millions of transactions, keep records of multiple sensitive information related to the account and the account holder. For any financial institute to be successful, they need to be able to not only securely conduct the required transaction but also maintain the privacy of records. However, in today's world, with a rapid increase in cyber-crime, it has been a challenge for multiple financial institutions around the world to stop breaches in transactions and exposure of customer's valuable and sensitive information. (Shah & Jani, 2018).

Blockchain can be an underlying technology to solve the various existing problem in traditional banking and finance. Traditional banking provides homogeneous service in a uniform scenario which leads to poor customer experience. With blockchain, each service provided can be personalized as it allows point to point contact which would enrich customer experience. Today's banking and payment is dependent on many intermediary clearing firms that involves several processes, bookkeeping, transaction reconciliation, payment initiation, etc. The costs of these processes are high and generally lengthy. With blockchain, point-to-point payment can be implemented which would eliminate third-party intermediary institutions. This not only increases the service efficiency of the bank but also reduces the transaction costs. This also makes it easy to make cross-border payments. (Guo & Liang, 2016).

The current centralized banking system is not tampering proof as it can be hacked into and the personal information can easily be leaked. If the institutions using centralized system such as banks, switch to the decentralized system blockchain, there can be better and secure storage of files. This is because it would be difficult to hack into the system that uses asymmetric key encryption and automatic validation and there won't be accidental loss of files (Tilooby, 2018).

One of the most ineffective sectors in banking is the credit information system. There is a scarcity of good quality data to make personal credit judgments, with lacking proper inter-institutional data sharing and unclear ownership of user data. With data encryption done via Blockchain, users can control their data and establish ownership. This would make the data more reliable and reduces credit agencies the costs of paying for data collection (Trautman, 2016). The big data with personal ownership would become the credit resources required to make proper credit decisions. This would also ensure the safety of customer's identity and sensitive information. Blockchain's digitalized ledger would contain a full history of financial institution's transactions with its customers. These transactions are recorded within the system into several blocks that contain an individual's bank statement. Blockchain would make payment processing, transfer, settlement and trade much easier and safer with its key features as timestamp, immutability, traceability, and inherent data provenance.

Some earlier adopters of block chain in banking and financial area includes:

- Standard Chartered introduced Ripple, an enterprise-level blockchain platform, to implement its first cross-border transaction that reduced the settlement process time from 10 days to 2 days.
- JPMorgan, Royal Bank of Canada, Australia and New Zealand Banking Group have teamed up to launch a new initiative, i.e., the Interbank Information Network (IIN), to enhance customer experience and decrease the time and the costs involved with payment delays. The technology is powered by Quorum, a variant of the Ethereum blockchain allowing secure data sharing.
- State bank of India is introducing a safer banking option by implementing blockchain in their banking system. It has introduced Bank Chain, which is a community of banks in India that currently has 27 members in India and the Middle East. It is undertaken to increase the efficiency of transactions without compromising on data and transaction security.

The implementation of blockchain in finance also faces some concerns and limitations, i.e., integration concern, security and privacy concern, and initial cost, as summarized below.

- Integration concern: The existing centralized banking and finance system needs to go through significant change or complete replacement if Blockchain were to be implemented. This makes it difficult for the financial institution to switch to blockchain immediately, but they rather have to strategize and carefully plan the transition.
- Security and privacy concern: Membership to the blockchain needs to be restricted to users who have been subjected to required scrutiny and background checks. They ought to have real-world legal credentials and are unlikely to disengage. The communication between different nodes and their components need to be secure and the entire network must be resistant to internal and external attacks. Public key encryption must be enforced for details of transactions so that they cannot be compromised (Manta, 2017). There should be cross checks and audits to contracts in the initial phase where they are written so as to eliminate the vulnerability risk of the flawed program.
- Initial cost: Although Blockchain promises tremendous savings in transaction costs and time after its adoption, the initial capital costs to implement it are very high. Since it is still in a nascent stage, banks take it as a concern to make such a huge investment.

Applications of Blockchain in Information Systems

The information system is an essential part of many businesses as it is used to collect, store, and process data to provide information, knowledge about the firm and its environment. It helps organizations carry out vital operations, interact with their suppliers, customers, and gain a competitive advantage in the market. Information systems play an important role in running inter-organizational supply chains and electronic markets such as processing financial accounts, managing human resources, and managing their online business. Many major companies such as eBay (online auction marketplace), Amazon (electronic mall and cloud computing service), Alibaba (e-marketplace), Google (search engine) are built around the information system (Brandon, 2016).

Millions of transactions are collected, stored and processed electronically in corporate information systems. The information in an organization is usually kept in separate databases spread across multiple geographical areas. It is difficult to get a specific document on demand because of the various individual points that need to be contacted in order to retrieve the document. In the blockchain, all the records and information would be stored in a decentralized system where every node would have a copy of the record. (Sarkintudu et al. 2018). This allows the retrieval of information by any authorized stakeholder to happen at a faster speed.

In addition, the trustworthiness of an information system depends on its ability to maintain the confidentiality and integrity of the transaction. The information system must be available to any authorized parties to view the transaction as requested and in a timely manner. It should fulfill the "CIA Triangle" (i.e., confidentiality, integrity, and availability) of modern information security (Whitman & Herman, 2016). The interpersonal and inter-organizational relationships of business are fundamentally dependent on the reliability and trustworthiness of the information system.

Blockchain helps organizations preserve the goal set forth by CIA triangle. The decentralized system makes it difficult to gain unauthorized access to a large amount of information that is stored in different nodes and

protected with encryption and hash functions. The network of nodes become aware of any hacked data as the cryptographic hash will no longer match the data from other nodes. This helps reduce the risk associated with transferring transaction information and maintains the trust in the system. Third parties are usually trusted by organizations to handle their records. The financial records constructed by a bank, health record constructed by a hospital, educational records constructed by universities are usually maintained in third party repositories that are vulnerable to attacks and corruption. With blockchain an infrastructure can be created where no particular party will have full control or possess absolute power over the information. This means that no one can distort the available information. The technology liberates the organization from costly third parties and provides individuals with better control over their private records. (Beck et al. 2017)

A dominant application of blockchain in information systems is related to Internet of Things (IoT), in which a multitude of devices can be connected with each other, over a network, which helps initiate communication between machine and people. IoT has been applied to, for example, home automation, transportation, defense, and public safety (Fernández-Caramés & Fraga-Lamas, 2018). IoT requires large datasets that could capture all the real-world transactions. Having a centralized dataset would not be feasible and would not scale well. Blockchain can help solve this issue as it allows there to be a centralized hub that references the various distributed storage servers where dataset is stored and can be accessed or distributed. This is possible as every transaction creates a block which is broadcasted to all nodes, and once validated is added to the chain with references to the previous block.

Early adopters of Blockchain in Information Systems (specifically, IoT) include:

- Dorri et al. (2017) have proposed a new secure, private, and lightweight architecture for IoT, which is based on blockchain technology. The proposed structure is hierarchical, consists of smart homes, cloud storage and network that is connected to blockchain to maintain privacy and security while eliminating the overhead cost.
- Gupta et al. (2016) have proposed a secure electronic health records exchange using blockchain with consumers as ultimate owners. Only the metadata about health and medical events such as patient identity, visit ID, provider ID, player ID will be stored in the blockchain and the actual medical records are stored separately in universal health cloud.
- Xu et al. (2017) proposed Sapphire which is a storage system that works on a blockchain platform. It exploits the computing power of IoT device in order to execute software like smart contracts and to compute the data collected from a smart environment. It not only assures reduction of the data transfer on the IOT network but also improves the execution time. (Panarello et al. 2018).
- Alphand et al. (2018) proposed IoT Chain, which is a platform for IoT security management. It is made up of an authorization blockchain. The blockchain provides a flexible and trusted way to handle authorization. (Panarello et al. 2018).

Implementation concerns and limitations of using blockchain for Information Systems include:

- Scalability: Blockchain scales poorly as the number of nodes in the network increases. Since IoT devices are expected to contain billions of nodes in their networks, blockchain would not be able to function properly for such large networks (Zhu & Badr, 2018)
- Processing power and time: Blockchain usually has similar objects with high processing power to perform the encryption processes. Since IoT has different devices in the network, the processing power, and the speed to encrypt varies between the objects.
- Storage: Blockchain doesn't require a centralized system as the transactions are recorded in the nodes of the network. The devices in IoT would have the very limited storage capacity to record all the information generated.
- Lack of skills: Blockchain is still comparatively a newer topic and most people do not have a clear understanding of blockchain and what the technology can do. In order for IoT devices to properly adopt blockchain, the knowledge regarding the technology should be well imparted anywhere IoT is of significant use.
- Legal compliant: Since blockchain is a new decentralized system that allows anyone from any part of the world connect to it without any formal legal compliance in place. This could create hindrance for the adoption of blockchain in general and in IoT in particular.

Applications of Blockchain in Marketing

Marketing is one of the most essential functions of a business. Marketing plays a vital role getting product and services out to customers. Marketing is dependent on several factors, including the data collected for analysis and usage. This data help make important marketing decisions affecting business success. As there are multiple media of data collection available today, the availability of data has skyrocketed. This abundance of data, also known as Big data, deals with 4 Vs including volume, velocity, variety, and veracity (i.e., the reliability, accuracy, and transparency of data)—among the 4 Vs, veracity of the data is the biggest challenges faced in marketing because it is difficult to verify if a data comes from a reliable source and how accurate the data is. Blockchain technology can help solve the limitation related to the veracity of data to provide transparency in our data-driven society (Harvey, et al. 2018).

Marketers use third parties such as Facebook to gain valuable data about their customers. The costs of such third-party intermediates are high and sometimes the data collected might not be as reliable. Blockchain can help solve this problem for marketers by providing a single platform for consumers to share their information without going through an intermediary (Subramanian, 2018). For consumers to share such data, marketers can provide incentives in the form of cash, store credit or loyalty points. This would minimize the rate of inaccurate or incomplete customer data that is being collected, and reduce fraudulent activity related to data.

Another effective tool introduced by blockchain for marketing is smart contracts. They are virtual agreements that can be made without validation from third parties. With the use of smart contract, the marketer can enroll in data collection where it automatically rewards the customer for engagement with their email, website or links. This would create a direct link between consumers and markets without the need for a third party. Blockchain enables 'willingly consumed' advertisements that can verify ad delivery and consumer engagement. The overserving of emails that create customer dissatisfaction could be avoided using the technology and the irrelevant ads can also be prevented.

One of the biggest problems faced by marketers is mass phishing spam that discourages the customers and dilutes the effectiveness of marketing. About 135 billion spam email is sent, out of which only 1 reply is received. Setting up a micropayment incentive where a certain method of payment is given directly to the recipient of an email with the help of blockchain would eliminate the problem. This would also help identify and retain customers interested in the product and service. Blockchain allows fraud verification, which would help verify the origin and methodology of marketers that create transparency and build consumer trust. Companies that have earned consumer trust would be given greater access to consumer's personal information.

Verification of online authenticity is made possible with Blockchain. The bots cannot automatically set up fake social media accounts and send misleading messages to users. This would allow marketer to reach their target audience without first having to check their authenticity. The impact the marketing would have on its target group would be easier to track which would justify the marketing expenditures as well.

Blockchain empowers individuals to create relevant works that would proportionally be valued by their success. The artist can proclaim their art and have control over it if there is a ledger with digital documentation of rights to the works of art. This will eliminate the existing problem of theft of online content and enable automatic payment for the use of their artwork.

The modern data-driven marketing is made more transparent with the integration of blockchain technology as a consumer's journey is analyzed and validated through verified ad delivery. This confirms that a real person saw the ad as per the specifics of a media contract. There will be proper control and delivery of assets by marketers as they can monitor ad placement, alleviating ad fraud from automated bots and ensure the authenticity of consumers engaged with the ads.

Early adopters of blockchain in marketing include:

- Coupit is a company that made it possible for marketers to differentiate between dormant and loyal customers. For that, it employed a blockchain-based technology that allows marketers and customers to become part of loyalty programs where they can trade rewards with each other (Ghose, 2018). The knowledge of the different customer base helps them send over targeted material to each group differently.

- Brave is a web browser that uses Basic Attention Tokens (BATs) with the help of a blockchain platform. It provides better privacy as it allows publishers to monetize value-added services and capture growth related to advertising. (Ghose, 2018). It helps to remove the involvement of third parties such as Facebook or Google.

Implementation concerns and limitations of using blockchain for marketing include,

- Scam generation: The incentives offered to interact with advertisements might lead to people creating multiple scam accounts or providing fake information.
- Slower speed: Because of its distributed nature, validation of transaction takes between 10–30 seconds. This restricts it from validating transactions that occur in milliseconds such as advertising technology transactions.

Applications of Blockchain in Supply Chain

Blockchain is expected to have a significant impact on supply chain. Supply chain processes consists of a network of individuals, organizations, technology, resources, and activities that initiates from product manufacturing to the end delivery to consumers (Min, 2019). One of its goals is to deliver or get the product in the right condition, in a timely manner, at the lowest costs and to reduce possible risks. The decentralized blockchain will help achieve supply chain management (SCM) benefits related to cost, speed, sustainability, quality, flexibility, dependability and reduction of risk by increasing the transparency and accountability. In the area of the supply chain, we have already seen drastic technological influences with the latest innovation including radio-frequency identification (RFID) tags, sensors, barcodes, GPS tags, and chips. The technology has proven to be supportive in several stages of the supply chain to allow real-time tracking of the location of products, packages and shipping containers at each step (Apte & Petrovsky, 2016). The supply chain process is expensive and cumbersome as it involves massive record keeping with manual verification. There is a lack of proper traceability and accountability that can lead to immense overhead costs.

One of the key characteristics of blockchain is identity management. With this function, actions in supply chain can be directly linked back to the accountable entity. This improves the dependability of supply chain, as it demands partners involved to become more responsible and accountable for their actions. The key outcomes and performance of the SCM process can be effectively measured and validated with blockchain as the input tracking data that goes into the ledger become immutable (Yingli, et al., 2019). The shipments, deliveries progress can be easily tracked by multiple suppliers that help build trust among the suppliers. This allows individual suppliers to perform their own checks and balances in real-time without having to wait on the reports from middleman auditors.

Blockchain eliminates the risk of poor-quality products as the data for a certain product can be tracked during the entire transportation process (Dills, 2018). The data on the travel path can be constantly updated in the blockchain system which informs the suppliers if the product was in a wrong place or in a certain location for too long (Norberg, 2019). It helps to identify risk sources to avoid risk by avoiding shipping routes with high sea piracy or avoiding seaports vulnerable to frequent bottlenecks and labor strikes.

Blockchain can help reduce supply chain costs by eliminating the manual paper-based processes and human carrying documents as air courier expenses. All the documents can be fully digitized and can be tracked. The certification processes in the supply chain can be automated which allows the right amount of resources to be allocated to perform related activities. In today's world, consumers are becoming more concerned about the sources of their food and beverages. Blockchain helps to verify the sustainability by making it more quantifiable and meaningful with the accurate immutable data stored in the system.

Blockchain helps shippers and receivers ensure that proper drivers and trucks arrived to pick up or deliver a shipment. Since all the complete information about the shipment such as the driver's records, truck description, licenses, and certificates will be stored in the system and made immutable, it mitigates the risk of cargo theft. The backtracking of the shipment would also be quick and easy.

Early adopters of blockchain for Supply Chain include the following:

- Trade lens: An open platform proposed by Maersk and IBM to implement wider blockchain co-operation along the global supply chains. It will help with digitizing documentation, connecting sources as port and terminal operators, customs authorities, freight forwarders, transportation and logistics companies to form a more efficient, predictable and secure exchange of information in order to foster greater collaboration and trust across the global supply chain.
- Food trust framework: Blockchain based framework proposed by Alibaba along with AusPost, Blackmores, and PwC to fight fraud in the food industry such as selling lower quality foods and food with counterfeit ingredients. The major goal is to improve integrity and traceability that can be used by everyone participating in the global supply chain from the suppliers of raw material to the end consumers.
- Pharmaceutical drugs safe delivery: A pilot program introduced by Swiss startup Modum and the University of Zurich for the pharmaceutical industry. It deals with the blockchain-based delivery protocol for safe delivery of pharmaceutical that needs to be transported under exact temperature, humidity and light conditions in order to ensure usability. Currently, the system is focused on monitoring the temperature of the ambient products that do not require refrigeration. The data related to the medicines is transferred to Ethereum blockchain once it reaches the destination. The solidity based smart contract compares the data against various regulatory requirements and the product is released only after the conditions are fulfilled or else the concerning parties are notified of the deviation.
- Walmart: Walmart teamed up with IBM to trail-test a service that could monitor products from suppliers to the end consumers. The first project tracked products from Latin America to the U.S. and tracked pork products in the Chinese market. With blockchain, the digital tracking of individual Chinese pork products and mangoes from Latin America reduced to a few minutes (2 minutes and 2 seconds), compared to many weeks it would take with non-blockchain technologies. It also provided detail information about the farm, factory, batch number, storage temperature, and shipping information. This helps to assess the authenticity of products and if there is any danger of food contamination; it also helps with pinpointing the specific products for recalls rather than recalling the entire line.

There are also some concerns and limitations for the implementation of blockchain for supply chain. The global supply chain is a complex process with different parties that need to comply with diverse laws, regulation, and institutions. Since the established laws, customs and institutions are managed by human beings spread internationally, it is a complicated task to implement a blockchain based solution as it would be difficult for all the relevant parties altogether. It may also increase the vulnerability to attacks, as it would be easier for the hacker to target a few nodes in the network.

Blockchain system can only fully thrive in an environment with a high degree of computerization. This is difficult to achieve for developing countries due to the lack of proper infrastructures. Since the global supply chain partners are scattered around the world, including the less developed countries, the blockchain system cannot be adapted and used to its full potential.

Blockchain may impose some threats to competitive advantage. Blockchain provides transparency to the customers but also to the company's competitors which makes it difficult for a company to achieve competitive advantage as its information would be available to its competitors. This might also promote competitors to damage the existing relationships that a company has with its vendors, as they will be able to view such company relationships.

Finally, another potential concern is the 51 percent problem, i.e. any company that has more than 51 percent of processing power involved in the mining of blockchain would ultimately have full control over the transactions in the supply chain.

RQ2: What is the current status of existing blockchain research in business?

In this section, we will first provide an overview of the selected papers, with a focus on publication date, publication source, publication types and the related business fields. We will elaborate on the current research status, research gaps and future research directions in the discussion section.

Figure 1 shows the distribution of selected papers by publication year. All selected papers were published after the year 2015. This reflects that Blockchain is a fairly new concept for research in Business. However, the papers that focused mainly on Bitcoin and technical working of blockchain date (which were excluded from this study) was published as early as 2012. When we pay closer attention to the publication year, we can see that out of all the selected papers, only 3 papers (6%) were published in 2015, 8 papers (16%) in 2016, 12 papers (24%) in 2017, 23 papers (46%) in 2018, and so far 4 papers (8%) in 2019[2]. This shows an upward trend with an increasing number of papers each year, which suggests that there is a growing interest in blockchain technology in different business areas.

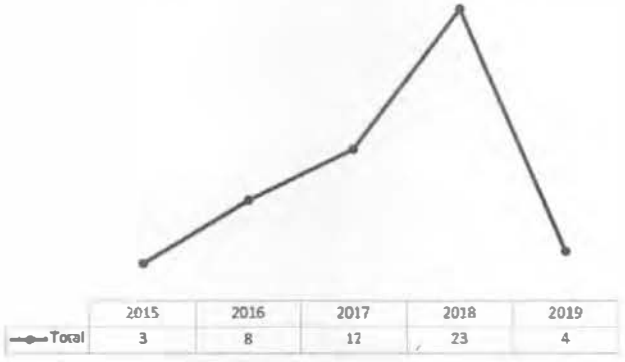

Figure 1. Publication Year of Selected Papers

Figure 2 provides a summary of the publication sources (academia or industry). Academic sources are the ones written by experts in the field for the audience who are familiar with the topic in order to make the research available to the scholarly world. Industry sources are the ones written by free-lance or scholars for the general population with little to no familiarity with the topic in order to provide general/ informative information about the topic. Our result showed that 40 papers (80%) were published by academic sources, 10 papers (20%) were published by industry sources. Please note that the results might be due to the tendency for scientific databases to not include industry papers.

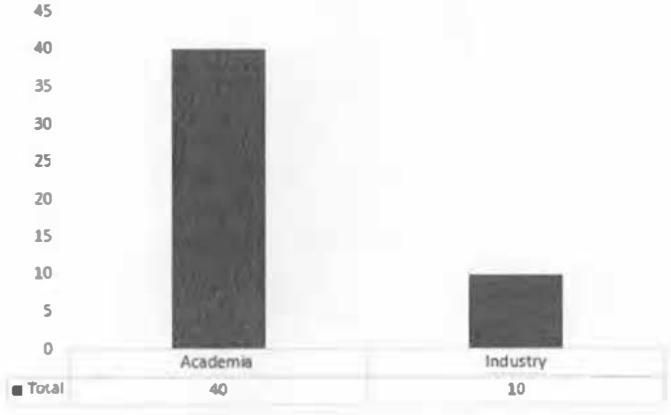

Figure 2. Publication Source of Selected Papers

Figure 3 shows the different publication types (i.e., the channel where the paper is published, as listed in Table 2). Most of the papers were published in journals (52%) or industry article/magazine (20%). The other types include working paper (10%), book (6%), thesis/dissertation (6%), and conference proceedings (6%).

[2] The data for 2019 is only for the first 4 months and it is likely that more papers will be published before the end of the year.

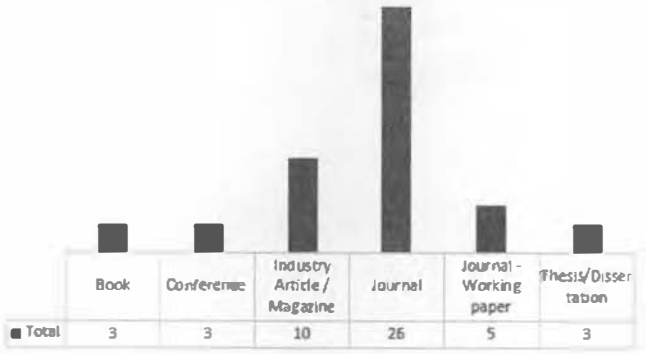

Figure 3. Publications Types of Selected Papers

The distribution of business fields related to selected papers is shown in Figure 4. The largest number of papers were published with the IS filed 15 papers (30%) with 11 papers focused on Internet of Thing (IoT), and supply chain with 10 papers (20%). The accounting field had 7 papers (14%), the finance field had 8 papers (16%), marketing had 2 papers (4%), and there were 8 papers (16%) that talked about the use of blockchain in general business setting.

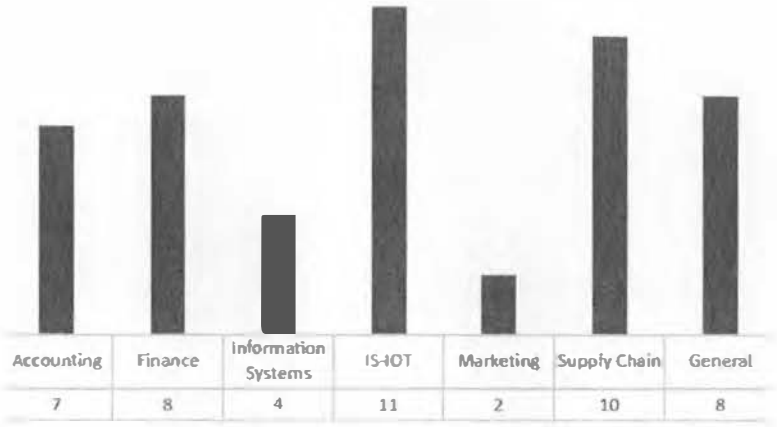

Figure 4. Publications by Different Business Fields

Discussion

Using the systematic mapping method, this paper seeks to understand the applications and existing research status related to blockchain in business areas (i.e., accounting, finance and banking, information systems, marketing and supply chain). Our study shows, first, that there are a number of journal articles on blockchain; in addition, there are quite a few industry articles and thesis/dissertation articles that focus on the application of blockchain in business areas. Most of these publications are made by academic (rather than industry) sources.

As to the distribution of papers across displaces in business, many research papers focuses on the application of blockchain in information systems (mainly IoT), followed by the application in the supply chain area. There are fewer research papers focusing on blockchain applications in accounting and finance and even fewer papers focusing on the marketing field.

As to the topics examined, supply chain research mainly focused on topics regarding the use of blockchain for supply chain sustainability, risk management, resilience, distributed data-driven application systems, and excipient supply chain. Information systems research, on the other hand, focused on topics of collaborative blockchain, operation management interface, proof of work, machine economy, and IoT

dataset. Finance research mainly focused on topics such as financial blockchain technology, fintech, virtual currency, sustainable development, and banking industry transformation. Marketing research focused on the use of blockchain for programmatic marketing, data veracity, data-driven marketing, and consumer satisfaction. Finally, accounting research focused on blockchain accounting, triple-entry accounting, request network, real-time accounting, automated audit future accounting and assurance, and credit risk modeling.

Research Gaps and Future Research Directions

One of the research gaps that we identify when conducting the review is the abundance of research papers on bitcoin and the relative lack of research focusing on the business areas, especially in the fields of marketing and accounting. Since both fields are likely to be heavily impacted by the implementation of blockchain, further research needs to be conducted. In addition, due to the complexity and fundamental changes that may be introduced by blockchain to different business fields, future research directions for blockchain in different business areas may be varied and it would be interesting to see where each business area is heading. Since the 2018 cryptocurrency crash, bitcoin's popularity has significantly declined. Academic and industry researchers are more interested in understanding the application of the fundamental technology behind blockchain from both business and technical perspectives. We believe that as more businesses start using blockchain in their day-to-day functioning, it will generate a significant amount of new research regarding the adoption of blockchain technology in different contexts. As the blockchain scope and user base increases, more attention needs to be paid to overcoming implementation limitations and challenges (e.g., the scalability issues) discussed earlier. The security and privacy issues would be especially important, as more and advanced attacks are likely to target the blockchain network with its increasing popularity.

The second research gap we identify is that most research focuses on blockchain application by companies (especially large companies). If the adopters were small-medium sized companies or teams or even individuals, would our existing understandings about blockchain hold or not? Accumulated knowledge in information systems indicate that factors affecting individual versus team versus organizational attitudes and behaviors (e.g., adoption) towards an innovation are likely to vary (e.g., Hwang 2005; Park, Lee, & Yi, 2011; Venkatesh et al 2013). Hence, future research should examine attitudes and behaviors towards blockchain at different levels of analysis.

The third research gap identified is that most of the current studies focused on the technical aspect of blockchain. The behavioral and regulatory aspects related to blockchain need more attention. For the behavioral aspects, researchers could study, for example, what factors (e.g., individual or organization or industry or cultural characteristics, blockchain characteristics, network externality) (e.g., Venkatesh et al 2003; Venkatesh and Zhang, 2010; Veiga et al 2001) influence the (initial and continued) (e.g., Bhattacherjee & Premkumar, 2004) adoption and implementation of blockchain? How the different concerns mentioned earlier (e.g., concerns for privacy) affect adopters' attitudes and behaviors towards blockchain? Does the blockchain technology exhibit the same bandwagon pattern as we have seen with other popular innovations (e.g., Abrahamson & Rosenkopf, 1993)?

In addition to the behavioral aspect, the regulatory aspect (i.e., industry or national regulations) also deserves more attention. For example, Chinese government imposes restrictions on the amount of money that individuals and companies could transfer to overseas. What kind of challenges would blockchain bring to such regulation? In addition, when disputes arise regarding transactions that happened on blockchain platform, what kind of authority (if any) could help to settle the dispute?

Finally, we noticed that the majority of blockchain applications in different business areas are still in the experimental or pilot phase. There is limited data published related to the success or failure of blockchain in different business fields. Future research should continue looking for such data. Also, researchers may examine market responses (e.g., stock market price change) to companies announcing the adoption and implementation of blockchain (e.g., Wang, 2010).

Conclusion

As an emerging and in-fashion technology, blockchain, a decentralized, distributed ledger, where transactions are validated by the participating nodes and are visible to everyone on the network, as quite some attention in academia and industry. Using the systematic mapping method and extracting 50 primary papers from various scientific databases, this paper conducts a systematic review to understand the applications and current research status related to blockchain in different business areas. Research gaps are identified, and future research directions are pointed out.

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