Title: Blockchain Literature: A Bibliometric Study

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Abstract

This paper presents the current trends of studies on blockchain and provides journal citation reports. For example, the report includes the number of citations, and how many articles have been published yearly, etc. The publications are searched in three databases namely IEEE Xplorer, Scopus, and WebofScience. The study shows that 69 publications including journal and conference papers have been published over four years from 2013 to 2016. The report also indicates that approximately 64% of the total publications has never been cited. Conversely, two papers have been cited more than ten times while 12 articles have been referred to less than ten times.

In addition to the citation Journal reports, the results from the search engine will be analysed to identify the recent techniques, applications, commercial research regarding the use of blockchain technology.

1. Introduction

Blockchain is a technology behind Bitcoin, a cryptocurrency which has gained popularity since its creation in 2008 by a Japanese programmer, Satoshi Nakamoto. The success of Bitcoin is down to its nature as a decentralised system which allows users to transfer bitcoins from machine to machine without official authorities (Decker & Wattenhofer, 2013).However, the field of blockchain did not draw attention from researchers until 2013. There were only two publications of blockchain research in 2013, but this research interest began to grow gradually. The result also shows that the majority of the research articles are multiple researcher teams. The publications demonstrate several areas regarding the practice of blockchain.

One of the areas where blockchain technology has been proposed is in the financial sector. For instance, the technology is being proposed to cut down the operation cost and speed up the payment transactions because blockchain enables transactions to be done without the presence of authority. On the other hand, other studies show that the technology can be used in the management industry which adopts smart contract protocol. For example, Ujo Music allows artists to use smart contracts for licensing by storing their music files, recording royalties, and

work of contributors. In addition to its use in contractual management, blockchain is also applied in the public sector to track and validate land and property transactions. As a consequence of blockchain discussion, this bibliometric study will give necessary information about blockchain technology which can be beneficial for researchers who wish to conduct future research on the blockchain subjects.

The following sections of this paper will be categorised into three main sections. Firstly, the methodology of blockchain is presented. Secondly, the paper examines the trends of the blockchain study provided by the growth in literature, authorship pattern, citation pattern and blockchain core journals. Thirdly, it discusses the current practice of the blockchain technology by splitting the section into three subsections namely blockchain technology, blockchain applications and blockchain in the financial areas. Finally, the conclusions and future work will be presented.

2. Methodology

This paper will use bibliometric as a tool to analyse a pool of publications providing statistical data. The data consists of article titles, authors, publication titles, year of publication, the number of pages, article citation count, number of references. The query keyword for this study is "blockchain" starting from 2008 to 2016. The search shows that there are 32 results returned from the IEEE Xplorer database, 88 records from Scopus and 30 records from Web of Science. Overall, there are 150 publications from the three databases for the blockchain bibliometric study. However, there are only 69 distinctive publications because other 81 publications were published in more than one database.

3. Results

3.1. Growth of Blockchain Literature

Blockchain, the mining engine of Bitcoin was established in 2008 by a Japanese programmer. However, there had not been any publications regarding its technology published until 2013, the first journal paper released by Moser, Bohme, and Breuker (2013). Following the first publication, another journal paper by Decker was also published afterwards, ending up only two publications in the year of 2013 (Decker & Wattenhofer, 2013). The growth of publication then

continued from 2014 with 6 articles, 24 articles in 2015 and 36 articles in 2016. The growth over the last 3 years means blockchain has substantially drawn more attention from researchers. (*The number is shown in Figure 1*)

The cumulative of blockchain publications can be defined as $Y = 1.834\ X^{2.578}$, where Y is the cumulative number and X is the number of years. According to the model, it can be estimated that the number of publications will be 1.8 in the year 2013, 10.9 in 2014, 31.1 in 2015, 65.3 in 2016 and 116.2 in the upcoming year 2017. (*The number is shown Figure 2*)

Among the total of 69 publications, 14 are published in 13 journals, and 55 are published as conference papers. The 4-year publications have been written by 166 authors. Therefore, on average, there are approximately 17 publications released by 41 authors each year.
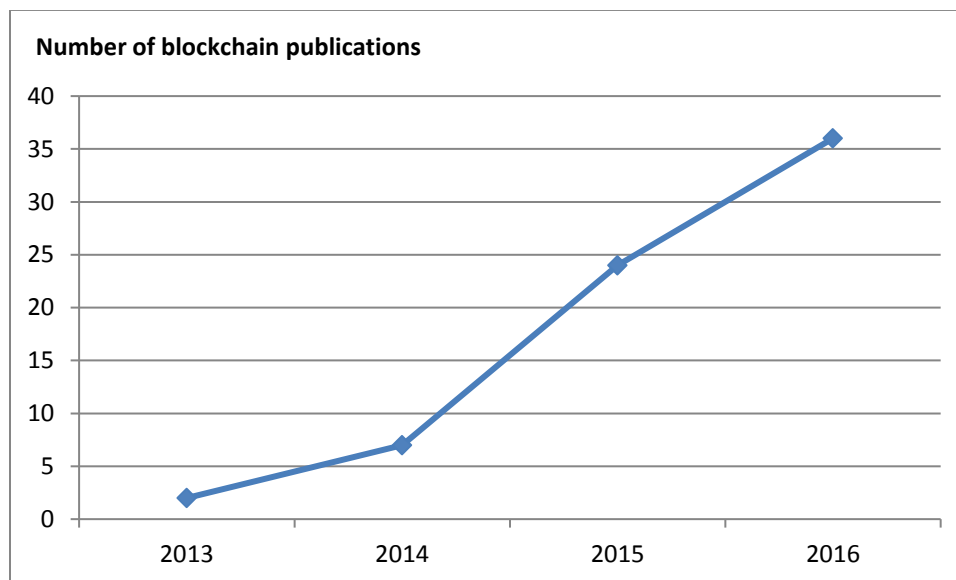
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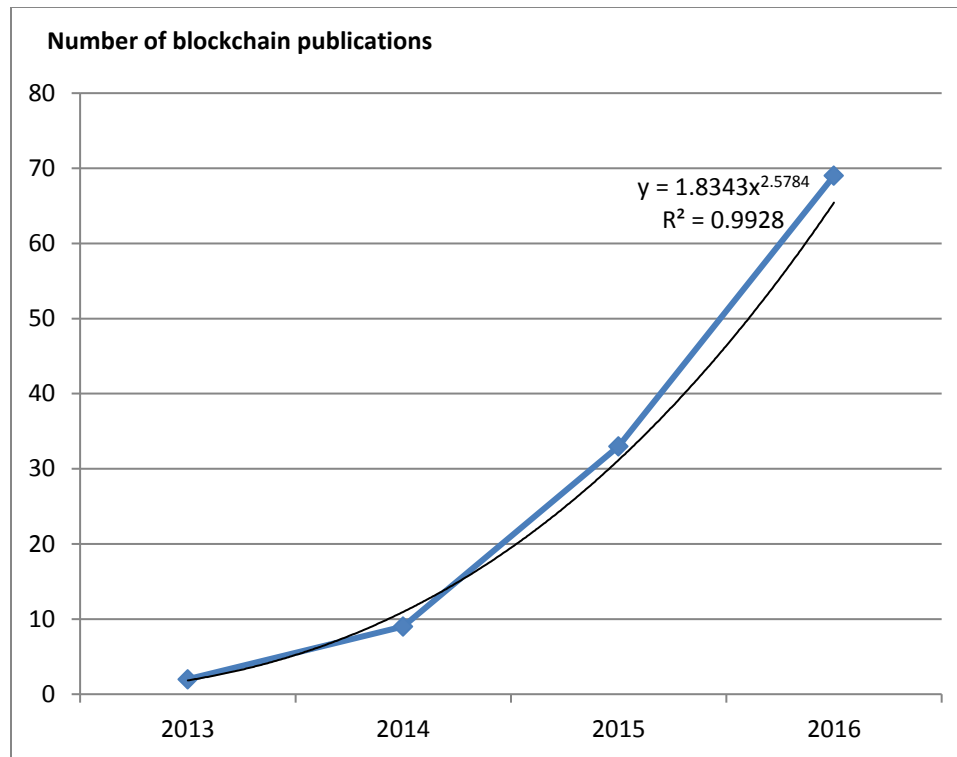
Figure 1: Growth of blockchain publications

Figure 2: Cumulative of blockchain publications

3.2. Authorship Pattern

The study shows that the largest number of the publications is contributed by the two-author partnerships, account for 33.33%. On the other hand, 20.29% are contributed by single authors. The analysis also indicates that the figure for the publications by three authors is comparatively small, account for 13.04% which is slightly below one-third of the publications by two authors. While there is a minor increase in the number of publications of four authors, the figure for publications of more than five authors drops again at 14.49%.

Overall, the research by two authors is relatively popular compared to the research by single authors. In contrast, the multiple researcher partnership is less preferable in the study of blockchain. (*The data is shown in Figure 3*)

No	N. of Authors	N. of Publications	%	Cum%
1	1	14	20.29	20.29
2	2	23	33.33	53.62
3	3	9	13.04	66.67
4	4	13	18.84	85.51
5	5+	10	14.49	100.00
	Total	**69**	**100.00**	

Figure 3: Authorship Pattern

3.3. Most Productive Blockchain Authors

The most creative authors will be measured as the authors who have released at least two publications in blockchain research. According to the compiled database, the analysed data shows that there are nineteen most productive authors in this field. On the other hand, most research was carried out by Fujimura who outnumbers other authors with five publications following by Akutsu, Decker, Kishigami, Nakadaira, Watanabe, and Wattenhofer with four articles. The least productive authors with two publications are Ateniese, Giaglis, Miyazaki, Moser, Norta, Seidel, Sirer, Tsai, Wen, Zhang, and Zhu.

3.4. Citation Pattern

The report shows that 44 publications, which are equivalent to 63.77%, have never been cited for the last four years. On the other hand, 11 (15.94%) articles have been cited once. There are six journal articles (8.70%) which have been cited twice. Similarly, the other six journal papers have been cited between three and 10 times. The two most cited articles have been referred to from 11 to 20 times. (*The statistics are shown in Figure 4*)
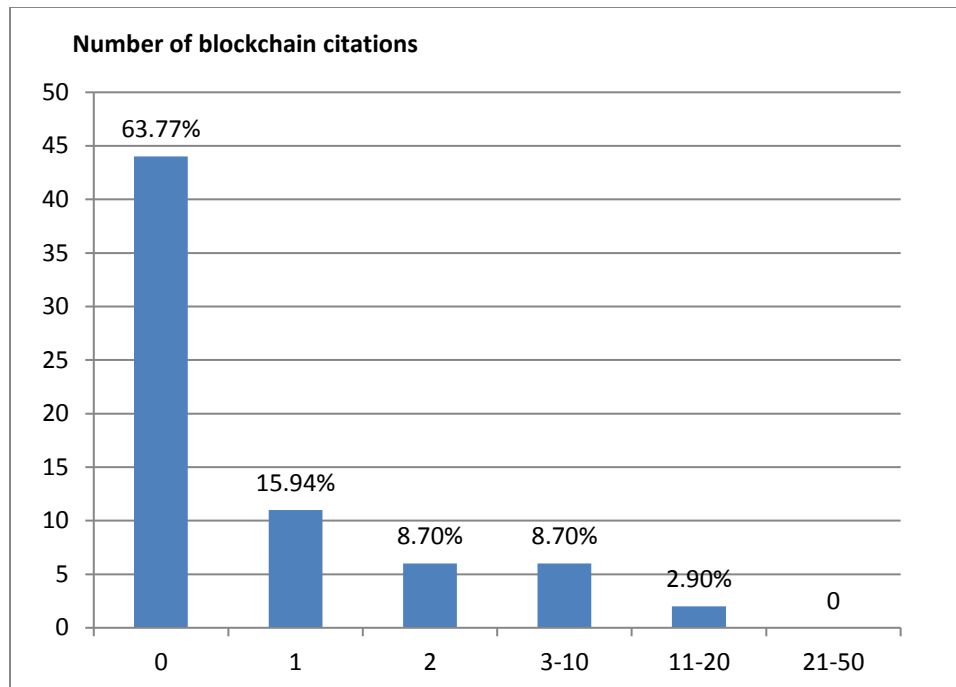
Number of blockchain citations

Figure 4: Citation pattern

3.5. Blockchain Core Journals

Among the 13 journals, the Peer-to-Peer Networking and Applications is the leading journal with two publications. In contrast, one publication was published by Duke Law Journal, F1000Research, Future Internet, Huazhong Keji Daxue Xuebao, IEEE Access, IEEE Communications Surveys & Tutorials, Independent Review, Journal of Business Ethics, Telematics and Informatics, TripleC, Zhongguo Dianji Gongcheng Xuebao, and Zidonghua Xuebao/Acta Automatica Sinica.

4. Recent Practice

4.1. Blockchain Technology

Many researchers are interested in using blockchain technology as a solution to solve problems in various industries. Rather than a system for a cryptocurrency, blockchain is widely developed with other purposes (Watanabe et al., 2016). According to the recent studies, the blockchain technology is used to apply for other areas such as the contract management, Internet of things, identification systems, voting systems and data privacy management.

4.1.1. Smart Contract

Smart Contract is a technology which allows users to convert from paper-based contracts into digital contract forms (Mattila, 2016). For example, Smart Contract converts contractual clauses such as bond and collateral into computer codes and store in software or hardware (Christidis & Devetsikiotis, 2016). For this reason, the contracts made are just between the two parties without the presence of the third party making the reduction of cost.

The technology has extended its practice from e-commerce to automated access control (Mattila, 2016). For instance, a car dealer can withdraw access from the buyer if the buyer is found not fulfill the payment properly. In addition, the smart contract technology is also suggested for the music industry. For example, Ujo music is a recording service company which uses smart contracts based on the concept of blockchain to enable artists to record their music files, royalties, and contributors. The revenues from every digital download in a digital currency will be sent to associated contributors via the smart contract (Mattila, 2016).

Watanabe et al. (2016) propose the hybrid blockchain method which uses the combination of the proof-of-stake and credibility score concept in the digital rights management. Proof-of-stake is an algorithm of verifying a new block which is chained with a previous block. The algorithm is similar to proof-of-work, however, it consumes less computing power. Conversely, the credibility score is a method which defines the number of parties who a contractor associates with. Based on the two algorithms used, the hybrid approach can detect illegal contract alterations attempted by attackers. The detection is very important to ensure the credibility of the contractors (Watanabe et al., 2016).

4.1.2. Internet of things

Internet of things (IoT) is a network platform where all devices can be interconnected at anytime and anywhere (Ray, 2016). However, the current model of IoT is costly in terms of supporting system maintenance. For instance, it is costly for a device manufacturer sends the software updates to a large number of devices up to millions of devices (Christidis & Devetsikiotis, 2016).

On the other hand, the manufacturer can solve the problem by connecting all the devices in the same blockchain network and each device uses smart contracts to store a hash code of the latest

firmware. The clients then can retrieve the new firmware updates with the hash on the blockchain network (Christidis & Devetsikiotis, 2016).

Moreover, blockchain technology offers a distributed platform which allows all the network users communicate each other without relying on any trusted party certify the users (Mattila, 2016). For this reason, the combination of the existing IoT features and blockchain can lead to the innovation of building a marketplace where devices can share their resources and charge fees for their services by cryptocurrency (Christidis & Devetsikiotis, 2016).

4.1.3. Identification and Reputation Management

Besides the contractual management and IoT business innovation, the blockchain technology has also seen its potential use for identification tracking purposes.

Tian (2016) proposes the use of blockchain technology with RFID to create a tracing system which records all the reliable sources of food information in the agricultural sector, China. The main purpose of the system is to ensure food safety.

Yasin and Liu (2016) present a systematic framework which is based on smart contract for collecting identities of people in social media websites to analyse their real personalities by their digital reputation. Digital reputation can be defined as "the general public feeling or sentiment about a product, person or service" (Hearn, 2010). For example, YouTube provides its viewers with the "like" and "dislike" feature, and Amazon let the buyers make comments on their buying experience (Liu & Sun, 2014). Because the user's real personality is different from their online personality, the result from the digital reputation study is useful for companies to get real and valid feedback from their clients (Yasin & Liu, 2016).

4.1.4. Online Voting Systems

Because blockchain has the characteristic as a public system with anonymity, the technology can be used to build a voting system by emulating the concept of transferring a cryptocurrency with sending personal votes to the election poll (Mattila, 2016). This mechanism allows the voters to verify their votes assuring fair election and democracy (Mattila, 2016).

4.1.5. Data Privacy Management

As collections of personal information have been widely used by companies or governments for commercial purposes, data privacy remains a concern among social network users (Navuluri, Mukkamala, & Ahmad, 2016). To reserve privacy, users should have been given rights to manage their data instead of relying on third parties (Zyskind, Nathan, & Pentaland, 2015).

Without having to damage the service provider's security control, the blockchain technology is proposed as an access control manager to keep and manage all the data in a blockchain. First of all, users are given an encryption key to encrypt all the data before sending to the blockchain. To manage privacy, users can set permission on their data in the blockchain. Therefore, when service providers or third parties want to query the data, blockchain will verify the request via a digital signature confirming whether the data is requested by the owners (Zyskind et al., 2015).

On the other hand, the blockchain is also proposed for developing authentication protocols in personal clouds which every data control is in the hand of users (Faisca & Rogado, 2016). The reason for developing personal clouds is because relying on service providers causes concerns over data privacy and security. In this proposed solution, blockchain can be used as a distributed storage to store registration data including key-pairs. Conversely, JSON data format is used to carry user's authentication information (a signature included). When a user sends a request to the cloud, the blockchain verifies the user's signature with its corresponding key. Therefore, without having to login, the authentication process can be validated securely (Faisca & Rogado, 2016).

4.2. Blockchain Applications

4.2.1. E-commerce Rating System

It is a blockchain-based reputation system which is built to allow the product buyers to rate the sellers on e-commerce applications (Schaub, Bazin, Hasan, & Brunie, 2016). Without the involvement of the trusted third parties, the rating system is truly decentralised. There are three parties involved in the system namely sellers, buyers and participants.

The system uses blockchains to create a distributed database which stores all the information regarding customers' rating. Each transaction made in the blockchain will form a block. A participant will be rewarded with a coin for verifying the transaction made by the buyer.

Therefore, the seller will earn reputation only after the block has been verified. This mechanism will prevent the seller from creating fake reputation (Schaub et al., 2016).

4.2.2. Electronic Registration System

The electronic registration system is a security interest system which records loans and interests of banks' borrowers in the United States (Gerstl, 2016). The system has been modernised from paper-based to a computerised system which uses blockchain to integrate the databases from the 50 states into a single distributed database. As the blockchain proof-of-work underlies its security strength, an unsatisfied borrower or a hacker cannot alter the records of loans (Gerstl, 2016).

4.3. Blockchain for financial applications

Despite its practice in the management industries and other technology areas, blockchain technology has attracted banks because of its advantages. A lot central banks in Australia, the UK, China and the US have made statements about the adoption of accounting ledgers based on blockchain (Tsai, Blower, Zhu, & Yu, 2016).

The analysis from the banking sector states that the blockchain might have a positive impact on cross-border payments, business-to-business and peer-to-peer payments because of the removal of middlemen (Meijer, 2015). In addition, blockchain technology can mitigate the complexity of IT infrastructure replacing expensive databases and middleware interfaces and providing security against frauds (Tsai et al., 2016). As a consequence, the banks will be able not just to reduce customer frees but also the spending on expensive hardware and software.

Conclusions

This bibliometric study provides recent knowledge of blockchain technology for future researchers who wish to conduct research on blockchain in accordance with their fields of interest. The study offers statistical data of the blockchain study trends from 2008 to 2016. The results of the research show that there are 69 publications as a compilation from three databases namely IEEE Xplore, Scopus and Web of Science. The data analysis concludes that the publications of blockchain will grow as determined by an equation of $Y = 1.834 \, X^{2.578}$, where Y is the cumulative number and X is the number of years. The findings also show that 44

publications have never been cited, 11 papers were cited once, and 14 articles were cited more than once.

In addition to the citation reports, this study also discusses the current practice of blockchain. The implication of blockchain is classified into three categories namely the technology, applications and financial applications. The findings show that the majority of researchers are interested in proposing blockchain techniques for various areas of management such as contractual systems, identification systems, voting systems and data management. At the same time, central banks and financial institutions also see the potential opportunities of blockchain in transforming the financial systems by hoping the technology will offer the high level of security against threats as well as the cost alleviation (including customer fees, hardware and software).

Future work will be the study on applying the blockchain technology in the payment systems in the banking sectors. As crossed-country banking system might have different banking infrastructures, blockchain would be a potential solution to integrating payment systems from different regions. It would speed up payment settlements as well as to reduce the payment transaction fees if blockchain technology was to address the integration issue.

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