Blockchain: The Introduction and Its Application in Financial Accounting

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INTRODUCTION

Listed companies partially reduce information asymmetry with outside information users by regularly providing financial statements audited by independent auditors. However, the existence of agency problems weakens the active role of financial accounting and independent auditing in resolving information asymmetry (Healy & Palepu, 2001). As a decentralized ledger technology (hereafter DLT), the blockchain technology has characteristics of transparent, secure, permanent, and immutable (Antonopoulos, 2017; Narayanan, Bonneau, Felten, Miller, & Goldfeder, 2016), and it has the potential of enhancing the trust between market participants. Yermack (2017) discusses the potential implications of using blockchain technology in corporate governance. This article mainly discusses possible impacts that the application of blockchain technology could have on financial accounting and its potential influences on independent auditors and financial accountants.[1]

This article argues that the application of blockchain technology in financial accounting is progressive due to its problems of limited data processing capacity, information confidentiality and regulatory difficulties. Firms could use blockchain as a platform to voluntarily disclose financial and nonfinancial information in the short run. It is a high-quality signaling that enables firms to solve the trust problem with outside information users. In the long run, the blockchain technology and smart

Blockchain, as a decentralized ledger technology with characteristics of transparent, secure, permanent and immutable, has been applied in many fields such as cryptocurrency, equity financing, and corporate governance. However, the blockchain technology is in the experimental stage and has several problems to be solved including limited data processing capacity, information confidentiality, and regulatory difficulties. This study sheds light on the potential application of blockchain technology in financial accounting and its possible impacts. We argue that in the short run the public blockchain could be used as a platform for firms to voluntarily disclose information. In the long run, the application could effectively reduce errors in disclosure and earnings management, increase the quality of accounting information and mitigate information asymmetry. We also discuss potential impacts that the application will have on independent auditors and financial accountants.
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contracts[2] can help to reduce errors in disclosure and earnings management and effectively improve the reliability, timeliness and comparability of accounting information, accordingly, mitigate information asymmetry.

However, the application of blockchain in financial accounting has the potential threat that firms would construct transactions to get desired accounting numbers. It will shift the focus of independent external auditing from detecting major misstatements of firms to analyzing the reasonability and authenticity of business transactions and events. Meanwhile, the duty of financial accountants will also change from recording transactions and preparing financial statements to ensuring the authenticity of source documents and the reasonability of smart contracts used in accounting blockchain. We also propose that applying permissioned blockchain could partially mitigate information confidentiality and regulatory difficulties problems but this remedy will weaken the advantages brought by accounting blockchain.

The next section introduces the mechanism, characteristics and current applications of blockchain technology. Section "Application in Financial Accounting" describes the potential application of blockchain technology in financial accounting and introduces the threats exists in the application. The final section concludes.

INTRODUCTION OF THE BLOCKCHAIN TECHNOLOGY

The Mechanism of Blockchain Technology[3]

The blockchain is an electronic ledger that records transactions and information (Antonopoulos, 2017; Narayanan et al., 2016). Each block contains a block header and the current block's transactions and information. The block header contains the hash value[4] of the previous block,[5] the timestamp[6] and other information, the nonce[7] and the Merkle Tree Hash value, which based on all transactions and information recorded in the current block. The hash value of the previous block contained in the current block is calculated by the hash function. Blockchain uses sequential blocks to record information and connects each other with hash values. Once there exists manipulation in the previous block, all hash values in the follow-up blocks will change.

Each node[8] tries to find a nonce that can make the first few digits of the current block's hash value to be zero by trial and error. In the blockchain, if you change the data in one block, the hash values for that block and all subsequent blocks will change (see formula (1)). For example, node A has tampered with the data recorded on the ith block, and the hash value of the ith block changes immediately. This in turn causes all subsequent blocks' (i.e., block $i + 1$ and the following blocks) hash values to change.

$$
\begin{aligned}
&\text{Hash value of Block}_i \\
&\quad = H(\text{Information contained} \\
&\quad \text{in block header of Block}_i) \\
&\quad = H(\text{Hash value of Block}_{i-1}, \\
&\quad \text{timestamp and other} \\
&\quad \text{information, Nonce,} \\
&\quad \text{Merkle Tree Hash value})
\end{aligned} \tag{1}
$$

The blockchain is a distributed ledger, which consists of a series of nodes, that is, copies of the ledgers. Nodes are computers connected to the blockchain network, who are responsible for validating and relaying information in the blockchain. Each node in the blockchain network has a copy of the ledger. If information of one node in the blockchain has been tampered with, the final hash value of this node will be different from those whose information has not been tampered with. This mechanism ensures the traceability that the tampering will be quickly discovered. Through distributed ledger technology and hash chaining, the blockchain ensures information to be transparent, secure, and immutable.

The existing blockchain technology mainly uses the proof-of-work (PoW) mechanism[9] to help mining[10] new blocks. PoW assigns the right to construct new blocks and certain rewards to the earliest user who has calculated the nonce. Specifically, each node in the blockchain competes for the right to construct a new block by participating in the calculation of a nonce. The node who first calculates a nonce will not only acquire the mining right but also receive some bonus.[11] In order to obtain the bonus attached to each block, all nodes are motivated to participate in the construction of new blocks. In this competition, the first node who obtains the nonce has the right to record new information in a new block and relay it to other nodes. After validating the authenticity of this block's information, other nodes will add this new block to their ledger copy.

PoW allows each node in the blockchain to have the

Exhibit 1

The Mechanism of Blockchain Technology

[Color figure can be viewed at wileyonlinelibrary.com]
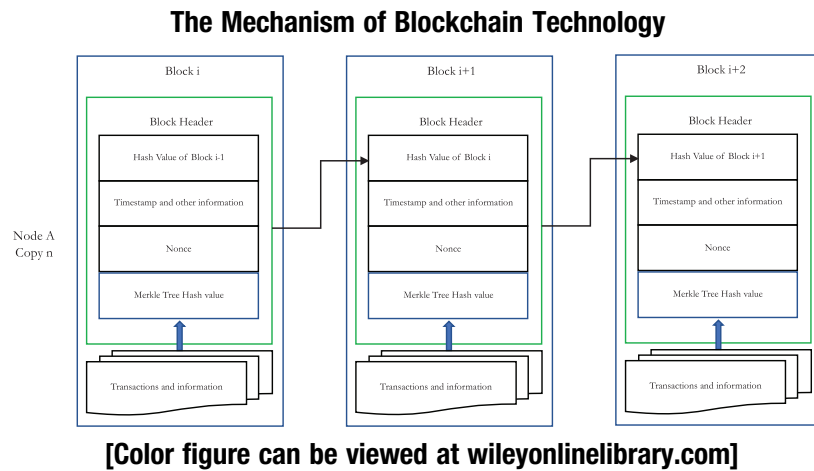
right of mining. Given there are tens of thousands of nodes, the probability of any node getting the mining right is small.[12] If two nodes find the nonce at the same time and construct two new blocks and relay them to the blockchain network, where one node contains false information while the other contains authentic information, the false one will finally be abandoned. Because in order to retain the chance of receiving subsequent indefinite rewards, other nodes have the incentive, after validating these two new blocks, to copy the new block containing the authentic information to their own copy of the ledger.[13] Through this process, the blockchain can record and validate all information in an open and transparent manner without relying on any centralized intermediaries (such as a bank or an exchange) and realize the authenticity and immutability of the information.

The DLT guarantees the authenticity of the information in most cases, but it still faces the risk called the "51% attack" or "majority attack." And accordingly, there exists the risk of data management and counterfeit. If more than 50% of nodes in the blockchain network is under the control of one single agent, then the agent can use nodes under his control to influence what new information to be recorded in new blocks, ideally, the agent can manipulate the blockchain information recorded. However, the "51% attack" is only theoretically possible since the actual cost of investing 51% of the computing power of the entire network may outweigh the benefits of successful attacks. And in reality, it is very difficult for an agent to control the vast majority of nodes.

Blockchain can be divided into public and permissioned blockchain based on its openness.[14] In the public blockchain, everyone can read and write, and the mining right of new blocks depends on the PoW mechanism. The permissioned blockchain includes private chain and consortium chain that only permissioned nodes can read, write, and build blocks. In the consortium chain, instead of using PoW mechanism, it is the central controller, the size of the stake, or the outcome of the group vote that determines who has the right to read and/or write in the blockchain. Therefore, the authenticity and immutability of the information in the blockchain will be somewhat weakened, but confidentiality and efficiency will accordingly rise.

Characteristics of Blockchain Technology

Public blockchain has four advantages. First, the distributed nature of the blockchain ensures information openness and transparency since each node of the blockchain has a copy of the ledger. Second, the distributed storage assures that it is difficult for all nodes to be attacked and destroyed at the

same time, which ensures the security of information. Third, the hash chaining makes sure that once historical information been tampered with, it will be quickly found, accordingly, data fraud is almost impossible. Fourth, PoW mechanism increases the cost of counterfeiting and lowers the probability of fraud in a new block, which guarantees the authenticity and reliability of information in the blockchain (Iansiti & Lakhani, 2017).

However, the blockchain technology also has limitations. First, current blockchain technology has limited ability to process huge data. For instance, the bitcoin blockchain constraints the block to be 1 MB at maximum. Second, though the distributed nature of the blockchain ensures information openness and transparency, it also makes it hard to keep information confidential on the blockchain. Third, it is hard to regulate the blockchain since nodes in the blockchain are worldwide and anonymous, if some nodes collude and add false information in the block, regulators cannot timely contain this action and it is difficult to punish afterwards.

Current Applications of Blockchain Technology

Bitcoin. Bitcoin is the first and most successful application of blockchain technology. It is a cryptocurrency that is stored and traded on the bitcoin blockchain. Bitcoin distribution and trading are based on bitcoin software protocols and do not require any centralized financial intermediaries. In 2008, Satoshi Nakamoto (2008) first came up with the concept of

bitcoin. On January 3, 2009, Nakamoto dug the first block of the bitcoin blockchain and was rewarded 50 bitcoins. On December 10, 2017, there are about 498,000 blocks in the bitcoin blockchain, of which 16.73 million bitcoin has been excavated. The total market capitalization of bitcoin is as high as $237.9 billion. Currently, there are about 11,800 bitcoin nodes globally, of which about 27% are in the United States.[15]

Bitcoin is a decentralized cryptocurrency without government control, which makes it difficult to become the legal tender. However, since bitcoin has characteristics of transparent, secure, fraud-free and trader-anonymous, it has drawn wide attention since it emerged. Without the cumbersome process of transaction confirmation and settlement at banks or exchanges, bitcoin has some advantages over traditional banking systems in terms of efficiency.

Financing and trading. Currently, firms can issue shares to investors through an initial public offering (IPO), while stocks issued by an IPO can be traded on a stock exchange. Primary market transactions provide firms with financing opportunities, and secondary market transactions provide liquidity for firms' equity and also can timely reflect the relevant information. In Europe, the United States, China, and so on, firms must be registered or receive a regulatory approval before conducting IPOs and being traded on the secondary market. The process involves brokers, lawyers, auditors and other intermediaries going through series of confirmation and

clearing activities and the entire process usually takes 1–3 days.

Initial coin offerings (ICO) are the process that a firm raises money using the blockchain technology. It avoids the involvement of many intermediaries and centralized exchanges. In addition, due to the characteristics of blockchain technology, all blockchain-based equity transactions are transparent and reliable. On April 30, 2016, the decentralized autonomous organization (DAO) raised money on the Ethereum blockchain. On May 21, 2016, the DAO raised more than $150 million, which is the largest ICO until June 30, 2017. However, due to the deficiency of screening and monitoring, there are high risks of fraud in ICO (Tirole, 2017), and China has prohibited the ICO in 2017.

Shareholders' voting. Participating in the shareholders' meeting is an important means for investors to exercise and protect their own rights. However, currently, minority shareholders' willingness to participate and exercise their voting right through the shareholders' meeting is not strong. The main reason is that investors have high costs in participating in the shareholders' meeting of listed companies because of long distance or time conflicts. Moreover, the fairness and transparency of voting at the shareholders' meetings are hard to guarantee. The latter problem persists even if applying online voting.

The application of blockchain technology in voting in the shareholders' meeting decreases the cost of investors' participation in the shareholders' meeting to some extent. Moreover, the

voting history is transparent, traceable, and immutable. NASDAQ has tested voting at shareholders' meetings using the blockchain technology on the Tallinn Stock Exchange in Estonia (Nasdaq, 2017).

In sum, there are some applications of the blockchain technology in cryptocurrency, corporate finance and corporate governance. We argue that it also has huge potential in financial accounting.

APPLICATION IN FINANCIAL ACCOUNTING

Traditional Accounting and Auditing

Accounting and auditing are naturally evolved mechanisms of realizing mutual trust and investor protection. Modern accounting originated from the commercial transactions in the 13th century Italy. In order to improve the accuracy of accounting records, merchants invented the double-entry bookkeeping method, which was widely adopted after Luca Pacioli summarized it in his mathematics textbook published in Venice in 1494 (Waymire & Basu, 2008).

The continuous expansion of firms' activities has gradually led to a demand for external financing, and firms have incentives to obtain the trust of capital providers to reduce the cost of capital. Meanwhile, capital providers including investors and lenders also demand information to keep track of the financial positions and operating performance of the firm in order to ensure the safety of their capital. In order to gain the trust of capital providers, firms have incentives to provide financial information to existing and potential capital providers.[16] In theory, insiders have more internal information about business operations than outsiders. The existence of information asymmetry provides opportunities for firms to manipulate reports. To obtain more capital or out of personal interests of insiders, insiders have incentives to mislead outside capital providers about the financial positions and operating performance of the entity (Watts, 1977; Watts & Zimmerman, 1983).

In order to assure the integrity of financial statements and disclosure, the independent external auditing system emerged (Watts & Zimmerman, 1983). Through the implementation of auditing procedures, auditors could discover fraud and errors in financial statements and accordingly reduce the opportunistic behaviors of insiders to some extent. Therefore, the external auditing system could to a certain extent reduce information asymmetry between firms' insiders and the outside information users and increase the value of the firm (Jensen & Meckling, 1976; Watts & Zimmerman, 1983). However, the Enron and WorldCom accounting scandals have shown that the external auditors did not properly maintain independent, or cannot fully discover fraud and errors in firms' financial statements. Its supervision and restraint on firms' insiders are not strictly effective. Except for auditors failing to reduce the detection risk well, the inherent and control risks of the audited firm are also important factors of audit risks.[17] In other words, auditing, as a third-party monitoring mechanism, can only reduce but not eliminate fraud and errors in firms' disclosure.

In summary, the emergence and development of financial accounting and independent auditing is to solve the problem of information asymmetry between firms and external information users. However, due to conflicting interests between insiders and outsiders, the opaqueness of accounting and auditing, and nonindependence of the auditing, financial accounting and external auditing cannot completely solve the problem of information asymmetry between insiders and external information users.

Tentative Plan for the Application of Blockchain in Financial Accounting[18]

Listed companies need to disclose financial statements including balance sheet, income statement, statement of cash flow, statement of changes in equity, and notes to the market on a regular basis under the current regulatory system. For the sake of maximizing insiders' own interests, management may mislead information users by manipulating accruals, constructing transactions, and disclosing false information (Healy & Palepu, 2001; Lie, 2005). The reliability of publicly disclosed financial statements and notes is guaranteed to some extent after auditing. However, outside information users are unable to observe the true transactions and accounting process of a firm. By simply looking into the final financial statements, they cannot get a full, accurate and timely understanding of the company's financial position, operating performance, and cash flow situation.

The blockchain records and validates information in a decentralized way, and the entire process does not require any authority intermediaries, and the blockchain technology guarantees the information to be transparent, secure, tamper-proof and reliable through the distributed ledger technology, hash chaining, and PoW mechanism. As a result, the blockchain technology has great potential of enhancing the trust between market participants (The Economist, 2015; Yermack, 2017), and we argue that the application of blockchain technology in financial accounting has the potential of making firms' accounting process transparent, improving the quality of external reporting information and effectively reducing the information asymmetry between firms and outside investors.

Tentative Plan for the Accounting Blockchain

The application of blockchain technology in financial accounting includes two aspects. On the one hand, listed companies disclose accounting information on the blockchain. Firms post source documents of transactions and events and attach billing fees, as well as the accounting policies and methods embodied in smart contracts to the accounting blockchain. Once the smart contract has been set up, if the firm discretionarily changes it, all modifications would be recorded on the blockchain and are traceable.

On the other hand, various stakeholders, as blockchain nodes, will participate in competitive mining and promptly record and validate information submitted by the firm into

a new block, and then relay it to the blockchain network. Institutional investors with technical and financial advantages are more likely to become blockchain nodes since except for the mining rewards for building blocks, they are also motivated by the information advantage with the earliest access to corporate information. Moreover, intermediaries such as auditors and lawyers are also likely to become nodes in the blockchain. Auditors can audit the source documents and smart contracts posted by the firm and issue their audit opinion on the blockchain. Finally, regulators and Stock Exchanges will also become important nodes in the accounting blockchain to better play their monitoring roles.

Blockchain in Financial Accounting and its Influence

The long-run application of blockchain in financial accounting. Though firms are required to apply accounting methods specified by accounting standards for recording, presentation and disclosure in traditional accounting, they still have discretions over accounting methods such as accounting policies used and accounting estimates and judgments made. Listed companies only provide regular financial statements to the market, but do not publicize the accounting procedures for the preparation of reports. Although this institutional arrangement could protect the proprietary information of firms, there are a series of negative consequences as well. First, the risk of tampering and damaging transactions exists whether the firm use paper-based or electronic-

based ledger. Second, the managers or controlling shareholders of listed companies may carry out manipulation or construct transactions to maximize personal interests. Because the accounting process is opaque, it is very difficult for outside information users to find out problems (Healy & Wahlen, 1999). Finally, even if there exists external auditing, the auditors may not be able to detect all fraud and errors of the firm, or may not have the independence to inform the market of the problems discovered.

The advent of blockchain technology provides novel ideas for financial accounting and will have a tremendous impact on recognition, measurement, presentation and disclosure in financial accounting, which can reduce errors in disclosure and earnings management, therefore largely improve the quality of information.

First, firms can post source documents to the public blockchain, and the public blockchain will automatically generate accounting ledgers and financial statements through smart contracts. Accounting standards and assumptions used by firms will be reflected in smart contracts, which will be permanently recorded. This process fundamentally changes the measurement, presentation and disclosure in financial accounting.

Second, the application of the blockchain technology in financial accounting can reduce operational risk and measurement errors since financial statements are automatically generated by smart contracts. Moreover, the timely provision of accounting information

partially reduces the time lag between the generation of accounting information and reporting. The transparency and traceability of accounting blockchain will increase the probability of fraud being found and largely increase the counterfeiting costs. With fewer opportunities and higher costs, the earnings management will decrease.

Third, using blockchain in financial accounting means there will be thousands of backups once it is posted on the public blockchain and all transactions are visible to all members of the network (Yermack, 2017). This will make the process of accounting and reporting more transparent and traceable since they are verified and supervised by all nodes in accounting blockchain, which will increase the reliability of accounting information. Moreover, with the application of the blockchain technology, financial statements can be produced in a timely manner, while traditional financial reporting is annually based, which increases the timeliness of information. And more radically, outsider information users can even aggregate firms' transactions into financial statements at any time by themselves (Yermack, 2017). Furthermore, the traceability of accounting policies and assumptions in smart contracts will make the accounting choices and judgments more transparent and correspondingly increase the comparability of accounting information.

In sum, the advent of blockchain technology will have a tremendous impact on measurement, presentation and disclosure in financial accounting, which reduces errors in disclosure and earnings management, largely improve the qualitative characteristics of information and mitigate the problem of information asymmetry.

The short-run application of blockchain in financial accounting. However, based on the analysis in section "Introduction of the Blockchain Technology," the blockchain technology is in the experimental stage, there exist problems of limited data processing capacity, information confidentiality and regulatory difficulties. First, the accounting information of firms is huge, which the current blockchain technology could not handle well. And it will cause considerable costs to firms that want to apply this technology since the billing fees will be huge. Second, because of the transparency and permanence characteristics, the information can be downloaded and viewed by anyone at anywhere, which will increase the proprietary costs of firms with proprietary information. If the disclosure of information leaks the commercial secrets of the information provider, it incurs a proprietary cost, which will adversely affect firms' operations.[19] As a result, firms with exceptionally high proprietary costs may not have incentives to use blockchain for information disclosure. Finally, with the diversity and anonymity of nodes, and the existence of "51% attack," the difficulty of regulation will rise. Because corporate information disclosure is important in affecting stock price, it is likely that some nodes will add false information on the blockchain to manipulate the stock price and make a one-off profit. This problem is exacerbated if nodes that collude can handle more than 50% computing power.

Therefore, in the short run, it is not realistic for all firms to carry out the accounting and reporting through the blockchain. However, as long as the technology is mature enough, the first problem can be solved. And if firms foresee the proprietary costs of disclosing specific information, they will choose the appropriate amount of confidential information to disclose on the blockchain after balancing the costs and benefits. And after solving these two problems, many firms will have the incentive to use blockchain as an important voluntary disclosure platform in the short run since the flow of information could reduce information asymmetry and lower the cost of capital to firms (Shroff, Sun, White, & Zhang, 2013).

As mentioned above, the technical characteristics of blockchain make the information disclosed highly transparent, traceable, and tamper-proof. For firms that want to reduce information asymmetry with investors, voluntary disclosure through the blockchain is a very attractive way.[20] In the short run, firms may disclose some valuable but not compulsory information through the blockchain such as earnings forecasts and corporate social responsibility reports. Such self-disclosure helps investors better understand the business and make more informed decisions. In addition, even disclosing publicly disclosed information through the blockchain has many positive effects. On the one hand, historical information has some feedback value. Especially in the case of major uncertainties, investors will verify the existing

information by looking up historical information (Drake, Roulstone, & Thornock, 2016; Hail, Muhn, & Oesch, 2017). On the other hand, disclosing publicly available information through official channels can have an impact on investor decision-making (Christensen, Eric, Lisa, & Mark, 2017; Fedyk & Hodson, 2017).

Short-run to long-run transition. In the long run, when firms and investors recognize that voluntary disclosure on the blockchain is a high-quality signaling mechanism to reduce the cost of trust, more and more firms will choose to conduct voluntary disclosure on the blockchain after balancing the benefits and costs. And as more information disclosed on the blockchain, the comparability of information will become a problem. Regulators may require information to be standardized[21] to improve the comparability of information.

Foreseeing that blockchain technology could increase the authenticity, accuracy and comparability of disclosure information and reduce the earnings management of firms, regulators may even use blockchain as a major platform for mandatory disclosure.[22] The content of mandatory disclosure would be the source documents of transactions and events, as well as the accounting policies and methods embodied in smart contracts. This kind of information should be disclosed on a real-time basis. Other nonconfidential information such as earnings forecasts, corporate social responsibility reports and business reviews, which are common contents firms would like to voluntarily disclose in

the short run should also be disclosed on the blockchain. However, disclosure frequency should depend on the discretion of firms. If firms want to make a good impression on the market, they will have the incentive to disclose the nonconfidential information in a timely manner.

In summary, compared with the traditional financial reporting methods, the use of blockchain technology in financial accounting has advantages of high transparency, traceability, timeliness, and tamper-proof. In addition, smart contracts can realize the automation of financial statements generation, which can not only greatly reduce the cost of financial accounting, but also improve the timeliness, reliability and comparability of information. Moreover, it can also reduce errors in disclosure and earnings management so that the financial statements can truly and accurately reflect the financial position and operating performance of the firm. Correspondingly, the problem of information asymmetry can be mitigated. However, due to the existing shortcomings of blockchain technology, the above advantages take time to become a reality. With the maturating of blockchain technology, accounting and financial reporting through blockchain will become a viable and attractive option in the long run.

Potential Impacts and Threats of the Application

In the long run, adopting blockchain technology in financial accounting has two main effects. On the one hand, the raw data posted on the

blockchain has the characteristic of tamper-proof. On the other hand, smart contracts allow the automation of accounting and reporting, which helps to trace business activities. These changes will increase the difficulty of firms to manipulate accounting data, but it does not mean that the use of blockchain in financial accounting can eliminate fraud because as long as the potential benefits are large enough, there are still incentives for firms to cheat by faking the source data.

As a result, one potential threat of the adoption of blockchain in financial accounting is that firms may turn to construct transactions to get the desired accounting numbers. As to auditing, this change means that the control risk in the audit risk will decline while the inherent risk may increase. Under such circumstances, the auditors' main focus will shift from preventing major misstatements from accounting to analyzing the reasonability and authenticity of the business of the audited entity.

The application of accounting blockchain has other threats if applied in the long run. They are shifting duties of accountants, the information confidentiality problem for firms and rising difficulty of regulation. The blockchain technology could realize the automation of recognition, measurement, presentation and disclosure, which replaces the position of traditional financial accountants in the long run. It reduces traditional accounting jobs such as recording and preparing financial statements but creates more jobs on assuring the

authenticity of source documents and the reasonability of smart contracts. It is a new challenge for accountants.

Moreover, the information confidentiality problem, in the short run, only affect the quantity of information that firms voluntarily disclosed on the blockchain, but in the long run, radical change in the automation of financial statements generation will largely increase the proprietary costs of companies, which would probably cause hindrance to the application.

There also exists the problem of rising difficulty of regulation. With the diversity and anonymity of nodes, speculators could make use of the mining right to put "useful" information to gain one-off profits. Even the false information could be discovered quickly, it is hard to find out the speculator who posts the false information. Moreover, the existence of "51% attack" also increases the difficulty of regulation. Though it is difficult to have more than 51% calculating power of the blockchain, there is a possibility of collusion. Regulators are impossible to contain this action if it does happen.

One possible solution is to apply permissioned blockchain instead of public blockchain. The basic idea of permissioned blockchain is that one central organization control that has the right to read and/or write new information in the blockchain. It can partially solve the information confidentiality problem and rising difficulty of regulation. However, it will weaken the fundamental characteristics of blockchain technology that are decentralized and immutable.

CONCLUSION

This article sheds light on the possible impact that blockchain technology will have on financial accounting. Due to the fact that the technology is in the experimental stage, the application of blockchain technology in financial accounting will be progressive. In the short run, the blockchain technology could be used as a platform for firms to voluntarily disclose information, which is a high-quality signaling that enables firms to solve the trust problem with investors. In the long run, the application could have a tremendous impact on financial accounting. It could effectively reduce the errors in disclosure and earnings management, largely increase the quality of accounting information and mitigate the problem of information asymmetry.

The threat brought by the application is that firms could cheat on raw data, but this problem could be mitigated by auditing. The focus of independent auditing will shift from preventing counterfeiting in accounting to analyzing the reasonability and authenticity of business operations. Moreover, the duty of financial accountants will change from recording transactions and preparing financial statements to ensuring the authenticity of source documents and the reasonability of smart contracts used in accounting blockchain. Other threats including the information confidentiality of firms and increasing difficulty of regulation can cause hindrance to the application. One possible solution to solve these problems is to apply consortium blockchain instead of public blockchain, but it will

correspondingly weaken the fundamental characteristics of blockchain technology. Overall, the application of blockchain in financial accounting has opportunities and threats. And once the technology is mature enough, it probably will bring fundamental changes to financial accounting and auditing even the whole financial markets.

NOTES

1. The blockchain technology can also make a difference in management accounting. This article focuses on how this technology could partially reduce information asymmetry between firms and outside information users. Its impact on internal management and decision-making is not elaborated in this article. We do not discuss the financial accounting issues relating to bitcoin transactions neither. Raiborn and Sivitanides (2015) have a detailed discussion of the recognition, measurement, and disclosure issues of bitcoin transactions.
2. Smart contract is a program that automates some transactions or procedures. Under certain conditions, smart contract codes can be automatically executed by blockchain networks without the involvement of third parties.
3. This section introduces principles of the blockchain technology, more details can be found in Narayanan et al. (2016) and Antonopoulos (2017).
4. A hash value is a fixed-length collection of numbers and letters that generated by cryptographic functions for all information contained in a block header. Since the information contained in each block is essentially unique, the hash value of each block is also unique.
5. The first block in the blockchain is the genesis block, which does not contain the hash value of the previous block.
6. Each block has a timestamp and it is part of the block's information.
7. The nonce must be able to make the first few digits of the block's hash value to be zero. Because the

number can only be calculated by trial and error, so every node in the blockchain network have the opportunity of mining (Antonopoulos, 2017; Narayanan et al., 2016).

8. Nodes are computers connected to the blockchain network, which are the basis of block mining and confirmation.

9. Proof of work (PoW) is one of the most commonly used consensus mechanisms for mining. The advantage of PoW is that it can ensure the reliability and immutability of information. The disadvantage is that it largely consumes electricity. Another important consensus mechanism is the Proof of stake (PoS), which uses nodes' share of the stake as a basis for mining. Compared with the PoW, the PoS does not require each node to compete for calculating the nonce, which can save energy. However, the disadvantage is that it is difficult to ensure the reliability and immutability of information.

10. Mining is the process of adding transaction records to the public ledger.

11. In the bitcoin blockchain, the bonus for the new bitcoin block is bitcoin. Under the bitcoin protocol, bitcoin blockchain will not generate new bitcoins after the year of 2140. The party who submits new transactions must attach billing fees to the node who will record the transaction.

12. The nodes in the blockchain can increase their odds to get the right nonce by increasing the computing capacity. However, given large numbers of nodes, it is impossible for a single node to obtain the mining right all the time.

13. Assuming that the total number of nodes is N, the number of nodes who records false information is K: as long as the nodes who recorded authentic information (N-K) is more than the number of nodes (K) where the false information is recorded, the probability that the faithful nodes (N-K) obtains subsequent mining right will be greater than the nodes recording the false information, accordingly, the probability of the block with authentic information being accepted by the entire network is larger. This process ensures the ledger copy that recorded authentic information will be copied by other nodes in the blockchain while the blockchain node containing false information will not be accepted by other nodes because their chain is shorter. Those nodes with false information also lose the opportunity to construct subsequent new blocks and the corresponding rewards. Therefore, unless one party controls more than 50% of the total number of nodes, the blockchain technology can ensure the authenticity and tamper-proof of the information on the blockchain (Antonopoulos, 2017; Narayanan et al., 2016).

14. A permissioned blockchain restricts recording rights to a select group of authorized users who negotiate governance and control rights among themselves, in a process loosely resembling a partnership agreement (Yermack, 2017).

15. The data of nodes' number comes from https://bitnodes.21.co/, and other data comes from https://blockchain.info/stats.

16. In 1929, the Great Depression occurred in the United States. Many people think that accounting fraud and insufficient information disclosure are important reasons for the crisis. Therefore, in the early 1930s, the United States established the Securities and Exchange Commission (SEC) and required listed companies to provide financial information regularly to the market to protect the interests of investors (King, 2006, pp. 55–63).

17. The audit risk depends on the risk of material misstatement and the risk of detection. The risk of material misstatement depends on the inherent risk and the control risk. Inherent risk refers to the risk of misstatement that occurs when there is no internal control. Control risk refers to the possibility that internal control fails to prevent, detect and correct the material misstatement that has occurred in time. If the inherent risk and control risk of financial reporting is too high, the auditors must reduce the detection risk to a very low level to reduce the audit risk to an acceptable level.

18. This article conceives of the application of blockchain in financial accounting in the short and long run.

19. Firms with lots of patents such as pharmaceutical companies or companies with strong political relations usually have high proprietary costs (Leuz & Wysocki, 2016).

20. In theory, the blockchain's transparency and permanence characteristics have increased the probability and cost of false disclosures. Therefore, firms tend to disclose real and reliable information on the blockchain, and in turn, investors will require a lower rate of return on equity since they have the high-quality information (Lambert, Leuz, & Verrecchia, 2007).

21. Standardization means providing information in a comparable way.

22. Meanwhile, the application of blockchain technology makes the accounting information more reliable, accurate and timely, and may prevent the corporate tax evasion behavior.

REFERENCES

Antonopoulos, A. M. (2017). *Mastering bitcoin: Programming the open blockchain*. O'Reilly Media, Sebastopol, CA.

Christensen, H. B., Eric, F., Lisa, Y. L., & Mark, M. (2017). The real effects of mandated information on social responsibility in financial reports: Evidence from mine-safety records. *Journal of Accounting and Economics*, 64(2–3), 284–304.

Drake, M. S., Roulstone, D. T., & Thornock, J. R. (2016). The usefulness of historical accounting reports. *Journal of Accounting and Economics*, 61(2), 448–464.

Fedyk, A., & Hodson, J.. (2017). *When can the market identify stale news?* (Working Paper).

Hail, L., Muhn, M., & Oesch, D.. (2017). *Do risk disclosures matter when it counts? Evidence from the Swiss franc shock* (Working Paper).

Healy, P. M., & Palepu, K. G. (2001). Information asymmetry, corporate disclosure, and the capital markets: A review of the empir-

ical disclosure literature. *Journal of Accounting and Economics*, *31* (1–3), 405–440.

Healy, P. M., & Wahlen, J. M. (1999). A review of the earnings management literature and its implications for standard setting. *Accounting Horizons*, *13*(4), 365–383.

Iansiti, M., & Lakhani, K. R. (2017). The truth about blockchain. *Harvard Business Review*, *2017* (January–February), 118–127.

Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, *3*(4), 305–360.

King, T. A. (2006). *More than a numbers game: A brief history of accounting*. Wiley, Hoboken, NJ.

Lambert, R., Leuz, C., & Verrecchia, R. E. (2007). Accounting information, disclosure, and the cost of capital. *Journal of Accounting Research*, *45*(2), 385–420.

Leuz, C., & Wysocki, P. D. (2016). The economics of disclosure and financial reporting regulation: Evidence and suggestions for future research. *Journal of Accounting Research*, *54*(2), 525–622.

Lie, E. (2005). On the timing of CEO stock option awards. *Management Science*, *51*(5), 802–812.

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

Narayanan, A., Bonneau, J., Felten, E., Miller, A., & Goldfeder, S. (2016). *Bitcoin and cryptocurrency technologies: A comprehensive introduction.* Princeton University Press, Princeton, NJ.

Nasdaq. (2017, January). *Is blockchain the answer to e-voting? NASDAQ believes so.* Retrieved from http://business.nasdaq.com/marketinsite/2017/Is-Blockchain-the-Answer-to-E-voting-Nasdaq-Believes-So.html

Raiborn, C., & Sivitanides, M. (2015). Accounting issues related to bitcoins. *Journal of Corporate Accounting & Finance*, *26*(2), 25–34.

Shroff, N., Sun, A. X., White, H. D., & Zhang, W. (2013). Voluntary disclosure and information asymmetry: Evidence from the 2005 securities offering reform. *Journal of Accounting Research*, *51*, 1299–1345.

The Economist. (2015). *The great chain of being sure about things.* Retrieved from https://www.economist.com/news/briefing/21677228-technology-behind-bitcoin-lets-people-who-do-not-know-or-trust-each-other-build-dependable

Tirole, J. (2017). *There are many reasons to be cautious about bitcoin.* Retrieved from https://www.ft.com/content/1c034898-d50f-11e7-a303-9060cb1e5f44

Watts, R. (1977). Corporate financial statements, a product of the market and political processes. *Australian Journal of Management*, *4*, 53–75.

Watts, R. L., & Zimmerman, J. L. (1983). Agency problems, auditing, and the theory of the firm: Some evidence. *Journal of Law and Economics*, *26*(3), 613–633.

Waymire, G. B., & Basu, S. (2008). Accounting is an evolved economic institution. *Foundations and Trends® in Accounting*, *2*(1–2), 1–174.

Yermack, D. (2017). Corporate governance and blockchains. *Review of Finance*, *21*(1), 7–31.

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