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Overview and Impact of Blockchain on Auditing

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Abstract. Blockchain has become very popular as the underlying technology powering Bitcoin. However, the benefits behind this technology further surpass just supporting cryptocurrencies. Blockchain can be defined as a digital ledger that allows to capture transactions conducted among several parties on real-time and serves as a decentralized database where each participant keeps an identical copy of the ledger. The appeal behind blockchain resides on its peer-to-peer network infrastructure along cryptographic capabilities. This combination enables users to conduct transactions without a trusted third-party intermediary. Benefits in accounting are even more promising as blockchain will provide a triple entry accounting system where all transactions are immutable and have been time stamped, recorded on real-time and encrypted (Alarcon & Ng, 2018). The purpose of this paper is to review extant research on this technology and assess the impact of blockchain in the audit profession, including new risks, change in procedures and additional opportunities.

Keywords: blockchain, auditing, accounting, smart contracts.

1. INTRODUCTION

Blockchain has become one of the most widely hyped technologies since its inception in 2008. According to International Data Corporation (IDC), a market intelligence firm, companies are expected to invest close to $3 billion in blockchain related technologies in 2019 (International Data Corporation, 2019). A survey of 200 commercial banks showed nine out of 10 institutions are investing in blockchain solutions for their individual clients while 15% are developing commercial blockchain applications. Likewise, investors are pouring close to $1.5M in blockchain ventures (Myers, 2017). IBM is predicting two-thirds of all banks will have blockchain products by 2020 (Sadu, 2018).

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Blockchain can be simply defined as a digital ledger that allows to capture transactions conducted among several parties on real-time and serves as a decentralized database where each participant keeps an identical copy of the ledger. No intermediaries are needed to settle transactions and validation are performed by multiple users. Once a transaction has been accepted by the network, all copies of the ledger are updated. Multiple transactions are combined into "blocks" which are then chained (thus, the name of blockchain) and cannot be altered or deleted. As a result, blockchain provides several benefits, including authentication of peer-to-peer transactions and automated, encrypted and real-time registry of such transactions (Bible et al., 2017).

Researchers are predicting this technology may impact several industries, including auditing (Fanning & Centers, 2016). This is especially true as blockchain will provide a triple entry accounting system where all transactions are immutable and have been time stamped, recorded on real-time and encrypted (Alarcon & Ng, 2018). Thus, it is not surprising Big Four accounting firms have been exploring this technology, conducting research and publishing numerous reports and surveys on this topic. While there is still plenty of room for progress in the development of blockchain-based accounting and auditing solutions and more importantly, public adoption of blockchain is still yet to be seen (O'Neal, 2019), academics and practitioners must remain alert. The contribution of this paper is to provide a current assessment of the impact of blockchain in the audit profession, including new risks, change in procedures and additional opportunities.

2. OVERVIEW

In 2008 Satoshi Nakamoto introduced Bitcoin, an electronic currency based on a peer-to-peer network. On this network, transactions are time stamped by hashing them into a continuing chain of records (Nakamoto, 2008). Blockchain is the technology that enable this virtual currency to be transacted without the need of a third party conducting any validation tasks. In doing so, numerous uses have been found for this technology, including real estate transfers, contract settlement, health records exchange, food traceability, and inventory or asset tracking and ownership. Blockchain can be defined as a digital ledger that allows to capture transactions conducted among several parties on real-time and serves as a decentralized database where each participant keeps an identical copy of the ledger. Because transactions are settled without the need of an intermediary, there is no need for a clearing agency. Transactions are validated by more than one user and once a transaction has been accepted by the network, all copies of the ledger are updated. Multiple

transactions are bundled into a "block" along the hash code from the header of the prior block, the time stamp, and the "nonce" which is a random number related to the proof-of-work algorithm. The contents of the block are then identified by the final root hash, Tx_Root, -or- Merkle root (Kokina et al., 2017). These blocks are then chained to the previous block (thus, the name of blockchain) and once linked, transactions cannot be altered or deleted. If any of the elements of the transaction data inside a block is altered, the hash of the block header will change (Yermack, 2017). Therefore, if modifications are made, the block would not sync with the network resulting in its exclusion from the blockchain. Figure 1 shows a graphical representation of how Blockchain is structured.

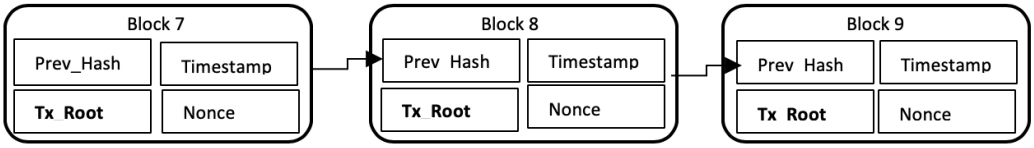

Figure 1. Representation of Blockchain structure

There are two major classifications of blockchain networks: permissionless and permissioned. Blockchains can be set up so the data can be shared with anyone who has access to the Internet (i.e., permissionless or "public" blockchain), or shared with only certain participants (i.e., permissioned or "private" blockchain). Because a permissionless blockchain is open to any user, anyone can participate in the chain. However, it also means transaction information is exposed to anyone. Government applications may be hosted in a public Blockchain environment to ensure all residents can access the information. On the other hand, private or permissioned blockchains restrict participation in the blockchain network to those participants who have been approved by agreed-upon administrators. These blockchains are most likely to be set by a consortium of parties where they can benefit from the shared ledger features of this technology while avoiding the risk of the wide distribution of information to the entire network. This classification can also be seen from a notion of centralized versus decentralized blockchains. In a centralized blockchain, the ability to access or view the data is provided by a central authority whereas in a decentralized blockchain, each participant generally has the same level of access (O'Leary, 2017). Figure 2 shows a matrix depicting examples of what kind of applications would fit better on each type of blockchain.

	Centralized	Decentralized
Public	Voting Voting records Whistleblower	Currencies Betting Video games
Private	Construction National defense Law enforcement Military Tax returns	Supply chain Government financial records Corporate earnings statements

Figure 2. Examples of public, private, centralized and decentralized blockchain

3. IMPACT OF BLOCKCHAIN IN AUDIT

Given the disruptive impact blockchain and other new technologies may have on the profession, the American Institute of Certified Public Accountants (AICPA) has been monitoring the current state of legislative agendas to assess how the way CPA firms work may be influenced (AICPA, 2018). In their advocacy newsletter issued in February 2018, AICPA reports states like New York, Tennessee and Arizona have introduced legislation related to blockchain in areas such as record keeping, smart contracts, electronic signatures, and the authenticity of blockchain transactions. AICPA also reports states like Hawaii, New Jersey and Vermont have introduced legislation supporting the use of virtual currencies. In addition, the AICPA has launched a Blockchain learning program to enable practitioners to better understand this technology and determine practical applications and business uses. The Big Four accounting firms have also been researching and investing resources on this technology. In August 2016 the Big Four met with the AICPA to explore blockchain solutions for the accounting industry, which may be conducive to the creation of a distributed ledger consortium (Kokina et al., 2017). PwC is advising Cred on the issuance of a United States dollar-pegged cryptocurrency. It is also partnering with Northern Trust, a leading global asset management firm, to enable real-time audits via Blockchain and therefore, ensuring transparency in all transactions. PwC is also investing in VeChain, a cryptocurrency startup that specializes in web services, supply chain management and anti-counterfeiting. PwC has also released a cryptocurrency auditing solution to meet the needs of firms

engaged in cryptocurrency transactions. Likewise, in April 2018, Ernst & Young (EY) released Blockchain Analyzer, which allows to capture the entire transaction data from a firm's multiple blockchain ledgers. A more recent update of Blockchain Analyzer enables audit, tax and transaction monitoring. In March 2019, EY launched Crypto-Asset Accounting and Tax (CAAT) software to assist US firms to report their crypto asset transaction when filing their tax returns. EY has also developed Tattoo, a Blockchain platform designed to track wine. Specifically, this solution allows customers to determine the quality, provenance and authenticity of imported European wines. In addition to becoming a corporate member of the Wall Street Blockchain Alliance (WSBA), KPMG has been driving efforts on this front by partnering with Guardtime to offer blockchain-based services to clients. It is also working with the US Food and Drug Administration to integrate blockchain in the pharmaceutical supply chain. KPMG is also advising United Arab Emirates officials in the testing of blockchain-based Know Your Customer, or KYC, application. In addition, KPMG is also joining forces with Microsoft, R3 and Tomia to develop a blockchain-based settlement solution for the telecom industry (O'Neal, 2019). The firm also launched a Digital Ledger Services aimed to financial services companies to exploit the full potential of Blockchain (La Quercia, 2018). Deloitte was the first Big Four firm to become involved with this technology. In May 2016 Deloitte developed its first blockchain lab in Dublin. Since then, three of the largest Ireland's banks are using a blockchain solution developed by Deloitte to validate employee's credentials. Furthermore, the firm installed a Bitcoin ATM on its Toronto office. In addition to being accessible to the general public, the machine showcased the firm's interest in cryptocurrencies. The firm recently started to support Startup Studio, a new Blockchain accelerator program, in partnership with 22 other companies to enhance their skills to succeed in business. Then, the firm also launched a blockchain-based platform to enable users to conduct demonstrations and experiments (O'Neal, 2019).

Because transactions in blockchain are recorded automatically, encrypted and immutable, it is expected to become the "single source of truth" (Appelbaum & Smith, 2018). A detailed audit trail may be available along the ability to review exceptions from an entire population rather than a sample and conduct audits on a continuous basis based on trusted data (Kokina et al., 2017). Therefore, tasks such as reconciliations and confirmations may no longer be needed. As a result, concerns have surfaced about the need for financial audits. However, the occurrence of a transaction is one of the many assertions auditors must attest. After all, an audit

requires evidence that must be relevant, reliable, objective, accurate, and verifiable. While the occurrence of a transaction may be confirmed once it has been accepted into the blockchain network, no evidence would be available regarding the nature of such transaction. A Deloitte report (Bible et al., 2017) reveals the following issues may still impact this transaction:

- unauthorized, fraudulent or illegal
- executed between related parties
- linked to a side agreement that is "off-chain"
- incorrectly classified in the financial statements.

In addition, because financial statements are subjected to management's estimates, auditors are still needed to perform audit procedures on such estimates. Even though the role of an auditor conducting accuracy and verification tasks may be reduced, the judgement, oversight and insight will be more critical. Thus, the focus of an audit will shift from record tracing and verification to complex analysis, such as systemic evaluation, risk assessment, predictive audits, and fraud detection. Blockchain adoption may result in increased efficiencies during the audit process as there will be a higher level of auditability on the information. For instance, as transactions are continuously recorded in blockchain, a complete track and history of items for such transactions can be generated. Even documents could be shared among related parties for cross-validation (Dai & Vasarhelyi, 2017). One of the greatest benefits from blockchain is the enablement of smart contracts. Smart contracts are computer code stored on blockchain that executes actions under certain conditions and/or criteria. Such protocols that may serve to facilitate, verify, execute and enforce the terms of a contract are not specific to blockchain and were first referenced by Szabo (1994) who used a vending machine as an example since it is designed to accept certain inputs and will provide an output based on pre-set rules. Thus, if a customer enters the specified amount of money and select the product, the vending machine will release the product provided this is available and the amount of money entered by the customer is greater or equal to the price of the product (Szabo, 1994). Previous examples can also be found on digital rights management (DRM), which was a technology developed to enable copyright enforcement by limiting user's ability to view, copy, play, print or modify digital files (Kiviat, 2015). Smart contract features were even present on bitcoins with its proof of work-based blockchain, which enable agreement on the transactions among the parties (Buterin, 2014). By using smart contracts, manual tasks can be automated improving speed, accuracy and cost efficiency and may serve as the basis

for smart audit procedures or the autonomous analysis of audit evidence. For instance, smart audit procedures can be configured to match key provisions in smart contracts from those of actual sales contracts to identify fictitious, unauthorized or erroneous sales contracts (Rozario & Vasarhelyi, 2018). There are indeed challenges on this regard since even encoding simple contract clauses may result in a complex programming task. In addition, smart contracts have not been tested thoroughly in courts (Bible et al., 2017) as there is lack of clarity how smart contracts may fit within the legal framework of the Uniform Commercial Code and even the general common law (Kiviat, 2015).

4. NEW RISKS AND CHANGE IN PROCEDURES

According to Sadu (2018), one risk auditors must be aware relates to an attack to the so-called "51 percent" or "majority rule". In this attack, inaccurate data is introduced by a user in the blocks to create a fraudulent transaction, which is them accepted as true by most nodes. This would also impact the reliability of Blockchain as a financial reporting tool as any group with 51 percent of the computing power could modify the transaction history. If the Blockchain is kept private, then a firm may have 100 percent control over transaction validation but it would then be able to modify the transaction history as needed. A solution to address this issue either in private or public Blockchains would be to engage auditors in the transaction validation process. A bigger dilemma firms will encounter is whether to use a private or public Blockchain. While the latter will enable stakeholders, such as investors, the ability to access the data, no controls will be in place to prevent other unauthorized parties from reading or even writing to this Blockchain. Therefore, a private Blockchain may be more appealing to firms but without the ability to distribute the data properly to all users, participation from all required stakeholders may be limited or even lost. It would also require all stakeholders to use the same Blockchain technology which could then hinder adoption at this point (Coyne & McMickle, 2017).

Vulnerabilities surrounding endpoints within blockchain can also be targeted by hackers impacting data integrity. While transactions are stored securely in Blockchain, individual users retain private keys for these transaction in "wallets" which are susceptible to theft (Kokina et al., 2017). Furthermore, assessing the validity of a transaction from an accounting standpoint along the correct ledger entry may require extensive accounting expertise (Coyne & McMickle, 2017). As usual, implementation risks such as technology interfaces with legacy systems and

the adequacy of migration strategies must be addressed by auditors. Auditors must also address the lack of a master copy of the database by a database administrator. As a result, issues related to access responsibilities (e.g. read/write, access control, etc.), timing and speed of data availability, cryptography features to ensure completeness, integrity and nonrepudiation of data, adequacy of validation controls and audit trail, and existence of data backup and disaster recovery processes must be addressed by firms when implementing Blockchain systems.

Because the new risks identified above, auditors will need to modify their audit procedures accordingly. Statistical sampling techniques may no longer be needed since blockchain ensures all data is available on real time. As a result, auditors may need to rely on data analytics to test the entire database. This raises another risk, which is then the heightened expectation that financial statements are free from most material errors or frauds since all data has been tested (Appelbaum & Smith, 2018). In addition, traditional reconciliation and validation tasks are not necessary. Therefore, auditors may place stronger reliance on the adequacy of controls. Focus on non-automated activities, such as governance, risk management, monitoring, reporting and evaluation, will continue. An important caveat to note is the admissibility of Blockchain-based evidence in courts, which could have a great impact on reducing audit costs (Appelbaum & Smith, 2018). Rosario and Vasarhelyi (2018) foresee challenges when adopting blockchain in audit may relate to: 1) current statutory requirements, 2) security and privacy of Blockchain and Smart Audit procedures, 3) scalability and flexibility, and 4) the auditor judgement. Such challenges are very comprehensive and include changes in the concept of materiality, the timing of the audits or even how the annual audit opinion may be replaced by some sort of seal of approval. On the other hand, Coyne and McMickle (2017) provide a more skeptical view in the use of blockchain due to the lack of access controls in public blockchains (e.g. permissionless) and lack of adequate validation controls. A public blockchain is open to anybody so there are no controls preventing users from reading or writing the data. While a private blockchain may address these issues, it may prevent other key stakeholders (e.g. investors) from participating in the blockchain and benefit from its features. Then, verification methods in Blockchain are designed only to prevent double spending. However, no controls are available to validate the economic events surrounding the transaction that may impact assertions such as completeness, valuation and classification.

5. FUTURE ROLES FOR THE AUDITOR

Auditors must embrace the challenges blockchain may bring in as new technologies often represent future opportunities. To ensure auditors can capitalize on such opportunities, new standards must be implemented regarding the use of blockchain technology in accounting processing information and auditors must be engaged with their clients during blockchain system developments. By doing so, auditors can suggest the appropriate audit modules to be inserted as part of the blockchain implementations. In addition, auditors must ensure the required technical skills are deployed among their staff. Last but not least, auditors should take advantage of artificial intelligence as well as any other new technologies to leverage new features available in blockchain and make the audit process more efficient and provide a quality service to their clients (Sadu, 2018). Few objectives that must be accomplished on this regard include: ability to check digital signatures and counterparties; the design of appropriate audit strategies given the complexity of blockchain systems; development of the adequate framework with regulatory bodies and other industry partners, and the availability of adequate cyber and software auditing (Boillet, 2017).

Dai and Vasarhelyi (2017) describes a new audit paradigm, which will consist of two components: the physical world and a virtual model that mirrors the physical world. The physical world consists of the company, its products, business processes, machine and systems as well as all stakeholders. The virtual world consists of three layers: blockchain, smart control and payment and, by connecting to the physical world via IoT or other communication technologies, will ensure all transactions are carried out smoothly, validated and recorded autonomously. While it may take some time for this new paradigm to become a reality, a Deloitte report sponsored by AICPA, CPA Canada and the University of Waterloo (Bible et al., 2017) reveals potential new roles for accountants as blockchain systems are standardized across industries:

1. Auditor of Smart Contracts and Oracles: As smart contracts can be embedded in a blockchain to automate business processes, contracting parties may want to engage an assurance provider to verify that smart contracts are implemented with the correct business logic.

2. Service Auditor of Consortium Blockchains: Users of a blockchain system may require an independent party who can attest the stability and

robustness of its architecture. CPA's are uniquely qualified to perform such due diligences in an efficient and objective manner.

3. Administrator Function: A central access-granting administrator is required with permissioned blockchains. This function requires a trusted, independent and unbiased third party who could be responsible for verification of identity or a further vetting process to be completed by a participant before they are granted access to a blockchain.

4. Arbitration Function: Disputes are common during business arrangements and the creation of an arbitration function might not only help settle disputes among the consortium-blockchain participants efficiently but also enforce contract terms.

6. DISCUSSION AND CONCLUSIONS

Given the increased noise surrounding Blockchain, it is critical auditors understand how this technology will impact the profession and more importantly, how it can be used for their advantage. The business world is getting increasingly complex and auditors need, more than ever, effective and reliable tools that allow them to provide the assurance that is required and is expected from them. Furthermore, auditors are also seen as business consultants and therefore, are expected to be subject matters in all relevant technologies. As a result, even if the impact of Blockchain on auditing is minimal, auditors will need to understand how such technology is impacting a client's business.

This paper has gathered the key concepts from previous studies to examine the feasibility of using Blockchain when conducting audits. By doing so, it allows readers gain a good understanding of what has been researched and done so far as it pertains to accountants. As any other technology, Blockchain is evolving and therefore, the information provided on this paper may need to be revised in the near future. In addition, future research may be focused on how "smart features" (similar to those built in Smart Contracts) can be implemented to provide the robust controls needed to satisfy other assertions, such as completeness, valuation and classification. Building such features may represent a challenging programming task as may need to mirror not only contractual clauses but also accounting standards. However, once this task is overcome, the use of Blockchain in audit will be closer to a reality.

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