THINK OUTSIDE THE BLOCK: BLOCKCHAIN APPLICATION IN THE AUDITING PROCESS

Author:

Hanna Batchelder

Faculty Sponsor:
Hossein Nouri
Department of Accounting & Information Systems

ABSTRACT

Blockchain possesses special abilities to directly transfer anything of value safely from one party to another without any intermediaries getting involved. Business entities are experimenting with blockchain solutions and are seeking guidance from auditing firms for implementation and reporting purposes. By harnessing this technology, blockchain will be a formidable industry disruptor in the accounting and auditing industry.

Auditors must assess client transactions and ensure that audit opinions are supported with relevant, reliable, objective, accurate, and verifiable evidence on the presentation of financial statements. Transactions recorded on the blockchain may be sufficient evidence for testing of internal controls. On the other hand, auditors must be aware of the risk of potential fraud or error due to blockchain—a topic this paper will cover. Overall, this paper aims to explore the applications of blockchain technology in the accounting profession at the different phases of an audit, while considering the new audit risks associated. The analysis begins with a high-level overview of blockchain's history and its relationship with Bitcoin. This study will guide auditors by expanding upon existing academic literature and professional sources that discuss blockchain in auditing industry. Throughout the paper, blockchain will be examined critically and its limitations in auditing will be addressed. More specifically, this paper makes the following contributions:

1. Highlight blockchain implementation as a public versus a private system. Existing studies overhype and explain the far-reaching potential of blockchain. This paper highlights the actions public accounting firms can take now in order to understand blockchain adoption and address the potential risks involved.

2. Provide an overview of how blockchain will impact and change public accounting firms' services to their clients. Audit firms must consider the complexities and guidance rollouts that clients will need to navigate in the blockchain realm.

3. Offer suggestions for potential research questions and future avenues in blockchain-related auditing and consulting fields.

LITERATURE REVIEW

At its core, blockchain technology can directly transfer anything of value safely from one party to the next[1] without any central institution or middleman getting involved. Blockchain technology goes beyond the transferring of physical goods. Blockchain includes digital assets, photos on Instagram, college transcripts, house or car deeds, crypto assets, and financial instruments like stocks and bonds[2]. Furthermore, transferring goods safely across the blockchain is ensured by tracking everything on the distributed ledger. Traditionally, digital assets could be copied and attempted to utilize their value more than once. But blockchain technology prevents the "double spending" problem by verifying and approving against the ledger. To explain, each block contains the data, the current block's hash, and the previous block's hash. A hash serves as a fingerprint. Each new block created is linked to all previous blocks and assigned to a unique ID in the

[1] Transferring anything of value to another 'party' is open-ended. A 'party' (identity) can be a person or thing (i.e. establishing a physical asset like a car or house as a verifiable identity). But if a person is the identifier in the transaction, blockchain can validate that this is an actual person by requiring certain credentials like a degree or certificate.

[2] This is not to say that physical assets cannot be transferred along the blockchain. Physical assets like a house, a piece of fine art, or a car can be represented as a coded value and digitally transferred between parties.

digital ledger[3]. Transactions that change for a specific block will alter the unique ID of the hash. In other words, hashes can detect changes in the current and past blocks. If any of the blocks in the chain is tampered with, all following blocks are deemed invalid because there is no longer a matching hash.

To initiate a transaction, each party utilizes a set of "keys," which are unique numeric identifiers linked together through cryptography to accept exchange (Figure 1). Blockchain technology ensures the transfer of value is secure and direct by verifying the transactor's identities, recording the transactions permanently (tamper-proof and irreversible), and sending a copy of the transaction to distributed nodes[4] around the world (McCauley, 2018). Ultimately, this transfer of digital assets removes the intermediaries, verifies the identity between parties with public and private keys, traces each transaction, and publicly displays the exchange on the blockchain leaving a traceable audit trail. At a high-level overview, blockchain functions as a secure, distributed database that leverages cryptography and peer-to-peer[5] technology to group data into blocks and create an immutable chain of transactions (AICPA, 2018b).

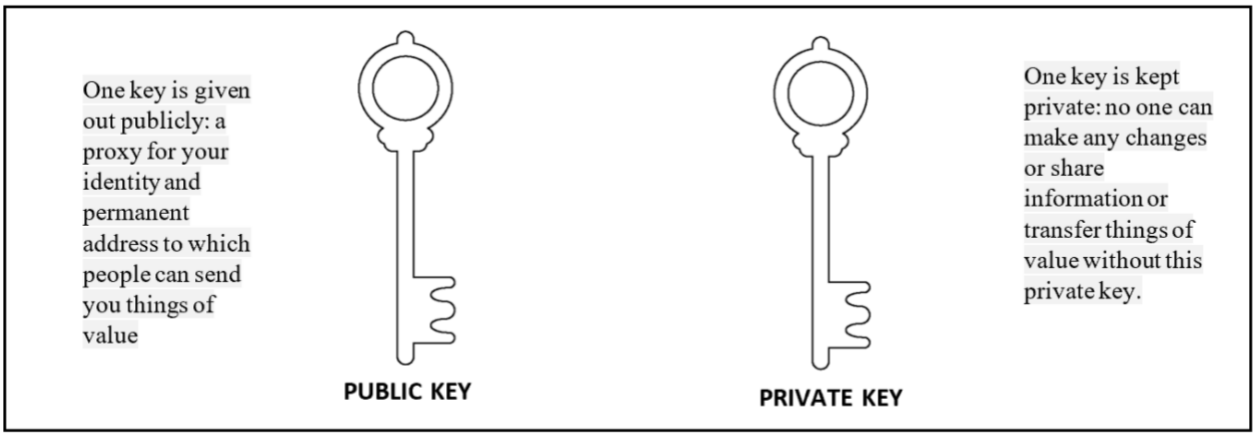

Figure 1. Understanding the Public versus Private key

A. PERMISSIONED VERSUS PERMISSIONLESS BLOCKCHAIN

Not all blockchains are created equal. It is vital for auditing firms to be aware of the two distinct types of blockchain networks: permissionless and permissioned. Each type of network has its benefits and its risks involved, but the biggest difference between these networks is the extent of user/party access.

The most familiar network is Bitcoin's permissionless blockchain. The appeal of Bitcoin is the public acceptance of transactions by a majority of network users. The platform is updated by miners, monitored by everyone, and owned and controlled by no one. A permissionless blockchain offers the benefit of decentralization; however, it has its drawbacks. For example, a permissionless blockchain, such as Bitcoin, has a speed limit in processing large volumes of transactions, which constrains its large-scale application as compared to the existing credit payment systems (Liu. M; Wu, K.; Xu, J. J, 2019, p. A22). As highlighted earlier in the paper regarding Bitcoin's processing speed, it is not very fast. The proof-of-work for each Bitcoin averages 10 minutes in order to add a new block to the chain. This time lag is a tradeoff for the

[3] The link between each block is called a "hash" and serves a powerful purpose. A hash not only links two blocks together but generates a unique identifier by running the previous block's hash and the data stored in the current block. Essentially, hashing serves a digital fingerprint that stores the history of the blockchain from its origin. If a block is altered, reversed, or tampered with, the block would produce a different fingerprint to document the changes. Therefore, if someone tried to hack the blockchain, they would have to change the current and all the past blocks (which is incredibly difficult.)

[4] A node is a connection within a network. Nodes serve as the validators of every transaction on the blockchain record. Every node will compare to the respective record and ensure there is a match. If the nodes do not agree with the rules stated, the record/transaction is rejected.

[5] A pure "peer-to-peer" network is the best way to describe the blockchain and its decentralization feature. Blockchain's ultimate purpose is to connect two parties directly, without the need of intermediaries. To take this further, "extreme peer-to-peer" is the -near-total extraction of the middleman.

heighted security that protects the blockchain from being tampered with or manipulated. Thus, allowing the public blockchain to function in favor of the miners. In addition, Bitcoin is a form of pure decentralization. Instead of utilizing a central entity to manage the chain, blockchains use a peer-to-peer network and everyone is allowed to join. When someone joins, they get a copy of the chain. The new block is sent to everyone on the network, and if accepted by the majority, the block is accepted. Lastly, for the permissionless blockchain such as Bitcoin, it is constantly evolving.

One of the most recent innovations of blockchain is the introduction of smart contracts. These contracts are simple programs that are stored on the blockchain and can be used to automate certain tasks based on the conditions applied. To combat the time lag of adding a block to Bitcoin, many miners set up smart contracts to automate the mining process and add thousands of blocks consecutively to the chain. In general, smart contracts provide the incentive of "automating the contract process and enabling monitoring and enforcement of contractual promises with minimal human intervention. Automation can improve efficiency, reduce settlement times and operational errors" ("Blockchain Technology and Its Potential Impact on the Audit and Assurance Profession", 2021, p. 9). But likewise, smart contracts have its risks and limitations. Since smart contracts are executed based on a specific rule set, the parties implementing the process (either management or the auditor), may decide not to address every possible out in order to not limit themselves. Consequently, the lack of smart contracts and automation could lead to vulnerabilities or errors that predict undesirable or inaccurate business outcomes. If auditing clients rely on smart contracts and blockchain for internal control procedures, it may be difficult for auditors and third-party users to understand the process and implications since the technology is so new and has a lack of regulation and oversight. Auditors must exercise professional skepticism and potentially conduct further testing to provide reasonable assurance that the accompany smart contracts are implemented correctly with the corresponding blockchain. To achieve this level of competence, new and current auditors will need to receive continuing education and training to prepare for these foreseen risks. Regardless, smart contracts offer the ability for heighted security and automation within the auditing process.

But permissionless blockchains like Bitcoin are not always the most advantageous network for every organization. Entities and clients that wish to experiment with blockchain solutions may desire more centralized privacy because public distributed ledgers might compromise business secrets. In contrast to a permissionless blockchain, a permissioned blockchain places restriction in its membership and control procedures. In such a blockchain, participants' roles are defined in which certain members can access, write information on the blockchain, or approve admission of new members. A permissioned blockchain is deemed partially decentralized because different members have different access control authorizations. On one hand, with appropriate deployment of access-control layers, a permissioned blockchain has a greater potential to maintain privacy and fit business governance needs than a permissionless network.

But a hybrid decentralization has its risks. Assume the central administrator of the permissioned blockchain validates, enforces, and monitors the network. If this function is performed by an individual or a small group of collaborators of a business entity, this could compromise objectivity if the users validate transactions in the interest of the company. From an auditor's point of view, this could be difficult to detect fraud or error because the blockchain doesn't appear tampered or modified since the transactions are approved in a consensus. The goal of blockchain is to create trust in auditing and financial reporting, but this could compromise its function. As a solution, due care will be needed when establishing both the blockchains function and governing responsibilities. As a trusted professional, the entity should consider introducing an independent CPA who is capable of understanding the nature of the business and related blockchain technology ("Blockchain Technology and Its Potential Impact on the Audit and Assurance Profession", 2021, p. 12).

B. SENTIMENTS TOWARD BLOCKCHAIN ADOPTION

Blockchain's driving force is the promise of decentralization. Corporations, academic institutions, cryptocurrency startups, and government agencies are dreaming of how blockchain could redefine the digital world in the next decade. They are transforming our digital lives into something that values and embraces real transparency, trust, and accountability. Hundreds of the world's largest companies have joined the blockchain and decentralization movement to collaborate, learn, and experiment together. According to the Deloitte 2020 blockchain survey of 1,488 "blockchain-savvy" senior executives worldwide, roughly 86% of the senior executives believe that there is a compelling business use case of blockchain technology. Furthermore, 83% of senior executives fear that their organization or project will lose a defining competitive advantage if blockchain technology isn't adopted. It is becoming more apparent that blockchain can redefine business transactions among the financial sector and related industries. The Deloitte survey highlighted that "leaders no

longer consider [blockchain] technology groundbreaking and merely promising—they now see it as integral to organizational innovation" ("Deloitte's 2020 Global Blockchain Survey", 2020).

While blockchain is still in the infancy stages, make no mistake: we are at the dawn of the next great wave of disruption. Blockchain technology has created an opportunity for entrepreneurism but also a new set of challenges to overcome. Even with the great promise of decentralization, fundamental issues of scalability, user experience, governance regulations, high overhead costs, and organizational collaboration impede the progress of blockchain adoption. According to the Deloitte 2020 blockchain survey, 41% of senior executives believe blockchain technology has the inability to create fair and balanced governance rules. In addition, 36% of senior executives strongly believe there will be severe onboarding challenges with implementation ("Deloitte's 2020 Global Blockchain Survey", 2020). Despite less than half of the participants believing these fundamental challenges pose significant constraints, once government-related concerns and regulations are established, increased acceptance of blockchain will follow in the business sector.

C. NAKAMOTO AND BITCOIN

In the realm of new technology, there will always be more questions than answers. A common point of confusion in the blockchain realm is its relation to cryptocurrencies such as Bitcoin. Is blockchain Bitcoin? In reality, blockchain serves to aid Bitcoin in its usage and implementation. Bitcoin debuted in 2009 as the first cryptocurrency. It offered the world a decentralized currency without the assistance or backing of any financial institution. Satoshi Nakamoto, the founder of Bitcoin, believed that "an electronic payment system based on cryptographic proof instead of trust, [would] allow any two willing parties to transact directly with each other without the need for a trusted third party" (Nakamoto, 2008). Later, in 2009, Nakamoto released the first Bitcoin software, launched the network, and mined the "genesis block" of 50 Bitcoins—all accounted for on the public distributed ledger. Utilizing the ability of the hash function and the "proof-of-work" mechanism, Bitcoin was able demonstrate that a peer-to-peer network with no centralized institution involved would work. For instance, Bitcoin takes 10 minutes to calculate the required proof-of-work and add a new block to the chain. This mechanism makes it difficult to tamper with a block since one would have to recalculate the proof-of-work for the thousands of following blocks individually. So, the security of Bitcoin comes from its creative use of hashing and the proof-of-work mechanism. Instead of using a central entity to manage the chain, Bitcoin is a public peer-to-peer network that everyone is allowed to join. When someone joins, they receive a copy of the existing chain of blocks. When a new block is created, it is sent to everyone on the network, and only accepted if a majority agree to it. To successfully tamper with a Bitcoin chain, all blocks would have to be changed to match the new hash, redo the proof-of-work for all block, and achieve a 50% consensus from the members.

After demonstrating the possibilities of a decentralized cryptocurrency, Nakamoto released the remaining code and domains to the growing cryptocurrency community and allowed individuals and teams to mine[6] the rest of the available Bitcoin. The early interest, optimism, and opportunity surrounding Bitcoin can be described best as "The Gartner Hype Cycle" (Figure 2). Nakamoto's whitepaper was the trigger of innovation that spurred excitement and craze in the cryptocurrency community. Soon after the hype, the real challenges of implementation, government regulation, and application became apparent. Over time expectations matured, and many sought to overcome these challenges surrounding Bitcoin and blockchain. Twelve years later, after analyzing its many opportunities and challenges, Bitcoin is in the stage of enlightenment on the Garner Hype Cycle (marked with an 'X"). Today, we are starting to see firms like Tesla, Microsoft, and PricewaterhouseCoopers (PwC) accept Bitcoin as payment for goods and services. Tesla became the first automaker in 2021 to accept Bitcoin payments in exchange for its products subject to industry and government regulations. At the same time, Tesla purchased $1.5 billion worth of Bitcoin "to further diversify and maximize returns on [the company's] cash" (Kovach, 2021). Elon Musk's adoption of Bitcoin payment and his support of the cryptocurrency on Twitter brought new volatility concerns as Bitcoin prices surged (Figure 3). Since the announcement of Bitcoin acceptance, Tesla's (blue) and Bitcoin (purple) stock prices were positively correlated. Simultaneously, both stock prices significantly outperformed the S&P 500 (yellow) over the same year period. Then in May, Tesla and Bitcoin stock prices dropped once Tesla stopped accepting cryptocurrency payments. This change in sentiment shifted the market, ultimately affecting

[6] Miners can be anyone—individuals, teams, and communities. They serve the purpose of contributing to the ledger by running nodes and producing blocks of transactions. In return, miners are rewarded with cryptocurrency tokens (a medium of exchange) in order to keep centralized institutions like banks, government agencies, etc. out of the transaction.

investments in the two stocks. According to Bloomberg, due to high fossil fuel emissions, Tesla will accept Bitcoin payments again once mining uses 50% or more renewable energy (Saul, 2021).

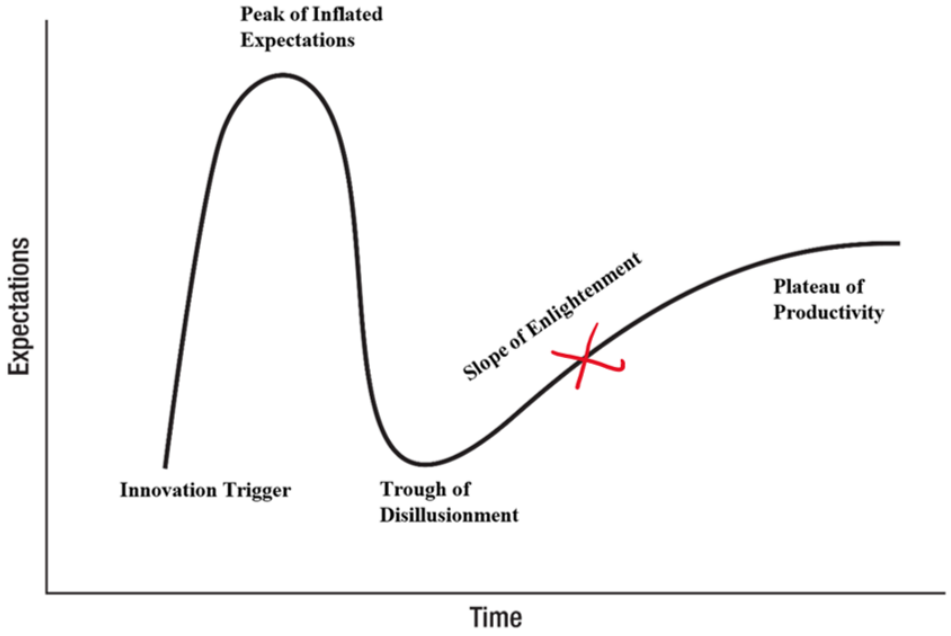

Figure 2: The Gartner Hype Cycle for Bitcoin.

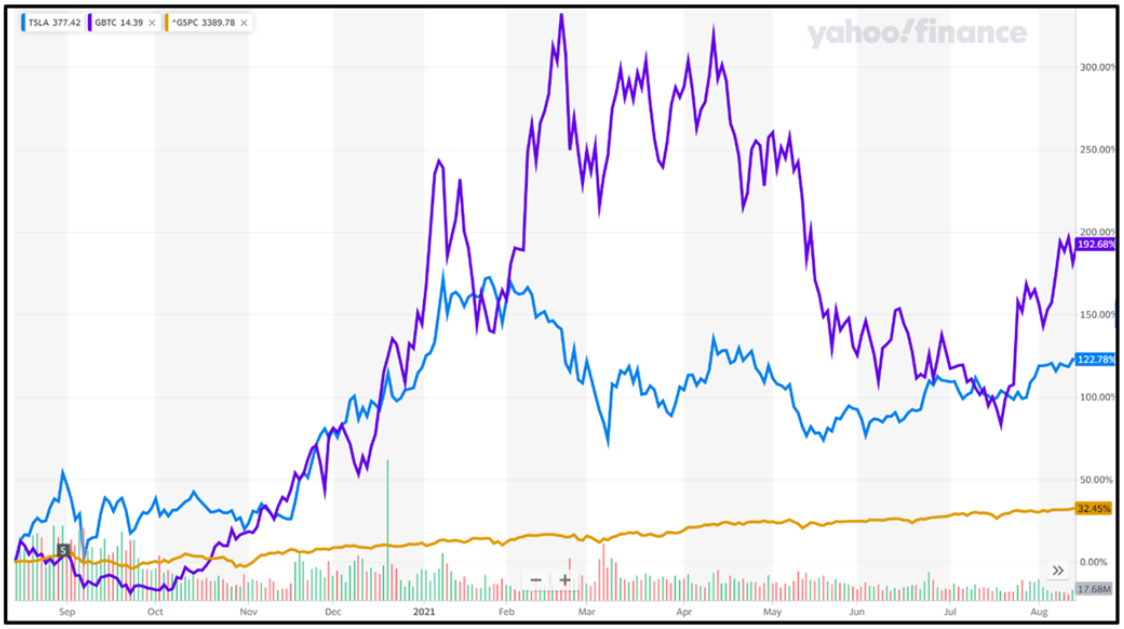

Figure 3. Stock comparison chart of Tesla (blue), Bitcoin (purple), and S&P 500 (yellow) from August 2020 – August 2021 (Source: yahoo finance)

But acceptance of Bitcoin payments is no passing trend. PwC's Hong Kong office started accepting Bitcoin payments back in 2017 for their professional advisory services. PwC noted that Bitcoin's historic $11,000 price four years ago "resulted in the emergence of questions on whether Bitcoin is a true store of value and means of exchange that can be utilized in transactions" (Althauser, 2017). Despite Bitcoin initially sparking debate, confusion, and even fear as it threatened the traditional, centralized nature of society—we eventually embraced the unknown. After years of testing and exploring the possibilities of Bitcoin, today, we have thousands of digital currencies in development. Some of these digital currencies, unlike Bitcoin, are easing their way into the decentralized nature of blockchain. For Libra, a

cryptocurrency developed by Facebook, it is designed utilizing smart contracts[7] and blockchain technology while being supported by a reserve of real assets (Libra, 2019). Libra offers a different approach to Bitcoin in terms of including a form of centralization by verifying transactions through the Libra Association and backing the cryptocurrency to limit volatility. The Libra whitepaper is still in the development stages; however, it supports the growing blockchain adoption trend in the crypto community. People are accepting decentralization as the new norm.

D. BLOCKCHAIN ACROSS INDUSTRIES

As an ownerless, stateless, and value-transfer system, Blockchain technology delivers trust in a trustless society. There are many opportunities for businesses to streamline their internal processes utilizing blockchain-based systems to foster collaboration in complex ecosystems. As per (Hyperledger, 2019).:

> In the agricultural industry, blockchain revolutionized food traceability, food fraud, and false labeling. Walmart partnered with Hyperledger Fabric to solve the issue of food-borne outbreaks. Traditionally, it can take days, if not weeks, to find the source of contaminated food. Better traceability in the food industry could help save lives by allowing companies to act faster and protect the livelihoods of farmers by only discarding produce from the affected farms and executing this process involved "suppliers [using] new labels and [uploading] their data through a web-based interface. The Hyperledger Fabric blockchain-based food traceability system built for the two products worked. For pork in China, it allowed uploading certificates of authenticity to the blockchain, bringing more trust to a system where that used to be a serious issue. And for mangoes in the US, the time needed to trace their provenance went from 7 days to... 2.2 seconds"

In the health care industry, electronic health records can receive enhanced security, privacy, and regulatory compliance through blockchain implementation. Furthermore, blockchain can track the progression of vaccines or developmental drugs at their different trial levels—invoking a new sense of transparency and accountability with the public.

In the education industry, blockchain can fight against credential fraud and cut administrative costs to verify degrees. Additionally, student transcripts can disintermediate third-party systems that traditionally sent the files to colleges or employers. Blockchain's peer-to-peer network and ledger system will reduce the student burden of the timing and cost constraints.

In the transportation industry, blockchain can eliminate paper-based systems to achieve hyper-visibility of goods as they move through the supply chain with sensors and tracking technology. On a global scale, blockchain can increase the efficiency of managing shipping containers and accelerate the movement of goods across borders.

These are just a few industry examples that blockchain can revolutionize. Blockchain technology can also shapeshift the nature of today's auditing practices. Forward-thinking firms are exploring the application of blockchain on audit, tax, and advisory services. Imagine the possibility of this disrupting technology and its impact on the future of financial reporting. If blockchain technology is fully accepted and implemented and the challenges surrounding industry regulations are overcome, businesses will thrive on increased traceability, enhanced security, and reduced long-term costs. Blockchain is invoking a set of changes in accounting practices, driving toward the goal of greater efficiency.

E. EMERGENCE OF BLOCKCHAIN FROM BITCOIN

Satoshi Nakamoto's 2008 whitepaper was ignored by all except for a small group of Bitcoin-gurus in the early stages. Later, the cryptocurrency craze exploded and attracted tech-based entrepreneurs looking to capitalize on the opportunity. Then, Bitcoin caught the public's eye in 2017 because of the swarming media coverage over the currency's skyrocketing price jump (Figure 4)[8]. Fast-forward to today: the whitepaper spurred thousands of companies to build

[7] Smart contracts are a fundamental concept of blockchain. They establish a predefined set of rules and instructions that allow blockchain transactions to self-execute the desired process. Smart contracts can enact traditionally manual processes autonomously like releasing passwords to designated personnel, transferring funds to agencies, or allowing the next step of the audit process to proceed.

[8] Google Trends is a website by Google that analyzes the popularity of top search queries in Google Search across various regions and languages. The website uses graphs to compare the search volume of different queries over time. Bitcoin's (the red line) height

crypto-businesses, experiment with blockchains, and invest in the technology. But the outcome of these projects is often clunky, impractical, costly, and unscalable to today's standards. This is nothing new. If we look back on the history of technology, this is how they all start out. With anything new, we need to push forward to set the base, construct business models, and improve the user experience through trial and error.

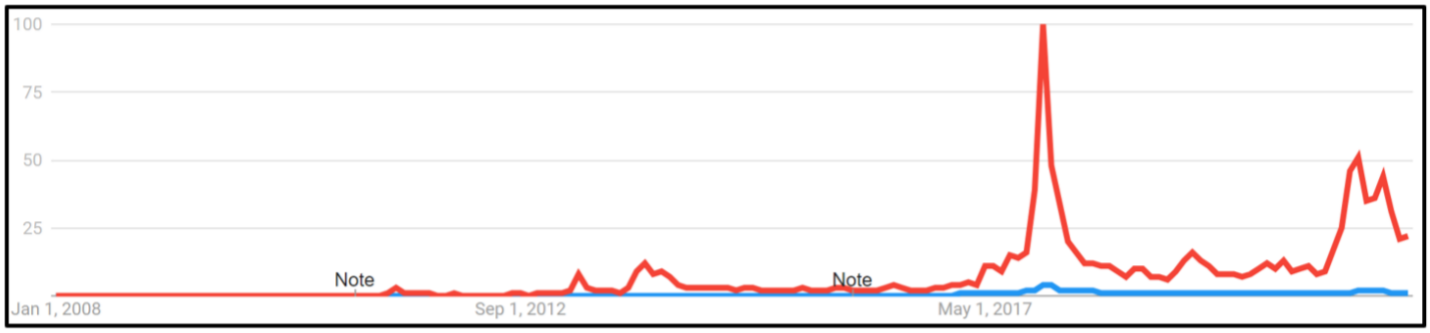

Figure 4. Google Trends comparison between bitcoin (red line) and blockchain (blue line) from 2008 – 2021 based on interest over time. (Source: google trends)

The speed of innovation and adoption varies across the scale—some initiatives will take off in a couple of years while others will take decades to reach the attention of the public. According to Deloitte's 2020 Blockchain survey, roughly 40% of organizations have adopted blockchain into production, a 26% increase from the last year. This new data suggests that blockchain is making the leap from a theoretical application to a practical application ("Deloitte's 2020 Global Blockchain Survey", 2020). These leading pioneers and organizations that are immersing into blockchain-driven experiments, collaborations, and software developments are paving the future of decentralization.

But there is debate in the blockchain community over what decentralization really means, how far it should go, and weighting the opportunity costs of forgoing the traditional centralized system. As we see more businesses adopting blockchain into their systems, it will most likely be an addition to an existing centralized system. Since blockchain only recently emerged as a new area of research, scholars have based their studies predominantly on early adopters of the technology in their professional literatures, online sources, and reports. In the accounting field, the number of academic publications is even more limited since auditing use of blockchain have not been fully implemented. Next section reviews academic and professional publications, blockchain-savvy articles, and crypto-centered whitepapers addressing blockchain in the accounting and auditing industry.

F. BLOCKCHAIN TECHNOLOGY SCHOLARY SOURCES

A search on Google Scholar utilizing the keyword search terms 'blockchain', 'distributed ledger technology', and 'auditing' was used to find related articles regarding blockchain use cases in auditing. Next, the search was narrowed from 2016 – 2021 in order to populate the most relevant source material. From this initial search pool, only peer-reviewed academic journal articles or book chapters written in English were considered. Conference papers, book reviews and newspaper articles were not considered. After reading the top filtered sources, articles whose content was not related to blockchain technology or cryptocurrency in the accounting and auditing domain were also removed. Following this process, book chapters and journal articles were excluded that mention blockchain technology in the context of research fields irrelevant to this study, such as the health sector, capital markets, agriculture, telecommunications, and supply-chain management. Moreover, sources that only mention blockchain technology and/or distributed ledger technology and accounting and/or auditing without engaging in the application in context were not considered for the scope of this study.

Due to the limited nature of scholarly work on blockchain technology in the accounting and auditing domain, I turned to major professional accounting and audit firms worldwide for publications. This step was crucial to find more comprehensive outlooks of how auditing practitioners are searching and developing practical applications of blockchain

of popularity was in 2017 when the stock price soared. Soon, the stock price fell which decreased the cryptocurrency's brief moment of fame. However, recently the Bitcoin term is making a comeback as firms like Elon Musk's Tesla are accepting cryptocurrency payments in exchange for products.

technology in the accounting industry. Exploring practitioners' views and perceptions of blockchain could help an understanding of the potential this technology would affect accountants and auditors in the profession.

While the impact of true blockchain-led transformations will be massive, it will most likely take years to fully seep into the foundations of our economic and financial institutions. Even the core idea of decentralization is widely debated. In recent studies regarding full-scale blockchain adoption in the accounting industry, many scholars warn that "auditors [will] become marginalized, or even irrelevant, as accounting transactions recorded on the blockchain are confirmed as true and accurate", where "given access to the blockchain containing the accounting transactions, anyone can aggregate these transactions in real time into financial statements without the need for auditors to vouch for the accuracy of the books" ("Blockchain as the Database Engine in the Accounting System", 2019, p. 312). But this extreme scenario is unlikely. This study seeks to expand upon existing studies that embrace a blockchain-driven world where this technology aids in the audit process. In 2019, a series of scholars consisting of Karajovic, Kim, and Kaskowshi published a paper describing blockchain's potential to completely reshape the auditing practice. They highlighted at the early stages of blockchain implementation, auditing will become a streamlined process through triple-entry accounting systems and smart contracts. CPAs will have available time to concentrate more on value-added work such as data analysis and client advisory services (Karajovic et al., 2019). To build upon the insights of the Karajovic et al.'s study (2019), this paper explores the possibility of both a public and private blockchain system in auditing as well as smart contract implementation. To this end, this study will apply blockchain on micro scale and how each phase is affected.

BLOCKCHAIN USES IN ACCOUNTING

A. A BIG FOUR IMPACT

It is evident that this new technology will be the next industry disruptor. Few organizations are prepared to deal with level of uncertainty and navigate through the many changes needed to decentralize the accounting systems. And many will, understandability, hesitate to join these pioneers through the pain change requires.

Big Four accounting companies (PwC, Deloitte, EY, and KPMG) want to thrive in incoming blockchain wave by learning and navigating effectively in the new space. Currently, all Big Four companies demonstrated some interest in blockchain technology as their client's gauge in the cryptocurrency space (O'Neal, 2019). In 2019, Deloitte dived headfirst into the blockchain craze by piloting "Blockchain in a Box" that provided an intuitive blockchain demonstration. Deloitte customed built a mobile platform "capable of hosting blockchain-based solutions across four small-form-factor compute nodes and three video displays, as well as networking components that enable integration with external services, such as traditional cloud technologies. Each node accepts Secure Digital (SD) card media, facilitating rapid selection and exchange of demo solutions tailored to specific client needs" (Deloitte Debuts 'Blockchain In a Box' (BIAB), 2019). There was significant value in Deloitte building this early blockchain platform. As business leaders, Deloitte saw beyond the "hype cycle" and demonstrated their understanding of blockchain. Clients reacted to this blockchain pilot with curiosity and excitement as more use cases of the technology emerged. And the other competitors followed Deloitte's lead.

EY introduced the Blockchain Analyzer that is designed to foster collaboration within audit teams by documenting transaction data across distributed ledger technology. Auditors can inspect and investigate the data to validate transactions as well as reconcile and identify transaction anomalies. So far, the technology has been proven to support testing of multiple cryptocurrencies like Bitcoin and other crypto assets managed or traded by exchanges or asset management firms (Thomas, 2018).

PwC is taking a different approach to blockchain adoption and focusing more on the cryptocurrency aspect. As the first Big Four accounting firm to accept Bitcoin payments, PwC is diving into the blockchain platform and providing survey insights. PwC already observed blockchain integration in firm's enterprise software platforms of finance, accounting, human resource, and customer resource management divisions. According to their research, PwC mentions notable key player like "Microsoft, Oracle, SAP and Salesforce [announcing] blockchain initiatives" and that "in the future, many core business processes will run on—or interoperate with—blockchain-based systems. Using blockchain in concert with enterprise resource planning platforms will enable companies to streamline processes, facilitate data sharing and improve data integrity" (PwC Global, 2018).

KPMG may be late to the game, but it is entering the blockchain realm in a divisive partnership with global software leader Microsoft. Expanding beyond the auditing industry, the focus of this partnership is to propose a

blockchain solution utilizing smart contracts in order to reduce disputes between carriers and mobile operators. Smart contracts would be structured with specific instructions to include critical information of correct carrier rates, destination, and bilateral deal information. KPMG believes that blockchain will be useful in scalability by outsourcing settlements. According to KPMG, "at present, cross-border and cross-carrier settlements are reportedly a complicated and lengthy process. These settlements can purportedly take weeks to resolve and are frequently outsourced to third parties due to their complexity" (Boddy, 2019).

There is a strong motivation for all four of these firms to understand and navigate blockchain opportunities even as it is still emerging. Common themes among these firms are the fact they are recognizing the disruptive nature of blockchain and exploring the countless opportunities to decentralize trustless systems. But more than ever, these firms are piloting private (permissioned) and public (permissionless) blockchain technologies to better adapt to client needs. Because of these pilot projects, there will be an increasing number of lucrative partnerships to reflect the growing impact blockchain has in the accounting and auditing industry.

B. TRADITIONAL ACCOUNTING SYSTEMS AND BLOCKCHAIN APPLICATION

Prior research also compares the traditional accounting information systems (AIS) to blockchain technology in the auditing cycle. While the scholars provided a high-level overview of blockchain's implication, they neglected cross-comparing to the existing accounting systems in place. Furthermore, they left out key elements of how blockchain can be utilized to reach the application phase. Table 1 highlights the process of getting to 'use case' phase of blockchain in the auditing practice, followed by the detailed explanation of each auditing step.

Blockchain Application on Stages of the Auditing Process		
Auditing Step	**Traditional AIS**	**Blockchain's Application**
a. Planning, Advising, Documenting	• External auditors' setup a shared software portal (or third-party website) where clients are expected to upload records and documentation. • High costs to upkeep client documentation portal • Limited time for analysis since professionals and resources are focused on gathering information to meet deadlines.	• Collect client records and documentation utilizing a permissible blockchain to ensure protection of private data. • Ensure complete, accurate records for auditors to quickly spot problems, prioritize plans, and find long-term patterns.
b. Sampling/Evidence Gathering	• Statistical and/or Non-Statistical audit sampling of population (unable to sample 100% of population due to timing, cost constraints, and efficiency purposes) and auditors are only expected to provide reasonable assurance of financial statements.	• Ease of audit sampling the population with enhanced scalability on a public/private blockchain. • Digital access of transaction history with client information shared between external auditors and client on distributed ledger—new opportunities, pose new risks for internal control.
c. Validating & Reconciling Transactions	• Requires auditors to test internal control procedures and accounting systems to ensure they are valid by conducting walkthroughs with client's internal auditors. • Documentary evidence with valid dates need to be manually reviewed. • Review client's financial statements. • Audits are conducted on a monthly, quarterly, or annual basis (depending on client or regulatory deadlines). • Focus is on the double-entry accounting system.	• Real-time transaction validation by a community of miners (this can be individuals or teams hired by the external auditor to ensure client information is not leaked). • Continuous audit by automating reconciliations in a triple-entry accounting system[9] on the blockchain network. • Timestamping along the blockchain ensures verification of transactions (completely automated process).
d. Compliance Evaluation	• Manual review, trainings, and staying up-to-date on latest AICPA publications and guidance. • Accounting firms are embedding AIS systems with compliance regulations; however, these systems need to be manually updated if changes occur. Otherwise, fines, penalties, or PCAOB inspections may follow and can jeopardize reputation.	• Built-in compliance and regulation utilizing smart contracts to establish the guidelines. • Immediate detection of industry or regulatory violations because the immutable audit trail and smart contract implementation.
e. Financial Reporting	• Reporting is produced on a monthly, quarterly, or yearly basis based on client & regulatory deadlines	• Real-time, continuous financial reporting on a public or permissible blockchain • Error-proof due to recording the transactions permanently, and sending a copy of the transaction to distributed nodes
f. Decision Support	• Information is hoped to be delivered in a timely basis based on available personnel and resources. • Analytics are typically conducted at the end of the audit process once client information is received. Trends and patterns are identified.	• A peer-to-peer network allows for reliable and timely information to be transferred across the blockchain to perform analytics. • Embedding smart contracts with specific rules and instructions to execute desired analytical models to identify patterns/trends.

Table 1. Breakdown of blockchain application in the different phases of the audit process. Expanded upon the research of Liu. et al., 2019)

[9] The term "triple-entry accounting" stemmed from two individuals by the names of Yuji Ijiri and Ian Grigg. Ijiri coined the concept in 1986, but Grigg redefined the application of 'triple-entry accounting' in 2005. Utilizing his experience in financial cryptography. Grigg proposed a solution in 2005 to deal with accidental errors and fraud in accounting, and essentially 'decentralize' the recording process of business transactions. He believed that a "a third-party, cryptographically secured entry can be recorded at the same time

PLANNING, ADVISING, AND DOCUMENTING

Both the PCAOB and AICPA auditing standards indicate that auditors must plan the work of an engagement. Engagements should be properly planned to ensure sufficient appropriate evidence is obtained, help keep audit costs reasonable, and avoid misunderstandings with the client. In addition, the auditor must identify and assess risks of material misstatement, whether due to fraud or error, based on their understanding of the entity and its environment, including the entity's internal control. Ultimately, auditors seek assurance in a complex world. To do so, auditors conduct risk assessment procedures like inquires of management and analytical procedures to assess the business risk and risk of material misstatement. For the purpose of this research, auditors need to be aware of how blockchain technology can affect internal client processes in order to improve the quality and timeliness of delivering accounting information. Auditors inquire and inspect management's financial statements by asking where transactions come from, where the support for transactions can be found, and decide if further testing is required. Auditors are demanding transparency with their client to better serve their needs while staying compliant with regulatory guidelines.

Blockchain can offer this increased transparency between the auditor and client. As described earlier in the paper, entities can benefit greatly from utilizing a permissioned blockchain because of its hybrid-decentralization and enhanced security. Transactions posted and approved on the blocks can be traced, confidential, and visible based on the current and prior hashed blocks. Overall, private blockchain are proven to "lower risk of management accounting fraud, lower cost of validation and greater compliance with the legal requirement of primary responsibility for accounting information" ("Blockchain as the Database Engine in the Accounting System", 2019). Any members included in the private can monitor the flow of documents and data entering the chain based on mathematics and cryptography. To mitigate risks of material misstatement due to fraud or error, the auditor must be independent, understand the nature of the clients blockchain's internal control, and gather evidence to confirm the blockchain is functioning properly because of limited regulatory guidelines. The benefit of blockchain; however, allows accounting firms to not rely on a centralized system or outsource to third parties to gather client records and documents. Instead, management can look for patterns along the blockchain and focus on data analysis.

SAMPLING / EVIDENCE GATHERING

Audit sampling is the selection and evaluation of less than 100% of the population of relevance such that the auditor expects the items selected from the sample to be representative of the population and, thus, likely provide a reasonable basis for conclusion about the population. But obtaining a representative sample is difficult due to the fact that auditors never know whether a sample is representative even after all the testing is complete. There is the potential for sampling risk, which is the risk that an auditor reaches an incorrect conclusion because the sample is not representative of the population. Sampling risk is controlled by adjusting the sample size and selecting an appropriate method of selected items from the population. Traditionally, auditors use statistical and non-statistical sampling techniques in their audit of the financial statements. For both these methods, auditors must plan the sample, select the sample, perform the tests, and then evaluate the results. Nonstatistical sampling is a procedure that does not permit the numerical measurement of sampling risk while statistical sampling can quantify (measure) sampling risk in planning the sample (step 1) and in evaluating the results (step 4). Under auditing standards, auditors can use either statistical or nonstatistical sampling methods. When statistical sampling is used, the sample must be a probabilistic[10] one and appropriate statistical evaluation methods must be used with the sample results to make the sampling risk computations. Many data analytics tools and counting software exist in order to choose representative sample sizes and conduct risk assessments. Audits will test the clients' internal controls for operating effectiveness, conduct substantiative tests of transactions for monetary correctness, and perform test of details of balances on certain accounts for material misstatements. Transactions and accounts are sampled and tested based on thresholds established in the data analysis. For example, a threshold for account changes of 5% may be flagged in an auditing software and alert the auditor to go back and review. Then, the auditor would

for transactions between entities. In this third entry, the debit recorded by one entity is the credit recorded by the counterparty." (Cai, p. 76)

[10] Probabilistic sample selection is a process that does not involve any auditor judgement regarding the sample items selected. Various types of probabilistic sampling methods include simple random sample selection (elements have an equal chance of being sampled), systematic sample selection (elements are selected based on the size of interval), probability proportional to size sample selection (elements are emphasized based on larger recorded amount).

determine if the transaction or account needs more sampling and testing, as well as more evidence accumulation to ensure there is not a material or highly material misstatement.

For auditors in the profession, data analysis is a helpful tool for sampling a population and issuing reasonable assurance that the client accounts and transactions are not containing material misstatements. However, due to sampling risk, the sample selection may not always be representative of the underlying population, meaning that material misstatements could go undetected even if regulations and professional standards are followed when conducting the audit.

Alternatively, blockchain opens up the possibility for unprecedented population sampling driven by decentralization. For starters, statistical sampling techniques may be reduced be needed since blockchain ensures all data is available on real time. Transactions and account data can be stored along each block and members of the permissioned blockchain can verify. Most notably, blockchain may be able to overcome the limitations posed by traditional audit sampling procedures. Auditors are entering a territory where "test the entire population of transactions and account balances within the period under audit. Expanding the coverage of audited items by such an extent will greatly enhance the level of assurance provided by auditors, which in turn will elevate the perception of the audit profession" (Barandi, 2020, p. 208). Despite not being able to sample an entire population of the transactions, blockchain can look specifically into client accounts that are susceptible to frequent material misstatements. To elevate the blockchain sampling process, smart contracts can be implemented to support data analytics testing. Since transactions and account data are stored on an entity's blockchain, smart contracts can be programmed to automatously flag anomalies or accounts that exceed the organizations threshold (i.e. 5%). Unlike traditional data analytic models, smart contracts do not require human intervention to function as long as the rules and conditions are specified to carry out. Smart contracts are incredibly useful considering most internal control procedures do not change drastically year to year. However, the audit risk of utilizing solely blockchain could result in collusion among members in the permissioned group. If there is material misstatement due to fraud (i.e., management creates fictious, unauthorized, or erroneous entries and approves them), it may be difficult for the auditor to detect. Therefore, blockchain should serve as additional tool when testing for internal controls or substantive testing .

VALIDATING AND RECONCILING TRANSACTIONS

Blockchain technology has the capability to immutably trace the different parts of an audit. Management will actively leverage this feature to demonstrate that they comply with regulations and have verifiable data. This will set new standards for transparency—and ultimately an expectation for it, influencing other auditing firms to follow along. Clients' definition of quality audit practices will expand to include provenance of transactions. Blockchain offers the possibility of real-time transaction validation by a community of miners. As previously stated in the audit process, an audit involves an assessment that recorded transactions are supported by evidence that is relevant, reliable, objective, accurate, and verifiable. Under a permissioned blockchain, "the acceptance of a transaction into a reliable blockchain may constitute sufficient appropriate audit evidence for certain financial statement assertions such as the occurrence of the transaction (e.g., that an asset recorded on the blockchain has transferred from a seller to a buyer)" ("Blockchain Technology and Its Potential Impact on the Audit and Assurance Profession", 2021, p. 12). On the other hand, auditors are required to exercise professional skepticism, especially on new, emerging technologies because of the lack of oversight and guidance. Since most clients are more likely to utilize permissioned blockchains, it is essential that auditors understand, document, and test the internal control procedures. Auditors must look for any potential misstatements that could be caused by utilizing blockchain or any other new technologies. Additionally, a transaction in a blockchain may not provide sufficient appropriate audit evidence related to the nature of the transaction. In other words, a transaction recorded in a blockchain may still be:

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

Blockchain transactions for an asset purchase may provide sufficient appropriate evidence for transaction related audit objectives such as occurrence/existence, accuracy, and completeness assertions. For instance, under the occurrence assertion, blockchain can ensure the recorded sales for shipments were made to non-fictitious customers by tracing the origin of each shipment and ensure the asset was sent to the respective customer. Likewise, under the accuracy objective,

blockchain show auditors that recorded sales for goods shipped are correctly billed and recorded across the distributed ledger. Lastly, the completeness assertion ties directly to blockchain's feature of proving that existing sales transactions are recorded under GAAP, or another reporting standard based on the inputted smart contracts for the given transaction.

Another feature of validation and reconciliation of transactions is timestamping along the blockchain. Timestamping originated with Bitcoin and made it possible to prove when a transaction or block was posted to the chain. The timestamping feature ensures traceability, accountability, and transparency for all users in the public blockchain. In Deloitte's case study, the record keeping requirements in Germany requires the proof of immutability over the designated accounting period. According to Deloitte's findings "for paper receipts, the risk of unnoticed modification is seen as comparably low, because of their physical nature. In contrast, electronic files cannot be perceived physically and hence are especially vulnerable. As a consequence, digitalizing paper records introduces the necessity for further preventive measures" ("Blockchain technology: a game-changer in accounting?", 2016). Overall, blockchain makes it possible to prove integrity of electronic files easily. For example, based on ….

> one approach is to generate a hash string of the file. That hash string represents the digital fingerprint of that file. Next, that fingerprint is immutably timestamped[11] by writing it into the Blockchain via a transaction. At any subsequent point in time, one can prove the integrity of that file by again generating the fingerprint and comparing it with the fingerprint stored in the Blockchain. In case the fingerprints are identical, the document remained unaltered since first writing the hash to the blockchain ("Blockchain technology: a game-changer in accounting?").

Timestamping can be conducted at any point of transaction to validate and reconcile the transaction (i.e., timestamp when an electronic document is created from the client point of view). For instance, when a client posts a transaction to the blockchain, the date it was added is timestamped. Under a permissioned blockchain, senior management may have the authorization to accept or reject a transaction to be added based on if the event occurred. If the transaction is accepted, the timestamp records the date it is added which in turn allows the auditor to know the date the transaction was created. Timestamping is a feature of blockchain that streamlines approving, modifying, and archiving transactions throughout the year. However, while low in possibility, auditors must consider the risk of fraudulent timestamping. Fraudulent timestamping can mislead auditors and financial statement users because transactions are susceptible to being recorded in the incorrect month, quarter, or even year. If sales transactions are recorded and posted along the blockchain in the incorrect period, this could lead to an overstatement or understatement of sales on the client's financial statements. Auditors should be aware of this potential risk and continue to conduct auditing procedures to ensure the recording of transactions in the correct period.

One last interesting feature of blockchain in the validation and reconciliation process is triple entry accounting system. This might be the biggest game changer in auditing. For instance….

> "consider a payment transaction between Alice and Bob. Alice should pay Bob $100 for rendered services. In a double-entry system, the invoice exists in both Alice's and Bob's ledgers: Bob's credit and Alice's debit. In Grigg's triple-entry system, Bob writes a 'receipt' on a third shared ledger with a signature. At the same time, Alice sees this receipt, approves, and signs it as well (see Figure 1 for a simple illustration). If such a third entry is recorded immutably in a shared ledger, neither Alice nor Bob can record something differently in their own ledgers, nor can they change the internal record later. In effect, the third entry validates this transaction 'automatically'" (Cai, 2021).

The triple entry accounting system functions as a shared ledger. When there is a record of change of ownership of an asset, the ledger gets updated and will be shared to permissioned members. Therefore, this distributed ledger fits the triple-entry accounting system as a business transaction between two entities can be recorded in this third-party private ledger so that all eligible entities can visualize this updated ledger. Ideally, auditors can validate and reconcile transactions automatically without others such as banks or third-party systems.

[11] Timestamping demonstrates the point in time when a block or transaction is posted to the digital ledger. New blocks contain the list of approved transactions, the timestamp of the block, and the hash (a unique numerical fingerprint) of the previous block. Once majority of miners approve the transaction, the block is added to chain.

COMPLIANCE EVALUATION

There are many forms of value that clients have not traditionally emphasized in their communication to businesses. One key is to look for those forms of value that are best delivered by a centralized organization versus a decentralized organization. For the case of regulatory compliance with the PCAOB, AICPA, and GAAP regulation, audit professionals rely on these bodies to ensure they follow standard procedures. Collaboration with the AICPA on a public blockchain where rules and regulations could be inputted via smart contracts so that all accounting firms to follow. Furthermore, "the cost savings resulting from blockchain are another attractive aspect of the technology. Accounting, auditing, and compliance costs can be very expensive for firms…With blockchain, these errors and inconsistencies could be dramatically lessened because all the transactions would be recorded into the system automatically, in real time" (Karajovic, 2019). Furthermore, "tax compliance costs would also be significantly reduced because the taxation process could be automated via blockchain…These costs could all be avoided by using a decentralized ledger to share information and smart contract technology to self-execute accounting policies" (Karajovic, 2019). With implementation of smart contracts, the blockchain could immediately detect industry or regulatory violations because of its immutable audit trail.

FINANCIAL REPORTING

Real-time, continuous financial reporting on a permissioned blockchain is achieved by an immutable audit trail. Xero, a cloud-based small business accounting software package, is able to create an immutable audit trail.

Through this software, reporting of an invoice is used as an example. Xero can enable the accounting-based applications to link the data to the blockchain. But the shortcoming of this design is the risk of not knowing what was modified in an invoice if the invoice is tampered with after it has been finalized" (James, 2018). In traditional accounting system, it reveals….

> "the most common cause of audit deficiencies is the failure to gather sufficient audit evidence. Inability to verify whether the records are complete and accurate, supporting documents gathered are sufficient, supporting documents and account balances have not been altered, proper authorizations were followed in completing a transaction, balances between third parties and the client have been reconciled properly, there are no missing transactions…[are] some of the challenges auditors face during the evidence-gathering stage" (Vincent, 2020, p. 2).

As highlighted above, a significant limitation of traditional auditing is the fact that audits are generally completed months after the balance sheet year-end. The accounting industry is reliant on providing reasonable assurance that the financial statements are fairly presented. In order to give an opinion, auditors must gather sufficient appropriate evidence and complete the audit process, while considering timing constraints. In today's fast-paced digital world, clients want their information as soon as possible in order to appease financial statement users. Therefore, waiting 90 days to obtain an opinion on historical numbers is increasingly unacceptable to clients and the users of their financial statements, who expect auditors to provide assurance much closer to the date of the financial statements (i.e., year-end). As a result, there is a growing demand for continuous, real-time auditing. Blockchain can significantly improve the audit processes in this regard, as it enables near instant verification of transactions. Again, if auditors can verify that the client's permissioned blockchain is functioning properly by collecting sufficient evidence and making inquiry of the management, the potential for continuous auditing is possible. If the client's blockchain is sufficient, audit firms will be able to move away from year-end assessments to continuous online evaluations throughout the year. Ultimately, a continuous audit will diminish the time lag between transaction and verification dates and "could also enable auditors to concentrate on more complicated transactions that pose a higher risk of material misstatement, all while routine auditing would be substantially automated. This automation of routine tasks means that many of the time-consuming and labor-intensive data extraction and audit preparation activities could be eliminated" (Barandi, Z, 2020, p. 208).

DECISION SUPPORT

No one can do blockchains alone. It's a decentralized ecosystem and a community-driven technology that requires collaboration to be successfully implemented. In a true peer-to-peer network, information can be transferred across the blockchain to perform analytics. Since every piece of information can be stored on the nodes of the network, "the cryptographically linked logs, implemented through the storage of information records (blocks), ensure the immutability of data, and enforce non-repudiation; hence, facilitate the audit trail" (Vincent, 2020). And this is exactly what Deloitte capitalized on. Deloitte developed COINIA, a proprietary technological advancement to assist auditors in efficiently analyzing multiple types of digital assets, retrieving balances at specific block heights and dates, and verifying ownership of addresses in bulk. Because of this COINIA's blockchain technology which is "an extension of Deloitte's award-winning Cortex platform, a cloud-based data platform that harnesses the power of data by securely and seamlessly integrating data acquisition with data preparation and analytics. It combines advanced technology with business processes to generate meaningful and valuable insights in a repeatable and consistent fashion" (Raphael, J. & Steele, A., 2020).

CONCLUSION

There are many benefits and risks associated with the blockchain that auditors must address as they begin to work with this technology. There are bigger challenges to come, but even bigger rewards from this collaboration. The future of blockchain is optimistic and will ultimately resolve many obstacles in the field of auditing. Despite the promise and hype surrounding blockchain, there are existing limitations of this study of this new technology.

Blockchain is a hot topic at the moment, which is ultimately creating a blockchain blind spot. As the study mentioned, blockchain's were believed to be the solution to cyberattacks because of its impenetrable security. But recently, a group of hackers acquired $610 million of cryptocurrency from a decentralized finance company. According to sources, the intentions of the malicious cyber-attack was "for fun" and that the hackers stole the funds in order "to keep it safe" after spotting a bug in the computer code (Kharif & Mehrotra., 2021). So far, over half the stolen funds were returned to the finance company and the attackers plan to return the remaining amount in due time. But the harsh reality of this situation reveals that the blockchain's impeccable security system is not perfect. The following research questions may help to address such matters in a future study:

- How could decentralization pose a threat to the traditional accounting model, and how could decentralization reshape the market share and client experience in the industry?
- How can blockchain regain the trust of the clients, regulators, and auditors despite the potential security flaws in the system?
- To what extent would auditors be able to identify fraudulent blocks along a client's blockchain? And how is the role and expertise of an auditor going to change as a result?

As highlighted throughout the study, blockchain will succeed in a space of open collaboration. Audit firms must be open to innovation and virtual teaming to accelerate the development of blockchain. Among the Big Four accounting firms, they are reluctant to demonstrate this global collaboration in the blockchain space. Recently, Big Four accounting firms refused to share information with smaller rival firms regarding audit plans and approaches to technological advances such as blockchain. According to a public consultation that closed recently, the Big Four firms did not support the government's proposal to share audit plans with smaller accounting firms in efforts to break up the oligopoly. Deloitte, EY, PwC, and KPMG alone have control over all the Fortune 500 companies audits and other large business; however, they refused to give out their proprietary information to help the smaller accounting firms (Dwyer, 2021). Even though this issue wasn't blockchain focused, it does raise the question if accounting firms would be open to collaborating on a permissionless network. There is a rising concern that competition over market share in a limited accounting industry would compromise the future value blockchain has to offer. The following research questions may help to address such matters in a future study:

- How can collaboration and partnerships be formalized across public accounting firms?
- What kinds of blockchain partnerships are thriving and why do they work?
- What role do audit firms want to have in the broader ecosystem as blockchain technology matures?

This study has shed light on blockchain's potential in the accounting and auditing field. At the professional level, blockchain is challenging the status quo of the traditional accounting and auditing approach. As blockchain adoption increases, accounting firms will need to invest into retraining programs and acquire blockchain-enthusiasts into their audit field. Therefore, at the academic level, college institutions should raise awareness about the potential changes

introduced by blockchain technology. Academics should prepare undergraduates about the growing demand for tech-savvy skills. Another avenue of research can explore the possibility of blockchain's impact in accounting education.

Overall, this paper aimed to explore the applications of blockchain technology in the auditing profession at the different phases of an audit. Throughout the paper, existing studies were expanded upon the benefits and risks associated with blockchain streamlining the accounting processes. As blockchain technologies begin to take shape, this study will require more future research to uncover how blockchain can transform the client-auditor experience.

REFERENCES

Althauser, J. (2017): "Big Four Accountancy Firm PwC Now Accepts Bitcoin Payments", Cointelegraph. Retrieved from https://cointelegraph.com/news/big-four-accountancy-firm-pwc-now-accepts-Bitcoin-payments.

American Institute of Certified Public Accountants (AICPA), (2018b): "Accounting firm leaders and innovators gather for strategic discussions on blockchain technology". Press release, May 8, 2018. Retrieved from https://www.aicpa.org/press/pressreleases/2018/firm-leaders-innovators-gather-for-discussions-on-blockchain.html.

American Institute of Certified Public Accountants (AICPA), (2021): "Blockchain Technology and Its Potential Impact on the Audit and Assurance Profession". Retrieved from blockchain-technology-and-its-potential-impact-on-the-audit-and-assurance-profession.pdf (aicpa.org).

Boddy, M., (2019): "KPMG to Work With Microsoft, Tomia and R3 on Blockchain Telecom Solutions".

Barandi, Z., Lawson-Body, A, Lawson-Body, L., Willoughby, L. (2020): "Impact of Blockchain Technology on the Continuous Auditing: Mediating Role of Transaction Cost Theory". Issues in Information Systems, vol 21, n 2: p. 206-212. Retrieved from (SAMPLE IIS PUBLICATION PAGE) (iacis.org).

Cointelegraph. Retrieved from KPMG to Work With Microsoft, Tomia and R3 on Blockchain Telecom Solutions (cointelegraph.com).

Cai, C.W. (2021), Triple-entry accounting with blockchain: How far have we come?. Account Finance, 61: 71-93. Retrieved from https://doi-org.ezproxy.tcnj.edu/10.1111/acfi.12556.

Deloitte (2016): "Blockchain technology: a game-changer in accounting?". Retrieved from Blockchain_A game-changer in accounting.pdf (deloitte.com).

Deloitte, (2020): "Deloitte's 2020 Global Blockchain Survey". Retrieved from DI_CIR 2020 global blockchain survey.pdf (deloitte.com).

Deloitte, (2019): "Deloitte Debuts 'Blockchain In a Box' (BIAB)". Retrieved from Deloitte Debuts 'Blockchain In a Box' as a Mobile Demo Platform for Prototyped Solutions – Press Release | Deloitte US

Hyperledger, (2019): "How Walmart brought unprecedented transparency to the food supply chain with Hyperledger Fabric". Hyperledger. Retrieved from https://www.hyperledger.org/wp-content/uploads/2019/02/Hyperledger_CaseStudy_Walmart_Printable_V4.pdf.

James, R., (2018). "Creating an immutable audit trail on the blockchain with Xero & Tierion", Xero. Retrieved from Creating an immutable audit trail on the blockchain with Xero & Tierion | by Riley James | Xero Developer.

Karajovic, M., Kim, H.M. and Laskowski, M. (2019), Thinking Outside the Block: Projected Phases of Blockchain Integration in the Accounting Industry. Australian Accounting Review, 29: 319-330. Retrieved from https://doi-org.ezproxy.tcnj.edu/10.1111/auar.12280.

Kovach, S. (2021): "Tesla buys $1.5 billion in Bitcoin, plans to accept it as payment". CNBC. Retrieved from https://www.cnbc.com/2021/02/08/tesla-buys-1point5-billion-in-Bitcoin.html.

Libra (2019): "An Introduction to Libra White Paper". Libra Association Members. Retrieved from https://librabi.net/static/doc/LibraWhitePaper_EN.pdf

Liu. M; Wu, K.; Xu, J. J, (2019): "How Will Blockchain Technology Impact Auditing and Accounting: Permissionless versus Permissioned Blockchain". Current Issues in Auditing, vol. 13, n. 2: A19–A29. Retrieved from https://doi-org.ezproxy.tcnj.edu/10.2308/ciia-52540.

McCauley, A. (2018). *Unblocked*. Collins & Cross Publishing.

Nakamoto, S. (2008): "Bitcoin: A Peer-to-Peer Electronic Cash System. https://Bitcoin.org/Bitcoin.pdf.

O'Neal, S. (2019): "Big Four and Blockchain: Are Auditing Giants Adopting Yet?", Cointelegraph. Retrieved from Big Four and Blockchain: Are Auditing Giants Adopting Yet? (cointelegraph.com).

Olga, K. & Kartikay, M. (2021): "Hackers Return Funds From Likely Record DeFi Cryto Attack." Bloomberg. Retrieved from https://www.bloomberg.com/news/articles/2021-08-11/hackers-return-funds-from-likely-record-defi-crypto-attack?utm_campaign=instagram-bio-link&utm_medium=social&utm_source=instagram&utm_content=business.

PwC Global, (2018), "PwC's Global Blockchain Survey". Retrieved from PwC Global Blockchain Survey: PwC.

Raphael, J. & Steele, A., (2020): "Audit transformation and opportunities in cognitive, blockchain, and talent". Deloitte LLP. Retrieved from us-audit-transformation-and-opportunities-in-cognitive-blockchain-and-talent.pdf (deloitte.com).

Rozario, A. M. & Vasarhelyi, M. A. (2018): "Auditing with Smart Contracts", The International Journal of Digital Accounting Research, vol. 18, n. 1: 1-27. Retrieved from https://core.ac.uk/download/pdf/153445189.pdf.

Saul, J., (2021): "Tesla May Accept Bitcoin Once Crypto Mining Makes Green Shift", Bloomberg. Retrieved from https://www.bloomberg.com/news/articles/2021-07-21/tesla-may-accept-Bitcoin-once-crypto-mining-makes-green-shift.

Silverman, G. (2021): "State Street sets up digital unit to capitalize on crypto craze". Financial Times. Retrieved from State Street sets up digital unit to capitalise on crypto craze | Financial Times (ft.com).

Tan, B.S. and Low, K.Y. (2019): "Blockchain as the Database Engine in the Accounting System". Australian Accounting Review, 29: 312-318. https://doi-org.ezproxy.tcnj.edu/10.1111/auar.12278

Tan, B. S. & Low, K. Y., (2017): "Blockchain - A Database with a Twist", Australian Accounting Review. Retrieved from https://ssrn.com/abstract=2958565 or http://dx.doi.org/10.2139/ssrn.2958565.

Thomas, J. (2018), "EY announces blockchain audit technology". EY Global. Retrieved from EY announces blockchain audit technology | EY - Global

Vincent, N. E.; Skjellum, A.; Medury, S. (2020): "Blockchain architecture: A design that helps CPA firms leverage technology". The International Journal of Accounting Information Systems, vol. 38. Retrieved from https://doi.org/10.1016/j.accinf.2020.100466.