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Blockchain and the Future of the Audit

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Abstract

"In the future, virtually every function in the world of financial services will be displaced, disintermediated and decentralized. The Internet gave us a powerful way to share and access information. Blockchain now gives us a powerful way to share and access value." [1]

During a February 2017 AICPA roundtable, Chairman of the Wall Street Blockchain Alliance and previous Global Head of Trading Analytics at Thomson Reuters, Ron Quarantana spoke to the revolutionary scale of blockchain. Quaranta, viewed by many as an expert in financial technology, predicts that the adoption of blockchain, both by the Big Four accounting firms and their clients, will disrupt the accounting industry by greatly reducing the time and skill needed to perform a quality audit. Some, such as Thomson Reuters' Jon Baron, even claim that blockchain may eliminate the need for financial statement audits altogether. [2] To many, blockchain is synonymous with Bitcoin, the cryptocurrency that, over the past three years, has returned 3,310%, compared to 35% and 36% returns of the S&P 500 and Dow Jones Industrial Average (DJIA), respectively. Blockchain, however, is much more than Bitcoin, with applications stretching further than cryptocurrency. Rather, it is a peer-to-peer hosted public ledger that does not require a central authority to support or verify transactions, and is unalterable in future periods. In this study, I propose to examine what blockchain technology means for the 887,000 people currently employed by the Big Four. More specifically, I seek to expand upon whether the potential adoption of blockchain in the coming years will reduce audit fees, impact audit quality, or perhaps do away with the audit completely.

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[1] Jon Baron, "Blockchain, Accounting, and Audit: What Accountants Need To Know," Thomson Reuters, March 21, 2017, https://tax.thomsonreuters.com/blog/business/technology/blockchain-accounting-and-audit-what-accountants-need-to-know

[2] Baron, "Blockchain."

Chapter 1 - Introduction

In a sector that is still struggling to fully recover from the Enron and WorldCom scandals of 2002, the opportunity to provide investors with greater trust and transparency is paramount. Blockchain has the potential to do just that, while also reducing costs and improving efficiency. However, great risk and uncertainty accompany the possible benefits. Experts predict blockchain adoption is expected to accelerate during 2018 and may have a profound impact for enterprises as well as their auditors. Blockchain has been compared to both the computer and the Internet in that these technologies have had similarly powerful implications for business models across different industries. Broadening the scope, technology has drastically altered the way audits are performed over time, and will continue to do so moving forward.

"When I started, it was common for computers to be assigned to each engagement team, not each individual" wrote Elizabeth Paul, a PricewaterhouseCoopers (PwC) partner who has been with the firm for twenty-five years. [3] Flash-forward a quarter of a century, and engagement teams cannot operate without technology, leveraging "sophisticated, proprietary software to capture, analyze, interpret, and document" the vast amount of information that must be audited every reporting period. [4] Technological advancements, including the computer, Internet, email, and proprietary software development, have certainly improved audit efficiency. A note often forgotten, however,

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[3] Elizabeth Paul, "Then and Now: New Ways Tech is Shaping the Audit," *LinkedIn*, December 15, 2015, https://www.linkedin.com/pulse/now-new-ways-tech-shaping-audit-elizabeth-beth-paul/?trk=prof-post.
[4] Paul, "Then and Now."

is that the businesses being audited evolved with this technology as well, becoming larger and more complicated, while also having more data and transactions in need of auditing. So while, in a vacuum, auditing firms could have reduced cost and improved quality (although whether technology has actually improved audit quality to date can certainly be debated) due to timesaving, the added efficiency was instead necessary due to increasingly complex audits.

While not the sole reason for the Enron scandal in late 2001, technological improvements played a role in the fiasco that resulted in what was at the time the largest corporate bankruptcy in U.S. history. In the face of natural gas pipeline deregulation that took place in 1985, Enron altered its business model to stay profitable. Using high-speed internal networks, the company became a "Gas-bank", selling natural gas reserves to buyers when the price became profitable. [5] Enron then extended this strategy to futures contracts and derivatives in coal, steel, and other natural resources in the early 1990s. Its utilization of cutting edge data analysis and other technology allowed Enron to make a profit on most of these trades. In October of 1999, Enron dove further into developing their business with technology, with the introduction of Enron Online, a commodities trading website that gave the enterprise even more data points related to vital trading information that it could then use in its own business. The use of technology in its energy market trading was by no means illegal, but it both complicated and grew the business to the point that, by the late 1990s, Enron's external auditor, Arthur Anderson, had "a whole

[5] C. William Thomas, "The Rise and Fall of Enron," *Journal of Accountancy*, March 31, 2002, https://www.journalofaccountancy.com/issues/2002/apr/theriseandfallofenron.html

floor of auditors" working on the company at fiscal year-end. [6] The improved auditing efficiency due to technology in this case was offset by the business growth and changes, so much so that it allowed other errors to slip through the cracks.

The Securities and Exchange Commission (SEC) enacted the Sarbanes-Oxley Act (SOX) in 2002, in part as a response to the Enron and WorldCom accounting scandals that had previously taken place. SOX created an oversight board named the Public Company Accounting Oversight Board (PCAOB), whose role is to set standards for the auditors of public firms as well as inspect the quality of audits performed. [7] SOX drastically changed both the time and cost needed to perform a quality audit, as well as what exactly an audit of a public company entails. I will discuss the SEC, PCAOB, SOX, and how they relate to the audit further in Chapter 2. With the change in presidential office and majority party, there has been a push to alter some of the SOX requirements, some proposing the extreme idea of repealing the act altogether. While articles have been written both in support and opposition of SOX, it seems unlikely, given the fallout following the Enron, WorldCom, and Tyco scandals, that SOX will be altered in the near future. Thus, the further discussion of blockchain and how it will impact the audit refer to what an audit consists of on day of publication, with SOX still enacted.

The question of what technological changes will occur in the near future, and how they will change the audit, should constantly be on the minds of both decision makers and individual auditors of the Big Four, as well as the regulators of the accounting and

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[6] C. William Thomas, "Rise and Fall of Enron."
[7] Donald Simon, "Corporate Accountability: A Summary of the Sarbanes-Oxley Act," *LegalZoom*, December 2009, https://www.legalzoom.com/articles/corporate-accountability-a-summary-of-the-sarbanes-oxley-act

auditing industries. Throughout this paper, I will tackle these concerns as they relate specifically to blockchain. In order to do so, it is first necessary to develop a deep understanding of the technology, and how it may be implemented and used by businesses, accountants, and auditors. Will blockchain achieve all that its proponents argue it can, or is the excitement around the supposed groundbreaking technology supported solely by hype? Throughout my research, I sifted through articles claiming that blockchain will fully automate the audit and thus eliminate the auditor completely. Are these articles hoping to garner clicks and attention through outrageous claims, or is there something substantial behind them? Should those entering the auditing profession be worried that they will be out of the job in years to come? This study has implications for both current and future auditors, as well as the regulators of the accounting and auditing professions. The paper will further examine the stances that the PCAOB, American Institute of Certified Public Accountants (AICPA), Financial Accounting Standards Board (FASB), and SEC will take on the subject, as well as the potential new regulations therein. Tom Mornini, CEO of Subledger, a startup focused on helping businesses integrate blockchain into their accounting systems, commented that "the Big Four accounting guys clearly know it will affect their future, although I'm not quite sure that they are clear as to how." [8] This study will answer that very question, as well as examine the future of the audit, and what multibillion-dollar investment decisions audit firms should be making today regarding emerging blockchain technology.

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[8] Michael Scott, "Blockchain Promises Accountants, Auditors and Their Clients Better Data Sooner and Cheaper," *Bitcoin Magazine* accessed through *Nasdaq,* December 28, 2016. https://www.nasdaq.com/article/blockchain-promises-accountants-auditors-and-their-clients-better-data-sooner-and-cheaper-cm726746

Chapter 2 - The History of Regulatory Authorities and the Audit

In 1494, Franciscan friar Luca Pacioli published "Summary of Arithmetic, Geometry, and Proportions," which, among other teachings, outlined the double-entry accounting system. While many credit Pacioli for inventing what has become standard accounting practice, he instead was summarizing the methods being used by Venetian merchants to keep track of their day-to-day business. [9] Double-entry accounting is based on providing validation for every journal entry made with a corresponding event. In a simple example, in order to credit a revenue account, a merchant must have debited the cash account. This ensured that merchants were not recording fictitious sales or entering a sale twice. Pacioli should be credited, however, for compiling the method and publishing it accessibly for use in a textbook. An argument can be made that the double-entry method of accounting is overdue for an update, and blockchain proponents point to their technology as the basis for this upgrade.

It wasn't until the Industrial Revolution that the auditing of a company's financials, for the purpose of detecting fraud and establishing financial accountability, became relatively common. The Industrial Revolution, which spanned the late 18th and early 19th centuries, brought with it an influx of companies operating in the newly formed United States; and with these companies came new investment opportunities, such as the purchase of stock. The railroads specifically were instrumental in their reporting of

[9] Murphy Smith, "Luca Pacioli: The Father of Accounting" (paper made available through Social Science Research Network, revised 2018), https://ssrn.com/abstract=2320658

operating metrics and use of accountants. [10] Although the New York Stock Exchange (NYSE) was not the first stock exchange in the U.S. (that title goes to the Philadelphia Stock Exchange, which opened for business in 1790, one year before the NYSE), it quickly became the most popular and provided much needed liquidity to a company's shareholders. [11] New York, and Wall Street in particular, was at the heart of American business and entrepreneurship, and the NYSE's location helped it grow into the gold standard that it is today.

Prior to the development of the stock exchange, an investor would own a company's stock for the purpose of receiving a dividend. In the event that said investor wanted or needed to sell the stock, they would have to seek out a broker to negotiate a trade, and would often receive less than fair value for their sale. The NYSE, however, created a market for the purchase and sale of stock. While certainly a positive for economic growth and opportunity, the stock market allowed speculators to purchase stock for the sole purpose of selling it later at a higher price, without thought of the potential dividends or underlying business. The introduction of speculators to the market meant that investors began relying more on a firm's financial reports to ensure the company, whose stock they were purchasing, was sound. Not all firms at the time issued

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[10] Paul Byrnes, Abdullah Al-Awadhi, Benita Gullvist, Helen Brown-Liburd, Ryan Teeter, J. Donald Warren, Jr., and Miklos Vasarhelyi, *Evolution of Auditing: From the Traditional Approach to the Future Audit* (New York: AICPA Financial Reporting Center, 2002), 1-9, https://www.aicpa.org/content/dam/aicpa/interestareas/frc/assuranceadvisoryservices/downloadabledocuments/whitepaper-evolution-of-auditing.pdf

[11] Andrew Beattie, "The Birth of Stock Exchanges," Investopedia, February 6, 2018. https://www.investopedia.com/articles/07/stock-exchange-history.asp

financials, however, and those that did used inconsistent accounting principles and differed on the scope of their audits.

The mid to late 1920s brought soaring stock prices and a prolonged bull market, all at a time when the popularity of the stocks reached a new high. From 1924 to 1929, the DJIA quadrupled. [12] With relatively little history of a long-lasting bull market, some investors believed that stock prices would never go down and could only increase in the future. The gains that investors experienced during the "Hoover bull market", as it was coined, meant more ordinary civilians (those not directly employed in finance) began jumping into the market. Some mortgaged their houses and put the rest of life savings into stocks, while others simply invested on margin. By 1929, an estimated 40% of all bank loans were put into the market by investors. [13] Late October of 1929 saw the end of the bull market, and the crash that followed wiped out $25 billion in life savings, equivalent to $373 billion in today's dollars. [14] Black Thursday (October 25, 1929) saw a record number of shares, 12.9 million, traded, only to have that record topped on Black Monday (October 28, 1929). Black Monday and Tuesday saw the DJIA drop 25%, and investors who had bought on borrowed money faced margin calls and were forced into debt. While many factors were at play, experts point to irrational speculation as a cause of the crash. It wiped out businesses and retirement savings, banks began closing their doors, and it caused the public to lose faith in the stock market. Trust in business,

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[12] Claire Sudath, "Breif History of The Crash of 1929," Time Inc., October 29, 2008. http://content.time.com/time/nation/article/0,8599,1854569,00.html
[13] Claire Sudath, "Breif History of The Crash of 1929," Time Inc., October 29, 2008. http://content.time.com/time/nation/article/0,8599,1854569,00.html
[14] Claire Sudath, "Breif History of The Crash of 1929," Time Inc., October 29, 2008. http://content.time.com/time/nation/article/0,8599,1854569,00.html

financial reporting, and the capital markets is vital to a healthy economy. Following the crash, the trust of the American public was in need of repair.

Franklin D. Roosevelt was elected President of the United States in November 1932 after campaigning under the promise of a "New Deal" to help the country reverse the widespread economic depression. Within two months of taking office, Roosevelt, with the help of Congress, passed the Securities Act of 1933. [15] Prior to the "truth in securities" law, as it was often referred, an initial offering of stock to the public markets was regulated under individual state law, which allowed for looser regulation and a lack of transparency for investors.

The Securities Act of 1933 instead took the responsibility of regulation away from states and placed it in the hands of the federal government. Overseen by the SEC (which wasn't officially created until June 1934 when Roosevelt signed the Securities Exchange Act into law), the 1933 Act requires companies to submit a prospectus, containing a description of the business, the security type, management information, and certified financial statements, prior to an initial public offering. Shortly after review by the SEC, the prospectus becomes public and can be accessed by institutional and individual investors. The Act's two primary objectives are to "require that investors receive financial and other significant information concerning securities being offered for public sale; and (to) prohibit deceit, misrepresentations, and other fraud in the sale of securities."

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[15] Frank Freidel and Hugh Sidney, "The Presidents of the United States of America," White House Historical Association, 2006. https://www.whitehouse.gov/about-the-white-house/presidents/franklin-d-roosevelt/

[16] The Act specifically requires financial reports to "contain … audited financial statements" that are to be reviewed "by an independent public or certified accountant." Furthermore, the financial statements must be in accordance with the accounting principles of the "standard setting body." [17]

The federal government further protected investors by enacting the Securities and Exchange Act of 1934. Not only did this legislation officially establish the SEC, but it also requires all publicly traded companies listed on a U.S. exchange to submit various "annual and other periodic reports" [18] that are in accordance with generally accepted accounting principles (GAAP), as verified by an independent auditor, to the SEC, who will then release the reports to the public. [19] The SEC mandates that companies issue reports four separate times during a fiscal year, broken into three quarterly reports and one full fiscal year report. The Securities Act of 1933 and Securities and Exchange Act of 1934 cemented the need for auditors in public markets, with the role of provide assurance to creditors and other lenders that the financials prepared by management fairly represent economic position and are free of fraudulent information.

Before 1933, accountants in the United States followed standards issued by the United Kingdom-based Association of International Accountants (AIA). After its

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[16] "The Laws That Govern the Securities Industry," U.S. Securities and Exchange Commission, last modified October 1, 2013. https://www.sec.gov/answers/about-lawsshtml.html#secact1933

[17] "Securities Act of 1933," U.S. Securities and Exchange Commission. http://legcounsel.house.gov/Comps/Securities%20Act%20Of%201933.pdf

[18] "The Laws That Govern the Securities Industry," U.S. Securities and Exchange Commission, last modified October 1, 2013. https://www.sec.gov/answers/about-lawsshtml.html#secact1933

[19] The actual rules of what companies must follow these rules have varied over time. Currently, companies with over $10M in assets and more than 500 different shareholders must abide by these rules.

founding in 1934, the newly established SEC entrusted the responsibility for setting the accounting standards, known as GAAP, to the private sector. The AICPA served this role from 1933 until 1973, and was then replaced by the newly established FASB. Prior to the FASB, the AICPA organized and appointed members to the Committee on Accounting Procedures (CAP) to set standards. The CAP was then relieved of its duties in 1959 with the AICPA's establishment of the Accounting Principles Board (APB). The APB was still under the oversight of the AICPA, and was primarily instituted with the intention of developing a condensed conceptual framework. In addition to setting GAAP (through the CAP and APB), the AICPA provided oversight on auditing procedures and issued numerous Statements on Auditing Procedures, which altered the work required by an independent auditor to provide assurance on the financials. Despite the establishment of the FASB, the AICPA continued setting these generally accepted auditing standards (GAAS) for the independent audits of public companies up until 2002. [20] The AICPA issued the first auditing standard, Statement on Auditing Procedure No. 1, as a response to the McKesson & Robbins fraud case.

Prior to the Statement on Auditing Procedure No. 1, it was commonplace for independent auditors to trust, but not necessarily verify, management's assertions and verification routines. [21] McKesson & Robbins' independent auditor, Price Waterhouse (now part of PricewaterhouseCoopers), accepted the company as a client under the

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[20] "Public Company Accounting Oversight Board (PCAOB)," U.S. Securities and Exchange Commission, last modified January 16, 2013. https://www.sec.gov/fast-answers/answerspcaobhtm.html

[21] Paul Byrnes, Abdullah Al-Awadhi, Benita Gullvist, Helen Brown-Liburd, Ryan Teeter, J. Donald Warren, Jr., and Miklos Vasarhelyi, "Evolution of Auditing: From the Traditional Approach to the Future Audit," *AICPA Financial Reporting Center* (November 2002): 1-9.

agreement it would not examine inventories nor receivables. [22] After the fraudulent behavior was discovered, Price Waterhouse was forced by the SEC to repay all auditing fees received since it began serving the client, and the AICPA issued Procedure No. 1. While the procedure only "required that auditors inspect inventories and confirm receivables," [23] it took a major step in implying that auditors were responsible for independently performing specific auditing procedures on the business and its transactions itself, rather than simply relying on management's own work. Furthermore, the issuance of Standard Auditing Procedure No. 1 began a trend of reactionary measures to cases of fraud, which have shaped the auditing standards in place today.

The FASB established itself in 1973 as a seven-member board with the mission to "improve financial accounting and reporting standards." [24] Compared to previous organizations, the FASB was distinguishable through its independence. It required members to sever all ties with accounting firms and previous employers, removing the chance of a conflict of interests. The SEC recognized the FASB as its new private sector choice for setting GAAP. Apart from issuing new standards, the FASB hoped to improve on the AICPA's previous work, and created the Emerging Issues Task Force (ETIF) in 1984 to more rapidly serve the accounting community when problems regarding financial

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[22] W.T. Baxter, "McKesson & Robbins: A Milestone in Auditing," *Accounting, Business, & Financial History* July 1999. https://www.tandfonline.com/doi/pdf/10.1080/095852099330287?needAccess=true

[23] Paul Byrnes, Abdullah Al-Awadhi, Benita Gullvist, Helen Brown-Liburd, Ryan Teeter, J. Donald Warren, Jr., and Miklos Vasarhelyi, "Evolution of Auditing: From the Traditional Approach to the Future Audit," *AICPA Financial Reporting Center* (November 2002): 1-9.

[24] "About the FASB," *Financial Accounting Standards Board*. http://www.fasb.org/facts/

reporting occur. [25] The ETIF has been a positive step taken by the standard setters to quickly address issues that arise that cannot wait for a new standard to be issued, while also allowing the FASB to deeply assess what the longer-term solution should be. Regardless, the FASB is still criticized for the speed and timeliness at which they issue new standards, oftentimes years after financial reporting questions arise. To date, the FASB has issued eight concept statements regarding financial reporting and has also undertaken the project of condensing GAAP into a searchable database through the Accounting Standards Codification project.

2002 brought sweeping changes that the auditing profession hadn't seen since the early 1930s. President Bush even commented on the day that he signed SOX into law that it is "the most far reaching reforms of American business practices since the time of Franklin Delano Roosevelt" and that "the era of low standards and false profits is over." [26] Congress passed SOX as a response to the failure of the auditing profession to prevent or catch the fraudulent behavior that resulted in the Enron and WorldCom scandals. Named after its spokespersons, Democratic Senator Paul Sarbanes of Maryland and Republican Congressman Michael Oxley of Ohio, SOX is enforced by the SEC and compliance is mandatory for all public reporting entities. [27]

Aimed at improving accountability for both management and auditors, the law has increased both the cost of performing an audit as well as audit quality, although whether

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[25] "Emerging Issues Task Force" *Financial Accounting Standards Board*. http://www.fasb.org/eitf/about_eitf.shtml

[26] "The Laws That Govern the Securities Industry," U.S. Securities and Exchange Commission, last modified October 1, 2013. https://www.sec.gov/answers/about-lawsshtml.html#secact1933

[27] Kimberly Amadeo, "Sarbanes-Oxley Summary: How It Stops Fraud," The Balance, July 18 2017. https://www.thebalance.com/sarbanes-oxley-act-of-2002-3306254

this has occurred in a linear relationship is open to debate. SOX established the PCAOB as an oversight committee to the auditing industry that has the freedom to conduct inspections and investigations on specific audit engagements or the auditing firms themselves, and has the power to issue disciplinary fines or worse to public accounting firms. Furthermore, the PCAOB is in charge of registering the accounting firms that audit public companies, as well as establishing ethical and independence related standards. [28] The auditing community, up until SOX, lacked a regulating body for its own work, and after the Arthur Anderson debacle, it became clear that the PCAOB was a needed entity. The PCAOB has instituted major changes to auditing rules and regulations, such as prohibiting a firm's auditor from providing said client with consulting services, and instituting mandatory partner rotation and cooling off periods.

Other influential conditions of SOX are housed within Sections 302 and 404. Section 302 requires key members of management to personally certify the accuracy of their firm's financials. By doing so, management becomes responsible for cases of fraudulent behavior that materially effect the financials and investors, and can face charges brought against themselves by the SEC.[29] Section 302 rebalances the risk-reward structure that management faces when contemplating whether or not to commit fraud. Section 404 requires management to establish proper internal controls within their company and also requires independent auditors to opine on the adequacy of the internal controls as well as notify the public of any material weaknesses. Section 404 has

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[28] "Public Company Accounting Oversight Board (PCAOB)," U.S. Securities and Exchange Commission, last modified January 16, 2013. https://www.sec.gov/fast-answers/answerspcaobhtm.html

[29] Kimberly Amadeo, "Sarbanes-Oxley Summary: How It Stops Fraud," The Balance, July 18 2017. https://www.thebalance.com/sarbanes-oxley-act-of-2002-3306254

increased the cost of completing an audit drastically, yet "83 % of large corporations agreed that SOX increased investor confidence" and one third of those firms reported that it has reduced fraud. [30]

SOX has changed the auditing industry in an attempt to better protect users of a firm's financials from fraud and other inadequate accounting practices. Since SOX was enacted in 2002, both the public accounting firms and their clients' businesses have been impacted by technological changes, including the developments of automation, big data, and machine learning. It is important to understand the key players in the regulatory field, and the acts they've taken in the past, as it will help better predict the steps they may take in the future. Blockchain is a promising technology that the SEC has on its radar. In order to understand what impact blockchain may have on the auditing world, however, an in-depth knowledge of technology, and its benefits and limitations, is needed.

[30] Kimberly Amadeo, "Sarbanes-Oxley Summary: How It Stops Fraud," The Balance, July 18 2017. https://www.thebalance.com/sarbanes-oxley-act-of-2002-3306254

Chapter 3 - Blockchain: An Extended Discussion of the Technology

The cryptocurrency craze of the past year has driven the public's awareness of blockchain. Some only know that blockchain is the technology behind bitcoin, and often confuse the two terms or use them interchangeably. While blockchain is a vital component of bitcoin and other cryptocurrencies like Ethereum, it is not limited to serving as the building blocks of digitally encrypted money. In fact, the immutable link between blockchain and bitcoin has caused an association that some companies are either confused by or exploiting. For instance, certain companies have been rebranding themselves in an effort to either fool investors or drastically change their line of business.

On December 21, 2017, beverage producer Long Island Iced Tea Corporation issued a press release stating it would be changing its name to Long Blockchain Corporation, due to the "once-in-a-generation opportunity" that blockchain could, among other benefits, create "a clearer audit trail." [31] The company's NASDAQ listed stock jumped 300 % following the announcement, with its market cap increasing from $24 million to nearly $92 million in one trading period. [32] Whether the company will succeed in its new endeavors remains to be seen, but the NASDAQ is forcing its hand, with plans

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[31] Philip Thomas, "Long Island Iced Tea Corp. to Rebrand as 'Long Blockchain Corp.,'" *Long Island Iced Tea Corporation,* Press Release, December 21, 2017. https://investors.longislandicedtea.com/press-release

[32] Siddharth Cavale, "Long Island Iced Tea Corp's Shares Skyrocket After Renaming Itself 'Long Blockchain Corp,'" *Huffington Post,* Business, December 21, 2017 https://www.huffingtonpost.com/entry/long-island-iced-tea-corps-shares-skyrocket-after-renaming-itself-long-blockchain-corp_us_5a3be14fe4b0b0e5a7a07052

to delist Long Blockchain based on the notion that the company is attempting to "take advantage of general investor interest in bitcoin and blockchain technology." [33]

In the broadest sense, blockchain is a peer-to-peer network that securely keeps track of records or data and can be accessed publicly. Specifically relating to the financial world, blockchain is a distributed ledger platform that benefits from all of the underlying aspects of the technology. Before going further, it is important to note that there is not a single blockchain on which everything is stored. Instead, there are individual blockchains that serve a variety of specific purposes. There is a blockchain that coincides with every cryptocurrency, keeping record of the transactions involving, and trading of, each unique coin. The reason that there are multiple different cryptocurrencies, such as bitcoin, Etheruem, or Ripple, is that each is built on its own separate blockchain platform, all with subtle differences that support various attributes. As you'll recall, however, blockchain is much more than the support system for cryptocurrency, and this technology has the potential to be used in keeping record of all sorts of transactions, data, assets, or contracts. Briefly, however, we will focus on the bitcoin blockchain, as I believe it provides a simple example of what exactly a blockchain is. The statements below regarding the bitcoin blockchain are ubiquitous with all blockchains; however, conceptualizing the blockchain platform using a virtual currency makes it easier to develop an understanding of the technology. Differences in various types of blockchains will be discussed in depth once a general knowledge base is achieved.

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[33] Matt Egan, "Nasdaq wants to boot iced tea maker for taking advantage of bitcoin craze," *CNN Money,* February 22, 2018. http://money.cnn.com/2018/02/22/investing/long-blockchain-iced-tea-bitcoin-nasdaq/index.html

The bitcoin blockchain is a distributed ledger that contains, in chronological format, every transaction (as well as other data, such as time, sender, and receiver) that has ever occurred involving bitcoin, and can be viewed by anyone at any time. A distributed ledger is a ledger that is not stored on a single computer or single network. An example of a non-distributed ledger would be an excel file or other ledger-based platform that is saved in a single location, whether it be on a hard drive or on the cloud. Every time an addition to this type of ledger needs to be made, the user must open the file from the location where it's saved, make the change, and overwrite the previous copy. This is not the case when additions are made to a distributed ledger. Up-to-date copies of the ledger are stored across "thousands of computers" that are connected to the bitcoin network.[34]

The bitcoin distributed ledger is also, however, a searchable database, where any user can verify a specific transaction along with other information about said transaction based on an identifying combination of letters and numbers. Each transaction is housed inside a larger grouping known as a block. These blocks, which are identified by a number referred to as the block's 'height' (or less often a block's 'number'), contain an average of 983 distinct transactions. [35] A transaction, in this instance, would be one user sending any number of bitcoins to another user, either as a payment for services, goods, or other economic activity. The number of transactions in a given block will fluctuate over time and depends mostly on size of transactions, number of transactions occurring in the market, and computing power needed to solve complex algorithms (as part of the

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[34] – Paul Coletti, "Bitcoin's baby: Blockchain's 'tamper-proof' revolution," BBC News, *Technology*, May 20, 2015. http://www.bbc.com/news/technology-32781244

[35] https://blockchain.info/charts/n-transactions-per-block?timespan=all

encryption process). A block's identifying number is reported or referenced in the format of "block" followed by its height.

The first block of the blockchain began with the height (identifying number) of 0, and is thus referred to as block 0, and each block's height thereafter is simply one more than the previous block. [36] For example, the next group of transactions that occurred after block 0 are located in block 1, and so on. Thus, no two blocks in a blockchain can have the same height. At time of writing, the bitcoin blockchain consists of 512,239 distinct blocks, with the most recent block having the height of 512238 and being referred to as block 512238 (a block's height is reported without commas). [37] Remember, this single block, block 512238, contains hundreds (738 distinct transactions for block 512238) of individual transactions within it. [38]

Anyone can download the bitcoin blockchain (by going to bitcoin.org/en/download) and can then see an extensive list of the transactions that have taken place since inception of the platform in 2009 (although this requires a lot of memory space, at time of writing the file size is over 145GB). [39] Another option that will save the data cost is to visit a third party that reports on the blockchain, such as blockexplorer.com or blockchain.info. A portion of the downloaded bitcoin blockchain is reproduced in Exhibit 1. [40] The height of each block is reported under the "Number"

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[36] Benjamin Sherry, "What is the Genesis Block in Bitcoin Terms?," Investopedia, January 2, 2018. https://www.investopedia.com/news/what-genesis-block-bitcoin-terms/
[37] https://blockexplorer.com/blocks
[38] https://blockexplorer.com/blocks
[39] https://bitcoin.org/en/download
[40] Image from Footnote 1 – Paul Coletti, "Bitcoin's baby: Blockchain's 'tamper-proof' revolution," BBC News, *Technology*, May 20, 2015. http://www.bbc.com/news/technology-32781244

column and the number of transactions within each specific block is reported under the "Transactions" column.

Exhibit 1:

Number	Hash	Time	Transactions	Total BTC	Size (kB)
356987	141a6f95b2...	2015-05-18 13:28:14	1714	17353.00313324	749.227
356986	13cff723ec...	2015-05-18 13:11:53	2114	23805.24520712	749.204
356985	1128aa2601...	2015-05-18 12:27:49	594	6119.90095486	392.306
356984	140b0f27b9...	2015-05-18 12:20:14	1087	7849.33374079	544.102
356983	d1ea5bc1c7...	2015-05-18 12:08:01	830	7799.27270534	455.006
356982	76634b52be...	2015-05-18 11:58:42	221	1706.08443753	152.745
356981	ab5a643167...	2015-05-18 11:57:28	756	7245.57902445	372.38
356980	b780d34ab0...	2015-05-18 11:46:36	383	4623.1382688	430.319

Compiling hundreds of transactions into a larger group and timestamping when said transactions are processed isn't revolutionary. What makes the blockchain unique and useful, however, is in the encryption method that the platform uses in processing and verifying transactions. This technology is also what makes a blockchain immutable. New transactions are added to the ledger through what is known as 'mining'. Mining begins with a computer connected to the distributed ledger that also is running the bitcoin software (known as a node). Any computer with Internet access and enough storage can download the bitcoin software for free. Keeping the software running can prove costly, however, as it uses the computer's data storage and power source. [41] A node will create a new block from outstanding transactions on the network by solving a difficult mathematical problem. This is done approximately every ten minutes for the bitcoin

[41] Noelle Acheson, "How Bitcoin Mining Works," CoinDesk, January 29, 2018. https://www.coindesk.com/information/how-bitcoin-mining-works/

blockchain, but it is up to the programmer of the specific blockchain to design. The complex equation is produced by code written in the bitcoin platform, and must be solved in order for a node to add the new block to the ledger. The problem that needs solving requires finding a number that is based on the data in the newly organized block, as well as a hash function.[42]

A hash function is an encryption technique that takes input data, alters it in a manner that is consistent to a set of rules, and creates a fixed length output. If the input data is at all altered, the output hash will be different. One benefit of hash functions is that they can take a relatively large amount of input data and produce an output hash that is compressed. Blockchain's use of hash functions is what makes the ledger unalterable, secure, and trusted. The bitcoin blockchain mainly uses a hash function known as SHA-256 (Secure Hash Algorithm - 256), although RIPEMD, the RACE (Research and Development in Advanced Communications Technologies in Europe) Integrity Primitives Evaluation Message Digest, is also used. [43]

SHA–256, which was created by the NSA, will take input data and produce a fixed length output of letters and numbers that is 64 characters (256 bits in computer science) long. [44] For example, SHA–256 takes simple input data such as the text string "blockchain" and produces the output hash, known as the message digest in the

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[42] Noelle Acheson, "How Bitcoin Mining Works," CoinDesk, January 29, 2018. https://www.coindesk.com/information/how-bitcoin-mining-works/

[43] Sean Au, "If You Understand Hash Functions, You'll Understand Blockchains," Decentralize Today, November 29, 2016. https://decentralize.today/if-you-understand-hash-functions-youll-understand-blockchains-9088307b745d

[44] Sean Au, "If You Understand Hash Functions, You'll Understand Blockchains," Decentralize Today, November 29, 2016. https://decentralize.today/if-you-understand-hash-functions-youll-understand-blockchains-9088307b745d

encryption industry, of *ef7797e13d3a75526946a3bcf00daec9fc9c9c4d51ddc7cc5df888f74dd434d1*. However, if the input data is altered so that the string reads capitalized "Blockchain", the message digest, still 64 characters long, reads *625da44e4eaf58d61cf048d168aa6f5e492dea166d8bb54ec06c30de07db57e1*. [45] Another important aspect of hash functions is that it is nearly impossible (would take "years" of time spent computing) to take the message digest and discern the input data. [46] In other words, the output hash cannot be reversed to find out what the input data was, thus keeping the data secure and private. It is important to remember that other blockchains, besides the bitcoin blockchain, use hash functions and can be programmed using unique hash functions.

Nodes begin the process of adding a new block to the ledger by first verifying individual transactions. Nodes verify these transaction by "running a series of checks" that include confirming the coins being spent are available to the payer, confirming the payer has signed off on the transaction via his private password (key), and confirming that the payee's transaction information matches that of the payer. [47] Each transaction is tagged with its own transaction ID, or TXID. Each TXID is generated, not surprisingly, using the SHA-256 hash function to secure the information. This TXID, however, can be used to look up, at any time, information about the transaction, such as amount of money

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[45] https://passwordsgenerator.net/sha256-hash-generator/
[46] Sean Au, "If You Understand Hash Functions, You'll Understand Blockchains," Decentralize Today, November 29, 2016. https://decentralize.today/if-you-understand-hash-functions-youll-understand-blockchains-9088307b745d
[47] "How Do Bitcoin Transactions Work?," CoinDesk, January 29th, 2018. https://www.coindesk.com/information/how-do-bitcoin-transactions-work/

sent, sender, and recipient(s). The sender and recipient's identity is protected by the address system. An individual or company's address, or alphanumeric identifier used to specify the destination a payment would go to, operates similar to how an email address works. In order to the payer to send money to the payee, both must know each other's correct address. Transactions must agree from both the payer and payee's standpoint to be executed. To offer another layer of privacy, these addresses were only intended to be used for a single transaction. For instance, once the payer and payee have transacted, each should never use those specific addresses again. Instead, a payee will claim their money by entering their address along with a private alphanumeric key, which operates as a password of sorts.

When this public address is matched with the correct private key, the bitcoin, or other cryptocurrency, will be deposited into their individual account. Those who choose to operate with less privacy, however, tend to reuse their addresses instead of generating new ones. Once a node combines a group of verified transactions into a new block, it must solve the mathematical equation. This complex math boils down to guessing a number that combines with the transaction data included in the new block and the previous block on the ledger's own message digest or output hash. This combination of data then runs through the SHA-256 hash function to produce a desired output. The message digest required to solve the problem must start with a certain number of zeroes. [48] The number of zeroes required can be altered to make the equation more or less difficult to solve, generally based on the number of miners working to solve the problem,

[48] Noelle Acheson, "How Bitcoin Mining Works," CoinDesk, January 29, 2018. https://www.coindesk.com/information/how-bitcoin-mining-works/

but also to give the platform protection. For bitcoin's blockchain platform, the number that will produce an acceptable message digest from the hash equation, also known as a nonce, will be an "integer between 0 and 4,294,967,396." [49] Computers will guess at random and run the hash function, as it is impossible to predict the message digest produced based solely on the data and a number added to it.

Essentially, a massive game of guessing and checking followed by guessing again will continue until a nonce is found. Often, there is more than one nonce that will produce the required message digest. In other cases, no nonces exist that will combine with the specific input transaction data to produce the required message digest, and transactions must be either added or removed from the previous attempt to solve the equation. [50] The node will then work again to find a nonce based on the new grouping. In the bitcoin blockchain, the nodes that complete the mining are rewarded in bitcoins for the energy and computing power they have spent. It is a race of sorts to solve the complex equation and receive the reward. This economic reward is vital to a public blockchain such as bitcoin, as it ensures that transactions are being processed and that blocks are being added to the ledger. A more private-facing blockchain, however, can get around this bitcoin model through other means, which will be discussed in Chapter 4.

When a miner solves the equation, the new block can be added to the ledger. Once added, other nodes in the system verify the new block through a method known as 'consensus'. Consensus is the process of several separate miners providing validity to a

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[49] Noelle Acheson, "How Bitcoin Mining Works," CoinDesk, January 29, 2018. https://www.coindesk.com/information/how-bitcoin-mining-works/

[50] Noelle Acheson, "How Bitcoin Mining Works," CoinDesk, January 29, 2018. https://www.coindesk.com/information/how-bitcoin-mining-works/

new block. [51] This is done through the same process that a single miner uses to validate a transaction or block, but on a larger scale. Other nodes check the found nonce to see if the proposed block was solved correctly, and is valid. A simple way to think about consensus is that it is a checks and balances system for a decentralized ledger. Rather than requiring a branch of government to keep others in order, consensus operates by requiring multiple nodes to come to the same conclusion regarding a transaction block. It is the backbone that allows a public decentralized network to operate without foul play or mishap. If nodes think that the new block contains fraudulent activity, they can refuse to validate the block and create what is known as a fork in the blockchain, by either proposing their own new block and going through the entire mathematical process again, or by verifying a block proposed by another node. [52]

Once consensus is met, the new block is timestamped and added to the blockchain. It is transparent to the public, meaning any node can access it. When downloading the bitcoin blockchain, it would now include the verified block. Adding the approved block to the ledger uses the cryptography included in the previous step of solving the mathematical equation. Included in the input data entered into the SHA-256 hash function is the message digest of the previous block. By including the previous block's message digest (output hash) in the new hash encryption, the new block (along with all of the transactions housed inside it) can be added to the ledger and locked in

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[51] Karin Gräslund, "Potential of Blockchain Technology for Financial Auditing," Financier Worldwide, Finance & Accounting Expert Briefing, September 2016. https://www.financierworldwide.com/potential-of-blockchain-technology-for-financial-auditing/#.WrSp_ojwaUk

[52] Mohit Mamoria, "Is Proof of Stake Really the Solution?," Hacker Noon, July 5, 2017. https://hackernoon.com/is-proof-of-stake-really-the-solution-2db68487f4ba

place. The block cannot be re-arranged, removed, or altered in any way. Altering any of the data of either the previous block or the new block would mean altering the input data, and would thus produce a different message digest, breaking the cryptographic link and alerting those viewing the ledger that data has been changed. The only way for a hacker or someone else who wishes to alter the blockchain to do so without being detected would require what is known as a "51% attack" or majority attack. [53]

Such an attack could only occur in a scenario where more than 50% of all nodes operating the distributed ledger platform are attacked simultaneously and the ledgers cryptographic output hashes and links are rewritten. Another way to think of this is that a platform attacker would have to rewrite every single block of the ledger in a very small amount of time. This would take massive amounts of computing power and money, and is viewed as "practically impossible," [54] as long as the distributed platform is large enough. [55] Given the miniscule possibility of this occurring, the new block is chained into place on the ledger, unalterable, public, and free from error. All transactions on the platform have been verified.

So does this mean that the bitcoin blockchain and other blockchain platforms will never need to be audited? In regards to the bitcoin blockchain, the answer to this question is, at least for the time being, a clouded maybe. The question is complicated by the ethos

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[53] L.S., "How Bitcoin Mining Works," The Economist, *The Economist Explains,* January 20, 2015. https://www.economist.com/blogs/economist-explains/2015/01/economist-explains-11

[54] "What is Bitcoin Mining?," Bitcoin Magazine, *Guides*. https://bitcoinmagazine.com/guides/what-bitcoin-mining/

[55] L.S., "How Bitcoin Mining Works," The Economist, *The Economist Explains,* January 20, 2015. https://www.economist.com/blogs/economist-explains/2015/01/economist-explains-11

of bitcoin. While it served a general purpose in this paper of helping develop an understanding of how blockchain operates, bitcoin differs drastically from blockchain. Satoshi Nakamoto detailed what has now become known as blockchain in their white paper titled "Bitcoin: A Peer-To-Peer Electronic Cash System." [56] Nakamoto is the identity, or pseudonym, of the unknown designer or designers of the bitcoin system. Though never identified, Nakamoto is revered for creating a system that allows secure payments through a trusted platform, without having to rely on financial intermediaries to vouch for specific parties.

The platform relies on blockchain technology. Bitcoin, as well as other cryptocurrencies, have become a symbol of anti-establishment movements, as well as proof for the idea that trusted transactions can occur outside of the financial system of the 21st century. Hidden within its design is a resistance to central banking and financial institutions. Bitcoin represents a desire to transact without the use of government-sponsored currency. Furthermore, the transactions can be verified and separate parties can be trusted through the platform, without the need for an intermediary to vouch or attest. Blockchain technology, however, exists without the attached ideology of bitcoin.

The technology is the intersection of security, trust, and transparency. By operating in a distributed manner, blockchain is not stored in any location and cannot be altered by a single bad actor. Blockchain solves the double-spend problem, so that digital currency or assets cannot be spent or owned by more than one party. The double-spend problem has been a thorn for intermediaries since the use of digital currency became

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[56] Melanie Swan, *Blockchain: Blueprint for a New Economy* (Sebastopol, CA: O'Reilly Media, Inc., 2015).

commonplace. It occurs when an owner of cash is successful in spending the same money in two different transactions. Melanie Swan, author of "Blockchain: Blueprint for a New Economy," likens digital cash to an electronic document. This document can be saved as an attachment in various separate emails. In other words, it is "infinitely copiable." [57] Without blockchain, a third party (such as a bank, or "quasibank like PayPal") is required to validate transactions and confirm that the payee hasn't already spent the money used in a transaction.[58]

The double-spend problem also exists in regards to digital assets, where ownership of the same tangible item can exist between multiple parties until an intermediary verifies the correct owner. Blockchain solves this problem through both the cryptographic and distributed aspects of the technology. The benefits and broad use-cases of the technology give rise to the possibility that blockchain will be integrated into a company's business or accounting systems, changing what the audit may look like in the future. There are other specifics to blockchain platforms, such as the differences between permissible and semi-permissible blockchains, and proof-of-work platforms versus proof-of-stake platforms, that still haven't been explained. These will be discussed in Chapter 4 and 5 when analyzing in what cases it makes sense for a client to adopt blockchain platforms.

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[57] Melanie Swan, *Blockchain: Blueprint for a New Economy* (Sebastopol, CA: O'Reilly Media, Inc., 2015).
[58] Melanie Swan, *Blockchain: Blueprint for a New Economy* (Sebastopol, CA: O'Reilly Media, Inc., 2015).

Chapter 4 – Client Implementation of Blockchain Technology – Financial Firms

If blockchain is going to impact both the audit and the firms that perform audit services, it will need to find its place within the client's business. Roger O'Donnell, an audit partner at KPMG's New York office, reaffirmed this concept during a conference on current financial reporting issues that took place in late 2017. Commenting on leveraging the latest technology for the audit, O'Donnell mentioned, "A lot of it also depends on the clients (and) the systems that they have." [59] Auditing is a client service, and although auditors have a responsibility to the investing public, among other stakeholders, they ultimately shape their audit around the systems and models that their clients are using.

Are the Big Four's clients currently implementing blockchain, and if not, is it likely they will in the near future? The answer to this question will shape what steps audit firms should, or shouldn't, be taking with regards to investment the blockchain space. It will provide insight into the tangible and intangible skills required for students pursuing a career in public accounting. For clients to implement blockchain into their business, there needs to be a clear value add that outweighs the cost, both in terms of initial investment as well as operational spend. J.P. Morgan Chase (J.P. Morgan), audited by PwC, began a blockchain pilot program in October 2017, aimed at enabling "faster, more secure transfer of cross-border payments between (itself), Royal Bank of Canada, and Australia

[59] Michael Cohn, "Audit Technology Evolving Quickly at Big Four," AccountingToday.com, November 14, 2017. https://www.accountingtoday.com/news/audit-technology-evolving-quickly-at-big-four-firms

and New Zealand Banking Group." [60] Without blockchain, global payment processing, even for the nation's largest bank, must work its way through a complicated system with multiple participants and various points of communication. The Wall Street Journal estimates that verifying and processing these global payments, which can take up to two weeks using legacy systems, could be cut down to "hours" by implementing blockchain technology. [61] The legacy systems in place often require banks to make or reply to inquiries from the transacting party.

J.P. Morgan receives an average of 150,000 of these inquiries annually when processing payments. The blockchain pilot program, known as the Interbank Information Network (IIN), processes payments quickly by securely linking both multiple banks' information as well as their individual client records together, which will decrease "the number of steps needed… to check and rectify mismatches in a cross-border payment." [62] Clearly there is justified value proposition for updating global payments systems with blockchain. Unsurprisingly, little has been reported regarding the success of the pilot program. A bank as big as J.P. Morgan would be unlikely to broadcast either a success or failure of a pilot program, for fear tipping off competitors. A comment made by CEO

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[60] Emily Glazer, "J.P. Morgan's Jamie Dimon May Hate Bitcoin, but He Loves Blockchain," The Wall Street Journal, *Markets*, October 16, 2017. https://www.wsj.com/articles/j-p-morgans-james-dimon-may-hate-bitcoin-but-he-loves-blockchain-1508146203

[61] Emily Glazer, "J.P. Morgan's Jamie Dimon May Hate Bitcoin, but He Loves Blockchain," The Wall Street Journal, *Markets*, October 16, 2017. https://www.wsj.com/articles/j-p-morgans-james-dimon-may-hate-bitcoin-but-he-loves-blockchain-1508146203

[62] Emily Glazer, "J.P. Morgan's Jamie Dimon May Hate Bitcoin, but He Loves Blockchain," The Wall Street Journal, *Markets*, October 16, 2017. https://www.wsj.com/articles/j-p-morgans-james-dimon-may-hate-bitcoin-but-he-loves-blockchain-1508146203

Jamie Dimon at a conference in Washington, D.C., however, provides a clue that CEO Jamie Dimon has been pleased so far. "We actually use it. It will be useful for a lot of different things, God bless the blockchain." [63] CFO Marianne Lake commented that payments flagged for compliance "can be delayed for up to two weeks (using the legacy system), but this technology can reduce that to minutes." [64] Furthermore, other announcements from the bank point to the success of the pilot platform. Umar Farooq, head of innovation for J.P. Morgan, mentioned that the bank has extended work on six other blockchain prototypes in their newly established Blockchain Center of Excellence, powered by Quorum, an "enterprise-focused" blockchain platform. [65]

The pilot blockchain used by J.P. Morgan differs both from the distributed ledger that powers cryptocurrencies and from the blockchain that was outlined in Chapter 3. It would be illogical for a bank to allow the public to access the information on their global payments blockchain, yet a key aspect of cryptocurrency blockchains are their transparency. A bank, however, must protect both client information and information on flows of funds. No banking client wants his or her neighbor or coworker to be able to access and download the distributed payments ledger online. Cryptocurrency platforms provide both transparency and privacy through the use of unique addresses and private keys. Banks cannot operate in a similar fashion, as internally they must know the identity

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[63] Emily Glazer, "J.P. Morgan's Jamie Dimon May Hate Bitcoin, but He Loves Blockchain," The Wall Street Journal, *Markets*, October 16, 2017. https://www.wsj.com/articles/j-p-morgans-james-dimon-may-hate-bitcoin-but-he-loves-blockchain-1508146203

[64] Frank Chaparro, "Banks Have a Big Appetite to Join JPMorgan's Blockchain Party," Business Insider, February 28, 2018. http://www.businessinsider.com/blockchain-jpmorgan-says-banks-have-big-appetite-to-join-party-2018-2

[65] https://www.jpmorgan.com/global/blockchain

of account holders in order to comply with Know Your Customer (KYC) and Anti-Money Laundering (AML) regulation. Furthermore, complying with both AML and KYC not only requires institutions to maintain identity information on customers, but also requires the banks to continually monitor client's transactions, which certainly doesn't align with a blockchain designed for cryptocurrency. [66]

Taking a step back from financial institutions, similar compliance problems arise for other companies looking to implement blockchain technology. Companies in the U.S. must comply with parts of AML and KYC under Title 18 United States Code Sections 1956 and 1957. [67] While far less strict than the rules governing financial institutions, Sections 1956 and 1957 prohibit companies from taking part in transactions of greater than $10,000 that derive from either criminal or illegal activity. Thus firms are required to perform due diligence on their customers and suppliers, and continue to monitor both for any violations. This prevents businesses, not just financial institutions, from operating on a blockchain where identities are concealed.

The public transparency of the blockchain described in Chapter 3, but without private identities, doesn't suit businesses operating strategies either. No firm would willingly provide supplier information or up-to-the-minute sales data on a public blockchain that could be downloaded by a competitor. Furthermore, while the investing public tends to be in favor of further transparency, it remains to be seen whether the SEC

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[66] Jonathan Camhi, "Taking the Next Step in KYC and AML Compliance," Bank Systems & Technology, March 5, 2014. http://www.banktech.com/compliance/taking-the-next-step-in-kyc-and-aml-compliance/d/d-id/1296879?

[67] Michael Volkov, "AML Risks and Compliance for Non-Financial Institutions," Trulioo Blog, August 6, 2015. https://www.trulioo.com/blog/aml-risks-and-compliance-for-non-financial-institutions/

would allow firms to have current transaction data available instantaneously to the public. So while aspects of Satoshi Nakamoto's blockchain provides value that justifies implementation by firms, the broad transparency as well as anonymousness of individuals on the platform described in Chapter 3 creates problems for enterprises. Ironically, a public blockchain is both too transparent (instant access for anyone to information on it) and not transparent enough (hidden identities) to be implemented by firms. Vitalek Buterin, the co-founder of Ethereum and a leader in the blockchain space, wrote a blog post in early 2016 addressing the issue at hand. Buterin commented, "When I and others talk to companies about building their applications on a blockchain, two primary issues always come up: scalability and privacy." [68]

The development of what is known as a private or permissioned blockchain solved these aforementioned problems. Similar to a public blockchain in most aspects, permissioned blockchains tend cater more to the enterprise's needs. The major difference between public and private classes of blockchains is who can access and participate in platform. A private blockchain restricts access to the ledger in a similar way that any network can require credentials, such as a username and password, to gain access. [69] A private blockchain can take two forms based on the needs it serves. It can either be completely private, operating solely within one company, or can be distributed across a larger network, connecting multiple companies, while still restricting access to the public.

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[68] Vitalik Buterin, "Privacy on the Blockchain," Ethereum Blog, January 15th, 2016.
[69] Praveen Jayachandran, "The Difference Between Public and Private Blockchain," IBM Blockchain Blog, May 31, 2017. https://www.ibm.com/blogs/blockchain/2017/05/the-difference-between-public-and-private-blockchain/

[70] The only nodes serving a permissioned blockchain, whether fully private or semi-private, are those who have access to the blockchain itself. In other words, no computers can lend their processing power towards operating the blockchain except for those within the private network. The ledger is still distributed across multiple nodes, which helps provide additional security, compared to a file or database stored on single computer, which is subject to attack by a lone hacker.

The way by which transactions and new blocks are verified and added to the chain differs slightly as well. The public blockchain model, described in Chapter 3, validates transactions using what is known as a proof of work model. This proof of work consensus model is the 'mining' that specific nodes perform, or the validating transactions or blocks by solving the complex equation. The proof of work model performs well in public blockchains, but the nodes must receive some reward for the processing power or energy that they are contributing to verifying transactions. The energy costs of implementing a proof of work model to a private blockchain would be expensive, to say the least, as the mining nodes use an astonishing amount of power in their attempts to solve complex equations. In 2015, validating a single bitcoin transaction required the same amount of electricity as it would take to power one and a half American homes for a whole day. [71] Furthermore, even if cost wasn't an obstacle, the speed at which transactions are processed using a proof of work system may simply be too slow to be useful at the

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[70] Paul Roma, Florian Quarre, Adam Israel, Mark Johnston, and Alejandro Flores, "Blockchain: an Enabler for Life Sciences and Health Care," Deloitte White Paper & Case Study in collaboration with Amazon Web Services, copyright 2016. https://d1.awsstatic.com/blockchain_assets/deloitte_bc_paper.pdf

[71] Ameer Rosic, "Proof of Work vs Proof of Stake: Basic Mining Guide," Blockgeeks, Guides, March 23, 2017. https://blockgeeks.com/guides/proof-of-work-vs-proof-of-stake/

enterprise level. The proof of work consensus model is the fundamental scalability problem for public blockchains that Buterin refers to in his 2016 blog post.

Permissioned blockchains, however, tend to avoid proof of work as a method of establishing consensus in the ledger. Using proof of work would require running thousands of uncompensated mining nodes. Furthermore, the larger a proof of work based blockchain network becomes, the more mining nodes are required. [72] Instead, most private blockchains use a mechanism known as proof of stake to establish consensus. Rather than requiring a correct answer to an equation to determine which miner adds his or her block to the chain, the proof of stake consensus model simply decides which node creates the new block, based on a pre-determined attribute. [73] With cryptocurrency blockchains operating under the proof of stake model, the creator is generally determined based on total wealth, or stake, in the platform. This provides the incentive needed to maintain integrity, as a fraudulent platform would lead to a worthless currency.

On non-cryptocurrency permissioned blockchains, proof of stake can operate through any matter that the programmer decides. A popular solution is to randomly select the creator of the next block. Other nodes in the network then either agree with the block proposed or oppose that addition and propose a new path via a fork. [74] Agreeing with a block that contains no fraudulent transactions grants the node reliability, while agreeing with a fraudulent block can result in termination from the network. This process

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[72]Ajit Kulkarni, "How To Choose Between Public and Permissioned Blockchain for Your Project," Chronicled, January 25, 2018. https://blog.chronicled.com/how-to-choose-between-public-and-permissioned-blockchain-for-your-project-3c5d4796e3c8

[73] Ameer Rosic, "Proof of Work vs Proof of Stake: Basic Mining Guide," Blockgeeks, Guides, March 23, 2017. https://blockgeeks.com/guides/proof-of-work-vs-proof-of-stake/

[74] Mohit Mamoria, "Is Proof of Stake Really the Solution?," Hacker Noon, July 5, 2017. https://hackernoon.com/is-proof-of-stake-really-the-solution-2db68487f4ba

maintains the platform's legitimacy, as no node is aware that their 'proposal' block was randomly selected, and thus cannot take advantage of the privilege. Nodes are punished (removed from the network) for trying to defraud the platform.

Another added benefit of the proof of stake consensus model is that it operates with quicker speed. Blockchains using the proof of work consensus model tend to operate by processing "tens of transactions per second," as opposed to permissioned proof of stake blockchains, which can process "around a few thousand transactions per second." [75] Furthermore, proof of stake blockchains don't operate with anywhere close to the same energy costs as proof of work blockchains, due to the elimination of thousands of mining nodes continuously working on complex algorithms.

To summarize a complicated nuance, the difference between a proof of work model and a proof of stake model is the way in which consensus is met. This means that the encryption aspect of blockchains, the way in which they are unalterable, distributed, and free from error, all hold, regardless of whether the blockchain is public, private, uses proof of work, or uses proof of stake. Proof of stake systems are more cost efficient to the user, as they require less sophisticated computers and consume far less energy as a proof of work platform. [76] Proof of work systems, on the other hand, can only achieve the same cost efficiencies through the use of a public platform.

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[75] Ajit Kulkarni, "How To Choose Between Public and Permissioned Blockchain for Your Project," Chronicled, January 25, 2018. https://blog.chronicled.com/how-to-choose-between-public-and-permissioned-blockchain-for-your-project-3c5d4796e3c8

[76] Praveen Jayachandran, "The Difference Between Public and Private Blockchain," IBM Blockchain Blog, May 31, 2017. https://www.ibm.com/blogs/blockchain/2017/05/the-difference-between-public-and-private-blockchain/

While providing benefits such as speed and scalability over a proof of work system, some blockchain purists argue that a proof of stake system is too centralized. This argument may hold some merit, as proof of stake does open the door to foul play where a corrupt institution could demands all of its nodes (if it is the sole controlling entity of the nodes on the network) verify a fraudulent block. Proper internal control oversight can reduce this risk. Furthermore, it isn't yet viable for a company to launch a public or proof of work blockchain due to the challenges outlined above, and thus any ongoing and future initiatives will be based on a permissioned proof of stake blockchain.

A closer look into J.P. Morgan's IIN provides insight into how other blockchain systems, both current and future, operate within the financial sector. In an interview with ETHNews, Farooq explains that the bank's innovation strategy doesn't focus on trying to find instances to use blockchain. Instead, the innovation department "start(s) with the problem and then find(s) the appropriate technology." Farooq continues by pointing out that in the case of improving the global payments system, blockchain is the "ideal technology," but in other cases, blockchain isn't the solution. [77] When global payments occur, there are often multiple banks involved in a single transaction from payer to payee. One cause of slow transaction times is the inefficiency of information sharing that occurs between banks. If a transaction going through a bank's global payment system is flagged, due to entity involved, or the amount, timing, or frequency of the payment, a bank is required to gather more information on the transacting entity and the transaction itself.

Farooq compares the process to KYC protocol (although it differs as KYC is

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[77] Jordan Daniell, "ETHNews Exclusive: JP Morgan's Umar Farooq On The Interbank Information Network," ETHNews, October 30, 2017. https://www.ethnews.com/ethnews-exclusive-jp-morgans-umar-farooq-on-the-interbank-information-network

required at customer onboarding), as a flagged transaction requires confirmation that the person or entity is "not…involved in fraud or sanctions or any of those other things." [78] The legacy processes in place result in a "back and forth …via emails and faxes and phones" to gather the necessary information to approve a transaction, which can be as little as a date of birth. The IIN eliminates the inefficient back and forth via a permissioned blockchain. Transactions are recorded on a distributed ledger. In the event that a transaction gets flagged, the bank that needs information can send an encrypted request over the IIN to the client's main bank. That bank sends the information directly back to the bank that needs it, via encryption of course. As Farooq puts it, "Instead of multiple hops, you can reduce it to one hop… Instead of taking what could be several days… we can reduce this to a matter of minutes or hours." [79] The way that blockchain achieves this is through its distributed aspect as well as its advanced encryption techniques. In the case of the IIN, it seems J.P. Morgan was not primarily attracted to blockchain for the fact that it cannot be altered and is thus immutable. The technology is instead mostly being used for its security and subjective transparency (within permitted parties), and the immutability of the network is an added bonus.

Fortune magazine claims that the "most likely" extension of blockchain technology into the corporate world exists through financial firms, and points to "security clearance and settlements, cross-border payments, and insurance" as every day activities

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[78] Jordan Daniell, "ETHNews Exclusive: JP Morgan's Umar Farooq On The Interbank Information Network," ETHNews, October 30, 2017. https://www.ethnews.com/ethnews-exclusive-jp-morgans-umar-farooq-on-the-interbank-information-network

[79] Jordan Daniell, "ETHNews Exclusive: JP Morgan's Umar Farooq On The Interbank Information Network," ETHNews, October 30, 2017. https://www.ethnews.com/ethnews-exclusive-jp-morgans-umar-farooq-on-the-interbank-information-network

that can be made more efficient through distributed ledger technology. It is hard to argue with Fortune magazine, based solely on the idea that the first blockchain was designed to process transactions and already supports (albeit a new, digital form of) currencies. Banks in particular seem to be at the forefront of testing blockchain technology. Apart from J.P. Morgan, Bank of America (in collaboration with Microsoft), HSBC, ING, U.S. Bank, Barclays, UBS, Credit Suisse, and Northern Trust are experimenting with blockchain, either through investment, internal development, or prototype. [80]

Visa, the largest payment processer in the world, saw the benefits that blockchain can offer to transaction based networks, and launched a pilot business-to-business payments service based on the blockchain, named B2B Connect, in November 2017. [81] Unsurprisingly, both American Express and MasterCard have also filed patents related to their own blockchain networks. [82] The investment in blockchain technology amongst financial firms seems closely related to the fierce competition between industry rivals. Once one company makes the first step, others jump in with their own developments as well. The technology has the potential to alter payment processing in a way that missing out on the trend could negatively impact a firm's bottom line within the decade, and thus companies operating in the space are spending money on blockchain, either by hiring blockchain consultants, investing in joint ventures, or acquiring smaller, blockchain-

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[80] Robert Hackett, "Why Big Business Is Racing to Build Blockchains," Fortune, *The Ledger*, August 22, 2017. http://fortune.com/2017/08/22/bitcoin-ethereum-blockchain-cryptocurrency/

[81] Nikhilesh De, "Visa Launches First Phase of Blockchain B2B Payments," Coin Desk, November 17, 2017. https://www.coindesk.com/visa-launches-first-phase-of-blockchain-b2b-payments-system/

[82] Cecille De Jesus, "AmEx Jumps in on Blockchain, Files Patent for Mobile Invoice and Payment System," CoinGeek, March 16, 2018. https://coingeek.com/amex-jumps-blockchain-files-patent-mobile-invoice-payment-system/

technology focused firms.

Blockchain solutions for banks, credit card companies, and other payment processors such as PayPal are in development. Whether the solutions will provide enough value to justify the investments being made remains to be seen. Financial firms, however, only make up 15% (based on GICS, or Global Industry Classification Standard) of the both the S&P 500 and the S&P Total Market Index. [83] The remaining 85% of firms in both indices are comprised of the following sectors: Consumer Discretionary, Consumer Staples, Energy, Health Care Industrials, Information Technology, Materials, Real Estate, Telecommunication Services, and Utilities. [84] Although these sectors do not (directly, they outsource to third parties) take part in payment processing, blockchain technology still provides useful solutions to help simplify parts of their businesses. The pace at which companies are exploring what unique uses of blockchain may be beneficial to their specific operations has increased over the past year. 2017 saw 1,240 blockchain related patents filed across the world, a figure that more than doubled the 2016 numbers. [85]

While this hints at further investment and development in distributed ledger technology, it is hard not to compare this patent frenzy to that of the internet boom and resulting tech stock bubble of the late 1990s. While the technology is promising and can alter the speed and security with which companies operate, remember that blockchain

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[83] https://us.spindices.com/

[84] "The Global Industry Classification Standard (GICS): An Objective Language for Sectors," Fidelity, *Learning Center*, https://www.fidelity.com/learning-center/trading-investing/markets-sectors/global-industry-classification-standard

[85] Rachel McIntosh, "Over 1200 Blockchain Patent Applications Filed in 2017, Up From 594 in 2016," Finance Magnates, *News*, March 21, 2018. https://www.financemagnates.com/cryptocurrency/news/cryptocurrencynews1200-blockchain-patent-applications-filed-2017-594-2016/

should not be applied to every aspect of a business, as it does not provide enough value over legacy platforms to justify cost. This concept will be discussed further in Chapter 6. Firms that fail to fully understand blockchain or those that fail to allocate their money in a thoughtful manner toward the technology may find their investments fruitless and capital wasted. By fully understanding the use cases for blockchain within the financial industry, auditors can provide additional value to their clients that are in the process of implementing a blockchain-based system.

Chapter 5 – Client Implementation of Blockchain Technology – Non-Financials

Following two years of secret collaboration, International Business Machines Corporation (IBM) and Denmark-based shipping company A.P. Moller-Maersk (Maersk) announced to the public that the companies were forming a joint venture focused on improving global trade and more specifically, supply chain management, using blockchain. The announcement, which came on January 16, 2018, states that the New York City-based venture tentatively plans to go to market with a blockchain platform by the third quarter of fiscal year 2018, with firms such as General Motors and Procter and Gamble, as well as government customs offices in Singapore and Peru, reportedly interested. [86]

The Wall Street Journal estimates that the paperwork and trade documents required using legacy global trade systems equates to a 20 % increase in an enterprise's costs of supplies. [87] The complexity and volume of global trade has drastically outgrown older processing systems, with antiquated paper processes primarily serving as the cause of inefficiencies. The after-tax savings less cost of a platform that is better suited to handle this complexity and volume can have a direct impact on the bottom line, so the early interest of corporations seems justified. On a macro scale, the World Economic Forum estimated that eliminating inefficiencies platforms utilizing blockchain "could

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[86] Imani Moise and Dominic Chopping, "Maersk and IBM Partner on Blockchain for Global Trade," The Wall Street Journal, *Business*, January 16, 2018. https://www.wsj.com/articles/maersk-and-ibm-partner-on-blockchain-for-global-trade-1516111543

[87] Imani Moise and Dominic Chopping, "Maersk and IBM Partner on Blockchain for Global Trade," The Wall Street Journal, *Business*, January 16, 2018. https://www.wsj.com/articles/maersk-and-ibm-partner-on-blockchain-for-global-trade-1516111543

increase GDP by nearly 5% and trade by 15%." [88] Maersk states that the decision to use blockchain to improve supply chain management was an easy one. The blockchain-based solution will "create more efficient and secure platform for organizing global trade," and DowDuPont has already piloted early versions.

Supply chains are often slowed by paperwork and middlemen, and companies can struggle to find answers regarding if their shipment is in transit, the cause of a delay, and when said delay is expected to be resolved. Delays can impact firms with well-established supply chains at any time. Apple, for instance, was forced to delay the launch of its highly anticipated HomePod until after the 2017 holiday season due to struggles associated with its supply chain, losing potential revenue in the process. Any lost or misplaced trade documents or processing papers can grind a supply chain to a halt and leave a company unprepared to fill customer orders. IBM's CEO Michael White stated that utilizing blockchain in supply chain management presents "an opportunity to increase efficiency and timeliness for cargo movement," [89] and IBM's General Manager of the Blockchain Unit, Marie Wieck, commented "even small improvements can have a substantial impact in global trade." [90] As of March 2017, ten million of Maersk's shipping containers are managed via the pilot blockchain solution.

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[88] Robert Hackett, "IBM and Maersk Are Creating a New Blockchain Company," Fortune, *Shipping*, January 16, 2018. http://fortune.com/2018/01/16/ibm-blockchain-maersk-company

[89] Robert Hackett, "IBM and Maersk Are Creating a New Blockchain Company," Fortune, *Shipping*, January 16, 2018. http://fortune.com/2018/01/16/ibm-blockchain-maersk-company

[90] Robert Hackett, "IBM and Maersk Are Creating a New Blockchain Company," Fortune, *Shipping*, January 16, 2018. http://fortune.com/2018/01/16/ibm-blockchain-maersk-company

Similar to financial enterprises, firms looking to overhaul their supply chain systems must see a clear value-add proposition in order to make the investment, either through proprietary development or by purchasing a blockchain software service offered by a company such as IBM. While other small firms may focus on blockchain solutions to be offered as a service, in the same model as software-as-a-service (SaaS business model), I believe that larger firms such as IBM, Microsoft, Oracle, Intuit, or Alphabet will control the blockchain-as-a-service market, due to prior client relationships as well as potential future acquisitions. The value-add proposal that blockchain-as-a-service providers deliver through their supply chain solutions doesn't end with cost savings through eliminating inefficiencies. Walmart is one of the few corporations that piloted IBM's blockchain supply chain solution, and in doing so, realized other benefits alongside greater efficiency. In Walmart's case, they were able to use the technology to greatly improve food safety measures as well as limit the potential cost of issues arising from food safety problems.

Walmart began implementing the blockchain solution into their grocery supply chain. By doing so, the company tracked the shipments of food that were eventually sold to customers, and was able to discern the suppliers, location of suppliers, shipment routes, port cities, warehouses, processing facilities, and packing houses that individual items had come in contact with. [91] Walmart had never experienced this level of transparency in regards to their grocery supply chain. In order to test the capabilities of the platform, Walmart's Vice President of Food Safety, Frank Yiannas, derived an

[91] Jessica McKenzie, "Why Blockchain Won't Fix Food Safety – Yet," The New Food Economy, *Tech*, February 4, 2018. https://newfoodeconomy.org/blockchain-food-traceability-walmart-ibm

experiment. Yiannis decided he wanted to trace a single package of sliced mangoes on sale at a local Walmart to its original supplier, with information on whom else it came into contact with during its journey from supplier to shelf. Yiannas was imaging that this particular package of sliced mangoes was contaminated, and had infected a customer with E. Coli. Product contamination is a major problem for any firm that sells food or beverage.

Nearly 28 million U.S. citizens suffer from foodborne illness every year, with 3,000 of those infected dying as a result, as estimated by the Centers for Disease Control and Prevention (CDC). [92] This public health concern also impacts a company's business; it has the potential for material outcomes on both a firm's reputation as well as its bottom line. Failure to contain and eradicate foodborne illness quickly not only in costly recalls, but can also drive customers away from a brand. Chipotle is still recovering, both in reputation and sales growth, from the widespread E.coli outbreak that plagued the company in 2015 and 2016. Chipotle's stock price fell more than 40% from its $800 high prior to the scandal, and to date has yet to fully recover, as customers swore the company out of their restaurant rotation because of Chipotle's failure to identify and contain the problem. [93]

The package of sliced mangoes that Yiannas used to test Walmart's preparedness for a case of contamination illustrates the beauty of blockchain. Using the firm's legacy supply chain management system, it took a total of "six days, 18 hours, and 16 minutes"

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[92] Jessica McKenzie, "Why Blockchain Won't Fix Food Safety – Yet," The New Food Economy, *Tech*, February 4, 2018. https://newfoodeconomy.org/blockchain-food-traceability-walmart-ibm

[93] Yahoo Finance, https://finance.yahoo.com/quote/CMG

for employees to identify the mangoes supplier as well as other information about where the mangoes were cleaned, sliced, and packaged. The permissioned blockchain supply management solution that was provided by IBM, however, was able to solve the puzzle in a mere 2.2 seconds. [94] Walmart could then take steps to isolate the contamination and eradicate it, as well as pull all effected goods from the shelves within minutes of learning about the problem, rather than within days and weeks.

In-depth transparency is just one of the benefits that a company stands to gain by implementing blockchain into their supply chain. Imagine a car manufacturer that can easily isolate which models on the road are operating with a faulty ignition switch that was produced on one specific day in one of their supplier's factory in China. Instead of recalling tens of thousands of models and wasting both time and resources replacing adequate parts that are operating normally, the car manufacturer can recall solely the effected vehicles. Any company that may experience product quality issues due to a specific supplier stands to benefit from implementing blockchain into their supply chain management software system. Furthermore, firms can utilize the transparency provided through blockchain supply management systems in instances other than contamination or deficiency. Companies can provide specific product information to customers at time of purchase. Imagine purchasing a gallon of milk from a large grocery chain with the ability to know when and where the specific cow was milked. In many cases, consumers enjoy the additional information provided about the product, and firms that begin advertising specific data about their products may see a boost in consumer traffic.

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[94] Jessica McKenzie, "Why Blockchain Won't Fix Food Safety – Yet," The New Food Economy, *Tech*, February 4, 2018. https://newfoodeconomy.org/blockchain-food-traceability-walmart-ibm

Along with IBM, U.S. firms Amazon and Microsoft, as well as Chinese tech giants Baidu and Alibaba, currently offer supply chain solutions utilizing blockchain through the blockchain-as-a-service subscription model. [95] Each firm seems determined to gain share of the new market through different methods. Baidu, for instance, claims that its platforms are the most customizable. IBM, on the other hand, points to the "over 400 enterprise clients" that are utilizing its blockchain technology, including the likes of Nestlé, VISA, Kroger, and Unilever. [96] Research firm International Data Corporation's (IDC) Director for Blockchain Strategies, Bill Fearnely Jr., mentioned in a January 2018 interview that, "supply chain is a very, very hot topic right now and it is only accelerating from here." [97] Yet blockchain has the potential to alter other aspects of business as well. IBM commented in a recent white paper that it believes blockchain technology has the potential to disrupt general invoice and payment systems, as well as provide more data for marketing departments to use. [98] IBM's online information hub currently lists insurance, retail and consumer goods, government, and healthcare as the potential industries that it believes its blockchain solution will disrupt on top of the banking and financial markets industry. [99]

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[95] Adam Reese, "'China's Google' Baidu Has Premiered A Blockchain-As-A-Service Platform," ETH News, *Technology*, January 12, 2018. https://www.ethnews.com/chinas-google-baidu-has-premiered-a-blockchain-as-a-service-platform

[96] Anatol Antonovici, "IBM's Blockchain Used by 400+ Companies," Cyrptovest, *News*, March 12, 2018. https://cryptovest.com/news/ibms-blockchain-used-by-400-companies/

[97] Robert Hackett, "IBM and Maersk Are Creating a New Blockchain Company," Fortune, *Shipping*, January 16, 2018. http://fortune.com/2018/01/16/ibm-blockchain-maersk-company

[98] IBM Offering Information, "Streamline Business Transactions and Create Revenue Opportunities with IBM Blockchain," accessed April 3, 2018. https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=28014228USEN&

[99] https://www.ibm.com/blockchain/industries/

Deloitte and Amazon collaborated on a white paper that delivers an example of how blockchain can be used for in the healthcare space. On top of improving the paper-intensive transaction processing required for delivering drugs to both pharmacies and other customers (hospitals, urgent cares, etc.), blockchain could serve as a solution to improving both patient control and collaboration, the U.S. Food and Drug Administration's (FDA) approval processes (along with other foreign drug administrations' processes) for new treatment, and proper authentic care delivery. The current software systems used to store medical records of individual patients lack proper security. The electronic medical records (EMRs) of specific patients are often too large to be securely transmitted (without proper encryption) as they carry massive amounts of important patient data such as "treatment and genomic information." [100] Both the Bush and Obama administrations took steps toward both development and use of EMRs, yet today many healthcare facilities "are still not able to securely share data, even with other hospitals and clinics in their own healthcare group." [101]

Implementing blockchain encryption will not only protect sensitive patient medical information, but it will also allow doctors to deliver enhanced treatment through collaborative transparency. Using legacy systems, when a patient visits a new medical institution, his prior medical history tends to be is inaccessible. In the event that medical history for individual patients is stored securely within a provider's permissioned blockchain, a doctor at a separate institution could request access to the blockchain.

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[101] Lucas Mearian, "IBM Watson, FDA to Explore Blockchain For Secure Patient Data Exchange," IDG Communications, *Computerworld*, January 11, 2017. https://www.computerworld.com/article/3156504/healthcare-it/ibm-watson-fda-to-explore-blockchain-for-secure-patient-data-exchange.html

Although the Health Insurance Portability and Accountability Act of 1996 (HIPAA) would still protect sensitive patient information, a patient that waives protection could allow doctors, on a case-by-case basis, to (either temporarily or on an ongoing basis) securely access prior medical history. [102] Giving doctors knowledge of all prior injuries, surgeries, illnesses, diagnoses, allergies, and prescriptions in a protected manner allows for improved decision making when analyzing possible future treatments. This can be granted instantly through either collaborative permissioned blockchains or through granting access based on a doctor's institution. Once access is grated, doctors will only be able to identify the records of their specific patient, and the rest of the data stored on the blockchain network would be unidentifiable unless the doctor were given access to learn the public identifying keys of other patients. [103]

The process of FDA drug approval is justifiably a lengthy and costly one, yet it still stands to benefit from blockchain-oriented software systems. Currently, the process contains four phases, starting with preclinical testing before continuing on to phases one through three. The Pharmaceutical Research and Manufactures of America (PhRMA) recently published that, as of 2015, it takes an average of "at least ten years" and costs an estimated "$2.6 billion" for a new treatment to reach the patient. [104] While blockchain

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[102] "Summary of the HIPAA Privacy Rule," U.S. Department of Health & Human Services, Accessed

[103] Paul Roma, Florian Quarre, Adam Israel, Mark Johnston, and Alejandro Flores, "Blockchain: an Enabler for Life Sciences and Health Care," Deloitte White Paper & Case Study in collaboration with Amazon Web Services, copyright 2016. https://d1.awsstatic.com/blockchain_assets/deloitte_bc_paper.pdf

[104] "Biopharmaceutical Research & Development: The Process Behind New Medicines," The Pharmaceutical Research and Manufactures of America, Brochure, published 2015. http://phrma-docs.phrma.org/sites/default/files/pdf/rd_brochure_022307.pdf

likely won't shorten this process by a quantity of years, it can reduce time and money spent on some of the administrative aspects of the development.

Organization of data surrounding preclinical and clinical trials in a secure, condensed manner is where blockchain comes in. Clinical drug trials, along with participant data and outcome, can be stored and shared between pharmaceutical companies and the FDA through a permissioned blockchain. Furthermore, pharmaceutical companies will find it beneficial to have the security risk of storing clinical participant's data lessened. Pharmaceuticals may find it easier to track a specific drug and possibility of approval through the data stored within the blockchain. Finally, blockchain-based systems allow for more data, either about trial participant, outcome, environment during administration, and other aspects to be stored within the drug's 'account' on the blockchain. The FDA will be better able to analyze and attest on the safety and efficiency of the drug in question due to more secure, trustworthy data from all phases of clinical drugs' trials.

Proper authentic care issues plague a drug's parent company long after the research and developmental phases. Simplifying a complex matter, proper authentic care can be summarized as pharmaceutical companies struggling to properly trace and account for where drugs may be sold. In some cases, particularly those in countries with less developed drug administrations, drugs may be sold into the hands of those who plan to produce counterfeits of the drug and profit through bypassing patent protection. Factors tied to "lack of traceability and transparency" led to an estimated 30% of all drug sales in

developing countries being counterfeit. [105] Through the blockchain program outlined by Amazon, authentic identifiers can be "encoded on the blockchain to establish the drug's footprint." [106] This process allows for complete transparency regarding what hands the drug falls into through sales, thus reducing the possibility it may end up with parties planning to produce counterfeits. The information of drug location and intermediaries interacting with transport can help supplement government regulators in their attempts to crackdown on counterfeit drug sales, which directly benefits the pharmaceutical industry.

The real estate industry, as well as governments involved in lease contracting, is already experiencing the positive impacts of blockchain. The Dutch city of Rotterdam is on the forefront of the change. In collaboration with Deloitte and the Cambridge Innovation Center, Rotterdam implemented a blockchain pilot project in December 2016 aimed at recording "legally binding lease contracts," and has since expanded the platform to monitoring the rental payments associated with the contracts. [107] Similar to many of the other potential applications, blockchain helps in this instance through the reduction of transaction times and costs, which currently are mostly paper based. Deloitte Real Estate Manager Jan Willem Santing provided details on other benefits of a blockchain-based platform, stating that " by implementing blockchain applications in the real estate

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[105] Paul Roma, Florian Quarre, Adam Israel, Mark Johnston, and Alejandro Flores, "Blockchain: an Enabler for Life Sciences and Health Care," Deloitte White Paper & Case Study in collaboration with Amazon Web Services, copyright 2016. https://d1.awsstatic.com/blockchain_assets/deloitte_bc_paper.pdf

[106] Paul Roma, Florian Quarre, Adam Israel, Mark Johnston, and Alejandro Flores, "Blockchain: an Enabler for Life Sciences and Health Care," Deloitte White Paper & Case Study in collaboration with Amazon Web Services, copyright 2016. https://d1.awsstatic.com/blockchain_assets/deloitte_bc_paper.pdf

[107] Samburaj Das, "City of Rotterdam will Record Lease Agreements on a Blockchain," *Bitcoin* Technology, CCN, December 12, 2016. https://www.ccn.com/rotterdam-lease-blockchain/

industry… it enables decision makers to use data analysis for making future investment decisions on selling, buying, and constructing real estate." [108] This aspect, both in Rotterdamn's case and in other implementations of blockchain, cannot be understated. Not only does blockchain benefit the user through its immutability, transparency, security, speed, and encryption, among other aspects, but the secure condensed nature of data also leads to improved applications of data analytics. The lease agreements can't be stored on any software platform either, as their contents need to be unaltered in order to settle any disputes. Blockchain helps fulfill this need.

The past two chapters show that while nothing is certain, it appears that the use of blockchain by businesses in many industries will likely increase in the years to come. This means that at the very least, it is important for accountants and auditors, as well as business executives, to be familiar with the technology. It has been argued, due to aspects such as immutability and transparency, that blockchain could eliminate the need for the audit. Being familiar with a technology versus being replaced by a technology are vastly different outcomes.

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[108] Samburaj Das, "City of Rotterdam will Record Lease Agreements on a Blockchain," *Bitcoin* Technology, CCN, December 12, 2016. https://www.ccn.com/rotterdam-lease-blockchain/

Chapter 6: Blockchain and its Impact on Accounting Systems and the Auditor

In late November 2017, financial software firm Libra raised $7.8 million from private markets through a Series A round. The New York City-based startup mentioned in a press release that, "Libra's vision is to be the premier provider of next generation accounting, audit, and tax software … for the blockchain." [109] Libra is anticipating that the value proposal of incorporating blockchain into accounting systems is enough to justify firms making the switch. Articles on blockchain and accounting claim that the technology will cause disruption and change the role of the auditor in the future. In a PwC publication from 2017, Technology Audit Services Leader A. Michael Smith comments, "this technology has the potential to take those (audit) processes and controls to the next level," and "with the right approach, companies can create a blockchain-based system that has less chance for human error." [110]

Other articles go so far to state that blockchain will eliminate the need for the audit altogether. A quote from a collaborative publication by the CPA Canada, the AICPA, Deloitte, and the University of Waterloo Centre for Information Integrity and Information Systems Assurance (UWCISA) helps summarizes these thoughts. "Some publications have hinted that blockchain technology might eliminate the need for a financial statement audit by a CPA auditor altogether. If all transactions are captured in

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[109] Claudine Cornelis and Alecia V. Nieva-Woodgate, "Press Release – Libra Raises $7.8 Million in Series A Round," *Blog*, November 27, 2017. https://www.libra.tech/blog/libra-raises-7-8-million-in-series-a-round

[110] A. Michael Smith, "Auditing Blockchain: A New Frontier," PricewaterhouseCoopers, *Blog*, July 19, 2017. https://www.pwc.com/us/en/industries/financial-services/research-institute/blog/blockchain-audit-a-michael-smith.html

an immutable blockchain, then what is left for a CPA auditor to audit?" [111] As firms move their methods of transaction recording to blockchain-focused software, an immutable audit trail is produced. All of the transactions are verified through the network and cannot be altered (without at least alerting other users of the platform). The argument that the audit profession may become obsolete once all transactions are recorded on the blockchain is based on the notion that through completely traceable audit trails, software can be developed to fully automate the audit. Nicolai Andersen, Partner at Deloitte Germany, points out, "Since all entries are distributed and cryptographically sealed, falsifying or destroying them to conceal activity is practically impossible." [112]

Nicolai continues by comparing transactions recorded on the blockchain to transactions that are "verified by a notary." The argument states that these transactions no longer need to be checked or verified. If a customer has paid an outstanding bill, the bill is recorded as paid in the blockchain network, and cannot be altered in any other manner. Furthermore, the monetary amount of any outstanding accounts receivable, cash, or other material item cannot be altered by foul play. Any manipulation will break the blockchain and alert the network of fraudulent behavior. Supposedly, there is no longer a need for an auditor to sample transactions (in order to establish reasonable assurance), as the transactions are already approved through consensus. Furthermore, the blockchain can

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[111] Will Bible, John Raphael, Matthew Riviello, Peter Taylor, Iliana Oris Valiente, "Blockchain Technology and Its Potential Impact on the Audit and Assurance Professionals," CPA Canada, AICPA, UWCISA, and Deloitte, published 2017. https://www.cpacanada.ca/en/business-and-accounting-resources/audit-and-assurance/canadian-auditing-standards-cas/publications/impact-of-blockchain-on-audit

[112] Nicolai Andersen, "Blockchain Technology, A Game-Changer In Accounting?," Deloitte, March 2016. https://www2.deloitte.com/content/dam/Deloitte/de/Documents/Innovation/Blockchain_A%20game-changer%20in%20accounting.pdf

connect the accounting of a transaction to the transaction itself, so reconciliation becomes at the least less time consuming and at the most automated. [113]

The argument that blockchain will eliminate the need for auditors, however, is shortsighted and lacks sufficient evidence. There are various reasons for why blockchain does not put the future of the audit profession, and the firms that supply these services, in jeopardy. Let's begin with the role of an auditor. "Auditors … enhance trust in the information of the companies they audit and help a multi-trillion dollar capital markets system function with greater confidence." [114] The argument that audits can be replaced by blockchain is based on the idea that the transactions themselves can be trusted. The trust that blockchain provides, however, is simply that the transaction has occurred. There is no information about the nature of the transaction, which may still be "unauthorized, fraudulent, or illegal." [115] The aforementioned collaborative publication between CPA Canada and others mentions that the transactions recorded on a blockchain could "be executed between related parties, linked to a side agreement," or incorrectly classified.

So while, to some extent, transaction occurrence may be trusted when recorded on the blockchain, there is still a need for auditors to inspect the transactions, for either

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[113] Danny Bradbury, "How the Blockchain Could Stop Firms Cooking the Books," CoinDesk, February 7, 2015. https://www.coindesk.com/how-the-blockchain-could-stop-firms-cooking-the-books/

[114] Will Bible, John Raphael, Matthew Riviello, Peter Taylor, Iliana Oris Valiente, "Blockchain Technology and Its Potential Impact on the Audit and Assurance Professionals," CPA Canada, AICPA, UWCISA, and Deloitte, published 2017. Link in footnote 112.

[115] Will Bible, John Raphael, Matthew Riviello, Peter Taylor, Iliana Oris Valiente, "Blockchain Technology and Its Potential Impact on the Audit and Assurance Professionals," CPA Canada, AICPA, UWCISA, and Deloitte, published 2017. Link in footnote 112.

evidence of fraud or a classification error. [116] As Joseph Lubin, founder of blockchain consultancy ConsenSys, stated in a March 2016 interview, "Putting all this stuff on blockchain changes the nature of fraud." [117] It does not, however, eliminate fraud completely. Fraud may still be present on the blockchain, as "lies encoded on the blockchain are still lies. They're just immutable lies." [118] This problem doesn't persist in cyrptocurrency networks, because any transfer of bitcoin, for instance, cannot transfer hands without being published on the network. It is not possible for one party to pay another under the table with a cyrptocurrency (since the currency is solely electronic. For instance, I cannot hand anyone a bitcoin, I must transfer it to them through the network). Yet businesses that are using blockchain to record transactions, but still settling in currency off of the blockchain, can alter value of payment. Therefore, reconciliation between the blockchain-recorded transaction and actual payment is still needed for verification.

Another example that disproves the argument that auditors are no longer needed arises from the following. Proof that goods have been delivered and that there are no performance obligations outstanding cannot (currently) be discerned solely through analyzing transactions recorded on the blockchain. IBM is working on a solution to this problem, and at Think 2018 recently unveiled "the world's smallest computer" which is

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[116] Will Bible, John Raphael, Matthew Riviello, Peter Taylor, Iliana Oris Valiente, "Blockchain Technology and Its Potential Impact on the Audit and Assurance Professionals," CPA Canada, AICPA, UWCISA, and Deloitte, published 2017. Link in footnote 112.

[117] Oliver Staley, "The Unsexy Future of Blockchain is Accounting," Quartz, March 3, 2016. https://qz.com/629662/the-unsexy-future-of-blockchain-is-accounting/

[118] Danny Bradbury, "How the Blockchain Could Stop Firms Cooking the Books," CoinDesk, February 7, 2015. https://www.coindesk.com/how-the-blockchain-could-stop-firms-cooking-the-books/

"smaller than a grain of salt" and can "be a data source for blockchain applications." [119] Until this computer of sorts is attached to all goods, from thousands of different companies, the problem of proof of delivery will still exist. Regardless of if this ever happens, auditors will still be needed to assess management's valuations, classifications, and estimates of assets and liabilities, among other items.

It is important to note that while the technology has many use cases, it is unlikely that businesses will begin storing all of their transaction data on the blockchain within the next five years. Given the current blockchain environment, it is far too costly to implement and maintain these systems for all transactions. Vermont planned to implement blockchain technology for all of the registered property records, but "bailed on the plan after a year" due to its high cost. [120] Other reasons businesses may implement blockchain is to develop the concept of smart contracts. Smart contracts are not limited to the blockchain, but can be recorded on the platform for transparency reasons as well as other benefits provided by the technology.

Smart contracts are "computer programs that may execute under certain conditions." [121] An example of a smart contract is an invoice that continuously checks to see if the goods purchased have been delivered. Once delivery is recorded in a system

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[119] Monica Chin, "IBM Unveils 'World's Smallest Computer' with Blockchain at Think 2018'," March 18, 2018. https://mashable.com/2018/03/19/ibm-worlds-smallest-computer/#t20sLbKAggqc

[120] Jeff John Roberts, "Why Delaware Made It Easier for Businesses to Use Blockchains," Fortune, August 22, 2017. http://fortune.com/2017/08/22/fortune-500-blockchain-ledger-delaware/

[121] Nicolai Andersen, "Blockchain Technology, A Game-Changer In Accounting?," Deloitte, March 2016. https://www2.deloitte.com/content/dam/Deloitte/de/Documents/Innovation/Blockchain_A%20game-changer%20in%20accounting.pdf

(possibly a blockchain), the invoice will pay itself, transferring funds from one company to the other. The scope of these smart contracts can range from very simple, such as the example provided, to complex. These contracts will need auditing, but including them on the blockchain may lessen auditor work around confirmation. If they are tied into the blockchain, an auditor can, in theory, easily check the criteria under which the smart contract will execute, and reconcile it back to the transaction. However, the implementation of complex smart contracts may also increase time spent on auditing the contract criteria. For the purpose of this study, understanding the basic aspects of smart contracts, why they are appealing to companies, that they may be implemented on the blockchain, and the fact that they will still need to be audited, is enough. As with other areas of promising technology, smart contracts have the potential to streamline business workflow, but problems may arise, both for auditors and the businesses engaging in the contracts, if the programs do not run as intended. They will still need auditing.

I interviewed Will Bible, a Deloitte Partner who focuses on audit innovation, on February 16, and asked for his take on blockchain implementation. Bible stressed that in a majority of cases, especially those involving large corporations, it would be redundant to begin recording transactions on the blockchain. [122] The transaction processing and recording methods are often too engrained in businesses through legacy enterprise resource planning (ERP) and CRM systems to advocate moving them to blockchain. Essentially, the platforms are too sticky to justify switching costs. The systems are often tied to accounting systems, and the processes of monitoring and recording transactions operates relatively smoothly as is. Bible noted that he doesn't see a rush for large

[122] Will Bible, Personal Interview, February 19, 2018.

corporations to redesign their legacy systems. [123] A majority of investment in blockchain-based systems may only be recovered (depending on the business and systems in place) through cost savings on audit fees. Given the current environment, any transaction that a firm wishes to record on the blockchain would similarly be recorded elsewhere in their legacy systems, either through the accounting department or through an ERP system. The blockchain could be connected with these systems, but redundancy occurs from storing the transaction data twice, once on the blockchain and once in the other software system. A firm would have to completely replace transaction-tracking legacy systems with blockchain to eliminate this inefficiency, which, given the current cost discrepancy, appears unlikely.

Further solidifying this argument, Bible pointed out that firms do not design their systems to benefit the auditor. [124] Businesses have designed their internal software and data information systems to align with their own processes, business practices, and workflow. As auditing is a client service based profession, it instead falls on the auditing firm to adjust their systems in order to extract the transaction data and information needed to complete an audit. Bible closed the interview by stating that companies whose business model depends on blockchain may find it more reasonable to use the technology in their transaction records and accounting systems. [125] In these cases, it could be possible that an audit be conducted solely on data stored on the blockchain. Companies such as these are still in early stages, and even in these cases, Bible mentioned he would not be surprised if it were simply more cost efficient for them to use accounting software like

[123] Will Bible, Personal Interview, February 19, 2018.
[124] Will Bible, Personal Interview, February 19, 2018.
[125] Will Bible, Personal Interview, February 19, 2018.

Intuit's QuickBooks. [126] While the blockchain will not eliminate the audit, professionals will have to audit blockchain-based transactions as well as audit companies that are on the front line of blockchain implementation.

In order to opine over internal controls (as is required by SOX), auditors need to be familiar with the blockchain and how it operates. Reports suggest that the application of real-time auditing may be a possibility. "The concept behind real-time auditing is to inspect transactions closer and closer to the point of occurrence." [127] Real-time auditing is beneficial to the firms providing services as "real-time, authentic data makes predictive analytics more valuable." [128] More valuable predictive analytics correlate with higher quality audits, as deviations from informed predictive analytics can be investigated further. While a full real-time audit will not be achieved due to the likelihood that only a portion of transactions will be recorded on the blockchain, a part of the substantive procedures related to the blockchain-recorded transactions can be shifted to the present, rather than near the end of the quarter.

Blockchain promotes real-time auditing by allowing auditors access to the permissioned network. Auditors are then able to inspect and sample transactions as they occur. This also frees up time for auditors at year-end to devote their attention to more complex accounting matters involving valuation or classification, or to investigate transactions that have been flagged as unusual. The risk of fraud may be higher with

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[126] Will Bible, Personal Interview, February 19, 2018.
[127] A. Michael Smith, "Auditing Blockchain: A New Frontier," PricewaterhouseCoopers, *Blog*, July 19, 2017. https://www.pwc.com/us/en/industries/financial-services/research-institute/blog/blockchain-audit-a-michael-smith.html
[128] L. Gary Boomer, "Blockchain – Hype or Reality," Accounting Today, *Blog*, July 5, 2017. https://www.accountingtoday.com/opinion/boomers-blueprint-blockchain-hype-or-reality

blockchain-related transactions, as perpetrators could see an opportunity given the supposed accuracy and security of blockchain. The information presented on the blockchain, however, is only as good as the people on the network.[129] If there is a consensus across multiple parties to conclude that a transaction has occurred, it can be cryptographically entered onto the network and seem legitimate. Therefore, sampling of transactions along with other procedures still needs to occur, although the timing of the audit procedures can be much closer to transaction date.

Jeremy Dane, CCO of Libra, one of the companies that in my opinion best understands the impact blockchain will have on the auditing landscape, published an article in late 2016 titled, "Wait, Blockchains Need Audited?!?" Throughout the article, Dane denies claims that the audit will become automated or eliminated. Instead, Dane states that Libra's goal is to develop software to help "change the timing of (auditor's) service from post-transaction to real-time." [130] Arguments have been put forth that the blockchain will reduce the size of audit teams through automation and thus lead to a reduction in audit costs. Besides a shift toward some real-time auditing, the technology also "allows organizations to synchronize audit trails between partners in a supply chain." [131] This is why the blockchain is often compared to both a ledger and a database, as it can serve as a source of the information needed to perform an audit. Until auditors no longer

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[129] Jessica McKenzie, "Why Blockchain Won't Fix Food Safety – Yet," The New Food Economy, *Tech*, February 4, 2018. https://newfoodeconomy.org/blockchain-food-traceability-walmart-ibm

[130] Jeremy Drane, "Wait, Blockchains Need Audited?!?," Libra, December 21, 2016. https://www.linkedin.com/pulse/wait-blockchains-need-audited-jeremy-drane

[131] Aaron Lieber, "Trust in Trade: Announcing a New Blockchain Partner," IBM, *Blockchain Blog*, March 9, 2017. https://www.ibm.com/blogs/blockchain/2017/03/trust-trade-announcing-new-blockchain-partner/

need to receive confirmations from suppliers and customers it is questionable whether this aspect of the blockchain will save as much time as is often reported.

The claim that blockchain will result in cost savings is difficult to analyze. Unless a majority of transactions occur on the blockchain, the audit work of the future may look starkly similar to how it looks today. Furthermore, public accounting firms may find it difficult to cut costs through automation without sacrificing quality. While the Big Four firms are always seeking to improve margins over the long term, they may be more focused today on improving the quality of service. Jon Raphael, Chief Innovation Officer at Deloitte, took time out of a press conference during the 2017 Financial Executives International's Current Financial Reporting Issues Conference in New York to emphasize this point. When questioned about how broad technology implementation in the audit may lead to cost savings, Raphael answered, "I think that audit quality is paramount … that's number one, regardless of the fee. That's what our intention is and what we're always going to deliver." [132]

While access to real-time information through the blockchain may present a greater opportunity to apply audit analytics, substantive procedures will still need to be completed to achieve proper assurance. Reduction in lower-level audit staff may have unforeseen impacts down the line for the public accounting firms. The pool of future partners is spread, thinly albeit, throughout the current audit staff. Reducing staff numbers may alter the quality of future partners by limiting the size of that pool.

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[132] Michael Cohn, "Audit Technology Evolving Quickly at Big Four," AccountingToday.com, November 14, 2017. https://www.accountingtoday.com/news/audit-technology-evolving-quickly-at-big-four-firms

Regardless, I believe that, if hiring numbers trend lower in the coming years, it will be less because of firms implementing blockchain, and more because of other technological advancements, such as the increased use of audit analytics.

Challenges exist for auditors to adapt their processes to accommodate the blockchain. These involve extracting useful data from the blockchain for use in audit processes. In order for auditors to document their work on an engagement, the transaction data needs to be taken from the blockchain and imported into their own workbook software and other systems. For this reason, it is important for auditors to be engaged in discussions with their clients about plans to implement blockchain. It will help prevent unnecessary system inefficiencies if auditors can prepare in advance rather than rush to develop techniques during the audit. Other challenges that exist include how to assess the internal controls surrounding blockchain, and what stance regulators will take in regards to blockchain. Regulators will ultimately have the final say regarding the procedures that are needed to provide assurance over the blockchain.

Until specific guidance is passed, it is up to the public accountants to implement what they believe are the proper procedures to provide assurance on a firm's financials. To date, PwC, Deloitte, Ernst & Young (EY) and KPMG have all issued press releases indicating they have either successfully completed audits of the blockchain or offer blockchain auditing services to clients. A Wall Street Journal article from March 2018 states that for transactions that "occur on the blockchain, PwC logs them and applies

controls and testing criteria." [133] Deloitte's blockchain focused team, named Rubix, "applied existing guidance and attestation standards to the permissioned blockchain," during their successful blockchain audit in February 2017.[134] Currently, it appears the Big Four are applying auditing standards for general transactions (not on the blockchain) to those recorded or completed on the blockchain. Conservatism around auditing the technology makes sense, and until regulators come out with specifications, it is unlikely the Big Four will implement any real-time auditing or other groundbreaking automation into the picture.

Depending on the view that regulators take on blockchain, auditing of the technology may become more streamlined and efficient, and generate realized cost savings. "For example, if a significant class of transactions for an industry is recorded in a blockchain, it might be possible for a CPA auditor to develop software to continuously audit." [135] These technologies likely need to be cleared by regulation first, however, before they can be properly implemented. The cost and time savings here would result from the elimination of "manual data extraction and audit preparation activities," though it is important to remember that this would only occur for transactions that are recorded on the blockchain, not all transactions for an entity. Regardless, auditors will continue to

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[133] Michael Rapoport, "PwC Has an Answer for Blockchain: Audit It," The Wall Street Journal, March 16, 2018. https://www.wsj.com/articles/pwc-has-an-answer-for-the-blockchain-audit-it-1521194401

[134] Samburaj Das, "'Big Four' Giant Deloitte Completes Successful Blockchain Audit," CCN, February 14, 2017. https://www.ccn.com/big-four-giant-deloitte-completes-successful-blockchain-audit

[135] Will Bible, John Raphael, Matthew Riviello, Peter Taylor, Iliana Oris Valiente, "Blockchain Technology and Its Potential Impact on the Audit and Assurance Professionals," CPA Canada, AICPA, UWCISA, and Deloitte, published 2017. Link in footnote 112.

treat blockchain-recorded transactions as if they were completed off the distributed ledger platform for the time being. "The still-new technology faces a host of obstacles to adoption, PwC says—legal and compliance concerns within companies and other organizations, issues of corporate controls and risk management." Until these concerns are addressed by regulation, the major benefits of blockchain, from an auditor's standpoint, will be on hold.

Chapter 7: Regulators' Response to the Blockchain

On December 5, 2017, PCAOB Board Member Jeanette M. Franzel was invited to present to attendees of the AICPA Conference on SEC and PCAOB Developments. Franzel's speech was titled, "Update on PCAOB Efforts to Enhance Audit Quality," and in it, she addressed the impact of technology on the accounting profession and the PCAOB's recent research agenda on how the use of technology will affect financial reporting and auditing. Franzel mentioned that the research project was driven by the fact that, "Certain technologies, such as robotics, artificial intelligence, and distributed ledger technologies, also known as blockchain or distributed database technology, have the potential to seriously disrupt financial reporting and auditing processes." [136] Franzel continues, stating that the technological changes represent both threats and opportunities to auditors. Near the end of her speech, Franzel says, "the general question to be addressed by PCAOB's research project is whether there is a need for guidance, changes to PCAOB standards, or other regulatory actions in light of auditors' increased use of technology-based tools in the conduct of audits. Some areas of uncertainty have been identified where guidance may be needed to clarify how certain auditing standards apply." [137] Franzel concludes by mentioning she anticipates the PCAOB will provide an

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[136] Jeanette M. Franzel, "Update on PCAOB Effort To Enhance Audit Quality," Speech, December 5, 2017. Accessed through Public Company Accounting Oversight Board, Speeches & Statements. https://pcaobus.org/News/Speech/Pages/Franzel-update-PCAOB-efforts-enhance-audit-quality-12-5-17.aspx

[137] Jeanette M. Franzel, "Update on PCAOB Effort To Enhance Audit Quality," Speech, December 5, 2017. Accessed through Public Company Accounting Oversight Board, Speeches & Statements. https://pcaobus.org/News/Speech/Pages/Franzel-update-PCAOB-efforts-enhance-audit-quality-12-5-17.aspx

update on the matter during the Standing Advisory Group meeting scheduled for June 5th, 2018.

While Franzel's speech implies that guidance on blockchain may be coming soon, other statements suggest otherwise. Franzel spoke earlier in the year (October 2017) at the National Association of State Boards of Accountancy annual meeting in New York. During a panel Q&A-style session, Franzel stated that, with regards to blockchain, the PCAOB has "dedicated a fair amount of resources to this and we've got some staff really doing a deep dive on this." [138] She continues, however, stating, "Our current emphasis is on data analytics and artificial intelligence. I think blockchain will come later. If I had to predict what we're going to do (and again, I'm speaking for myself), I think we probably will lean toward guidance and there have been several areas where necessary guidance has been identified." [139] So while it appears that the PCAOB has decided it needs to issue guidance on the blockchain, it will likely be some time before this is done. This can lead to setbacks in the planning and development of how exactly auditors will provide assurance on the blockchain. It is unlikely that the Big Four will pour money into developing any automated auditing solutions for the blockchain until they fully understand the PCAOB's stance.

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[138] Michael Cohn, "PCAOB's Franzel Leans Toward Issuing Blockchain and Data Analytics Guidance," Accounting Today, November 1, 2017. https://www.accountingtoday.com/news/pcaob-leans-toward-issuing-blockchain-and-data-analytics-guidance

[139] Michael Cohn, "PCAOB's Franzel Leans Toward Issuing Blockchain and Data Analytics Guidance," Accounting Today, November 1, 2017. https://www.accountingtoday.com/news/pcaob-leans-toward-issuing-blockchain-and-data-analytics-guidance

The PCAOB has been criticized in the past for the time it takes to issue new guidance. In late 2014, SEC Chief Accountant James Schnurr commented that, "some of the most important projects … are simply moving too slowly." [140] Schnurr has entered into discussions with former PCAOB Chairman James Doty about speeding up the process. Doty responded that the PCAOB "should issue new rules only after thoughtful assessment of the need to improve audit quality and evaluating the economic impact of any rule-making." [141] In reality, both Doty and Schnurr are right. It is in the best interest of all participants for the PCAOB to operate swiftly when issuing new guidance. In most cases, the topics they are addressing are affecting businesses in the present. As chairman of the AICPA Kimberly Ellison-Taylor said, "there is an immediate need to identify standards and regulations surrounding the use of this technology." [142] Yet it is vital for the PCAOB to be thorough and develop a fundamental understanding of the issue before turning their attention to the guidance aspect.

While CPAs, the Big Four, and other regulatory organizations can put pressure on the PCAOB to speed up their processes, they ultimately will be left waiting until the PCAOB feels confident in their research, and issues what they deem as appropriate

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[140] Ken Tysiac, "SEC Official: PCAOB's Standard Setting Too Slow," Journal of Accountancy, December 8, 2014. https://www.journalofaccountancy.com/news/2014/dec/pcaob-auditing-standards-201411477.html

[141] Ken Tysiac, "SEC Official: PCAOB's Standard Setting Too Slow," Journal of Accountancy, December 8, 2014. https://www.journalofaccountancy.com/news/2014/dec/pcaob-auditing-standards-201411477.html

[142] Ken Tysiac, "Blockchain Considerations for Management and Auditors," Journal of Accountancy, December 4, 2017. https://www.journalofaccountancy.com/news/2017/dec/blockchain-for-management-and-auditors-201717994.html

guidance. Barry Melancon, CEO of the AICPA, is quoted in a December 2017 article stating that CPAs need "to challenge the standards-setters to keep up, and to look at our methodology for auditing." [143] Perhaps the PCAOB is struggling with understanding how to approach the "dozens of variants" of blockchain. As PwC reported, "If we looked at 20 of our clients who are deploying blockchain, we would find that they all resulted in different use case scenarios." [144]

The SEC has gone ahead and provided considerations on how auditors should proceed until the PCAOB issues official guidance. The SEC stated that auditors should "determine the nature of the audit procedures to perform based on the circumstances of the issuer and the assurance standards used." [145] Amy Pawlicki, Vice President of Assurance & Advisory Innovation for the AICPA, noted that "auditors are already auditing transactions in the blockchain" using the SEC's considerations. Until the PCAOB alters the guidance surrounding blockchain, however, the blockchain will have little impact on auditors, as they must treat the distributed ledger transactions as they would transactions on legacy systems. Perhaps a Blockchain Regulatory World Summit, as is predicted by Avani Desai, Principal Privacy Leader and Executive Vice President of

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[143] Daniel Hood, "Melancon: Accountants Must Commit to Change," Accounting Today, December 6, 2017. https://www.accountingtoday.com/news/aicpas-melancon-accountants-must-commit-to-change

[144] A. Michael Smith, "Auditing Blockchain: A New Frontier," PricewaterhouseCoopers, *Blog*, July 19, 2017. https://www.pwc.com/us/en/industries/financial-services/research-institute/blog/blockchain-audit-a-michael-smith.html

[145] Ken Tysiac, "Blockchain: An Opportunity for Accountants? Or a Threat? ," Journal of Accountancy, November 17, 2017. https://www.journalofaccountancy.com/news/2017/nov/blockchain-opportunity-for-accountants-201717900.html

independent standards compliance assessor Schellman & Company, is what the PCAOB is waiting for to help outline its guidance. [146]

It is pivotal that auditors work with the PCAOB in their development of guidance. Doing so will not only help with implementation of the new standard or other guidance, but will set the tone for how the blockchain environment, both in terms of investment and eventual use, will look in the future. Jeanne Boillet, Global Assurance Innovation Leader at EY, notes that "current regulatory and legal frameworks don't take into account the use of blockchain," and that auditors will have to "work closely with regulators to either develop (blockchain) solutions that conform to the current frameworks or alter them to align with the new ways of working." [147]

The SEC has been busy dealing with other issues arising from the blockchain revolution. Firms wishing to raise public capital while avoiding the need to issue an audited S-1 have found a loophole in the traditional financial system through what has been dubbed initial coin offerings (ICOs). An ICO allows a firm to raise capital through issuing digital tokens or coins. These coins are recorded on the blockchain and to date have been issued mostly by startup firms that are either engaged in blockchain development or that currently offer blockchain products. The digital tokens sold to investors "entitle … owners to future products or services developed by the company."

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[146] Michael O'Dwyer, "How Blockchain Technology Will Change The Audit World," Ipswitch, *Blog*, November 7, 2017. https://blog.ipswitch.com/how-blockchain-technology-will-change-the-audit-world

[147] Jeanne Boillet, "Is Audit Ready for Blockchain? ," Accounting Today, August 17, 2017. https://www.accountingtoday.com/opinion/is-audit-ready-for-blockchain

[148] Apart from the publicity that an ICO creates, these companies are using ICOs to avoid regulation while simultaneously raising capital. The SEC "has said that many of the deals are actually securities sales," and thus should be under the regulation of investor-protection laws. [149] Brad Garllinghouse, CEO of blockchain startup Ripple, agrees with the SEC's rulings and believes that blockchain-focused firms need to cooperate with regulation and follow traditional capital raising methods. He mentioned that "ICOs are taking advantage of grey areas in securities law" during a December 2017 interview. [150]The process that a company must undertake prior to a public offering, such as issuing an audited S-1, was developed in the interest of protecting potential investors. Auditors provide assurance over a company's S-1 prior to stock being sold to investors. Bypassing this process may provide dubious companies with opportunities to defraud investors. The SEC has stepped in, and as of December 2017, has "sued two ICOs that it said committed fraud by allegedly taking investors' money for tokens that didn't exist or promising outlandish returns." [151] Furthermore, the SEC seems set on preventing other firms from escaping regulation, as it "intervened to halt a $15 million ICO by Munchee., a restaurant app, saying the deal should have been registered as a securities offering." [152] The

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[148] Dave Michaels and Gabriel T. Rubin, "Bitcoin Catches U.S. Regulators Off Guard," The Wall Street Journal, *Business and Finance,* December 26, 2017.
[149] Dave Michaels and Gabriel T. Rubin, "Bitcoin Catches U.S. Regulators Off Guard," The Wall Street Journal, *Business and Finance,* December 26, 2017.
[150] Paul R. La Monica, "SEC Suspends Trading of Red-Hot Bitcoin Stock," CNN, *Money,* December 19, 2017. http://money.cnn.com/2017/12/19/investing/bitcoin-crytpocurrencies-sec-bubble/index.html

[151] Dave Michaels and Gabriel T. Rubin, "Bitcoin Catches U.S. Regulators Off Guard," The Wall Street Journal, *Business and Finance,* December 26, 2017.
[152] Dave Michaels and Gabriel T. Rubin, "Bitcoin Catches U.S. Regulators Off Guard," The Wall Street Journal, *Business and Finance,* December 26, 2017.

processes required before issuing stock are in place to allow auditors to serve their role to the investing public. Blockchain may get a bad reputation amongst investors if fraudulent ICOs are allowed to continue. The SEC has done well to limit the damage, "digging in on a case-by-case basis and trying to look at all of the token offerings." [153]

Looking to the future, regulators such as the PCAOB and SEC need to act swiftly to address how both auditors and investors use and view blockchain. The timing of their actions will have tangible impacts on auditing firms' and their clients' blockchain investment decisions. On August 1st, Delaware (where more than two-thirds of Fortune 500 companies are incorporated) passed a law that "permits companies … to keep their list of shareholders on a blockchain." [154] This may be the first step of a broader shift towards keeping records and other secure information on the blockchain. Supposedly, Delaware is developing a platform, and drafting required legislation, that will allow companies to "do everything from file incorporation documents to register shares via a blockchain." [155] Delaware states that this shift may result in "much quicker auditing and due diligence processes." Until the PCAOB issues guidance, firms will invest millions into blockchain, as the technology still needs to be audited using outdated procedures. [156]

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[153] Dave Michaels and Gabriel T. Rubin, "Bitcoin Catches U.S. Regulators Off Guard," The Wall Street Journal, *Business and Finance,* December 26, 2017.
[154] Jeff John Roberts, "Why Delaware Made It Easier for Businesses to Use Blockchains," Fortune, August 22, 2017. http://fortune.com/2017/08/22/fortune-500-blockchain-ledger-delaware/
[155] Jeff John Roberts, "Why Delaware Made It Easier for Businesses to Use Blockchains," Fortune, August 22, 2017. http://fortune.com/2017/08/22/fortune-500-blockchain-ledger-delaware/
[156] Jeff John Roberts, "Why Delaware Made It Easier for Businesses to Use Blockchains," Fortune, August 22, 2017. http://fortune.com/2017/08/22/fortune-500-blockchain-ledger-delaware/

Chapter 8: Conclusion

Blockchain is a fascinating technology that will alter some of the ways that businesses transact. Yet for all that blockchain offers in encryption, enhanced auditability, and information transparency, it is important to realize that given current cost constraints, blockchain is neither for every business nor every transaction. Even with widespread implementation, which is worth recalling is by no means certain, the blockchain will not eliminate the auditor. Some of the straightforward procedures, such as transaction verification, may be automated through advanced software. Furthermore, firms will begin auditing blockchain transactions closer to the transaction date.

Auditors will still need to assess the appropriateness of management's valuations, classifications, and recognitions, among other complex matters. General Electric (GE) is currently facing a probe from regulators regarding the recognition of revenue resulting from "long-term service contracts for projects like power-plant repairs and jet-engine maintenance." [157] The valuation of contract assets "relies in part on GE's own estimates and assumptions." Implementation of blockchain technology will not reduce the need for auditors to determine the reasonableness of GE's estimates and assumptions. The impending probe was made public in January 2018, and since, a Wall Street Journal article reported that proxy advisers Institutional Shareholder Services and Glass, Lewis, & Co. have urged shareholders to pressure the board to vote against retaining auditor KPMG due to "previously-undisclosed liabilities and accounting issues." [158]

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[157] Thomas Gyrta, "GE Faces an SEC Probe of Accounts," The Wall Street Journal, *Main*, January 25, 2018.
[158] Thomas Gyrta and Joann S. Lubin, "GE Urged to Dump Auditor KPMG After 109 Years by Proxy Advisers," The Wall Street Journal, *Business,* April 6, 2018.

So while blockchain will not wipe out auditors and will not immediately alter most of an auditors' workflow, it does not mean that current and future public accountants should ignore the technology. EY Global Technology Leader Channing Flynn implied just this, stating that "waiting for the technology to take hold is too late. Now is the time to start defining the questions and influencing policy that will lead to answers." [159] The reality of the matter is that at blockchain will impact some aspect of businesses' operations by the end of the decade. Auditors will need, at a minimum, to have an idea of how the technology operates in order to properly assess internal controls and to understand the client's business. This will lend itself to higher quality audits. Auditors and accountants also need to pay close attention to and work with regulation around the technology. This will guide how both auditors and their clients are able to use blockchain, and will have a direct impact on how influential distributed ledger technology will be.

The general viewpoint throughout the accounting profession, and within the audit community in particular, should be that blockchain technology provides more of an opportunity than a threat. It remains to be seen how the implementation of blockchain will impact size of audit teams. This question will remain unanswered until standards are updated and new regulation is issued, at which point the Big Four can properly invest in developing blockchain solutions. Ami Beers, Director at the AICPA, comments that blockchain "can reduce cost; it can transact faster cheaper. And it gives you an immutable record of all transactions that cannot be changed, so that's automating the

[159] L. Gary Boomer, "Blockchain – Hype or Reality? ," Accounting Today, July 5, 2017. https://www.accountingtoday.com/opinion/boomers-blueprint-blockchain-hype-or-reality

audit trail…. We look at it as an opportunity to make audits more efficient in the future." [160]

Auditors and accountants need to invest time and energy into understanding how exactly companies will implement blockchain. Perhaps the hype surrounding blockchain is blown a bit out of proportion. It will not eliminate the audit or the auditor. What it will do, however, is allow auditors "to spend more time exercising their professional judgement." [161] In PCAOB board member Jeanette Franzel's aforementioned 2017 speech, Franzel comments, "the emergence and use of new technologies in the audit will require professional skepticism and critical thinking by auditors in new ways. These technology tools and approaches may also highlight the need for stronger skills in more subjective and qualitative areas." [162]

Having a proficient understanding of blockchain technology, amongst other technologies, will begin to shape the hiring tendencies of the Big Four. I interviewed EY Partner Mieke Velghe in February 2018 and asked for her opinion on the impact blockchain may have on EY's recruiting strategies for its assurance practice. Velghe responded that it's about "making sure we have that expertise inside the firm. Making sure we're hiring people that understand these technologies. It's very difficult to assess

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[160] Tammy Whitehouse, "Auditors Develop Early Plans for How to Audit Blockchain," Compliance Week, April 3, 2018. https://www.complianceweek.com/news/news-article/auditors-develop-early-plans-for-how-to-audit-blockchain#.Ws1c6YjwaUl

[161] Jack Shaw, "The Blockchain Transformation of Accounting and Auditing," NJCPA, December 18, 2017. https://njcpa.org/stay-informed/topics/article/2017/09/14/the-blockchain-transformation-of-accounting-and-auditing

[162] Jeanette M. Franzel, "Update on PCAOB Effort To Enhance Audit Quality," Speech, December 5, 2017. Accessed through Public Company Accounting Oversight Board, Speeches & Statements. https://pcaobus.org/News/Speech/Pages/Franzel-update-PCAOB-efforts-enhance-audit-quality-12-5-17.aspx

audit risks if you don't know how the technology by itself works." [163] In my opinion, the largest need for skill development amongst future auditors is in computer science and statistical inference, as these aspects will become more prominently integrated into auditing procedures through blockchain. By improving in these areas, developing an in-depth understanding of blockchain technology, and focusing on the new regulation that will be issued by the PCAOB and SEC, auditors can prepare themselves for any impact that blockchain will have in the future.

[163] Mieke Velghe, Personal Interview, February 20, 2018.

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