12-2018

Discussion of the Potential of Blockchain in Finance

Andrew Kincaid
University of Arkansas, Fayetteville

Discussion of the Potential of Blockchain in Finance

by

Andrew C. Kincaid

Advisor: Dr. Dobrina Jandik

An Honors Thesis in partial fulfillment of the requirements for the degree Bachelor of Science in International Business in Finance.

Sam M. Walton College of Business
University of Arkansas
Fayetteville, Arkansas

December 15, 2018

Table of Contents

1. Introduction

This paper analyzes the current application of blockchain technology to demonstrate its disruptive potential that blockchain has across industries. At the same time, this paper analyzes the potential difficulties that blockchain technology must face and overcome to realize this potential.

Blockchain is a new database technology that has grabbed the attention of the business world (see appendix 1). As displayed by Cong and He (2018), the popularity of bitcoin and blockchain have risen drastically over the past few years. Blockchain was designed with purpose of decentralizing financial ledgers by using cryptographic proof to secure the information stored and entered into the ledger. The Merriam-Webster dictionary defines Blockchain as "a digital database containing information (such as records of financial transactions) that can be simultaneously used and shared within a large decentralized, publicly accessible network" as well as "the technology used to create such a database."

Blockchain offers many benefits relative to technology that is already in place including its ability to be more efficient and lower costs. Most of the efficiency that comes with the blockchain technology is in its ability to decentralize processes that historically have taken major capital resources to run. The decentralization also contributes to blockchains two greatest advantages - transparency and irreversibility. However, many industries and institutions are structured in very centralized ways because of the risk that these industries inherently have. The blockchain innovation could influence many industries within the finance world including corporate finance, banking and financial services. Consumers of these different industries stand to benefit the most with lower prices and fees associated with a more efficient and decentralized system.

2. Key Features of Blockchains

Blockchain technology functions with five basic underlying principles as described by Berke (2017): Distributed database, peer-to-peer transactions, transparency with pseudonymity, irreversibility and computational logic.

2.1 Distributed Database

Blockchain is built upon the idea that the decentralization of information reduces cost while increasing transparency and efficiency. In general, the classic set up of different finance industries such as banking, investment and corporate finance tend to be centralized - one institution or a third party must help facilitate any given transaction. This creates two major economic costs - the cost of verification and the cost of networking which will be discussed later. By distributing the ledger system to the public, these two costs are cut drastically. With a public blockchain ledger, all parties have the ability to see all transactions while the technology autonomously matches people for transactions and verifies all goods and funds that go into the transaction. This leads to lower costs and quicker transactions. There are two ways to create these databases, public and private. The public version of blockchains allows for total visibility into all data and lends itself to more inherent trust. On the other hand, not all data is safe to share with everyone. For this reason, a private configuration also exists. In the private set up, a "gatekeeper" would allow access to users and limit who could add data. Both systems allow for the distributed ledger; however, the private configuration adds an intermediary which can add costs to a transaction.

2.2 Peer-to-Peer Transmission

As a result of the previously listed decentralization, transactions on a blockchain are

directly peer-to-peer. This takes out the need of a third-party intermediary. As noted before, less people in a transaction has the potential to lower costs and a quicken the process. As described by Iansiti and Lakhani, a good illustration of how important the peer-to-peer system is to blockchain is by comparing it to the effect that eBay had on online retail. Connecting people directly is what allowed eBay to thrive and allow low fees which generated users.

2.3 Transparency with Pseudonymity

Transparency is the next feature in the foundation of blockchain. As stated previously, blockchain applications are created using distributed ledgers which, when public, allow all users to view all data and add data freely. The benefits of transparency are added trust of the system which lowers of the cost of verification in any given transaction. To go along with the transparency is the added benefit of Pseudonym, or the ability of one to stay anonymous if one chooses to. The best example of the pseudonym is the fact that the name Nakamoto which is used refer to the creator of bitcoin is itself a pseudonym. Mr. Nakamoto is still anonymous today.

2.4 Irreversibility

The key to ensuring that data can be trusted is making a blockchain irreversible. As blockchains grow in size, the data blocks are "chained" together creating a long line of blocks that each confirm previously entered data so that in order to change any information in a past block one must go through every block in the sequence and make the change. However, as new blocks are added, this becomes increasingly difficult to achieve as a new layer of confirmation is added with each new block. Berke (2017) describes this process by saying, "Various computational algorithms and approaches are deployed to ensure that the recording on the database is permanent, chronologically ordered, and available to all others on the network."

2.5 Computational Logic

This feature describes the blockchains ability to use programmable smart contracts that can intemperate information and make decisions without the need of a third party. This allows logic dictated by algorithms to autonomously activate transactions between two parties. This process is known as "Smart Contracts." These contracts function because of two previously stated features, Peer-to-Peer Transactions and Irreversibility. While a basic computer program could possibly execute a contract, a Smart Contract has the added bonus of the security and ease of networking that blockchain provides.

3. History of Blockchain

3.1 *The Creation of Blockchain*

The idea of blockchains can be traced all the way back to 1991 in a paper published in the Journal of Cryptology written by Haber and Stornetta. In this paper the authors describe a process that would become the predecessor of today's blockchain innovation. The authors proposed a new structure for time-stamping in order to protect intellectual property by using a hash function that rendered data into a new code that could not be reverted back to the original data. These hash functions protected data because any change in one hash function would cause a very distinct change in the sequence of all subsequent data. These changes would then cause a major distortion of the output making changes easy to observe. The second big component of their idea was publishing the records in a public source where data could be seen and verified by many. This was the first step in creating chained information linked together in a public setting. To continue this idea, Haber and Stornetta knew that scaling this chain was not going to be easy, especially with the computing power at the time. In later works, they described the bundling together of this information into blocks and using hash functions to connect these blocks. At this

point the basic idea of blockchain, a distributed ledger comprised of blocks chained together, was created.

Blockchain, as it is known today, began following the next big innovation that came from a man named Satoshi Nakamoto in 2008. Nakamoto is credited for creating Bitcoin and the first blockchain; however, the name Nakamoto has been used as a pseudonym for the unknown person or people who created Bitcoin as well as the first blockchain database. Mr. Nakamoto designed a blockchain ledger similar to what was described by Haber and Stornetta; however, as pointed out by Yermack (2008), Mr. Nakamoto had a deep distrust of financial institutions stemming from the financial crisis in 2008 which led him to creating a system with no sponsor or gatekeeper of the ledger. This meant no third party had control over the addition of new blocks. This decentralized the ledger and became the third identifying feature of modern blockchains.

3.2 Early Blockchain Innovation

The early stages of the concept of chaining information together were first introduced by Haber and Stornetta (1991) however, blockchains did not take off until Nakamoto (2008) proposed blockchain as a method of validating ownership of bitcoin. According to Gupta (2017), In the early days of blockchain there have been four major breakthroughs that have propelled the technology forward and allowed the new ledger system to be seen as more than just the new fad.

The applications that blockchain technology supports have taken the spotlight away from it. Blockchain's first major use is a good example of it being overshadowed. Gupta (2017) says, "the first major blockchain innovation was bitcoin, a digital currency experiment." Even today, cryptocurrencies, namely Bitcoin, get more mainstream media coverage then the blockchain technology itself. According to Coin Market Cap, an online database covering cryptocurrencies, as of October 2018, Bitcoin has a market cap of slightly more than $100,000,000,000. This valuation of Bitcoin has fluctuated from as low as about $60,000,000,000 to as high as around $300,000,000,000. Similarly, CoinDesk, an online source specializing in virtual currency, shows that the price of Bitcoin has changed from an all-time low of around $120 to an all-time high of around $17,000 in late 2017. In one year, the price has already dropped down to around $6,000 (Bitcoin Cryptoeconomic Index by CoinDesk, retrieved November 15, 2018).

The popularity gained from the cryptocurrency boom brought the second major breakthrough which Gupta (2017) called "blockchain." This self-named idea is less of a new product and more of the realization that blockchain could be used to support and change many different products and in many different industries.

Gupta (2017) describes one of the most promising innovations to come from the aforementioned idea that blockchain is more than the technology behind cryptocurrencies. This was the "innovation called the "smart contract"." Even in the early stages of blockchain there is a company known as Ethereum who has created "a decentralized platform that runs smart contracts: applications that run exactly as programmed without any possibility of downtime, censorship, fraud or third-party interference."

The final of the early innovations was already in itself an upgrade on how blockchain technology functioned in the beginning. Gupta (2017) says "the fourth major innovation, the current cutting edge of blockchain thinking, is called proof of stake." "Proof of stake" is a change from the previously popular "proof of work" system that was the baseline for blockchain technology when it got its start.

3.3 Recent Blockchain Innovations

Blockchain technology is still in a very young stage of its life cycle; however, there are many promising uses already on the market. Currently blockchain technology has its fingerprints

on various applications as the underlying technology that supports and allow them to function. This influence is reaching different industries such as finance and transportation as well as the academic world. In finance, blockchain is still relatively an unknown resource because there is a lack of empirical data making research difficult to conduct. However, blockchain is currently being used in cryptocurrencies and banking.

One of the most well-known uses for blockchain technology is its use as the software behind cryptocurrencies such as Bitcoin, Ethereum, Ripple and USD Coin. Since Bitcoin's inception, the price of a single bitcoin has fluctuated drastically in short periods of time. This pricing instability has seen bitcoin be a highly speculative financial asset used to make or lose money based on trading as opposed to a stable currency that is used to pay for other products or services either physical or virtual. USD Coin is the newest cryptocurrency innovation. This currency was created by cryptocurrency companies Circle and Coinbase. The innovative idea associated with the new currency is that it was created with the intention of staying pegged to the United States Dollar. Taking in to account the fact that one of the largest challenges cryptocurrencies must overcome is their natural instability, USD Coin has a natural advantage by being tied to one of the world's strongest currencies.

In banking, and particularly the financial service of transferring money, large banks such as JPMorgan Chase and Bank of America are already putting effort into adopting blockchain technology (Castillo 2018). This is not only in the United States – as an example Chinese banks, China Construction Bank Corporation and Industrial and Commercial Bank of China, are two of the largest early adapters of blockchain technology. The cryptocurrency company Ripple has created a platform to better facilitate cross-border exchanges of money and specifically cryptocurrencies that can then be exchanged into other physical currencies. According to their company website, major firms such as American Express, Santander and BMO are already part of the Ripple customer list that continues to grow, see appendix 2. As seen with most applications of blockchain, Ripple promotes four major benefits including the access to a standardized network of institutions, the speed to complete transactions in seconds, the transparency of all fees from the beginning and the lower costs because of their lower capital requirements.

4. Blockchain in Corporate Finance

While currently we do not have enough empirical evidence on the uses of blockchain in corporate finance, many of the early innovations have had an effect on the corporate governance. Companies could be affected in three major areas of corporate governance: the way investors trade and track public securities, the amount of transparency into managers compensation, the transparency auditors will have. Along with these impacts on corporate governance, smart contracts also have the potential to disrupt on a larger scale how companies run their operations. Yermack (2016) classifies these impacts into five different categories: greater transparency of ownership, managerial compensation, real-time accounting, accuracy of corporate elections and smart contracts.

4.1 Greater Transparency of Ownership

The greatest benefit of blockchain is the increased transparency that is derived from its use. This transparency comes from the use of blockchain to create distributed ledgers which, when made public, allows anyone who is interested in the information to access the data. The greatest use of the increased transparency in corporate governance is the ability for all stakeholders to view the arrangement of ownership of a company at any given time. This is important because it provides the market with even more information than it already has making

it more efficient as described by the Efficient Market Hypothesis framework. Prices then, in theory, would better reflect the true value of a company. However, this can create problems for different investors. Yermack (2016) counters the increased transparency point by emphasizing that not all shareholders would be in favor of this new layout. Some investors may want to conceal their trades in order to capitalize on market views or just wish to stay anonymous. These would include managers of an organization and activist investors.

4.2 Managerial Compensation

Yermack (2016) argues that blockchain based trading would reduce the effectiveness of share-based incentives for managers. More and more corporate executives are given stock options or restricted shares as part of their competitive compensation packages. Blockchain trading would as previously mentioned increase transparency of manager's trading and in return would increase the scrutiny that managers receive with every trade. This, according to Yermack (2016), may cut into managers' profits from what he calls legal insider trading and cause companies to have to increase base salary compensation to replace the potential loss of trading gains. He also points out that this transparency would highlight managers' personal holdings in many different firms including competitors. This would prohibit managers from hedging their potential losses by offsetting them with competitor stocks.

4.3 Real-Time Accounting

The next feature of blockchain technology that has an impact on corporate governance is real-time accounting (Yermack, 2016). This is the idea of firms posting their transactions on a visible blockchain which would occur automatically if the company uses cryptocurrency in their transactions. He points out that, "Like all blockchain transactions, the firm's routine accounting data could be recorded permanently with a time stamp, preventing it from being altered ex-post. The company's entire ledger would then be visible immediately to any shareholder, customer, lender, trade creditor or other interested party." This would have a tremendous impact on many people inside and out of each firm using this system. Accountants would be put under a more intense scrutiny with each mistaken entry being impossible to change and viewable by auditors and other stakeholders immediately. Earnings management is another process that would be affected by real-time accounting. Yermack (2016) states that, "Real-time accounting on the blockchain would greatly reduce opportunities for firms to engage in accounting gimmicks to manipulate reported earnings. With irreversible, time-stamped transactions, managers could not use strategies such as backdating sales contracts to a prior reporting period or amortizing operating expenses, which should be expensed immediately, and pushing them into future periods." This increased transparency into the accounting functions of a company would mean that shareholders would not have to rely on the morality of accountants and managers to be ensured that information that has been provided is correct.

4.4 Accuracy of Elections

Voting in corporate elections is another aspect of corporate governance that could be influenced by blockchains. Yermack (2016) describes the current process for corporate elections, a proxy system, as "archaic" and as having "surprisingly few concessions to modern technology." The voting system for corporate elections is the perfect example of a process that blockchain technology can have an immediate and drastic impact. Voting could happen almost instantly with much more transparency then currently exists. Yermack (2016) also points out that not many companies use confidential voting which allows a blockchain's inherent transparency to thrive. He also adds that, "Due to its speed and transparency, blockchain voting would help resolve ambiguities about the outcomes of corporate elections and could greatly reduce

management's ability to manipulate outcomes." Along with these benefits, more voters could easily and quickly cast their votes encouraging increased voter turnout for corporate elections. Increased turnout along with more accuracy and a harder to manipulate system is the goal of all elections and would have the effect, as Yermack (2016) concludes, of more frequent elections that have more defeats of management in regard to compensation and governance.

4.5 Smart Contracts

Smart contracts have an effect on both how a business operates and how agency problems can be mitigated. With smart contracts, no human intermediation is needed which would reduce costs and create a much more efficient process for whatever type of business they are being used in. As stated previously actions can be preprogrammed to happen without the need of an intermediary to facilitate the process. Yermack (2016) describes the smart contract like a mechanical coke machine saying, "a smart contract is designed to assure one party that the counterparty will fulfill his promises with certainty." Like the coke machine, a smart contract can verify that the money that one party has is the valid amount and at the same time verify the product is actually in its place. Then the machine automatically facilitates the transaction. This could help drive earnings by reducing costs and allowing businesses to utilize employees in different, more complex roles. When dealing with agency problems, Yermack (2016) argues that smart contracts "could create significant long-term effects by deterring widely known agency costs of debt such as risk shifting and strategic default. This would have beneficial effects such as reduced adverse selection in credit markets and a lower cost of debt market-wide." These benefits would be seen because smart contracts take away the costs of verification, which is mentioned in the next section. Some uses of smart contracts include automatic financial derivatives, pre-contracted default solutions and reducing the opportunity for corruption.

4.5.1 Autonomous Financial Derivatives

Financial derivatives such as futures and options contracts function on an if-then basis meaning that if one action occurs then another should automatically happen. For future contracts this is the passage of time. On a pre-agreed date, money will transfer from one party to the next while either a foreign currency or commodity will be transferred back the other way. As of now, a clearing house stands in between these two parties to ensure both sides have accurate information and to ensure both sides have the ability to fulfil their side of the contract. With a smart contract, this deal could be completed autonomously without the need of a third party clearing house. This would reduce fees and added costs as well as speed up the transaction. For options, if the holder chooses to exercise their option or if the expiration date arrives, then a smart contract could autonomously transfer the stock from one party to the next. At the same time, the smart contract will work to verify instantaneously the validity of the stock and any cash that trades hands in the transaction. Again, this process removes a cost adding middle step that decreases the efficiency.

Autonomous derivatives could also lead to increased risks. Financial derivatives are highly leveraged investments meaning that small changes in market pricing can have an outsized effect on any specific contract. Without a third party managing the counterparty risk inherent to these contracts, bad contracts could be nearly impossible to sell out of and in return hurt the system.

4.5.2 Pre-Contracted Default Solutions

The idea behind pre-contracted default solutions is that when a company faces financial stress and enters bankruptcy, automatic steps can be taken to facilitate the movement of funds from the now bankrupt company to the debt holders and shareholders of the firm. This would help reduce the risk of debt holders slightly because a cost adding step of bringing in lawyers to

facilitate the distribution of funds could be skipped and money could be directly transferred on a trusted and transparent service.

4.5.3 Reduced Opportunity for Corruption

Lastly is that with the increased transparency and autonomous nature of smart contracts, there is an inherent advantage of reducing the risk of corruption. Taking people out of the process of handling contracts and funds automatically reduces the opportunities of corruption in a given transaction. Not only would any changes make to a blockchain be obvious and public, but also making changes to a blockchain once data is entered is nearly impossible. This is because every entry into a blockchain is confirmed by each new entry into that chain. This means that one would have to each entry from end to the point of origin before a new block is added to the chain. Otherwise, this new block would confirm the old data adding another step in the process and collectively making changing a past data point almost impossible.

5. The Costs – Verification and Networking

Using simple economic theory, Catalini and Gans (2018) describe the way in which blockchain technology will shape innovation in digital platforms. They do this by describing the affect blockchain will have on two main costs: 1) the cost of verification; and 2) the cost of networking. The cost of verification relates to the process of assessing the ability of all sides in a transaction to fulfill their part. The cost of networking relates to the ability to operate an online transaction without the need of a tradition intermediary. Catalini and Gans (2018) then go on to describe the results saying that "the resulting digital marketplaces are characterized by increased competition, lower barriers to entry, lower privacy risk, and allow participants to make join investments in shared infrastructure without assigning market power to a platform operator. They also challenge the existing revenue models of incumbents, and open opportunities for new approaches to data ownership and licensing, digital advertising, incentivizing product adoption, auctions and reputation systems."

5.1 Cost of Verification

Markets facilitate buyer's and seller's transactions with each other however, there are many aspects that need verifying before these transactions can occur. While in physical transactions many of these aspects are easily verifiable, this is not the case with virtual transactions. Buyers cannot easily verify the quality of goods and sellers cannot easily verify the authenticity of the funds being used in return (Catalini and Gans 2018). These statements become especially more important as differences between buyers and sellers grow. In the past, third party intermediaries have been the key source of verification in the market for both buyers and sellers; however, this is done as a service transferring risk to the intermediary at a cost. High costs due to these intermediaries can become a barrier to trade and in return slow down overall trade in a given market.

Catalini and Gans (2018) then go on to describe how blockchain has created "costless verification." Verification costs so low that they are not relevant considering the value of the transaction as a whole. This costless verification allows the process to be completed much more efficiently and at a much lower price. The effects of this is already being seen in the market today. The authors point out that this new approach to verification has already seen the service begin to crumble as it was known in the past saying that "The effects of this change have been mostly felt on the intensive margin of production and for digital assets, as established players have moved existing types of transactions onto blockchain-based systems to lower operation costs" (Catalini and Gans 2018).

5.2 Cost of Networking

The benefit of blockchain on networking is described by Catalini and Gans (2018) as the ability of "a network of economic agents to agree, at regular intervals, on the true state of shared data." The authors then go on to describe the reduction of networking cost as a function of its effect on market power and censorship risk.

New digital markets allow the market power to align with the owners of the virtual currency instead of intermediaries because now consumers do not have to rent the resources on the internet from a third party. In the past consumers had to rely on these intermediaries to facilitate transactions. Now with an open market that facilitates trust, because of the lack of verification costs, consumers can connect directly without costly intermediaries such as clearing houses. To add to this new market power, intermediaries do not have the power to censor access to public ledgers because there is no gatekeeper by design. Catalini and Gans (2018) explain that, "Promising solutions to these problems are being deployed by startups such as Filecoin, which is attempting to turn data storage and transfer into a commodity, and through blockchain-based distributed computing platforms such as Ethereum."

6. Challenges Facing Blockchain

At the current point of blockchain's lifecycle, there is not enough information and research to be sure that blockchain is not a fad that will pass as newer technology arises in the near future. Blockchain has many challenges and significant barriers to entry that it must clear before becoming the revolutionary technological change that it has the potential to be. The toughest problems blockchain has to overcome include finding the best way to create scalability, balancing the savings versus the new costs that will arise and overcoming the costs that retraining people and replacing existing technology creates.

In order to scale a specific use of blockchain, computing power and energy is needed to continue to build the chain in an efficient manner. This can be seen, as pointed out by CNBC and Morgan Stanly "The original blockchain, which underlies bitcoin, runs on an algorithm that could eat up more energy than Argentina this year" (Zhao 2018). These increased energy costs could directly offset the savings created by decentralization. Until more empirical data as available, companies expanding blockchains will have to balance the savings gained and the increased energy costs.

Further costs could arise as well. These include the need to pay for more storage space and possible the need to use expensive legacy systems and infrastructure. "Today, investment banks spend an estimated two-thirds of their IT budgets on legacy back-office infrastructure" (Bloomberg 2018). Bloomberg argues that instead of reducing the costs of legacy infrastructure, blockchain will actually increase them. As blockchains grow there is a need for more and more storage which will have to be created by outside firms so that financial institutions have access to their ever expanding blockchains. Bloomberg describes these institutions as those that primarily run on mainframes which have both a service cost and a physical storage cost. Both of these will be passed on to the institutions as their blockchains grow.

One of the greatest challenges that blockchain faces is the balancing the value gained from decentralization versus the value lost from expertise that is cut out of the system. As described early, blockchain allows transactions to occur without intermediaries. While this can add efficiency and lower costs, it also has the potential of losing a significant amount of value from the expertise and specialization offered by these intermediaries. Without research it is impossible to say whether one cost out ways the other; however, it is important to note that industries which contain these experts will be a large barrier to entry for blockchain applications. Banking for example is full intermediaries which add value to transactions. Whether that is

reducing risks or adding expertise to help facilitate transactions, this value lost could be significantly more than the value gained from simply having a more efficient transaction.

Even if blockchain technology finds its role and begins to grow in its use, the people and their inability to quickly adjust will serve as a barrier that slows its growth. Training programs would have to be implemented for those who are already in the workforce and those who are in school will have to learn an updated curriculum. Another issue that arises due to the people aspect of blockchain technology is the fact that data must be entered with a higher precision then with other ledger technology. As previously mentioned, with blockchain, data is more secure and harder to manipulate, but at the same time human error that arises in data entry are much more difficult to remedy.

7. Conclusion

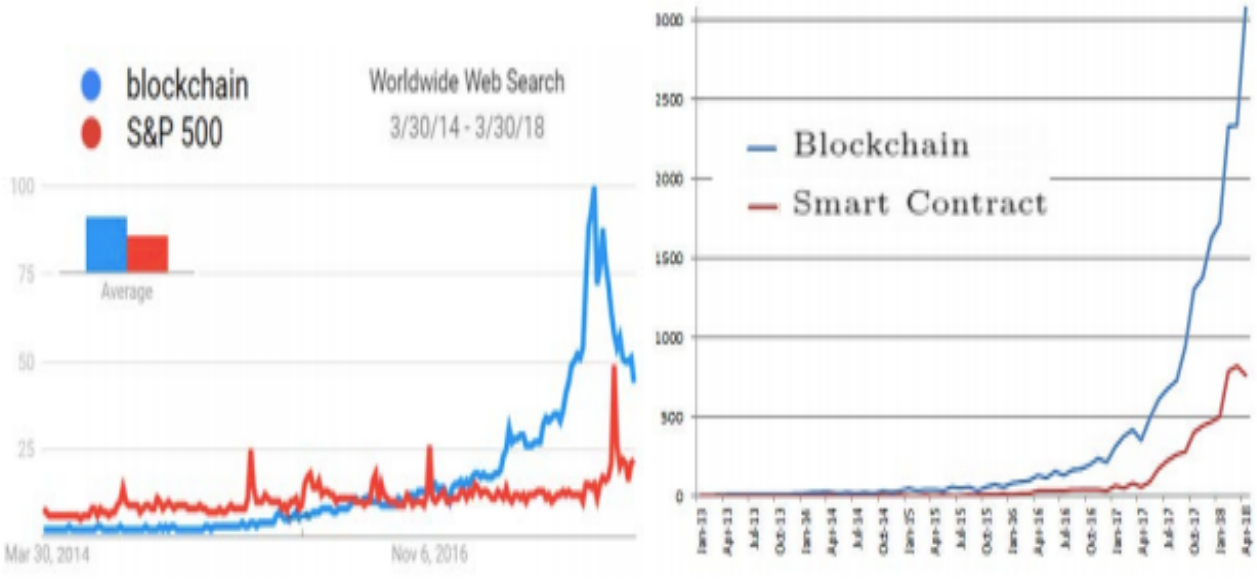
Blockchain technology has the potential to be one of the most innovative and disruptive technologies the finance industry has seen since the internet. Blockchain's design allows for five prevalent features to be seen in every aspect of the technology. The most important of these are decentralization and transparency. The two largest costs that blockchain reduces are the cost of verification and the cost of networking. Both of which are major contributors to increased fees and slower transaction times. When these two costs are reduced, trade becomes much less expensive and a much more trusted process that is available on a peer-to-peer level.

There are however many costs that come with decentralizing the transaction process which include the loss of added value from specialization, the increased energy costs, the increased storage costs and the costs of retraining the workforce. These factors could be serious deterrents to the use of blockchain and prevent blockchain from being scaled into uses at the enterprise level.

While there are many challenges that blockchain still faces before it can become this revolutionary technology, there are many promising applications of the technology already being used. While smart contracts are the most promising and widely used innovation stemming from blockchain technology, cryptocurrencies have already taken their spot in mainstream finance. Blockchain's start as the technology behind Bitcoin helped propel the new technology; however, much of blockchain's perceived value is still in its yet-to-be developed-applications. These include applications that will allow corporations to better govern themselves. The biggest hurdle in the path of blockchain is scalability. While in smaller projects blockchain seems to be the future, learning how to scale the technology is essential for its sustained use and further innovation. Even though blockchain still has a long way to go before becoming the biggest technical innovation since the internet, many large institutions and firms are already devoting large amounts of time and effort into the research of blockchain.

Appendix 1

The right graph shows worldwide web searches are being compared relatively between blockchain and the S&P500 showing how blockchain has grabbed the attention of the business world. The left graph shows the amount of blockchain and smart contract projects hosted on Github (Cong and He (2018).



Appendix 2

This list shows a portion of the customer list provided by Ripple on their website.

Bibliography

Ali, J. I. (2017, March 09). The Blockchain Will Do to the Financial System What the Internet Did to Media. Retrieved November 5, 2018, from https://hbr.org/2017/03/the-blockchain-will-do-to-banks-and-law-firms-what-the-internet-did-to-media

Berke, A. (2017, March 07). How Safe Are Blockchains? It Depends. Retrieved November 15, 2018, from https://hbr.org/2017/03/how-safe-are-blockchains-it-depends

Bitcoin (BTC) price, charts, market cap, and other metrics | CoinMarketCap. Retrieved November 5, 2018, from https://coinmarketcap.com/currencies/bitcoin/

Bitcoin Cryptoeconomic Index by CoinDesk. (n.d.). Retrieved November 15, 2018, from https://www.coindesk.com/price/bitcoin

Bloomberg, J. (2018, February 24). Don't Let Blockchain Cost Savings Hype Fool You. Retrieved December 13, 2018, from https://www.forbes.com/sites/jasonbloomberg/2018/02/24/dont-let-blockchain-cost-savings-hype-fool-you/#30fb8a8b5811

Castillo, M. D. (2018, July 03). Big Blockchain: The 50 Largest Public Companies Exploring Blockchain. Retrieved November 5, 2018, from https://www.forbes.com/sites/michaeldelcastillo/2018/07/03/big-blockchain-the-50-largest-public-companies-exploring-blockchain/#3d72c432b5b2

Catalini, C., & Gans, J. S. (2016). *Some Simple Economics of the Blockchain*. *SSRN*.

Comm, J. (2018, May 16). How Smart Contracts Could Change The Way You Do Business. Retrieved November 5, 2018, from https://www.forbes.com/sites/forbescoachescouncil/2018/05/16/how-smart-contracts-could-change-the-way-you-do-business/#45dc5321288f

Cong, L. W., & He, Z. (2018). Blockchain Disruption and Smart Contracts. doi:10.3386/w24399

Ethereum Project. (n.d.). Retrieved November 5, 2018, from https://www.ethereum.org/

Gupta, V. (2017, April 05). A Brief History of Blockchain. Retrieved October, 2018, from https://hbr.org/2017/02/a-brief-history-of-blockchain

Haber, Stuart, and W. Scott Stornetta, 1991, "How to Time Stamp a Digital Document" in Advances in Cryptology - CRYPT0' 90, Lecture Notes in Computer Science 537, 437–455.

Iansiti, M., & Lakhani, K. (2018, March 06). The Truth About Blockchain. Retrieved November 14, 2018, from https://hbr.org/2017/01/the-truth-about-blockchain

Solutions To Send Money Globally, Using Blockchain Technology. (n.d.). Retrieved November 5, 2018, from https://ripple.com/ripplenet/

Speer, D. (n.d.). Walton College Establishes Blockchain Center of Excellence. Retrieved November 5, 2018, from https://news.uark.edu/articles/42357/walton-college-establishes-blockchain-center-of-excellence

Tapscott, A. T. (2017, March 01). How Blockchain Is Changing Finance. Retrieved November 5, 2018, from https://hbr.org/2017/03/how-blockchain-is-changing-finance

Yermack, D. (2016). Corporate Governance and Blockchains. doi:10.3386/w21802

Zhao, H. (2018, February 27). Bitcoin and blockchain consume an exorbitant amount of energy. These engineers are trying to change that. Retrieved November 14, 2018, from https://www.cnbc.com/2018/02/23/bitcoin-blockchain-consumes-a-lot-of-energy-engineers-changing-that.html