Norwegian School of Economics

Bergen, Spring 2017

Blockchain and The Future of Money and Finance

A qualitative exploratory study of blockchain technology and implications for the monetary and financial system

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Master thesis in Finance

NORWEGIAN SCHOOL OF ECONOMICS

Abstract

Bitcoins original idea proposed a trustless monetary system, without the need of intermediaries. In recent years, these very intermediaries it originally tried to circumvent, have gained an increased interest in Bitcoin's underlying technology, the Blockchain. It presents a decentralized database technology, suitable for exchanging value in an untrusted environment. Consequently, it introduces an innovation in both economics and information technology.

In this explorative study, we aim to investigate how Bitcoin and Blockchain technology may impact the monetary and financial system. By conducting 20 in-depth interviews from a broad range of stakeholders and a literature review in this new topic of interest, we have identified two main themes introduced with this new technology. First, we seek to understand how the future of money could unfold with Cryptocurrencies and Central Bank issued Digital Currency (CBDC). The former is recognized to have a series of specialized architectures, spanning from simple monetary transactions to complex platforms enabling a decentralized economy to evolve. CBDC is not necessarily reliant on blockchain technology, but the of digitally issued currencies and blockchains introduces new fiscal and monetary policy toolkits. There are however a series of intricate questions that needs to be addressed before CBDC could act as a complement or replacement for physical currency. Lastly, we explore how the future of finance will be affected by blockchain technology and the cryptoeconomy. Banks may be facing increased competition from new entrants, where blockchain technology may facilitate reduced costs in terms of regulatory compliance, efficiency in transactions and settlement, and reconciliation. Moreover, new financial services are introduced by financial technology innovation. This might change the business model of banks and other financial institutions drastically. Furthermore, cryptocurrencies introduce new funding possibilities and enables organizations to evolve with no governing body. This might facilitate a new economic system, called the cryptoeconomy.

Development in blockchain technology is mentioned to be at the same maturity stage as the Internet by the early 1990s. There are several uncertainties regarding its future applications. However, smart contracts seems to be an interesting application, facilitating automation in a range of applications.

Acknowledgements

This thesis concludes our studies at the Norwegian School of Economics (NHH). The writing process has been interesting, challenging and comprehensive. We set out to understand a complex technology and how it could affect the monetary and financial system.

We would like to thank all our interviewees. Their insights and knowledge combined with interesting and educational conversations made this thesis possible. We truly appreciate that all of them offered us their valuable time.

Finally, we would like to thank our supervisor Tommy Stamland for valuable feedback and encouraging us in the research process.

Bergen, June 2017

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1. Introduction: Origins of Bitcoin

It is suggested that one of the many causes of the financial crisis was the opaqueness in banking and spurs of innovation in financial assets (financialization) creating an interconnected system. Moreover, incidents of questionable behavior by banks and insurance companies were under scrutiny amidst the turmoil (Calabria, 2011; Shull, 2010). In order to restore financial stability, several financial institutions and corporations were bailed out by governments ("TARP Programs," 2016). Bitcoin was introduced in the aftermath of the crisis in a white paper titled "Bitcoin: A Peer-to-Peer Electronic cash system" by the pseudonym Satoshi Nakamoto (Nakamoto, 2008). The introduction of Bitcoin was motivated to circumvent these very financial institutions.

The idea of Bitcoin starts with David Chaum and the "Cypherpunks" movement in early 1980s (S. Levy, 1993). “Cypherpunks” emerged as a response to increased government surveillance on the Internet (Radford, 2014). A group of people involved in cryptography and computer science were able to develop anonymous communication systems on the Internet through private mailing lists (Hughes, 1993). Consequently, Chaum (1981) introduced an anonymous application to send and receive electronic mail. It did not take long before a similar idea manifested in electronic money. The first digital currency was introduced with eCash in 1983 (Chaum, 1983).

Cryptography is the very foundation of digital currencies. It allows for an asymmetric encryption of information where networks can verify content of a transmitted message without being able to alter or read any sensitive information itself.

A pressing issue of early proposals in digital currencies was how to solve the problem of “Double-Spending”, how to prove a given digital currency has not been spent twice. The problem of Double-Spending in traditional currencies have been resolved with security measures such as security threads and ribbons. Moreover, financial institutions keep track of funds available to individuals by recording transactions on accounting ledgers. These security measures are harder to implement in a digital currency.

Combining ideas and techniques used in earlier attempts to create a digital currency, Bitcoin solved previous hurdles in an elegant manner. Consequently, this introduced a new way to facilitate the exchange of value on the internet without the need of trust in intermediaries to

conduct transactions. This was all based on an underlying technological infrastructure called "the Blockchain".

Bitcoin and blockchain technology have created something of an ideological, political, technical and economic debate following the idea of financial disintermediation. Following the introduction of Bitcoin and its open-source white paper, there has been a significant development of competing (complementary) cryptocurrencies and new applications for blockchain technology.

Figure 1: Bitcoin[1]

Figure 2: Blockchain[2]

Bitcoin and blockchain technology has been hailed as the solution for every problem in the financial system, simultaneously as being called "evil" with controversies such as the "Silk Road" scandal and other criminal activities (Hern, 2016; Krugman, 2013; Santori, 2017; Wagstaff, 2014). In this thesis, we seek to illuminate how cryptocurrencies and blockchain technology works. Moreover, we conduct a literature review and empirical research by interviews with experts and other stakeholders in banking and finance to explore potential applications and related hurdles in the event of adoption.

We hereby seek to examine the question:

"What implications does the blockchain technology bring for the traditional monetary and financial system?"

[1] Figure from Google Trends, retrieved 17.06.17, search term "Bitcoin"

[2] Figure from Google Trends, retrieved 17.06.17, search term "Blockchain"

2. Technical Introduction to Blockchain Technology

In this chapter, we seek to explain technical and conceptual principles of blockchain technology. By demonstrating the foundations of Bitcoin, the relationship between Bitcoin and blockchains become evident. Lastly, we present key topics demanding further elaboration to illuminate how blockchain technology ensures security and why it may not be a standard-fits-all solution to every database problem. This overview is inspired by the technical presentations of Flament (2017), Driscoll (2013) and Antonopoulos (2015). In the following, we present a simplified example of how Bitcoins works.

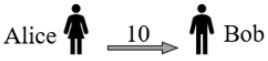
Bitcoin is simply a distributed database which lists accounts and money like a ledger, where everyone connected to the Bitcoin network shares the same ledger (Driscoll, 2013).

Name	Amount
Alice	50
Bob	100
Charlie	200

Figure 3: Ledger

Assume Alice wants to send Bob 10 bitcoins. First, Alice broadcasts a message to the Bitcoin network that she wants to send 10 bitcoins to Bob. Effectively, this reduces her balance of 10 bitcoins and increases Bob's balance of 10 bitcoins. Second, the message is broadcasted to the network and needs to be verified in order to be accepted. If the transaction is accepted, the ledger is updated and sent to everyone in the network.

Name	Amount
Alice	50
Bob	100
Charlie	200



Name	Amount
Alice	**40**
Bob	**110**
Charlie	200

Figure 4: Transaction process

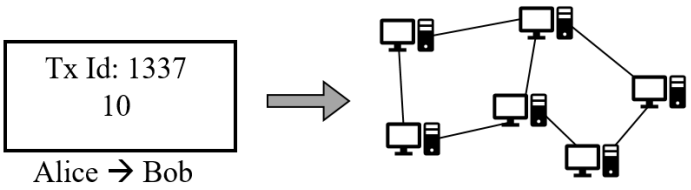


Figure 5: Transaction Broadcasting

To illustrate the verification process, assume further that after receiving 10 bitcoins from Alice, Bob wants to send 20 bitcoins to Charlie. A message (transaction) consists of the stated amount of bitcoins, referring to previously received bitcoins and outputs referring to the address he wants to send bitcoins. The difference between input and output amount can be seen as a transaction fee. Moreover, previously received bitcoins (i.e. the inputs) needs to be spent in its full amount, thus Bob sends "change" back to himself if the sum of inputs exceeds output. When Bob broadcasts the message, the network checks if Bob is the actual owner of these bitcoins. This is done by checking the transaction chain, examining the entire history of referred bitcoins in inputs to prove that Bob is the legitimate owner of these bitcoins, and these have not been spent.

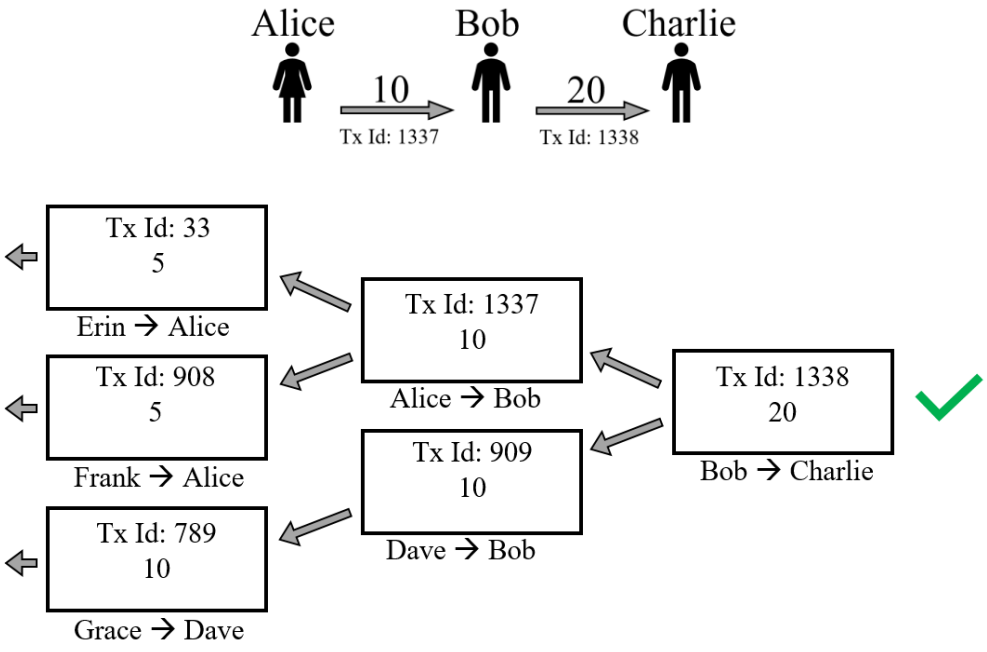


Figure 6: Transaction Chain (Driscoll, 2013)

The transaction is subsequently grouped into a block with other recently verified transactions. A set of special nodes called "miners" creates these blocks. Miners compete to add the next block of transactions by solving a mathematical puzzle. When a new block is created, every node receives the updated ledger, reflecting changes in the user's balances. Moreover, blocks

are linked to the previously created block in order to timestamp transactions, ultimately creating a chain of blocks. Hence, the fitting name “blockchain”.

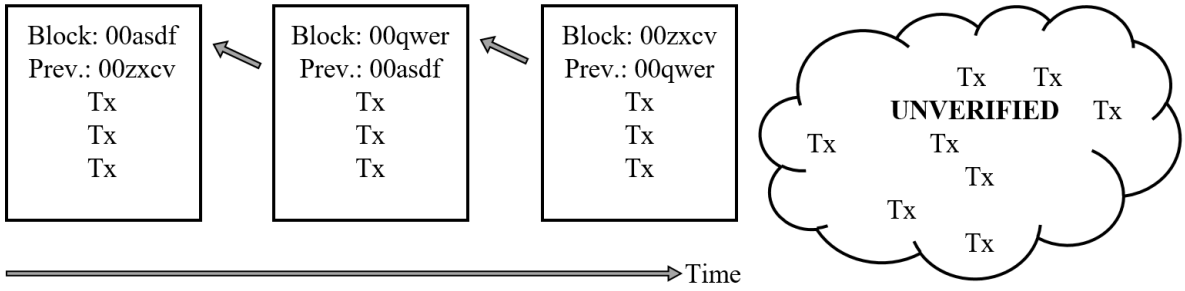


Figure 7: Block Architecture (Driscoll, 2013)

Before unverified transactions are added to the block, these are pooled in the memory of miner node. In the process of solving the mathematical puzzle, two miners may happen to solve it simultaneously, creating two blocks. Consequently, this creates two branches in the blockchain. However, this is fixed by the subsequent block which is added to one of these. The protocol ensures that every node agrees to continue with the longest chain of blocks.[3] However, the probability of two blocks being created simultaneously are extremely low. Further, the probability of this happening twice in a row diminishes exponentially. Should a transaction happen to be in a block of the rejected chain, the transaction will be sent back to the pool of unverified transactions.

Please note that a number of simplified explanations have been made above. In the following, we shed light on some key technical aspects of the blockchain and how it introduces a new technological innovation.

2.1 The Blockchain Ledger

First, the Bitcoin blockchain does not technically list the account balance for each single user in the network. The ledger contains a list of every transactions done in the history of the blockchain. Bitcoins are linked to a public key address as an Unspent Transaction Output (UTXO) with a complete transaction history (Antonopoulos, 2015). Every node receives the updated list of all transactions made in the network as new blocks are created. Account

[3] Protocol refers to the underlying open-source code found in the software of a cryptocurrency.

balances are thus a matter of summing up received amounts of all transactions sent to a user's public addresses.

Second, a decentralized public ledger, without needing an intermediary to record transactions and update account balances is a distinguishing feature of blockchain technology. It differs from VISA and other value transfer systems with the decentralization of the network structure (Pilkington, 2016). Moreover, agents are able conduct transactions with strangers simply by trusting the cryptography and mathematics, rather than middlemen ("The Trust Machine," 2015).

2.2 Cryptography and Security

Public key cryptography is a mathematically asymmetric encryption method (Ellis, 1970). Simply put, when Alice wants to send Bob some bitcoins, the network needs to verify that Alice is the owner of said bitcoins. A "private key" can be explained as the secret password to access the bitcoins she has received, meanwhile a corresponding public key can be denoted as her e-mail address. By appending private keys to the message (transaction), she creates a unique digital signature (fingerprint). Any changes in the message will create a different unique digital signature. By submitting the transaction to the network, the digital signature is used to verify the content of the message (i.e. the amount and public address of the receiver), the public address from which she sends bitcoins and the proof of ownership of private keys. This allows for the network to verify that a message has been sent by Alice and she is in fact the owner of the bitcoins.

Hashing is another essential cryptographic component involved in Bitcoin and blockchain technology. When miners are competing to add the next block of transactions, the result of finding the right answer of the computational puzzle creates a unique fingerprint of a block. This is called a "hash" and is used to identify a specific block. A block contains data with the added transactions from the unverified pool, the hash-ID of the previously created block, and the computational puzzle answer, called the "nonce". Every block refers to the hash of the previously created block, in which any attempt to change data of a previously mined block will break the chain.

Moreover, most blockchains and cryptocurrencies are published with open-source code. In the emergence of information technology and the Internet, a significant number of projects have

been licensed as open source.[4] This enables users to collaborate and peer-review the software. Advantages related to open-source licensing includes lowering costs of software development by enabling incentivized agents to contribute and peer-review the source code, ensuring greater security and robustness (OSI, n.d.). Further, open-source projects facilitate innovation by allowing contributors to collaborate and create new applications. However, there are drawbacks by releasing software as open-source. Even if software is released as open source, its security and robustness should not be taken for granted (Hansen, Köhntopp, & Pfitzmann, 2002). There might be severe security breaches in the source code in the event of lacking peer-review. Consequently, a project needs to facilitate modularity and governance measures in order to ensure user participation and secure the quality of peer-review (Benkler, 2006; Hansen et al., 2002)

Finally, Bitcoin provides users with a degree of anonymity. Transactions are pseudonymous as every transaction contains a transparent public key address. However, the public key address does not reveal any personal information regarding real-word identities (Böhme, Christin, Edelman, & Moore, 2015; Pilkington, 2016). Hence, transactions can be done without disclosing any personal information (Pilkington, 2016). However, there are techniques used to analyze and reveal identities linked to public addresses (Biryukov & Pustogarov, 2015). To counteract this, there are methods of anonymizing identities such as "mixing", which mixes inputs and creates new public addresses for each transaction.[5] This makes it extremely hard to identify the public address of involved parties. Moreover, a user can use the TOR network to increase anonymity (Biryukov & Pustogarov, 2015).[6]

2.3 Mining, Consensus and Cryptoeconomics

"Mining" involves verifying and adding new blocks of transactions to the blockchain. By utilizing a full version of the software (protocol client), miners pick a set of transactions from the pool of unverified transactions and add these into a block. New blocks are added by solving

[4] Examples of open-source initiatives include Apache (https://www.apache.org), SETI@Home program (http://setiathome.berkeley.edu), Linux (https://www.linuxfoundation.org)

[5] For more information regarding mixing services, we refer to https://en.bitcoin.it/wiki/Mixing_service.

[6] TOR is a network enabling anonymous communication

a mathematical puzzle requiring significant amounts of computational power and electricity. The difficulty of solving the puzzle is adjusted by the Bitcoin protocol to ensure new blocks are created every 10 minutes (Antonopoulos, 2015). The probability of a given node winning the next block is approximately the relative offered computational power to total outstanding computational power in the network.

A problem of decentralized networks is achieving consensus as nodes may receive information at different times due to geographical distances and latency. Moreover, the network may have malicious nodes sending illicit messages to other nodes. This is referred to as the "Byzantines General Problem" (Lamport, Shostak, & Pease, 1982). Consensus mechanisms facilitate an agreement in the network over the content of the database, modifications and computations done with the data, and the rules which govern storage and computation structures (Valkenburg, 2016).

An example of network disagreement happens in the event of "forking" as we have previously described. As nodes receive information at different times, several chains may exist temporarily. However, when a new block is created, the protocol ensures that every node agrees on following the longest chain. Consequently, other branches of the chains are no longer seen as valid by the network.

Another important aspect of blockchain technology is how incentives are aligned. In order for a decentralized P2P network to achieve consensus of a distributed database in a secure manner, economic incentives for agents need to be implemented. "Cryptoeconomics" ensures a secure P2P system by using cryptographic techniques ensuring validity of transactions, while aligning economic incentives of actors with rewards of new cryptocurrencies and transaction fees in maintaining the blockchain. Moreover, consensus mechanism needs to penalize unwanted behavior by malicious actors (Buterin, 2017a). This ensures a secure, decentralized P2P system which has been hailed as the "true" innovation of blockchain technology. By combining cryptographic techniques and network technology, this ultimately solved the "Double-Spending Problem".

In “Proof-of-Work” (PoW), miners are incentivized by transactions fees and block rewards. Externalities involved ensures making it extremely costly to attack the network.[7] Note that the “Proof-of-Work” found in Bitcoin incentivize miners to pool resources in “mining pools” to ensure a steady income for single miners (Ali, Barrdear, Clews, & Southgate, 2014). Further, there are incentives to overinvest in specialized mining hardware in response to economies of scale (Ali et al., 2014).

“Proof-of-Stake” (PoS) has been suggested as an alternative consensus model. PoS does not favor specialized computer hardware, nor does it require an excessive electricity consumption in mining. Rather, miners place an amount of cryptocurrencies, i.e. a bond, in a staking pool. The protocol subsequently chooses which node is granted the privilege to “forge” the next block, based on probabilities relative to coins at stake. The protocol aligns incentives by ensuring nodes earns money in betting in favor of a consensus block, and lose money if it bets against the consensus. Moreover, bonds are forfeited in the event of a malicious attack.

2.4 Blockchains Structures and Designs

Blockchains can be classified according to two criteria (Tasca, Aste, Pelizzon, & Perony, 2016). The first criterion regards verification:

- **Permissionless**: The network is unrestricted and everyone motivated to take part in the verification process as nodes can do so. Those providing computational power in maintaining the network are usually rewarded.
- **Permissioned**: The nodes acting as verifiers are chosen by one or several central authorities.

The second criteria regard access.

- **Public**: There are no restrictions on reading blockchain data and submitting transactions.
- **Private**: Direct access to blockchain data and submitting transactions is limited to a predefined list of participants.

[7] Externalities involves electricity consumption and hardware investments

Blockchains can be measured along a continuum of these categories, depending on the consensus model, governance mechanisms and other design properties.

Permissionless

The Bitcoin blockchain is a prime example of a permissionless systems. Permissionless systems allow anyone to download the client software to run the specific blockchain protocol and contribute to maintaining and appending new blocks of transaction data (Tasca et al., 2016). Such open architectures are useful when there is a motivation to exchange value in untrusted environments (Tasca et al., 2016).

Permissioned

Permissioned systems allow only specified nodes to observe transaction data and/or act as miners. Fully permissioned systems are often applied within an organization, while consortium blockchains could be operated by a set of permissioned miner nodes. Permissioned blockchains offer possibilities of connectivity between existing software solutions and facilitating security designs consistent with regulatory boundaries to solve current database tasks (Tasca et al., 2016).

However, there are trade-offs related to security in the network. Permissionless systems based on robust consensus models offers greater cybersecurity against malicious network attacks. The computing power required to maintain a permissioned blockchain is significantly less, as the need for consensus mechanisms as PoW is not required to maintain the ledger. Consequently, security decreases by the reduced number of miner nodes in a permissioned blockchain. However, permissioned blockchains are useful as it offers a higher degree of scalability in transaction volumes.

2.5 Smart Contracts

The idea of a self-executing contract was presented by Nick Szabo in 1997, in the article "The Idea of Smart Contracts" (Szabo, 1997). He exemplifies the idea of a vending machine to figuratively present a primitive smart contract. Everyone who has the money to pay for a product can buy it for the given price. Both the product and the money is secured from intruders by the machines features.

A second generation blockchain provides a foundation for applications. Writing a smart contract is possible by writing code in a Turing-complete programming language called Solidity ("Solidity," 2017). By the same features as described in the Bitcoin blockchain, these scripts are distributed and appended in the blockchain. All nodes in the network run virtual machine protocols to execute and handle these scripts. Compared to running such scripts on a private computer, the execution of smart contracts is much more resource intensive, as it is distributed to all participants of the network. Therefore, not all applications make sense in a blockchain environment, as higher complexity requires higher computing power. Ethereum charges a fee in the embedded cryptocurrency to execute computations, which is costlier the more complex the scripts are.

Smart contracts are agreements between two or more parties. It is self-enforcing and autonomous, responding to changes in the state of the blockchain (Tasca et al., 2016). Compared to a bitcoin transaction, a range of additional logic could be implemented, such as threshold requirements for contract fulfillment. One of the ideas behind smart contracts is to remove the need for a trusted third party to function as an intermediary, ensuring that the contract is executed (Tasca et al., 2016).

2.6 Differences between traditional databases and blockchains

Blockchains are essentially a distributed database (Tasca et al., 2016). So, what does a permissioned blockchain bring to the table when it reduces immutability and security advantages of a permissionless blockchain?

Permissioned blockchains are a type of centralized databases. Comparing a *distributed* database to a permissionless blockchain, as they are the most similar, traditional databases have several advantages (Tasca et al., 2016). Improved performance and throughput, and a potential higher degree of scalability is the main advantages of a centralized database.

According to Brennan & Lunn (2016), there are four checkpoints for a permissionless blockchain to be relevant. A given objective needs to:

1. Require a database
2. Have shared write access
3. Have unknown writers whose interest is not unified
4. Not trust a third party to maintain the integrity of the data

Ultimately, the key features a permissionless offer is the disintermediation of trust, immutability and potential applications with smart contracts. Trust is essentially is shifted to the entity granting permissions, permissioned blockchains offers immutability and smart contracts.

3. Methodology

3.1 Resarch-philosophy and approach

The overall goal of this masters' thesis is to gain a deeper understanding of the blockchain technology. We are aiming to develop new knowledge which can be used as an introductory overview. By applying an inductive approach, we aim to develop new theory by analyzing collected data (Saunders, Lewis, & Thornhill, 2016).

3.2 Research design

Due to the nature of our research question, we choose to apply an exploratory design. According to Saunders et al. (2016), an exploratory study is fruitful when you want to discover what is happening, gain insight about a topic and understand a phenomenon. Following these arguments, we find our research question particularly fitting.

3.2.1 Research strategy

Keeping in mind the chosen design, a case study strategy suits the overall objective of our thesis. Furthermore, we start of by having an initial set of questions that we seek to investigate, by collecting and analyzing relevant data (Yin, 2014). Researching blockchain technology in light of the financial industry, we find the most suiting strategy to be looking at this as one case with several units of analysis. According to Yin (2014), a case study is challenging and it is important to have a systematic approach while keeping the scope within our research question.

3.2.2 Methodological choice

We choose to apply qualitative method, by collecting data in non-numerical form. The primary sources of data will be obtained by conducting interviews. Secondary sources of data is obtained by an extensive literature review of articles, books, and web resources.

3.2.3 Time horizon

Our case study collects data over a short period of time. We are examining the phenomenon at a specific point in time, hence our study is cross-sectional in nature (Saunders et al., 2016).

Even though the technology is rapidly evolving, the time constraints of our masters' thesis makes this the most appropriate choice of time horizon.

3.3 Data collection

3.3.1 Interviews

Due to the nature of the subject we are studying and our motivation, interviews is particularly well suited to gain insights, nuances and untangle complexity, compared to structural forms (Johannessen, Christoffersen, & Tufte, 2011). Thus, we will be collecting primary data. However, interviews require several features from the interviewer. According to Yin (2014), the researcher needs to have an inquiring mind during the data collection and an ability to ask good questions.

3.3.2 Sampling

According to Saunders et al. (2016), the minimum sample size when conducting interviews should be between 5-25. A strategy in sampling is to stop when you experience data saturation, thus meaning that no new information or new themes are gathered from the data (Johannessen et al., 2011; Saunders et al., 2016). Our sampling process begins with simple web searches; uncovering relevant stakeholders and persons of interests. We will use non-probability purposive sampling, forming our basis for who we would want to talk to. As suggested by Johannessen et al. (2011), we begin by sending an invitation explaining our overall goal and research topics. We aim to get a heterogenous sampling, contacting people who are involved in different areas of the financial industry. According to Saunders et al. (2016), this strategy enables us to describe and explain key themes that emerge in the collection of data. A broad spectrum of people will be interviewed, from computer scientists to lawyers. Below is a table of our interviewees, in chronological order.

Table 1: Interviewees

#	Title	Industry/Sector	Place	Length	Language
1	Advisor	Business Consultancy	Face to face, Starbucks	45 min	Norwegian
2	Executive	Financial infrastructure	Videocall, Skype	30 min	Norwegian
3	Executive	Financial services	Videocall, appear.in + Telephone	35 min	Norwegian
4	Consultant	Financial services	Videocall, Skype	70 min	English
5	Professor	Academia	Videocall, Skype	15 min	English
6	Associate Professor	Academia	Videocall, Skype	80 min	English
7	Consultant	Financial services	Videocall, Skype	70 min	Norwegian
8	Founder	Financial Services	Videocall, Skype	50 min	Norwegian
9	Lawyer	Business law	Call, Skype	45 min	Norwegian
10	Founder	Financial technology	Videocall, appear.in	30 min	Norwegian
11	Executive	Financial technology	Videocall, Skype	50 min	English
12	Business Developer	Technology	Videocall, Skype	60 min	Norwegian
13	Consultant	Financial infrastructure	Videocall, appear.in	70 min	Norwegian
14	Director and consultant	Regulation authority	Group, Telephone	60 min	Norwegian
15	Founder	Financial technology	Videocall, Skype	60 min	English
16	Associate Professor	Academia	Call, Skype	25 min	English
17	Executive	Banking	Call, Skype	25 min	English
18	Partner	Business Consultancy	Face to face and Call, Skype, Office	75 min	Norwegian
19	Executive	Banking	Face to face, Office	80 min	Norwegian
20	Executive	Securities	Call, Skype	50 min	Norwegian

3.3.3 Interview preparation and execution

Based on a literature search, we create a semi-structured interview guide with the main topics important for further research. However, the interviews will be in the form of an in-depth interview. Thus. we will be using the guide to keep us within our scope, giving us the ability to probe and discover new topics of interest. The interviews are estimated to last 1 hour. A

majority of the interviews will be conducted using electronic communication tools. Preferably, we will aim to conduct the interviews using videocall applications. For those who are not able to participate by videocalls, interviews will be done by telephone. Interviews conducted face-to-face will be held in Bergen and the interviewees will choose when and where. For all accepting to participate in our research, we explicitly ask of consent to record the conversations, informing them that it is both anonymized and deleted at the end of the project.

3.4 Data preparation

After our data collection, our recordings will be transcribed as quickly as possible. In instances where we experience low quality recordings, the sentences we are not able to decipher will be excluded from our analysis. By keeping full sentences and reasoning, we are able to form new knowledge.

3.4.1 Data analysis

The data analysis will be conducted using Computer Aided Qualitative Data Analysis Software (CAQDAS), to handle large amounts of collected data. We will utilize NVivo 11 to perform template analysis, which involves assigning codes to interesting fragments of text (Saunders et al., 2016). First, we will upload the transcribed interviews into the program and begin sorting out data. Then, we will look for patterns emerging, using a hierarchy of codes to describe topics of interest; assigning quotes, phrases, and reasoning. These patterns will form the basis for our analysis.

3.5 Research quality

To judge our research quality, we will here discuss reliability and validity. When assessing the reliability of a study, one usually asks the question of whether a researcher following the procedures described and conducts the same study, will arrive at the same results (Yin, 2014). If such a research project arrives at the same conclusions, both errors and biases are minimized. However, our findings in this case study will only reflect the reality of the time it was conducted. It may be that someone conducting the same study in a year, will arrive at completely different conclusions.

When assessing validity, we will here discuss internal and external validity. Internal validity is the concern whether causal conclusions are correct. Carrying out interviews could be affected by both participant- and researcher error and bias. To reduce this, the interviews will be well-planned and we will minimize researcher influence. Additionally, to gain a deeper insight of how stakeholders think about the technology, we choose to keep our interviewees anonymous. This was motivated by an ex-ante assumption, in that we would achieve a larger sample and to gain a deeper insight. However, making inferences in the collected data is a challenging process. Consequently, we follow analytical tactics, such as pattern- and explanation matching and addressing rival explanations (Yin, 2014). External validity is the issue whether the findings of the study are generalizable beyond the immediate study (Yin, 2014). This is not addressable in our context, as our findings only will be specific within its scope.

3.6 Ethical considerations

Our research design involves humans and personal data. It is therefore important to take into account ethical considerations. We follow Saunders et al. (2016), by protecting the rights, dignity and welfare of those who are participating. Moreover, we aim to be open, truthful and promote accuracy in our research. Before conducting the interviews, our project was registered at the Norwegian Centre for Research Data, giving us guidelines in terms of how the data collected should be handled. Furthermore, participation in our project is completely voluntarily, and the interview invitations states our motivation, topics we are interested to discuss, and that we are aiming to protect privacy and anonymity. We are aiming for the highest standards in protecting privacy and confidentiality, to not put any participants in any undesirable positions (Yin, 2014). Furthermore, we also informed that in the interest of the subject, the participants position and industry could have significant impact for our research and would be included in an overview. We find that these considerations make it possible for the participants to make fully informed decisions and gives them the possibility to decline. Moreover, it is important to obtain research objectivity and not misrepresent the data collected in the analysis stage, and we will strive to keep a high degree of integrity (Saunders et al., 2016).

3.7 Weaknesses of this study

In exploring the application of a technology as students in economics and business administration, with no deep background in computer science, this pose as a weakness to this study. We are therefore reliant on our expert interviewees; that their opinions are well informed and based on a solid background in the field. Another point to emphasize, is the problem of examining a new research subject with a limited selection of academic papers. We must use our best judgement to ensure that our secondary sources are of high quality. Additionally, the infant nature of the technology poses linguistic risks, as there may exist differences in terminology. Lastly, this thesis is written in English, and native Norwegian interviewees participating in our research needs to have their interviews translated. We will do our best efforts to avoid data loss in this process.

4. Money and Banking Systems

In the aftermath of the financial crises, academia in economics has returned to questions regarding the complex nature of money, transactions and economic activity. Several voices spoke out loud about the lack of explanatory power behind the financial crises using contemporary economic theory (Bookstaber, 2017; Krugman, 2009).

What is money? How do we decide on why something is money and which functions it performs in an economy? Everyone agrees on the fact that money makes the world go around, but few understand how money is created, how money is essential to transit from an economic system of barter to modern capitalism and how society itself determines if something can be used as money. The many definitions and theories of what money is, given below, and how it is created seems to be complementary rather than competing theories. They all point to complex societal and economical dimensions involved in money (Jenssen, 2014).

In the following chapters, we introduce some key aspects regarding the functioning and different types of money. Furthermore, we try to establish a link between money, trust and memory. Next, we present how a decentralized cryptocurrency differs from traditional central bank-issued money and how it may alter the notion of trust in money and the exchange of value. Moreover, we analyze barriers of adoption and the possibilities and challenges for central banks facing decentralized currencies and technology. Consequently, this may have an impact on financial regulation, fiscal and monetary policy.

4.1 Money

Economists usually define money as anything that is generally accepted in payments for goods or services, with three key functions; medium of exchange, unit of account and store of value (Mishkin, 2013).

Goods and assets used as money in payments all have inherent properties such as being divisible, easily measured, and durable (Halaburda & Sarvary, 2016). These attributes are essential to explain what could function as money and how money facilitates trade. Definitions of money are best described by the functions they have from a societal and economical perspective. As we will see, money can be seen as solving the problem of sequential

transactions where trust and memory is of essence for the economy to run efficiently (Bengtsson, 2005).

4.1.1 Unit of Account

First, money should serve the role as a unit of account. Just as meters is used in measuring length, degrees in measuring temperatures and liters in measuring volume, a monetary unit of account enables relative asset pricing (Huber, 2017). This is essential in the allocation of resources and capital in economies. The given mandate of most developed countries' central banks is to ensure a stable unit of account through monetary policy.

For rational agents to optimize their allocation of resources, prices of goods and services are used as a common denominator reflecting the relative monetary value. This allows them to adjust their production of goods and services, and optimize their allocation of wealth by observing prices of assets, instead of trying to obtain complete information about an economy. As economies grows larger and diverges to complex systems of economic coordination, prices act as an efficient way of distributing information essential for efficiently economic ordering in a decentralized manner (Hayek, 1948).

4.1.2 Medium of Exchange

Secondly, money needs to fulfil the role as a medium of exchange. Money facilitates transactions by trading it for a given good, asset, or service in an economy. Further, it functions to settle debt and liabilities. Agents do not necessarily want to hold the money indefinitely, but are willing to accept it in transactions as they expect to be able to use the medium in a future transaction. Effectively, money should solve the problem of transforming sequential transactions to simultaneous transactions by carrying value between two interdependent transactions (Starr, 2010).

To function as a medium of exchange, money should be divisible to conduct transactions of any size, hard to counterfeit to ensure a direct or indirect scarcity of money ensuring integrity and trust in the money, and accepted by (most) agents within the geographical scope of the economy where the money is operating (Halaburda & Sarvary, 2016).

An economy is increasingly efficient when the medium of exchange facilitates specialized labor in the economy. Economic agents can specialize while being able to exchange goods and

services through a common medium of exchange. To illustrate, if a lawyer should desire a basket of eggs, he would have to spend a significant time in the search of a farmer in need of legal expertise to exchange his services for eggs. Moreover, should the lawyer be forced to produce his own eggs, the advantage of labor division would be severely reduced as the time the lawyer could spend utilizing his legal expertise contributing to an efficient production of wealth in the economy (Reisman, 1990). This problem of "double coincidence of wants" posits serious friction in an economy. Introducing money as a medium of exchange lowers the costs of matching agents in a transaction and increases economic efficiency.

A subtle, but important function of money is thus decentralization of the exchange process (Starr, 2010). Because money enables transactions to be done independently of each other, the process of exchange does not rely on a centralized structure.

4.1.3 Store of Value

Finally, money needs to function as a storage of value, retaining a stable value over time. Through monetary assets or other assets with a claim on future benefits, economic agents can postpone their consumption by storing income from participating in economic production. This facilitates purchasing power to be carried on into the future. This suggest that other assets such as stocks, bonds and real estate may be better alternatives in storing wealth, as holders get compensated by holding these assets. However, money is desired by the public for the embedded liquidity to conduct daily transactions. Liquidity refers to how easy the asset can be converted into another asset.

To summarize, the definition of money does not necessarily provide a binary outcome in evaluating whether a good or asset should be considered as money. Both Hayek (1990) and Keynes (1936) agree on the idea where any asset has an embedded degree of moneyness. Hence, assets should be measured along a continuum of liquidity and agents should be compensated for holding wealth in less liquid assets. Moreover, functions of money are all correlated and interlinked. Should one of the functions erode over time, the money in question would be not be deemed suitable, and the search for an alternative money would be set in motion.

4.2 Money, Trust and Transaction Costs

Considering the description of money's functioning and the evolution of money and payment techniques, the common trait seems to be related to an increase in efficiency of facilitating trade and transactions in an economy. By introducing a token or any other carrier of information, economic agents can be held credible on their promises in a transaction.

The importance of the three roles of money, and the attributes that support them, are related to transaction costs. Broadly speaking, money facilitates trade by lowering transaction costs if money satisfies all these roles well (Halaburda & Sarvary, 2016).

The overall progress of the development in money seems to be related to reduced costs of transactions in a globalized and increasingly integrated economy. Consequently, transactions should be the unit of analysis to explain why and how money facilitates lower transaction costs, boosting trade and increases economic activity (Williamson, 1981).

4.2.1 The Double Coincidence of Wants as a Transaction Cost

As mentioned, the function of money as a medium of exchange drastically reduces transaction costs related to the time spent finding others willing to engage in an exchange of goods and services, enabling labor specialization.

4.2.2 Storing Money as a Transaction Cost

In the evolution of various goods used as money, there has been a tendency to move from commodity-backed money with intrinsic value, to a fiat currency system. This has reduced the cost of storing money to a large degree, from storing goods such as gold in inventories with increased probability of robbery, to recording money as electronic deposits and bank loans, i.e. a debt-based economy.

4.2.3 Trust as a Transaction cost

It is necessary to implement mechanisms facilitating trust between counterparties in the exchange of goods and services. In a barter economy, trust would be established by social enforcement in the event of malicious attempts in the exchange of goods and services. In a trade economy, money enables agents to avoid these costs by ensuring the validity of payment

vehicle. Moreover, agents will only use money if, and only if, they expect the money to be credible carrier of value and other agents will be willing to trade goods and services.

The fiat system is based on the public having trust in the government and central banks. Fiat money represented by notes and coins does not have any intrinsic value, except the paper or metal used in the production of money. Rather, its value is a function of trust, network effects and the ability of governments to enforce agents to pay taxes and debts within a state (or regional, i.e. European Union) boundary.

4.3 Monetary Systems and Related Monies

Modern money can be viewed as a special IOU[8], or a financial asset that every agent in the economy trusts. A financial asset is a monetary claim on an agent in the economy. As financial assets are a claim on someone else, these will be mirrored as a financial liability for the opposite agent. Hence, a financial asset is always someone else's debt in the economy. If everyone kept a ledger of every transaction, where agents issued IOUs by themselves, this functioning of an economy could probably work without money (Kocherlakota, 1998). However, the idea of agents fully trusting everyone in the economy does not hold. As described above, money serves the function of memory in an economy where agents may not trust each other, but have trust in the medium of money (McLeay, Radia, & Thomas, 2014).

4.3.1 Commodity Money

Commodity money is a medium of exchange which simultaneously functions as a method of payments while having intrinsic value due their alternative usage (or opportunity cost). This alternative cost may have both cultural and economic value, hence a given commodity may be a suitable candidate as a money. Due to the alternative use as payments, people may have trust in the money to be accepted in future transactions. Precious metals have been used as money throughout the history (TBM, 2017). Metals have an inherent opportunity cost, constitutes scarcity and is costly to produce. Moreover, the quality can be assessed by agents.

As the alternative costs of storing metals in vaults and costs of production, transportation and risk of robberies, banks were early to issue commercial banknotes representing a claim on the

[8] Phonetic abbreviation of "I owe you".

metals. These notes were subsequently used as a means of payment, as they represented a less costly way to facilitate transactions (Bheemaiah, 2017). Moreover, banks were eager to issue an excessive number of banknotes, with outstanding claims above the value stored in their vaults. This was a valid strategy as the law of large numbers made it improbable for depositors to claim the metals, all at once (Menger, 1976). In the end, this marked the beginning of fractional reserve banking.

4.3.2 Fiat Money

The European Central Bank defines fiat money as money declared a legal tender, issued by a central bank (ECB, 2015). This means it is not backed by anything other than a statement of a central bank or government, promising that the issued money can be used to settle liabilities in the economy. Thus, fiat money has no intrinsic value other than the paper and metal used for producing notes and coins.

Fiat money systems offer some advantages over commodity money. It allows central banks to adjust the money supply in response to changes in money demand. As the demand for money is next to impossible to control, most developed nations have in place a central bank to conduct monetary policy. Central bank mandates may vary individually, but generally it aims to ensure price stability and a sound, robust financial system. Commodity money are relatively fixed in supply and any significant change in demand could result in large fluctuations of price levels.

However, the promise of a given money being a legal tender requires trust from the public. An agent needs to know that received money are not rejected in future transactions and does not decrease significantly in purchasing power.

5. The Future of Money

We denote digital currencies as any currency stored and transferred electronically (Boel, 2016). Cryptocurrencies is a decentralized digital currency, stored and transacted through a peer-to-peer computer network that directly links users where no single user controls the network (*Decenralized E-Money (Bitcoin)*, 2014). Further, cryptocurrencies can be seen as a digital manifesto of trust and memory as the underlying technology ensures a public and transparent record of transactions (Halaburda & Sarvary, 2016; Kocherlakota, 1998). Moreover, it is a digital asset designed to work as a medium of exchange by using cryptographic techniques to secure transactions. Money supply is determined by the protocol, ensuring a stable supply of new currencies until a maximum amount of units has been issued (Greenberg, 2011). Central banks issuing their own digital currency is distinguished from cryptocurrencies as digital representations of fiat currency. In other words, it is a claim on the central bank with a status as legal tender, subject to law and regulation. This separation is essential to understand the main drivers related to adoption, advantages and disadvantages, and obstacles of the respective digital currency.

5.1 Cryptocurrencies

Cryptocurrencies introduce a new way of thinking about money. It introduces questions of why people voluntarily agree to use money which does not have status as a legal tender, nor guaranteed by regulatory enforcement authorities. The advent of cryptocurrencies solved two issues which had not yet been fully solved in earlier versions of digital money, namely the problem of double-spending and counterfeiting. However, solving these issues was not by groundbreaking innovation.

"…the way in which blockchain is depicted, like it is a new technology, it is not at all. It is technology from the 70's. But it is put together in one system, for one purpose only."

- Interviewee #3

The stand-alone cryptographic and technological techniques utilized have existed for decades. However, innovation in economics and computer science involved the ingenious combination of techniques, ensuring a trustless, secure and robust system functioning simultaneously as a payment and money system.

The ideas in the white paper by Nakamoto (2008) and Bitcoin was followed by the introduction of several alternative competing (or complementary) cryptocurrencies. Cryptocurrencies differs in their protocols in how the network "agrees" on new transactions, the money supply and users' anonymity. Recent months have seen tremendous increases in market capitalizations of cryptocurrencies.

Table 2: Cryptocurrencies, price development

Rank[9]	Cryptocurrency	Market. Cap. ($B)	Price	Price Δ (12 months)
1.	Bitcoin	$45,096	$2,753.75	+ 302.01%
2.	Ethereum	$36,104	$391.38	+ 1,992.94%
3.	Ripple	$10,148	$0.280793	+ 3,970.13%
4.	NEM	$1,953	$0.223312	+8,836.05%
5.	Ethereum Classic	$1,891	$20.39	+2,212.94%[10]

Moreover, several countries now recognize cryptocurrencies as legal payment methods, consequently facilitating adoption by merchants and retailers to accept Bitcoin and other cryptocurrencies (Garber, 2017). Following this trend in legitimization, prices and transaction volumes have been increasing recent years.

However, there are reasons to believe that Bitcoin currently possess first-mover advantages, as our interviewee #6 put it:

"…the value of Bitcoin is not that it is better than any other altcoins, it is that it has become the de facto standard."

Money and payment methods possess two-sided network effects, in which increased demand of cryptocurrencies loops back into increased acceptance by merchants and retailers. As more users opt in the money, the recursive network effects will increase and a dominating standard may arise. Moreover, Bitcoin has not been exposed to severe security breaches and network attacks in its nine years of existence. The scandals in Bitcoin have been related to security breaches of specialized cryptocurrency exchanges in which users trust to handle their accounts

[9] Data from Coinmarketcap.com, retrieved 14.06.17

[10] Note: Starting from 24.07.16

to buy and sell cryptocurrencies, with fiat currency. Cryptocurrency exchanges differ fundamentally from wallets and cryptocurrency software as these are proprietary businesses. Exchanges builds on trust just as investors trust brokers as Western Union to deliver on their services and keeping money safe. However, in the period from 2009 to 2015, 33% of existing cryptocurrency exchanges had security breaches (Chavez-Dreyfuss, 2016). Consequently, its generally not considered wise to use an online exchange to hold significant wealth in cryptocurrencies. Conventional conduct suggests moving cryptocurrencies to personal wallets, a secure conduit in holding private keys. Wallets and cryptocurrency protocols are usually open-source to enhance and stimulate innovation of embedded security.

All cryptocurrencies serve a goal and purpose reflected in their protocol design. Bitcoin was designed to function as a money to circumvent gatekeepers of the financial system in a decentralized, non-proprietary network (Nakamoto, 2008). Meanwhile, Ethereum uses its embedded cryptocurrency Ether to bootstrap a "cryptoeconomy" by combining the Ethereum blockchain and smart contracts to facilitate novel ways in economic organization. Babbitt & Dietz (2014) defines "cryptoeconomy" as: "*an economic system not defined by geographic location, political structure or legal system, using cryptographic techniques to constrain behavior in place of using trusted third parties*." With intended use-cases in mind, consensus mechanisms and network security differs greatly. Decisions regarding the design and trade-offs will depend on preferences and use-cases of a cryptocurrency. Ethereum may facilitate faster and scalable transaction volumes and function as a platform for smart contracts, while Bitcoin serves to be a monetary system in an untrusting environment demanding a higher degree of security in the network. Hence, private cryptocurrencies all serve different purposes and competition among cryptocurrencies will only serve to increase innovation in this space.

5.1.1 Supply of Cryptocurrencies

Most decentralized cryptocurrencies have a fixed supply of tokens in the system which are introduced by rewarding miners for adding new blocks. Most cryptocurrency systems employ a decreasing supply as a function of time. In the declination of new supply, transaction fees need to constitute an increasing share of rewards.

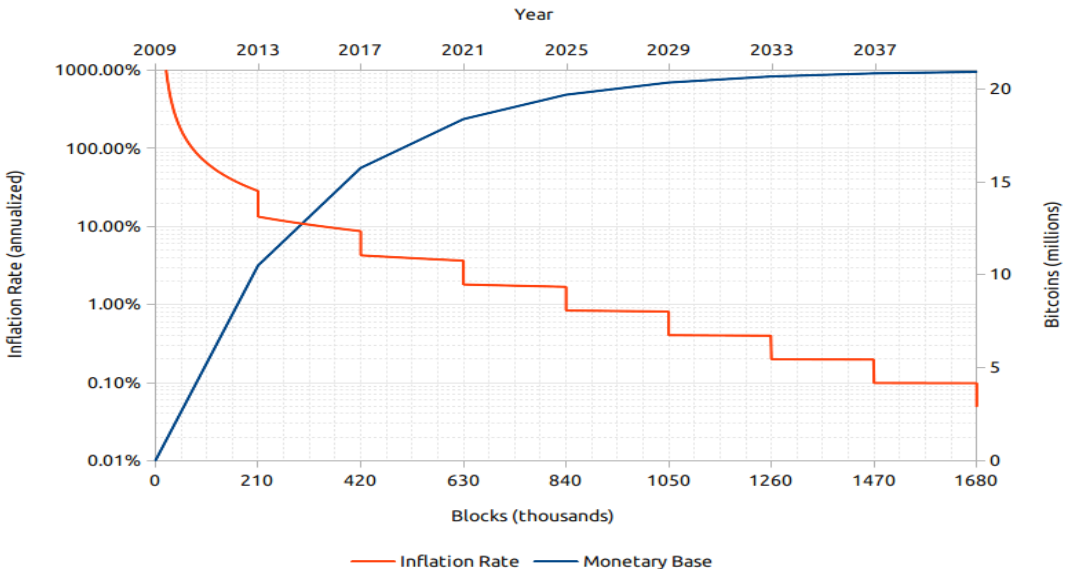


Figure 8: Bitcoin Inflation vs. Time ("Introduction to Bitcoin," 2015)

5.1.2 Demand of Cryptocurrencies

Cryptocurrencies as Money

In addition to retailers beginning to accept Bitcoin as a means of payments, cryptocurrencies constitute an efficient alternative to remittances and international payments with fiat money. Most academic papers have been tentatively conclusive to dismiss cryptocurrencies as being defined as money, as it fails to meet the necessary criteria described earlier (Ali et al., 2014; Yermack & National Bureau of Economic Research., 2013). Several factors, such as price volatility, lack of retail (daily-use) transactions and difficulties in providing units of account supports the dismissal. However, this may change in the future depending on the rate of adoption with related network effects and technological development.

Demand for cryptocurrencies may also increase in economic environments where fiat money might not be an efficient alternative as money. In the event of lacking financial infrastructure and monetary stability, cryptocurrencies may be seen as a better alternative than fiat money (Rands, 2017). In such circumstances, it is probable to anticipate government action to hinder adoption of cryptocurrencies.

Cryptocurrencies as Investments

Cryptocurrencies as an investment asset have been documented over the years (Glaser, Zimmermann, Haferkorn, Weber, & Siering, 2014). Early research shows that price changes were largely a result of public sentiment based on media headlines, social networks and search popularity on the internet (Garcia, Tessone, Mavrodiev, & Perony, 2014). Further, total

number of transactions have been found to be a driver of price fluctuations (Polasik, Wisniewski, Kotkowski, & Lightfoot, 2015). Lastly, research has found uninformed investors to treat cryptocurrencies as an speculative investment vehicle (Glaser et al., 2014).

Cryptocurrencies as an Ideological Statement

Although it may not be an important driver of the prices of cryptocurrencies, it seems worthwhile to take notice that a certain number of agents opt in to use cryptocurrencies as an ideological statement. “Cypherpunks” , anarchists and other groups feeling a sense of commitment and affiliation towards ideologies that represent ideas as less interfering governments, and a mistrust in the current financial system (Hughes, 1993).

5.1.3 Topics of Interests Related to Cryptocurrencies

A New Paradigm of Decentralization

Decentralization is often found to be one of the main arguments in favor of blockchain technology and cryptocurrencies. As we will see, there are several layers and fields in the topic of decentralization. We present the broad ideas and discuss our findings related to the respective layer.

To understand what decentralization means and what implications it has on the structure of the economy, we use the definition of decentralization as in Benkler (2006); “*Decentralization describes conditions under which the actions of many agents cohere, and are effective despite the fact that they do not rely on reducing the number of people whose will counts to direct effective action.*”

The Internet introduced an efficient way of distributing and sharing information, revolutionizing communication technology. This allowed for efficient peer-to-peer collaboration on several projects, exemplified by Wikipedia, Linux and Mozilla Firefox. These projects illustrate some of the potential in decentralization and open-source collaboration.

Buterin (2017b) clarifies related concepts of decentralization. He presents three separate axes of decentralization facilitated by blockchain technology:

- *Architectural (de)centralization:* How many physical computers the system is made up of, and how resistant the system is to failure of individual computers.

- *Political (de)centralization:* How many individuals or organizations have control privileges in the system.
- *Logical (de)centralization:* How the data structure is designed in the system.

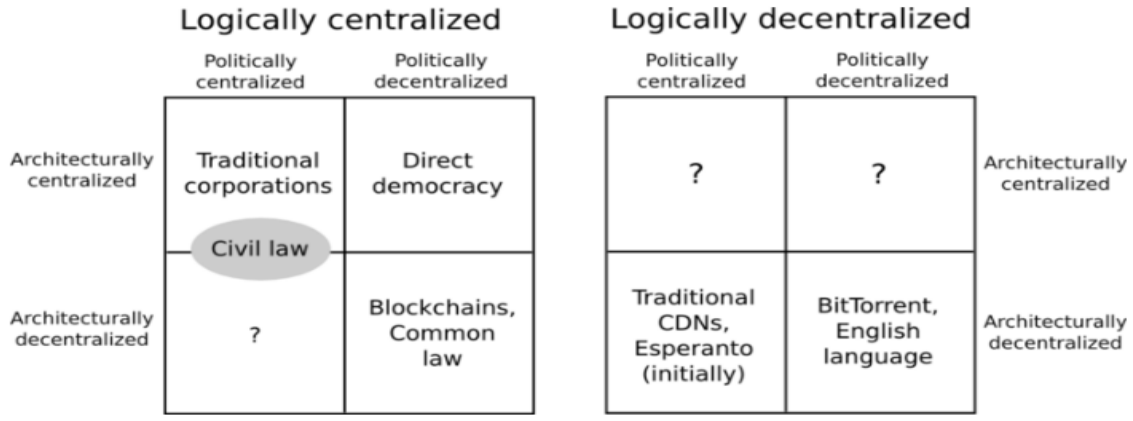


Figure 9: Three Types of Decentralization (Buterin, 2017b)

Cryptocurrencies can be seen as politically and architecturally decentralized, and logically centralized (Buterin, 2017b). Cryptocurrencies relies on decentralized networks where nodes are spread geographically to ensure that the system is robust in case of faulty nodes, natural disasters and governmental intervention. Moreover, the governance design tries to be politically decentralized to ensure a fair and democratizing power distribution, where no single entitiy can control the cryptocurrency. Finally, the system is built on a centralized logic where everyone has to agree on the current state of the ledger, in which the system behaves like a single computer.

Furthermore, Buterin (2017b) argues that decentralization is important due to three factors, each having implications in each of the respective layers of decentralization described above:

1. *Fault Tolerance:* Resistance of the network going down if a single unit goes down.
2. *Attack Resistance:* Lack of sensitive central points makes an network attack expensive.
3. *Collusion Resistance:* Participants acting together for own benefit is harder in a decentralized network.

These are presented to highlight the importance of understanding *when* and *how* cryptocurrency (and Blockchain technology) may be useful and potentially disrupting.

Technological Decentralization

Existing payment technology and related services of transferring value are all subject to centralization, meaning there is an ownership of the network. In some scenarios, this may constitute an efficient organizational and networking structure where speed and enforceability are key aspects within regulatory and jurisdictional boundaries.

Cryptocurrencies acting as both a medium of exchange and payments system may enable faster and cheaper transactions compared to existing payment systems, while making some of the intermediaries involved in the current payments systems redundant. Additionally, keeping (or increasing) the embedded security in the network with PoW, makes cryptocurrencies a robust and viable solution as a payments system. This especially holds for international cross-border payments where the average transaction cost is 7.45% in global remittances (*Remittance Prices Worldwide*, 2017).

The sustainability in significantly cheaper transaction costs by cryptocurrencies may not hold for the following reasons. First, the cost of maintaining and verifying transactions in Bitcoin are currently covered by the reward in new supply of cryptocurrencies. Due to economies of scale effects in mining operations, it is extremely costly to facilitate expected positive profits in mining. This incentivizes pooling of computing power and large investments in specialized mining hardware (Ali et al., 2014).

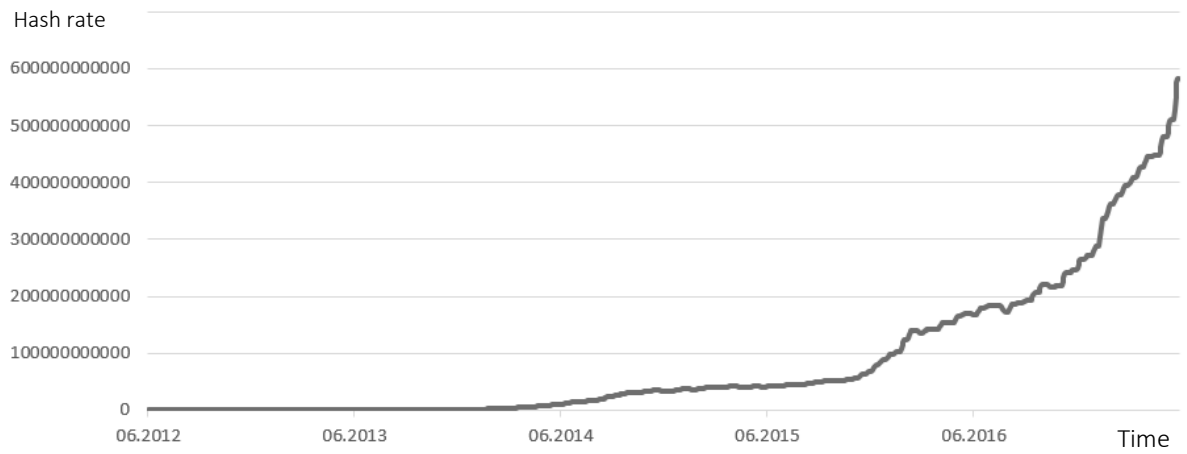


Figure 10: Bitcoin difficulty[11]

[11] Data obtained 14.06.17 from www.blockchain.info/difficulty

Supply of bitcoins decreases approximately every four years, decreasing compensation to miners. Hence, miners would demand an increase in transaction fees to be compensated of the electricity consumption and hardware investments. The current cap of 1 MB block size may consequently result in unsustainable transaction fees for Bitcoin to function as money, spent in every-day transactions. Ultimately, the network could be marginalized to a monopoly miner, thereby defeating their original design goals in decentralization.

Politics and Governance in Cryptocurrencies

Cryptocurrencies has no central ownership of the system. However, sound governance mechanism needs to be designed to ensure aligned incentives, stability and robust source code in the underlying protocol of a cryptocurrency. First, we describe the governance procedures of Bitcoin and Ethereum in a general sense and further discuss the trade-offs involved in the governance structure and the implications for politics.

Governance involves how decisions are made. In cryptocurrencies, this relates to how upgrades and changes in the protocol code are being made, how stakeholders can influence the outcome of decision-making and how the stakeholder's incentives are aligned in the network to achieve desired user behavior and desired properties of the system in question.[12] As we will see, trade-offs involved in the network and governance design differs with the goal and functionality of a cryptocurrency.

[12] We refer to stakeholders as the users, miners and developers in a cryptocurrency.

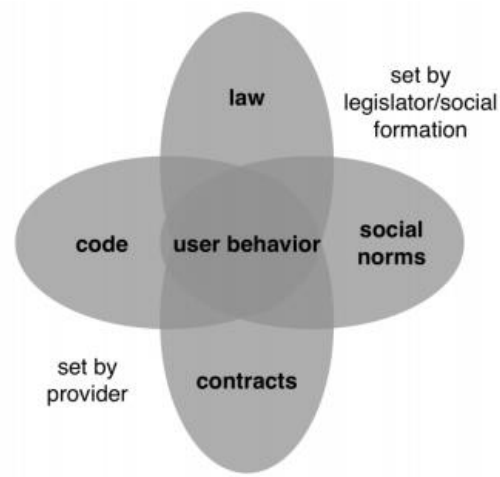


Figure 11: Governance factors in online services (Oermann & Töllner, 2015)

Most, if not all, cryptocurrencies are open-source software with a desired design in functionality, ensuring transparency in the underlying code. Moreover, open source facilitates peer-to-peer collaboration in improving the cryptocurrency, essential for technological development and quality assurance of the code.

Proposed changes and updates in the underlying protocol of a cryptocurrency can be submitted by anyone willing to contribute on the open-source project. This is done through discussion forums, mailing lists or other media. Suggestions are subsequently peer-reviewed by the community engaged in improving the software. Most cryptocurrencies usually have a lead development team[13], where final reviews are evaluated for implementation in the protocol. These changes are usually discussed openly by the lead development team. Major changes in the source code requires clarifications in the trade-offs involved in the decision. Proposed changes would subsequently need a majority consensus by stakeholders, where miners can exercise voting power by signaling willingness to proceed with the proposed changes. In the event of an agreed-upon change in the software, miners download the updated client and continues to maintain the blockchain.

Technical and governance differences in cryptocurrencies has significant impact on the network security and how economic and political incentives are aligned to update underlying software. Bitcoin on the one hand achieves its network security with PoW. In such systems,

[13] E.g.: Bitcoin has Bitcoin Core, Ethereum has the Ethereum Foundation

miners have voting power approximately reflecting their offered computing power relative to total computing power outstanding in the network. As this consensus mechanism incentivizes the formation of mining pools, the amount of voting power held by a single mining pool may pose risks to the decentralization of the network and the implementation of changes in the software. Likewise, Ethereum uses PoW[14] as well, but is currently in the process of implementing a new consensus mechanism named Casper, based on PoS. This is suggested to reduce the incentives to pool resources reduces the electricity consumption and overinvestment in hardware, currently found in Bitcoin. This could also alleviate problems related to potentially skewed voting power distribution in PoW. As externalities in electricity consumption and hardware decreases significantly, PoS may facilitate increased decentralization of the network and align stakeholder incentives efficiently by reducing externalities.

"Cryptoeconomics" involves how to design a system which aligns participants' incentives to achieve wanted user-behavior, facilitating fair conduct by users and impose significant punishment in the event of misbehavior. Economic incentives are achieved by the issuance of cryptocurrencies to bootstrap the system, as these tokens functions as both rewards and money by miners and users. Miners face the probability of severe punishment in losing tokens, should they try to tamper or add a faulty block to the blockchain (Buterin, 2017a). Trying to attack the system by stealing cryptocurrencies would not probably not be desirable, as the cryptocurrencies would not have any real monetary value in the event of a systemic collapse. Hence, a network attack would temporarily halt the addition of new blocks, but probably not much else.

The idea of a fully decentralized governance design is not easy to implement, nor is it necessarily desired (Buterin, 2017b). This implies a need for functional and pragmatic governance solutions to ensure stable and robust cryptocurrencies. In light of this, Bitcoin illustrates how governance design has an impact on the development in cryptocurrencies.

Bitcoin has been subject to political and technical discussion in which the main concern has been how stakeholders should vote on decisions related to suggested technical upgrades. To understand the dynamics and trade-offs involved, we need to identify the relevant stakeholders

[14] Albeit slightly different from Bitcoin's version of Proof-of-Work, as it has other desired properties and underlying foundation.

in the discussion of governance. During our research, we came about some interesting statements about how different stakeholders wants different properties in cryptocurrencies.

"People, you know, want to use Bitcoin as an means of payments, other people want properties in Bitcoin such as gold…"

- Interviewee #15

The main issue in the political debate has been the unwillingness of Bitcoin miners to adopt a proposed technical upgrade coined Segregated Witness (SegWit). This update introduces a 2 MB cap (Up from 1 MB) as well as other technical updates which could introduce solutions in scalability and speed in transactions, such as the Lightning Network.[15] This allows Bitcoin to be used as money. However, an increased transaction block and scalability may reduce transactions fees to the miners in the short-term, while SegWit may prove to increase the value of Bitcoin in the long-run. Hence, the balance of short and long-term incentives needs to be considered.

"If you are sort of using Bitcoin as a store of value, you are not really changing hands, you just want the value to go up, then, you know, status quo is the best answer."

- Interviewee #6

It all boils down to who has financial stakes in the system. A parliament system was proposed as a solution by one of our interviewees:

"…there is always the third party which is not financially vested, but also makes an impact on the decision […] I don't like the systems where only decisions are made by those who have the stake. Because then they will drive it for their own selfish benefit…"

- Interviewee #6

Lastly, geographical centralization of has been a topic of concern in cryptocurrencies. To illustrate, we present the case with Bitcoin. One of the principles underlying the idea of a decentralized network, is to ensure that everyone with a computer and internet access can participate to maintain the network. This still holds true, however the investments required to be profitable in mining have significantly increased. The idea of an architecturally

[15] Lightning Network enables increased scalability, opening a direct payment channel in a side-chain. Currently utilized by LiteCoin

decentralized network can be questioned, motivating a discussion of possible consequences of geographical centralization.

First, geographical centralization could incentivize governmental interference to shut down the system should it see cryptocurrencies a threat to its central-bank issued fiat money and financial stability. However, there seems to be a shift towards acceptance and legitimacy of cryptocurrencies by governments and central banks (Bershidsky, 2017; Kharpal, 2017a). Moreover, even if governments could seize mining operations within their jurisdictional boundary, the network would not be likely to shut down as the open source protocol would still allow anyone to maintain the network. However, the safety of the network could decrease as the hash rate provided by the mining pools taken down would decrease, making it susceptible to attacks.

Second, geographical centralization through mining pools could increase the risk of systemic failure as the points of attacks is reduced. The diversification effects of decentralized networks are one of the main reasons why (most) cryptocurrencies are stable and secure. Even if a protocol is decentralized, the network structure could be centralized (Platt & Romero, 2017). The costs involved in seizing the network is an increasing function of the degree of decentralization in the network structure. Consequently, the economic incentives to pool resources in mining pools could reduce the very advantage of decentralized networks significantly.

Finally, a geographical centralization in combination with mining pools could potentially facilitate tacit collusion (Sirer & Eyal, 2013). Mining pools could be incentivized to coordinate actions to exercise political control of protocol governance or in the extreme case, seize control of the network. We argue that this is currently the primary reason for concern with respect to network centralization.

Cryptocurrencies in Absence of Financial Infrastructure

Money can be anything, if people agree on the medium and it fulfils the function and properties described previously. This is in line with empirical observations where an interview participant pointed to the emergence of M-PESA in Kenya. M-PESA has emerged as an alternative payments system in a country which has a lacking and costly financial infrastructure (Monks, 2017). M-PESA started as a financial service in loan repayments but gradually developed into an alternative payments system and is now an integral part of the financial infrastructure.

People hand in cash to agents which in turn credits your account in M-PESA. In turn, users can send money and pay for goods and services at a cheaper rate compared to other money alternatives.

The success of M-PESA can be related to cryptocurrencies, as both can serve simultaneously as an alternative payments and monetary system. If existing financial infrastructure is significantly costly for end-users to conduct transactions and the sovereign fiat currency lacks public trust, there are arguments in favor of adopting an alternative money system. Anyone with access to the internet can participate in a cryptocurrency. Consequently, anyone can participate and facilitate transactions outside the existing financial infrastructure, proposing cryptocurrencies to be a valid alternative money.

Competition & Innovation in Cryptocurrencies

Open-source software development has several advantages compared to proprietary software development. First, the protocols of cryptocurrencies are (usually) open-source. This may sound like a perfect opportunity for hackers and malicious users to engage in harmful attacks and scams.[16] However, there is a broad agreement between our interviewees that the protocol needs to be open source to ensure robustness, integrity and embedded security through peer-reviews. Users and interested parties voluntarily involve themselves in the software development to analyze and criticize the source code in question. This is in line with the economics of peer-production proposed by Benkler (2006), where agents voluntarily participate in these types of projects. Participants are incentivized by networking opportunities, altruism and interesting projects in which they have an personal interest. The advantage of open-source in cryptocurrency communities is highlighted by an interviewee.

"... potential contributions can come from multiple sources and ideally that ecosystem could advance in a much faster pace."

- Interviewee #5

The participants organize the open-source development, programmers in this case, and no one is formally in charge of development. However, there is an lead development team which ensures modular tasks which developers contributes. In practice, a subset of programmers is

[16] We will come back to this in the section of smart contracts and TheDAO attack.

recognized as having a comparative advantage at organizing changes to the source code and making decisions for the development of the software.

Third Party Concerns and User Friendliness

Note also that cryptocurrencies do not currently have any safety checks to ensure the safety of user funds in the event of wrong-doings. Mistakes made by users are non-reversible as there is no entity to reverse mishaps. Submitting a transaction with a wrongfully stated amount or public key address, essentially means losing your money. The notion of disintermediation involves moving control back to the end-user. This "freedom" does not necessarily constitute that people will be willing to go over to this type of system.

Likewise, another observation is the problem of losing the hardware where your keys are stored. They are gone forever should you lose them. A loss of "trust anchor" in financial institutions and regulatory authorities, ultimately means you do not have the same degree of security in recovering funds. Cryptocurrency wallets are open-source, which leaves the validity and programming security in the hands of the crowd. However, wallets are using cryptographic techniques to ensure the software does not have access to your private keys remotely. There could be issues regarding the loss of mobile phones or malicious viruses. Consequently, a technique called "cold storing" involves printing your private keys on a metal plate to be stored in vaults or dug in the ground.

Network Consensus and Externalities

According to Digiconomist (2017), the Bitcoin network consumes an estimated 14,6 TWh annually, approximately annual electricity consumption of Slovenia (CIA, n.d.). In a fully decentralized network, PoW makes it extremely costly to attack the system. However, externalities related to electricity consumption and hardware may be reduced using another consensus model such as PoS. To maintain the the network security of Proof-of-Work while reducing the costs in externalities, an idea would be to rewire the computing power to contribute to a greater cause. Inspired by the SETI@Home program by UC Berkeley[17], the computational power could be used to keep the blockchain safe while simultaneously assisting research work demanding computational power (Wagner, 2014). However, the field of

[17] https://setiathome.berkeley.edu/

consensus mechanisms is moving forward and there is currently on-going research into how to maintain a robust consensus mechanism while dealing with the cost of externalities.

Regulation and Illegal Activities: Digital Fraud, Silk Road & Money Laundering.

Cryptocurrencies have been subject to black market and illegal activities. The take-down of the illegal market place Silk Road, made Bitcoin a main headliner in the media a few years back (Santori, 2017). Bitcoin is a pseudo-anonymous cryptocurrency, meaning that the transparency in the network and the linkage of blocks makes it possible to trace transactions. While a user of bitcoins can take steps to make his identity less obvious, the evidence available so far does not support the proposition that it is particularly simple to hide user identity (Meiklejohn et al., 2013; Reid & Harrigan, 2011).

Cryptocurrencies being decentralized also implies that regulators are for the most part not able to enforce law in the cryptoeconomy. Bitcoin does not invoke KYC or AML regulations within the cryptoeconomy. However, once the cryptocurrency is exchanged into fiat currencies, regular law applies. Banks and other financial institutions have been reluctant to offer bank accounts that involve bitcoin and other cryptocurrencies. This is exemplified by the termination of an bank account held by The Norwegian Bitcoin Association in 2016 (Norli, 2016). As banks and other financial institutions are subject to increasingly strict Know Your Customer (KYC) and Anti-Money Laundering (AML) laws, banks may not be able to meet the needed compliance of these rules with cryptocurrencies.

5.2 Central Bank Issued Digital Currencies (CBDC)

In recent times, several central banks have announced their desire to issue their own digital currency denominated in their national currency. Bank of England, Bank of Canada, Riksbanken, and Bank of Japan are all contributing to a growing body of research, investigating possible consequences and outcomes of implementing a central bank issued digital currency (Barrdear & Kumhof, 2016; Boel, 2016; Fung & Halaburda, 2016). The consensus view seems to envision a central bank issued digital currency to replace or complement physical cash. Using technology and ideas that originally sought to circumvent these systems, central banks now look at the possibilities of utilizing the very same ideas and technologies themselves. To understand why and how CBDC is attractive, we need to look at different aspects and incentives from a multi-stakeholder perspective. This thesis is limited in

its scope and hence we introduce topics that have been brought up in our empirical research and recent academic research in the matter of CBDC.

5.2.1 Financial Stability

Barrdear & Kumhof (2016) have found several potential macroeconomic effects in their formalization of CBDC. CBDC could increase financial stability by leveraging central banks' ability to develop public trust and impose changes of mechanisms in the financial infrastructure to mitigate systemic risks.

First, with CBDC and blockchain technology, central banks could facilitate instant settlements on their ledgers and decrease systemic risk involved by reduced collateral and the probability of default in agreed-upon transactions. Any payment involves some degree of credit and liquidity risk, as settlements are not made instantly. Usually, payments are cleared inter-bank, but netting happens at specified points in time. Consequently, CBDC can reduce credit and liquidity risk (Barrdear & Kumhof, 2016; Dyson & Hodgson, 2016).

Second, CBDC introducing a new payments infrastructure could reduce the idea of too big to fail (Barrdear & Kumhof, 2016). Introducing CBDC could facilitate the public having deposit accounts directly with the central bank. The authors argue that banks have a status as gatekeepers of the payment system. Banks achieving a sufficient market share gain a systemically important status. An alternative payment system provided through CBDC could ultimately reduce an amplification of a potential systemic failure if payments are impaired by insolvent banks. However, Dyson & Hodgson (2016) argue that a deposit account in a central bank could have severe consequences. In the event economic uncertainty and probabilities of commercial bank defaults, agents will move their savings into risk-free alternatives. This could leave other commercial banks without any liquidity and thus amplify the probability of a financial crisis.

Third, central banks could impose a legal anchor in their issuance of CBDC, should they deem cryptocurrencies a threat to the transmission mechanism of monetary policy (Camera, 2017). In the event of a mass adoption of private currencies, central banks' ability to effectively conduct monetary policy may be greatly reduced. However, private cryptocurrencies display significant price volatility with fixed monetary supply. This could have a significant impact on inflation in the event of public adoption of cryptocurrencies. Central banks could build public trust with their mandates to ensure financial stability and stable inflation, by issuing

currencies as legal tender and conducting monetary policy. There are incentives for central banks to adhere to goals in the long-term horizon to ensure monetary policy has an effect in economic activity and price stabilization. By introducing CBDC, central banks can simultaneously increase public trust while increasing efficiency in their monetary policy and ensuring financial stability. Should central banks be tempted to deviate from their mandates by flooding excess money supply to capture seigniorage, cryptocurrencies or other private money may appear to be an attractive alternative even if a given currency is deemed legal tender.

System Design

Most developed countries assign central banks the role of independently stabilizing inflation and facilitating an efficient financial infrastructure. Central banks need to think carefully about the trade-offs involved in the network infrastructure to ensure a resilient and robust system, subject to increasing demands of cybersecurity in issuing CBDC. In the event of a shut down or systemic failure, this could result in the loss of public confidence in central banks (Fung & Halaburda, 2016).

Using a permissioned blockchain as a technological infrastructure in the implementation of CBDC, seems to fulfill the criteria of feasible use-cases with blockchain as described in chapter 2. A permissioned and distributed blockchain, increases the points of failure in the network to facilitate robust network security, while ensuring regulatory authorities access to transactional data in the event of susceptible to illegal activities. Moreover, as blockchain technology is still in its infancy, the technological implementation of a CBDC could be done progressively. Applying the technology in small scale would enable technological maturity, before applying it full scale to ensure security and scalability. For instance, Hong Kong Monetary Authority (HKMA) in collaboration with R3 and Hong Kong Interbank Clearing LTD has been developing a prototype of a central bank issued digital currency and plans to trial the technology by applying it to interbank payment, inter-corporate payments in wholesale markets and delivery versus payments debt securities settlement by fourth quarter 2017 (*Development of Financial Technologies*, 2017).[18]

[18] R3 is a distributed database technology company.

However, one needs to consider the trade-offs and pragmatic solutions in the implementation of CBDC. A centralized network design by using relational, distributed databases in payments system has the advantage of handling a large amount of transactions per second and ensuring transactional data anonymity across entities. It seems to be a common agreement amongst our interviewees that the network design needs take into account the functions and mandates of a central bank from a regulatory and incentive perspective in the operation of facilitating a payments and accounts system. Moreover, a central bank introducing CBDC would likely forgo some of the advantages of decentralization aspect compared to networks such as Bitcoin. Essentially, there is trade-off between network security and ensuring validated nodes are responsible in maintain the network to impose enforceability and regulatory compliance. We therefore argue that a permissioned network design is the most viable alternative in implementing CBDC.

Central banks need to consider whether to internalize operations of a CBDC and offer everyone to hold an account directly at the central bank, or indirectly by allowing commercial banks to act as a gatekeeper and facilitate accounts on behalf of the central bank. Private financial institutions have a different set of incentives which could facilitate innovation and robust systems to facilitate network effects and trust in the CBDC, while having aligned incentives to increase profits by introducing new business models. An introduction of CBDC could potentially stifle innovation related to payments and settlement systems should it be fully internalized within central banks by reducing incentives in private investments (Fung & Halaburda, 2016).

Consequently, the task of validating new transactions and maintaining the network could be handed over to financial institutions, rather than having a fully centralized solution. An interviewee proposes that an umbrella organization, such as Bits, could be a possible administrator in such a scenario.[19] Outsourcing operations of the network infrastructure in CBDC regarding the network of payments and settlements could increase security, competition, innovation and decrease the workload of central banks.

[19] Bits AS is the umbrella organization of banks involved in the financial industry in Norway responsible for the financial infrastructure related to payments, settlements and clearances. Bits AS is owned by Finans Norge, the industry organization for the financial industry in Norway.

A critical factor in implementing CBDC successfully depends on technical and market expertise engaged in the project should a blockchain technology be implemented as the financial infrastructure of CBDC.

"First and foremost, I think there is a lack of technical competence in making these prototypes. The interest in creating new things is far greater than the speed it rolls out"

- Interviewee #10

Another interviewee suggests that there may be a lack of "highly" skilled human capital in the space of IT and computer science, as opposed to "blockchain specialists". Further, he elaborates that any highly skilled computer scientist can learn blockchain fundamentals. However, the sheer lack of numbers with the desired skills is crucial element in this regard. Consequently, public institutions may not be able to compete in wages to obtain the human capital needed to develop a sound system of CBDC compared to private entities.

Advantages of leaving the operations of the blockchain to financial institutions could alleviate some of the issues regarding technical standardization, governance, and innovation. Based on historical cooperation of banks in Norway, involved parties participates in discussions in a cooperative fashion, as standards reduces the total cost of operations for every bank. Cooperation between international banks and financial institutions may be harder to facilitate compared to smaller regions such as Scandinavia. However, there are signs of willingness to cooperate and initiatives to implement standardization is currently being set in motion. This is shown by the initiatives of the R3 consortia and ISO 2022 (Naden, 2017).

Secondly, by having an increased number of institutions responsible in maintaining the network could alleviate some of the potential moral hazard problems related to misalignment of incentives. It is important to think about who has financial stakes in the network, the possible ways the network could be misused and how to make sure the cryptoeconomics of the network is sound, to ensure minimization of unwanted behaviours. An interview participant remarks there are significant risks involved in having only financial institutions responsible for validating transactions. Even when trusted nodes can be held accountable of misconducts, these financial institutions may be induced to deviate from desired behavior, or even resort to tacit collusion such as the scandal of LIBOR fixing (Vaughan & Finch, 2017). Thus, it seems reasonable to forgo some security aspects to facilitate regulatory supervision

of operations, such as creating backdoors to get access and alter transactions (Lumb, Treat, & Jelf, 2016)

Seigniorage

Introducing CBDC could have implications on seigniorage of central banks. Seigniorage is defined as the revenue earned from the issue of money (*Backgrounders: Seigniorage*, 2013). According to Bheemaiah (2017), there are three sources of seigniorage for central banks in a fiat system. First, the difference in denomination of a given money and the production cost constitutes Seignorage. Secondly, when commercial banks are in need of liquidity, they reduce deposit holdings in the central bank, consequently reducing the interest on these deposits. Third, seigniorage stems from the proceeds of repurchase agreements made with commercial banks. Seigniorage has fallen since its peak in 2008, due to low interest rates (Dyson & Hodgson, 2016). Moreover, if the public opts to a mass adoption of private cryptocurrencies, central banks seigniorage revenues could decrease further (*Digital Currencies*, 2015). Dyson & Hodgson (2016) states that CBCD could enable central banks to recapture some of the revenues from seigniorage that commercial banks accrue when issuing bank deposits. If the public decides to hold wealth in CBDC these revenues will be channeled back to the central banks.

5.2.2 Cashless Society

Potentially, introducing CBDC could fully or partially remove physical currency in the monetary system. However, there may be indications that such processes are already taking place. This is exemplified by India demonetized 500 and 1000 rupee notes in November 2016, the ECB announcement in May 2016 to stop production and issuance of EUR 500 banknotes and South Koreas' trial-run of a coinless society ("ECB ends production and issuance of €500 banknote," 2016; Killawala, 2016; Rodionova, 2017).

However, as we see in the figure below, there are significant differences between countries in the outstanding amounts of cash in circulation. Cash as a means of payments will have an impact on the implementation of CBDC. Even if there is a negative relationship between increased debit card payment availability and demand for cash in most developed countries, several countries currently experience an increased demand of cash, despite a declining trend of cash as means of payment (Bounie, Abel, & Waelbroeck, 2016).

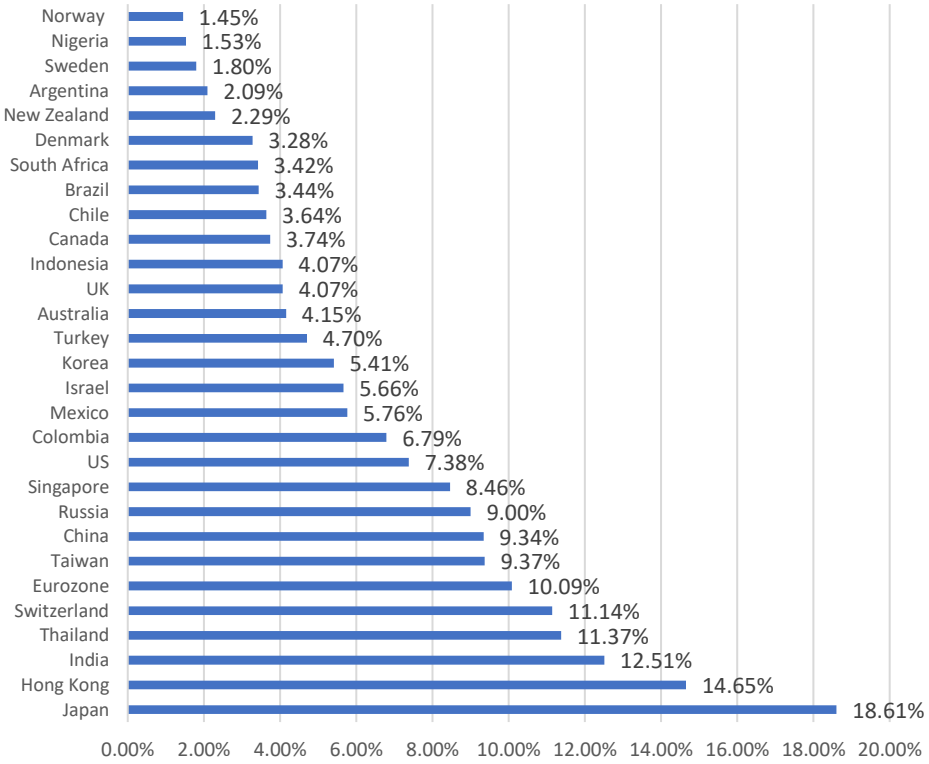


Figure 12: Currency to GDP ratio (Rogoff, 2017)

So, what does a cashless society propose to do and what potential advantages and risks does it impose?

Tax Evasion, Corruption and Illegal Activities

An interviewee suggests that the transition to a cashless situation with a pseudonymous CBDC leverages governmental control to combat illegal activities as tax evasion, corruption, terrorist financing and crimes related to drugs and money laundering. This is also suggested by Bheemaiah (Bheemaiah, 2017). The idea of removing physical cash from circulation, especially high-denomination notes, has been supported by a number of economists, central banks and financial institutions (Halaburda & Sarvary, 2016; Rogoff, 2014).

Tax evasion has been identified as a major reason to remove physical cash. IRS has estimated an average tax gap of $458 billion in the United States (*Tax Gap Estimates for Tax Years 2008-2010*, 2016). Transactions involving physical cash complicates tax collection and economic agents have clear incentives to avoid compliance reporting. The need for efficient tax collection is exemplified by the government of India, where only 3% of the population pays income taxes (BBC, 2013). Tax evasion consequently reduces government tax revenues which has an impact on government spending, for instance, in stabilizing business cycles and investments in infrastructure (Mehrara & Farahani, 2016). Alstadsæter, Johannesen, &

Zucman (2017) found that tax evasion facilitates wealth inequality. Using micro-level data from "Swiss leaks" and "Panama papers", these authors find that tax evasion rise sharply with wealth in Scandinavia, estimating that 30% of the ultra-wealthy avoid personal taxes compared to 3% of the population on average.[20] CBDC and blockchain technology can potentially automate and streamline a significant part of processes involved in tax reporting. An interesting observation with regard to the topic of taxes and blockchain, is The Norwegian Tax Administration summer vacancy listing to do a Proof of Concept for internal use (Karrierestart, 2017).

Further, high-denomination physical cash has been suggested to be a major means of payments in the illegal economy of corruption, terrorist financing, drug & human trafficking and money laundering (Sands, 2016). Physical cash in large denominations can be used to facilitate illegal exchange and saves storage and transportation costs compared to having low-denominated physical cash. Due to the anonymity aspects of cash, it is hard to empirically estimate the use of cash in circulation in illegal activities. Furthermore, the Tax Director in Norway emphasizes that physical cash enables black economy, compared to digital solutions (Sættem, 2016). Therefore, it seems reasonable to acknowledge that large denominated physical cash are used as a means of payments in illegal activities.

Removing physical cash and introducing CBDC to combat illegal activities and tax evasion needs to be carefully thought through. First, one needs to identify the possible money substitutions in the event of removing large-denominated cash. Potential substitutions could be fully anonymous cryptocurrencies such as Monero and Z-Cash, making it hard for regulatory authorities to track and analyze transactional data to combat illegal activities. Removing large-denominated currency could also increase the cost of handling physical cash If physical cash are still deemed attractive in the event of removing large denominated physical cash, storage and production costs will remain largely intact. Second, physical cash facilitates (at least partially) individual freedom to conduct legal transactions anonymously.

"If something should be established in Norway, it must follow regulatory compliance and Norges Banks' demands, it has to be a permissioned ledger"

[20] Ultra-wealthy is the top 0.01% in wealth distribution

- Interviewee #13

Based on the above statement, we find it highly unlikely that governments will be issuing fully anonymous digital currency on a permissionless blockchain. Consequently, this could have implications of excessive government monitoring. In the transition to CBDC, rules and protocols to mitigate incentives to exert excessive monitoring needs to be balanced with societal gains of tracking transactions combating illegal activities.

Monetary and Fiscal Policy

CBDC and the transitioning into a cashless society has clear implications for monetary and fiscal policy. Post-financial crisis has seen several central banks lower their interest rates into zero-range and even in negative territory. However, there are loud voices in academia rejecting the sustainability and effectiveness of a sustained negative interest rate policy (Acharya, Eisert, Eufinger, & Hirsch, 2015; Das, 2016; Lipton, 2016). In the following, we introduce a new set of tools in monetary and fiscal policies facilitated by CBDC. We further discuss possible consequences and summarize potential concerns in the implementation of these policies.

Several central banks have previously implemented unconventional monetary policies, such as quantitative easing (QE) by injecting liquidity and lowering interest. Further, central banks, such as Bank of Japan and European Central Bank have been charging commercial banks to hold cash reserves at the central bank to incentivize lending conditions in the private sector. All of these tools were set in motion to stimulate spending and reduce the propensity to save, consequently lowering real interest rates by adding "un-defaultable" debt to the economy (Barrdear & Kumhof, 2016). Ultimately, this should increase inflation and stimulate aggregate demand, thus boosting economic growth. However, both QE and prolonged negative interest rate policies by central banks have produced ambiguous results in addressing the goals of increased inflation. Summers (2016) suggest we have entered an era of "savings glut" and "secular stagnation" as the propensity to save outweighs the propensity to invest, reducing growth and inflation.

Introducing CBDC and phasing out physical cash could eliminate, at least to some extent, the zero-lower bound (ZLB) of nominal interest rates. Consequently, central banks can impose negative interest rates to obtain desired inflation rates between 2-4% depending on the given mandate and inflation target. CBDC could also increase the room of maneuvers of monetary

policy to stabilize business cycles and fight recessions in response to shocks on the economy. Should economic agents obtain CBDC accounts directly (or indirectly) in the central bank, this could facilitate direct injection of liquidity through direct asset purchases circumventing commercial banks. Possible motivations to circumvent commercial banks to intermediate asset purchases, may be the lack of increase in loan supply by banks, which has not improved lending conditions significantly under current expansionary monetary policy (Köhler-Ulbrich, Hampell, & Scopel, 2016). We argue that even if the introduction of CBDC enables central banks to have negative interest rates, it may not be a feasible policy strategy.

First, negative interest rates may disrupt public trust in the sense that economic agents are losing purchasing power by holding liquid CBDC (Raskin & Yermack, 2016). This is important, as public trust in government and financial institutions have been decreasing in recent years (McCarthy, 2016).

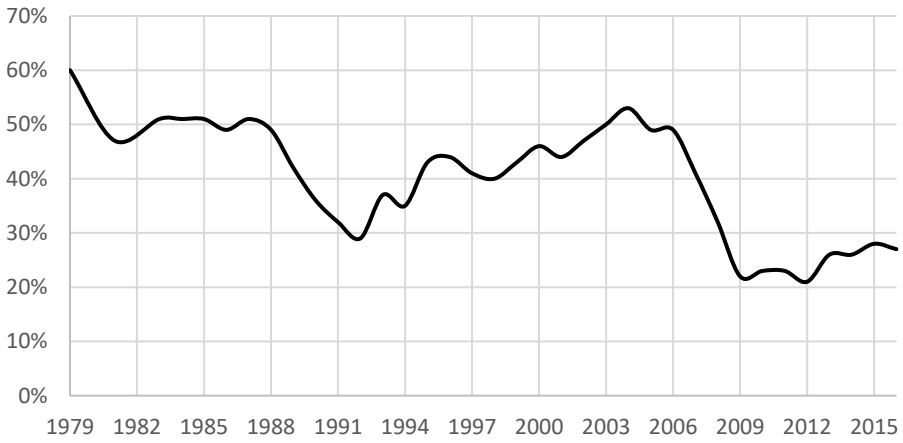


Figure 13: Response: Great deal/Quite a Lot of Trust in Banks (McCarthy, 2016)

One of the common mandates of central banks is to establish trustworthiness and credibility through communication. After all, money is an institution of trust itself and other alternative monies may be preferred in the absence of it. Should monetary policy ultimately succeed in imposing negative interest rates, central banks need to think about how to properly communicate the reasoning behind it should deposit rates turn negative as well.

Second, unconventional monetary policy such as QE and negative interest rates have an ambiguous impact on bank profitability and banks' willingness to lend. Acharya, Eisert, Eufinger, & Hirsch (2015) finds that Outright Monetary Transactions (OMT) program launched by ECB in 2012, did not have an significant impact on bank lending conditions and

economic growth, partially explained by "Zombie Lending" effects.[21] In the study, they show banks increased their overall loan supply, however a significant portion of were allocated to lower quality firms with pre-existing relationships with banks. However, both Riksbanken (2016) and Kandrac & Schlusche (2017) find evidence of positive effects in bank profitability and lending conditions explained by negative interest rates (more specifically, the increase in commercial banks reserves) and QE, boosting bank profitability and changes in risk-profiles by the banks. The ambiguous effects of unconventional monetary policy and its effects on the financial system forces central banks to think carefully regarding the implementation of CBDC to force through negative interest rates.

Barrdear & Kumhof (2016) suggest CBDC and blockchain technology can increase data quality, facilitating better tools to analyze economic variables. Moreover, there is currently an on-going information technology revolution in advanced data analytics, big data, artificial intelligence, and machine learning. These novel techniques can be utilized to implement monetary and fiscal policy with better information at hand with real-time high-quality data,. Moreover, a better understanding of economic complexity and inter-connectedness by central banks may provide new macroeconomic models based on these new insights. A hypothetical scenario where information available to central banks have increased significantly, prompts a discussion regarding the mandates of central banks in how monetary policy should be made in terms of inflation targets or basing new rules on information at hand to have several economic targets in mind (Barrdear & Kumhof, 2016).

Further, old ideas such as helicopter money, basic universal income, and revisiting "Chicago Plan" can be implemented to mitigate liquidity traps and technological unemployment. In times with persistently low interest rates, fiscal policy may demand some attention should monetary policy prove to be ineffective. Central banks could launch such fiscal policy tools, should the public possess CBDC directly in central bank accounts. Friedman's idea of helicopter money differs from QE as it expands central bank reserves directly, without going through the credit channels of commercial banks. Instead, it can be seen as a free lunch for public to boost spending.

[21] OMT was aimed to recapitalize countries banks by buying sovereign bonds, ultimately recapitalizing banks

5.2.3 Network privacy

There is a trade-off in how to balance anonymity in transactions while facilitating regulatory supervision. On the one hand, envisioning a “Big Brother”-esque situation where governments and central banks have full surveillance of transactions and users in the system. Hence, privacy must be considered in the implementation of CBDC, as traditional cash allows privacy for the individuals in the transactions. Privacy is necessary for several reasons.

First, privacy is a fundamental human right (UN, 1948). The amount of transactional data of each individual may be significant and could pose a risk of leakage and misuse.

Second, agents engaged in financial transactions may want to be private in order to not reveal sensitive information regarding competitive positions and strategies. However, there must also be a need to have the possibility to examine and trace transactions which could be deemed a threat or illegal to protect collective interests. Central banks would thus need regulatory authorities to have access in transactional data in accordance with the financial regulatory framework. Moreover, regulatory mandates are put in place to enable public trust in the financial system. Central banks could use cryptographic techniques to ensure pseudo-anonymous transactions while implementing safety mechanisms through data analysis and anomaly patterns using artificial intelligence and machine learning. With enough computing power and analytical experts, findings of anomalies could subsequently have grounds in law to be probed further into the transactions of interest.

5.2.4 Final thoughts of CBDC

A digital currency issued by the central bank is not strictly dependent on blockchain. Existing database technology could be utilized in the implementation process of a CBDC. However, blockchain has technological advantages which potentially outweigh advantages related to speed and efficiency of centralized solutions. The very essence of is the notion of consensus in a secure and robust manner. Hence, the operational costs related to reconciliation, ensuring data integrity and security and batching processes in a decentralized network platform would diminish rapidly in a centralized solution.

Moreover, the process of transitioning into a cashless society would not happen overnight and Haldane (2013) suggests a transition period between 20 and 30 years due to technological

challenges and demographic considerations where late generations might not be comfortable using this type of nascent type technology.

6. Financial Technology

Over the recent years, "FinTech", an abbreviation for Financial Technology, has been the buzzword in the financial sector. This umbrella term encompasses start-ups in financial services, utilization of advanced technology in traditional financial institutions and the emergent collaboration between technology start-ups and traditional financial institutions (Nicoletti, 2017). We distinguish between the different stages, or eras, of FinTech (Arner, Barberis, & Buckley, 2015):

- *FinTech 1.0 (1866-1967):* Characterized by an increasing globalization and the emergence of digitalization.
- *FinTech 2.0 (1967-2008):* Traditional banks adopted information technology in a high scale and internet fueled further developments.
- *FinTech 3.0 (2008-present):* A new presence of start-ups and non-traditional financial players entering the market of financial services, competing with traditional financial intermediaries.

However, some argue that we are now seeing an emergence of the 4th era of FinTech (Nicoletti, 2017). Characteristics of the new era involve integration of FinTech in the established financial system, and the systemization of technological solutions involving data gathering, integration and analysis (Nicoletti, 2017). Blockchain is a key part of this era and a noteworthy point is the technological development throughout the value chain in financial services (Dietz, HV, & Lee, 2016).

Fortunum, Mead, Pollari, Hughes, & Speier (2017) finds that investment activity[22] in FinTech nearly doubled every year in 2012-2015, peaking at $47B in 2015. However, a significant decline in the total number of deals and deal value followed in 2016. Several reasons may explain the recent decline in FinTech investment.

Following an investment spike, investors may be precautious to invest further to evaluate current developments in technological space. Further, macroeconomic and political

[22] Investment by mergers & acquisitions, venture capital and private equity.

uncertainty related to disturbances in the European Union and a change of leadership in the United States may also decrease deal activity.

Despite the decline in FinTech investments, venture capital investment in blockchain-related start-ups achieved an all-time high of $543.6M in 2016 despite a slight decline in number of deals (Fortunum et al., 2017). Increased valuations and a decline in deals may suggest that the "blockchain hype" is on its way down. Following a period of blockchain hype, investors and start-ups are gaining knowledge of what criteria projects need to be successfully launched on a blockchain. Consequently, investors may not jump on every ship available.

Just as the industries of entertainment, media and more recently transportation and accommodation have faced disruptions, finance and banking may now be the next in line. Financial services and infrastructure have not been subject to drastic structural changes, until recent years. New financial services are now emerging, exemplified by the introduction of mobile payments in Norway and mobile banking internationally.

According to Wall (2014), there are two significant drivers of innovation in finance, namely technology and regulation. Increased complexity in transactions and regulatory demands, costly papermill procedures, and inefficient information distribution across databases, may all facilitate demand in FinTech innovation and blockchain technology.

An interviewee suggests that even if blockchain technology might not be the solution for everything, it has sparked an awareness by banks to respond to innovation in financial. Incumbent financial institutions may lose parts in the value chain of financial services, in the event of failing behind technological developments. Facing competition by "tech giants" such as Facebook and Amazon, banks and other financial institutions have realized the need to respond to new competitors. Consequently, financial institutions have increased investment in financial technology, while initiating cooperation through consortia (Finextra, 2017; Kharpal, 2017b). Moreover, a number of financial institutions have started to cooperate with FinTech start-ups, rather than competing directly.

In the following chapters, we introduce problems related to current financial infrastructure and how distributed ledger technology may be an appropriate tool in solving these. Further, we present a general overview and empirical observations regarding smart contracts. Finally, we present emerging possibilities in finance as a result of blockchain technology and smart contracts.

6.1 Technological Infrastructure

A robust and efficient IT infrastructure is essential for any type organization. IT infrastructures should be reliable, efficient, flexible and possess upgradeability and support services (Arabyat, 2014). Further, flexibility is important to keep an organization efficient and able to respond to changing business needs. There is a clear link between IT-systems and productivity, where the combination of software, hardware and services increases efficiency significantly (Romdhane, 2013).

6.1.1 Core banking systems

Despite the increased interest in FinTech, several interviewees suggest that most of innovations in financial technology are mostly based on improving user interface and consumer friendliness.

"…it is a lot of innovation going on in front-end, but not in the core banking system…"

- Interviewee #2

Hence, few innovations are directly aiming to solve the main problem of current inefficient back-office IT systems found in most financial institutions. This development in front-end innovation has been described as *"putting lipstick on a pig"* (Mullen, 2015).

Core banking systems handles customer information, deposits, loans, card accounts and mechanisms for processing transactions (Minz et al., 2006). The first systems emerged in late 1960s, fulfilling the most general needs of a transaction infrastructure. Over the years, these systems continuously developed to facilitate expansions of operations, as well as accommodating changing needs in banking procedures (Kumar, Bannon, Van Druten, & Sawan, 2015). Consequently, as new technical solutions were built on top of existing infrastructure, these systems are now impaired by outdated legacy systems. Interviewee #13 makes the following observation:

"…there are significant costs in the maintenance of core banking systems [...] billions of NOK have been invested, and several of these core banking systems is what we call legacy systems, with roots from the 70's. It is quite inconvenient to develop applications on top of these platforms."

There are significant costs in running outdated IT systems. Falato, Buvat, Coumaros, & KVJ (2013) finds that banks spend 90% of their technology budgets on maintenance of legacy systems, while having a significant head-count working on paper-based back-office processes. Further, legacy back-office infrastructures are found to be limiting new business opportunities, posing threats in maintaining competitive advantage (Schneider, 2013). Old systems pose operational risks, such as being reliant on hardware that is no longer in production (Lamb, 2008). Ultimately, back-office legacy systems are holding back front-end development and imposes great costs on banks.

Financial institutions seem to be reluctant in undertaking drastic changes to upgrade its legacy systems, despite significant costs.

"…they are still using outdated legacy systems in which they do not dare to upgrade. This is a problem."

- Interviewee #8

Reasons in the reluctance to upgrade their core banking systems are manifold. First, lack of investment in core banking systems may be subject to the sunk cost fallacy. Due to technical infrastructure layering, the core system has been left static to ensure interoperability. This makes it increasingly expensive to undertake significant changes in the back-office infrastructure. As interviewee #3 put it:

" …I believe that within a bank, in an entity, the biggest obstacle is sunk cost. […] to present a business case to replace core legacy technology, that is difficult, it is hard to defend costs as you calculate on a marginal cost against a significant substance costs."

Moreover, financial institutions may be reluctant to undergo investments in back-office infrastructure to comply with regulatory demands. Interviewee #9 suggest that changes in technical infrastructure may impose problems as some legislations are rigid considering the technical solutions:

"…the technology itself are seldom object to regulation. It is how it is utilized, what consequences it has […] and possibly how existing regulation applies for new technology and new business models. Not everything which is written technological neutral in relation to the possibilities that are now…"

Hence, there seems to be a contradiction on the issue of degrading core banking systems. A standstill situation where regulation is one of the key hurdles to invest in core infrastructure, simultaneously, regulatory authorities have been criticizing current core banking systems in light of shutdowns in their IT system (Holton, 2016).

Consequently, regulatory sandboxes could prove to be a useful tool in facilitating innovation and investments in core banking systems. A regulatory sandbox is a set of rules that allows financial institutions and start-ups to test new products and business models in live environments (REMA, 2016). New products and technological innovations are partially exempt regulatory requirements with a pre-defined time-window while being supervised by regulatory authorities. Such initiatives are currently taking place in the UK, Singapore and Australia, while several other countries are looking into employing similar projects (REMA, 2016).

Moreover, as banks faces increased regulatory demands, this could incentivize banks to finally invest in new core banking systems.

"… seen from a bank's perspective, regulation is something we follow […] A cost which increases every year. […] let us try to use [blockchain] technology to reduce these costs…"

- Interviewee #7

However, there have been signals of a change in attitude among banks in dealing with their legacy systems recent months. As an example, Nordea is currently changing their core banking systems to keep up with competition (Eriksen, 2017). The process is both costly, time consuming and may impose downtime risks on their operations. However, incumbent financial institutions may be willing to invest in core banking systems in order to face changes in competition in financial services by "FinTech" entrants. Moreover, the potential to realize new business opportunities themselves, are subject to new revenue sources.

New entrants in the market, with modern purpose-built IT-infrastructure has tremendous cost-saving potential above legacy-systems (Lipton, Shrier, & Pentland, 2016). In short, such systems pose significant cost reductions in maintenance while being interoperable and flexible in facilitating new applications on top of its infrastructure.

The choice of an appropriate tool in designing the technological infrastructure to upgrade core banking systems involves several trade-offs. Choosing the right database model is an

important part of the technology stack in the infrastructure. Centralized databases, in which a single node has the sole write-access and the privilege to grant specific nodes read-access, possess significant advantages in confidentiality compared to blockchain (Greenspan, 2016). Confidentiality is an essential aspect for financial institutions, in order to comply with regulation and industry standards. Moreover, it has reduced probabilities in information leakages compared to a permissioned, decentralized database. Further, even if a permissioned blockchain can restrict read-access fairly well, it is still slower in operations compared to a centralized database due to the computational burden in verification processes in blockchain technology (Greenspan, 2016).

Utilizing a permissioned blockchain internally as a database solution, is essentially an extremely slow and inefficient centralized database. In the peak of the "blockchain hype", everything related to databases, technological infrastructure and new business opportunities were suggested to use blockchain technology. As interviewee #4 said:

"... now everybody talks about blockchain, everybody wants to have blockchain, stating: "That is what we need." Do you plan to use your network? "No, we want to use it internally, like a database." But that is not the blockchain."

So, when does blockchain technology propose a viable solution as a database? It all boils down to a need of a **shared database in a network** where **everyone generates transactions** while **not necessarily trusting each other** (Greenspan, 2015). Moreover, blockchains are efficient when there are interactions in transactions. Specifically, a transaction may trigger another transaction to be carried through as a response to changes in the database (Greenspan, 2015). Interviewee #15 further backs this:

"...when we talk about enterprise blockchains, the value of this technology is creating a decentralized database, where each party maintains meaningful control over its node. When we have something that is different from a centralized database in terms of its characteristics [...] it is a database which is under shared control by multiple parties. And that is something which you cannot do with a standard centralized database".

However, a single entity may use blockchain in cases when their internal ecosystems are significantly large and complex. A handful of global banks constitute a financial ecosystem by their own merits. These may develop blockchains as a database solution for internal use.

"[On ecosystem effects] Looking at BBVA, Santander, Barclays, or HSBC for instance, they are global players and they have a redundancy of nodes to run their own networks and facilitate international clearing and settlements on a blockchain internally…"

- Interviewee #3

"I do think that some firms will realize that they do want to manage their own blockchain and essentially build their own platform in their own ecosystem. Other will be using off the shelf solutions, like Microsoft and Ethereum."

- Interviewee #5

It may also be suggestive that a number of these global banks are now realizing their own projects by leaving consortiums, such as R3 (Young, 2016). There are considerations in how useful it is for several banks and financial institutions to be involved in several consortiums if they are not gaining sufficiently out of it.

"And if you are sitting all together in one board and if you are kind of developing this unified R3 blockchain or shared ledger, … like the ultimate blockchain solution for banking. Then it's like, okay, then you need to work on top of that, and then it's okay, how much do I share, how much do I get back out of it. So, I think it's always going to be a bit of this, back and forth. Am I winning, am I losing, am I what?"

- Interviewee #4

However, a number of financial institutions leaving R3 are still engaged in other consortiums such as Digital Asset Holdings and Enterprise Ethereum Alliance. This may signal a need to protect intellectual property rights related to their own research.

"I feel that banks need to engage in certain standards, we want to experiment on it and that type of thing, but we do not want to put all our money in one type if it turns out to be the wrong standard."

- Interviewee #7

This could mitigate risks by financial institutions to lose out on competitive advantage in sharing too much information. Consequently, some actors will develop their internal blockchain projects, before releasing these on a common platform stack. However, they may be still engaged in other projects where they see potential benefits in the network effects,

exceeding the need to protect their own research. This is also suggested by one of our informants.

" ... what they do first is to develop the technology internally […] they implement it internally, and next they establish interoperability between the models [blockchains]"

- Interviewee #3

To summarize, blockchain technology revolves around the need in having a shared database with network, in order to be an efficient tool as a database in core banking systems.

6.1.2 Standardization

Standardization is necessary in the adoption of blockchain technology to facilitate connectivity and interoperability in the financial infrastructure.

"… what blockchain technology is lacking at the moment, is kind of like a standard."

- Interviewee #4

Just as the Internet required a standard to have a common language in the network TCP/IP protocol, blockchain technology needs to have industry standards to utilize its full potential. This ensures that financial institutions are able to develop applications on a common technology stack of blockchain technology. Interviewee #13 illustrates this by the following:

"…there is a clear need for implementation of standards […] how should the data be structured, how should it be formatted, what is the international standard? If you are not able to align this, then every distributed ledger initiatives are going to fail, as these are not applicable to anything."

So, there is a clear need to get industry players to agree on a common set of standards. Should there be significant network effects and efficiency gains for involved parties, a set of standards may be realized sooner. However, as easy as this may sound, we assure the reader it is not. Aligning incentives, mitigating information leakages, designing governance and so forth are a few of several problems the industry needs to discuss.

"Like many technology standards, to get a blockchain in place, you often need many parties to agree on what the standard and protocol should look like. Those are the classic problems that you had before, of getting different industry players agreeing..."

- Interviewee #5

First, comparing the development of internet protocols to blockchain technology, it has differed somewhat. There is a need for academia and regulatory authorities to cooperate with leading blockchain institutions to ensure a robust and transparent process in creating standards.

"I think if you look at the history of that, you understand often what is moving the parts. Often, you will have to bring academics together with industry, with other, governments too to develop these standards."

- Interviewee #5

However, compared to the development of internet protocols, there has been an immense interest from several industries and businesses. This may pose both opportunities and threats in the establishment of standards. As the number of interested business ventures increases, the more research and effort is put down in agreeing to a set of standards. However, an entrant may be able to force through their blockchain technology, gaining significant market power.

"I think you will see it first in settings where one single entity can actually get everybody to agree right away. […] Some players will try to control this, putting their own label on it. But that may stifle innovation, so if you take one extreme, something like R3, or in the banking system where you have a consortium coming together and trying to build their own standard."

- Interviewee #5

The threat of an entrant capturing a significant portion of market power may also explain why some financial institutions are leaving R3, in fear that this may not be the optimal standard they want. Hence, governments and regulatory authorities need to be aware of this to ensure healthy competition, by reducing barriers of entry to stimulate innovation.

In general, there seems to be a necessity to have a single standard stack while having in mind potential pitfalls. This is in line with interviewee #6:

"The questions are whether this centralization of the protocol will continue […] we kind of see that centralization and this unification leads to bootstrapping things. We have http and we have IPv4, and now we have Googles and Facebooks and things like that which were not possible without this single standard technology stack."

Successfully implementing technological standards facilitates increased efficiency and robustness of new technologies. A success story of an industry agreeing to a set of standards is found in the payments systems in Norway. An interviewee suggests that Norwegian banks have a history spanning back in decades, sitting together around tables discussing non-competitive issues. These initiatives have led to the establishment of joint operational infrastructures in payments and settlements, which is in the interest of every stakeholder in the financial industry.

"We are one of the leading countries, we have the most efficient systems here in Norway, we are 5-6 million inhabitants and we have a 30-40-year history where banks cooperate. That is why we have had the opportunity to develop joint operational procedures and infrastructures to facilitate payments."

- Interviewee #2

However, this willingness to cooperate in order to facilitate jointly operational infrastructure do not necessarily hold internationally in the financial industry.

"Yes, it is significantly different. It exists a culture of cooperation in Norwegian banks already. […] it is not unusual for banks to sit in the same room and talk about common solutions, that is something we have always done. But this may not be the case in other countries, and that is why R3 is a big deal by the sheer number of involved institutions in the consortium, that is something extraordinarily for a private organization."

- Interviewee #7

To deal with previously lacking cooperation, there are currently initiatives being launched to facilitate an international body of standardization. An interesting observation is the creation of ISO/TC 307 – Blockchain and electronic distributed ledger technologies in 2016 (*Blockchain Standards Initiative*, n.d.). This working group is led by Standards Australia, involving 19 participating and 16 observing countries, where Norway takes part in the latter group. The initiative consists of 5 study groups; Reference architecture, Taxonomy and ontology, Security and privacy, Identity, and Use cases and smart contracts.

ISO/TC 68 – Financial Services, has also established a FinTech technical advisory group, which will give advice to TC 68 about what is going on in TC 307. We interpret such initiatives as a legitimization of the technology, moving beyond its "anarchistic" roots and gaining widespread acceptance as a possible solution where it may be applicable.

These initiatives are still in the experimentation phase in order to see how distributed ledger technology may prove to be an important technological innovation to mitigate inefficiencies.

"ISO standards have been initiated, where Australia took the lead role and Norway is part of the group. Several things are happening in standardization. But it is mostly experimentation to understand how the standards should be designed."

- *Interviewee #7*

As seen above, there are several hurdles and trade-offs to be made in creating a fair set of standards. Organizations and other bodies in charge of standards and facilitating jointly operating infrastructure needs to balance private incentives, competition while incentivizing financial institutions to join in order to obtain network effects. In the event where banks and other financial institutions might not be able to come to an agreement regarding standards, interviewee #13 states the following:

"A pressing issue is if the industry, not Norway necessarily, but internationally, does not come to an agreement on a common platform. Then, I believe [blockchain technology] only will be a hype."

6.1.3 Blockchain and Interbank Infrastructure

Financial transactions in the recent years have evolved in two ways. First, transactions volume has increased significantly, while gradually becoming more complex as a consequence of innovation in securitization (Mills et al., 2016). Second, technological infrastructure handling these transactions is heavily fragmented as financial institutions utilize several different internal operating processes and procedures (Mills et al., 2016). This creates several operating inefficiencies in the reconciliation of accounting ledgers.

Technological innovation, such as blockchain technology, present a way to deal with these frictions. An interviewee notes that blockchain can act as "glue" to facilitate interoperability across these fragmented procedures. This could facilitate significant cost reductions, automate a number of cumbersome processes, increase speed in clearing and settlements (Lipton, 2017).

There are several estimations regarding the magnitude of cost savings in banking in the coming years due to technological innovation and blockchains. These are all cost reductions by automating several back and middle-office tasks. Cant et al. (2016) estimates between 3 billion USD to 11 billion USD for retail banks, in the event of successfully implementing smart

contracts. In the same study, investment banks are estimated to save between 2 billion USD to 7 billion USD. Ripple (2016) estimates their solution may eliminate 30% of costs in payments; an estimated 18 billion USD per year.

The value of utilizing blockchain technology as technological infrastructure is increasing with the number of participants in the network. While several operational costs and inefficiencies are mitigated, there are advantages related to new business opportunities such as analytics. Interviewee #6 says that:

"…because of the ledger technology you can share anonymized data, you can share some analytics, and you can detect, for example, fraudulent behavior more easily if you combine multiple banks together. There is value in that. There is value in building some consortia and doing some offering for yourself to make your business better."

However, letting financial institutions be fully responsible in the implementation of technological infrastructure may not be feasible as mentioned in chapter 5.2. First, conflicting incentives could potentially disrupt the premise of immutability. As financial institutions may want to adjust previously recorded transactions, the blockchain needs to have a robust consensus mechanism to ensure legitimate transactions are altered in a correct way. Hence, a fully P2P network may not be feasible. It seems more likely that a blockchain design similar to a permissioned design found in the current financial infrastructure is inevitable. This could be exemplified as building private websites on the open internet architecture. Interviewee #10 states that:

« [Major bank] will probably not have an incentive to implement fully peer-to-peer solutions between banks, where other correspondence banks will not have an advantage. While [a small bank] wanting to transfer money to a small bank in New York, these two, which are on the border of the network, they have great advantages of such a P2P solution as they do not have to use correspondence banks in order to facilitate payments. Hence, the smaller banks and start-ups, and how much more risk they can undertake, these are the ones that will push [blockchain] technology onwards rather than large incumbents. Goldman Sachs and all of these banks involved in R3, these are similar to counter weights. They want to keep todays system in a sense, by increasing efficiency with blockchain."

Several informants described a pragmatic solution to the problem described above. First, SWIFT was mentioned as a potential candidate.

«SWIFT is a network owned by the banks. SWIFT could naturally be part of a blockchain or distributed ledger solution»

- Interviewee #3

The Society for Worldwide Interbank Financial Telecommunication (SWIFT) was founded in 1973 with 239 banks from 15 different countries. SWIFT is an example how standardization and collaboration may be beneficial for everyone. Today, there are 10800 *users* from over 200 countries, enabling cross-border payments through their messaging system. In their position paper, they conclude that blockchain-type technology is at best promising, but requires significant research and development to meet financial industry requirements (Le Borne, Treat, Dimidschstein, & Brodersen, 2016).

Secondly, Norwegian Interbank Clearing System (NICS) was also mentioned as a solution which could facilitate several improvements of the financial infrastructure by using DLT.

"So, I believe one of the possibilities [with blockchain] is to reimplement the Norwegian Interbank Clearing System. […] if all banks in Norway join a common ledger, a distributed common ledger, then we will have instant settlement, that is real-time settlements between the banks. This will remove some of the systemic risk in the model. It is an extremely interesting case, which will increase the flexibility in the economy, and it will facilitate instant payments."

- Interviewee #3

To summarize, financial institutions seem eager to participate in a several initiatives to take advantage of proposed cost reductions. Next, we present some of the interesting projects currently going in with

6.1.4 Examples of Blockchain Initiatives

Some prominent firms stand out in this sphere. R3 is distributed ledger technology firm leading a consortium of more than 80 financial institutions and technology companies. It recently launched a successful financing round of 107 million USD (Kharpal, 2017b). It aims to offer an open-source platform to host a wide array of applications in financial services. The platform enables distrusting participants to have "shared facts" regarding any financial agreement such as derivatives, bonds and whole-sale payments. However, information regarding the agreements and other transaction details are only available to involved parts. It aims to follow industry standards and compliance of financial regulation (Brown, 2016).

Ripple Labs is another start-up, offering international payments among banks by using distributed ledger technology. Offering international payments with a distributed ledger as back-office infrastructure promises increased efficiency and significant cost reductions related to reconciliation of databases. It differs from R3 by being a finalized product "of the shelf" in a plug-and-play manner (Ripple, 2017).

Other worthy initiatives to mention is the Enterprise Ethereum Alliance and IBM's project of Hyperledger. These are platforms which offers "Blockchain-as-a-Service", allowing several industries to facilitate a number of projects using blockchain technology, be built on top of their infrastructure.

6.2 Smart Contracts

A smart contract is an agreement between two or more parties, automatically executing terms of a contract linked to a distributed ledger. To determine if a given contract term is met, such as underlying stock price in a derivatives contract, oracles are used to monitor and report data affecting a contract to the distributed ledger. Hence, any changes in the state of the ledger will automatically execute a smart contract if contract terms are met (Irrera, 2017).

This constitutes a range of potential opportunities in financial services, such as trade finance, supply chain management and syndicated loans. Coding business logic into a smart contract mitigates several frictions related to monitoring, enforcing and execution of contracts between parties. Use-cases in financial services includes payments, trade finance, supply chain management, investment management, capital markets and capital raising (WEF, 2016).

Smart contracts are not likely to replace every type of contract. It could function as a standardized contract with a given set of input parameters in settings where contract terms are in a sense "complete". By "complete" contracts, we describe a setting where future outcomes of a contract are known by every agent (Grossman & Hart, 1986). Further, smart contracts will likely supplement contracting processes in financial transactions of a higher degree of "incompleteness". This is the notion of a "Ricardian contract" (Grigg, 2004). Smart contracts could take a reduced part in the contracting process, in agreements of contractual complexity. This is in line with the following observation:

"I can easily imagine a scenario in which smart contracts are embedded to regular contracts […] But it needs to be in a significantly standardized format. [Smart contracts] are not going to replace a regular contract, but it will function as an element in a regular contract, like a settlement procedure."

- Interviewee #9

Moreover, an anonymized smart contract could be placed on a blockchain with its unique hash to ensure there has not been any changes in contract terms, unless agents voluntarily agree upon this.

"You do not put everything [here: contract details] on the blockchain, you submit a hash, a referenced link of the proof of existence of the contract and that this has not been tampered with. Then you prove that the contract has not been changed, or if it has been changed, then everyone has had to agree on the change involved."

- Interviewee #7

By involving regulatory bodies to have access to necessary contract details, risks of moral hazard could be alleviated and facilitate enforceability in the event of unlawful breach of a given contract. This requires regulatory bodies and law entities to have access and overriding privileges in such cases. Further, in the event of an unforeseen fault in which a smart contract does not specify the outcome, legal entities may have write-privileges to ensure a fair interpreting of law.

"…if you make a mistake you need to be able to fix it, and it must be the case that if legal contracts state what is going to happen in the event of a mistake, you will have legal entities which can enforce a reversion of a transaction or submit a counter-transaction [to the blockchain]"

- Interviewee #7

Despite significant potential, there are several challenges in the implementation of smart contracts according to our interviewees. First, utilizing smart contracts in large and complex value chains could amplify the risk of a systemic breakdown. Lengthy and interconnected smart contracts across industries could promote a "domino" in the event of an unforeseen "default" of a contract. Hence, smart contracts need to have built-in mechanisms to deal with "defaulting" smart contracts to avoid a collapse in the value chain.

Another issue is the issue of human interpretation in smart contracts. Most (if not all) contracts are incomplete. Incomplete contracts are contracts which contains gaps, missing provisions and ambiguities to be completed, by renegotiation or courts (Hart, 1995; Schmidt, 2010). Hence, smart contracts need to have mechanisms put in place which deals with renegotiation, interpretation, and unforeseen events.

"We do not have those flexible mechanisms yet to somehow deal with humans. I think it is because most of the blockchain innovation was driven by programmers. The programmers tried to not think about the human in the loop too much. They sort of think about the code and the systems and the computers, but dealing with the soft matter; that is hard."

- Interviewee #6

Further, there are currently not mechanisms to incorporate "soft" considerations in an "if-else" world. Smart contracts rely on quantifiable and observable inputs where the outcome is dependent on whether coded agreements are met. Translating this to the legal system, interpretation plays a key part in every contractual agreement. Thus, the strict, precise, and formal system of smart contracts represents a significant obstacle. Consequently, smart contracts may only be suitable in agreements of "complete" contracts (Grossman & Hart, 1986).

"*There are nuances and other things to contracts, where we do not want a fully deterministic and algorithmic outcome as you will get in a smart contract. You may want to incorporate interpretation. You may want individual customizations and similar things, which I have interpreted smart contracts are not being well-suited for*."

- Interviewee #9

This is further illustrated by the implications of trying to implement smart contracts in a setting of incomplete contracting. Having legal entities and a court system solves issues which contracts cannot do as easily.

"A smart contract has limitations […] if you are going to program a smart contract covering what a normal contract would do, then you need to account for a significant number of events. You need to code in what is reasonable, which we have not succeeded in the description of law binding contracts previously. That is why we use legal standards. Doing this type of work through computers in the belief of making it simpler, I do not believe this could work."

- Interviewee #9

In light of these issues regarding human interpretation and incomplete contracting, a number of solutions has been proposed by our interviewees. It is suggested to implement smart contracts in simple use-cases of "complete" settings. Subsequently, in the implementation of smart contracts, border-cases could be identified where human interpretation of contract outcome is necessary.

"I think we have to start with simple things first and include humans in the loop. So, we need to have a mechanism to say that this is the border case, it needs to be dealt by humans or by some oracle or by some consensus. And then it feeds back […] you can quantify that. So, you can reach a point where all those new answers and all those incomplete information is actually resolved and leads to really precise statements"

- Interviewee #6

This could be compared to having a coded legal standard in smart contracts. However, circumstances and future events are probably unique for every contractual agreement, which could amplify ex-post ambiguity and moral hazard issues. Despite this, we believe such a solution could be facilitated by coupling border-case logic to the court system to ensure the protection of agents involved.

Finally, several issues may arise in the enforceability of a smart contract. It may be wrongfully and unlawfully signed and submitted, forced by violence, theft of identity or contracts signed by minors. Court systems and law enforcement needs to make sure there are mechanisms that deals with robust identification of involved agents in a contract, such as BankID. Moreover, these regulatory bodies may have access to anonymized data in order to verify contractual agreements and validity of involved parts ex-post.

Further, when dealing with real-world assets on a blockchain-based contractual agreement, trouble arises. One key point is that the values and tender the smart contract is handling, is based on the same platform. Handling real life assets in a financial world require statutory laws making it enforceable, an ID accompanying the signing and real life contractual properties.

To summarize, smart contracts may be potentially disruptive in two areas. First, it has applications on a blockchain with embedded tokens restricted to the cybereconomy. In a bootstrapped cybereconomy with an embedded token, while it develops mechanisms of self-

enforcement and self-governance may facilitate smart contracts to enable a new mode of economic organization.

"Smart contracts can function well, at least for Bitcoin and others where the system is controlled by the blockchain, and the inherent value is locked to the blockchain. […] Smart contracts may work great for digital assets registries and payments to the extent where these can be linked to a smart contract. But other than that, I feel smart contracts may be limited in applications."

- Interviewee #9

Second, smart contracts could have potential applications where real and financial assets may be digitized and traded on a blockchain, which facilitates both payments and ledger functions. Hence, several financial assets may be used issued and traded on a blockchain with a smart contract to automatically execute contract terms using "oracles". However, a number of enforcement and monitoring mechanisms needs to be put in place in the event of smart contract adoption linked to real-world assets.

"Once you step out of the boundaries of what a blockchain controls, then you are back on square one, where you do not have any other alternative than appealing to a court system. The court system needs something which they can relate to and interpret […] For now, they are not able to read code."

- Interviewee #9

6.3 New emerging possibilities

The combination of blockchain technology and smart contracts presents new opportunities in banking and financial services. We present a selected number of topics below in which most informants have mentioned will have an impact on competition and businesses processes in banking and finance.

6.3.1 PSD2 - Fighting for the end-user

One of the upcoming, major changes in the industry of banking and financial services is the introduction of a revised Payments Services Directive (PSD2), taking effect in early 2018 (EC, 2015). This directive grants Third Party Providers (TPP) access to infrastructure of banks accounts and payments. Hence, any entity can now offer services related to payment initiation

account information by accessing banks' Application Programming Interface (API). This allows companies such as Google, Facebook, and others to provide banking services on their own platforms by receiving a consent of a customer.

The overall objective of PSD2 is to facilitate competition and innovation in financial services by allowing FinTech start-ups, technology companies and others to build applications on-top of existing infrastructure. Moreover, the directive proposes solutions to unify the infrastructure among European nations to increase efficiency of cross-border payments.

Consequently, commercial banks need to think about how they should respond to this changing competitive landscape. This directive has emerged in most of our empirical research. It could be seen as an important driver of change in banking business models. However, an interviewee asks whether there is a link between PSD2 and blockchain technology at all. As we will argue below, there may be a connection between these nevertheless.

6.3.2 The Future of Banking and Financial Services

Significant changes in competition and market structures in financial and banking services are likely to occur following the introduction of PSD2. Granting external third-parties access to payments and accounts services poses risks and business opportunities in the market of financial services, where an influx of now players able to enter and compete.

According to Claessens (2009), increased competition in financial services and banking may have the following effects: First, it should lower costs and incentivize innovation to increase efficiency and improve quality of financial services. Moreover, competition is said to facilitate access to financial services and promote financial stability, albeit with less conclusive causal links.[23] Overall, policy goals affecting competition is to ensure a healthy and robust competitive market. Banking and finance are systemically important gears facilitating economic activity. Hence, regulation and competition authorities are heavily involved to ensure financial stability and sound risk-taking by banks and other financial institutions. This shows that increased competition has trade-offs and needs to be balanced to optimize consumer welfare.

[23] This is not as straight-forward. A number of articles have found positive effects of bank size and willingness to lend. See Claessens (2009) for further referred articles. In the scope of our thesis, we do not go into further details.

Competition in payments and accounts services are now allowing technology companies and FinTech start-ups to offer payments services. By letting consumers opt in to let third party-providers initiate payments and services, companies will now compete to obtain digital equivalent of oil; namely data ("Data is giving rise to a new economy," 2017).

"Clearly, data analytics is something which people claim «wow, with this we can create new business" combined with PSD2 [..] This will provide a plethora of new services when Facebook, Google and the rest introduces financial services, of course we are going to opt in."

- Interviewee #1

Data analytics introduces a significant number of novel and improved financial services. A new service can be found in asset management. This service utilizes fully automatic robo-advisory, using tools as AI, machine learning and investor information to provide personalized investment advisory. This could potentially reduce operating costs, while enhancing investment decisions. The potential of such an application has sparked interest with commercial banks, exemplified by Skandiabanken, which has announced an acquisition of shares in Quantfolio (Finextra, 2017). [24]

Further, there has been a switch of focus to deliver mobile phone applications in banking. Mobile phones have taken hold as an important every-day device for all generations. Consequently, a range of applications in banking and financial services are currently being launched on mobile phones (Lipton et al., 2016). For instance, consumer spending and savings could be managed and monitored to provide a better user interface of accounts information. Moreover, users could receive feedback on their purchases to keep spending within a given personalized budget. As TPPs and banks gather data with increasing quality and volume, statistical and data analytic tools can be used to assess the user's behavior patterns, spending patterns and credit worthiness. Hence, a similar idea in mobile applications could be applied to other financial services such as stock trading, consumer loans and insurance.[25] Further, TPPs can utilize consumer data to optimize consumer targeting in marketing.

[24] Quantfolio delivers algorithmic based portfolio strategies using tools such as AI and machine learning. http://www.quantfol.io/

[25] Robinhood is a mobile application which delivers free stock trading. See: https://robinhood.com/.

Considering these new applications and services, banks and other financial institutions needs to evaluate how they should position themselves in the competitive landscape. Most informants agree that commercial banks should focus on their core functions, accepting deposits and lending.

"…their core functions will still remain, that is commercial loans, real estate loans which is their primary source of profits. [Banks] need to focus on delivering these services better..."

- Interviewee #7

Hence, it seems inevitable for commercial banks to lose parts in the value chain of financial services. However, an interviewee suggests that a possible strategy for commercial banks would be to cooperate with FinTech companies, acting as a platform to deliver new services and applications. Commercial banks could potentially gather a significant amount of data to improve their own services in lending by opening their APIs. Cooperating with FinTechs could also increase efficiency and reduce costs of services and procedures in which commercial banks currently offers themselves.

Moreover, technological innovation and the emergence of FinTechs may spur into new business models and opportunities for banks. Another interviewee suggests that blockchain technology could provide commercial banks to launch a platform which enables new marketplaces related to crowdfunding, direct stock purchases and voting in general assemblies. The bank itself will thus not be directly involved in the applications, rather it will facilitate procedures in compliance and security. This could create a network lock-in effect by motivating start-ups and FinTechs to launch applications on their platforms, creating a new revenue source while gathering data by linking involved participants to their network.

Despite the intention to increase competition and facilitate innovation, the issue of legacy core banking systems may restrict performance and capacity in front-end innovation altogether.

Moreover, an interviewee asks how current the infrastructure found in payments and accounts services will be able to handle an increase in volume of transactions. Further, it is stated that the payment infrastructure is currently financed by banks which cannot bear the full expense of volume increase with the entrance of TPPs offering payments services. One solution would be to split expenses in maintaining and facilitating the payments infrastructure until a better infrastructure is implemented.

We propose commercial banks to look into distributed ledger technology, which has been suggested by several interviewees as a viable solution in some use-cases, as an efficient and robust database. Moreover, the technology may facilitate a number of new business models as described above. To summarize, intermediation in banking and finance are likely to persist as providers of skill in capital allocation, industry knowledge and maturity transformation. However, banking business models may be susceptible for change as a result of financial technology innovation, changes in consumer preferences and an underlying trend of "decentralizing" economic activities.

6.3.3 Microfinance and Banking the Unbanked

During our interviews, several suggests blockchain and FinTech start-ups may find new business opportunities by banking the unbanked in developing countries.

"People in the Philippines and Latin-America struggle with insufficient funds for goods and services like health care, schools or investments. They lack savings mechanism, they do not have the same access to banks and so on."

- Interviewee #4

Emerging economies experiences exponential growth in public access to the Internet and affordable smart phones (Poushter, 2016). This poses opportunities for banks and financial institutions to introduce a mobile banking system, offering financial services previously not available for a significant amount of people. Potential revenue sources by using blockchain technology to facilitate financial inclusion, consumer and SME lending and other financial services are estimated to $380B (Baruri, 2016).

However, banks and FinTech companies face competition by cryptocurrencies and established mobile banking companies. To illustrate, Ghana and Nigeria has respectively 61% and 40% unbanked (*2016 Ghana Banking Survey*, 2016; *EFInA Acces to Financial Services in Nigeria 2014 Survey*, 2014). Recent data from Google Trends[26] shows immense interest in Bitcoin from these countries. Lack of access in banking services, poor financial infrastructure in

[26] As of 12.06.17: 1. Nigeria (100/100); 2. Ghana (73/100)

combination with double-digit inflation rate, incentivizes adoption of an alternative monetary system.

There is no discrimination in the access to cryptocurrency wallets. Moreover, Bitcoin and other public cryptocurrencies functions simultaneously as a payments system, circumventing the need to establish technological infrastructure in payments. Banks, FinTechs and other financial institutions needs to cooperate with governments and central banks to offer payments systems with legal tender money. This could subsequently strengthen financial infrastructure in developing countries and promote economic growth and financial inclusion (Morgan & Lamberte, 2012).

6.3.4 Regulation and Regulation Technology

Simultaneously with FinTech, another abbreviation has emerged. “RegTech” or regulation technology aims to introduce technological solutions in processes of regulatory compliance and other mandates (Nicoletti, 2017). Regulation has four main objectives; securing financial stability, prudential regulation, conduct and fairness, and competition and market development (Arner et al., 2015). Moreover it ensures consumer protection, efficient credit allocation and sound monetary control (Greenbaum, Thakor, & Boot, 2016). Recent years has seen an increase in regulatory compliances as a response to increased complexity and interconnectedness in the financial system ("Dodd-Frank Wall Street Reform and Consumer Protection Act," 2010). Cumbersome processes in tasks related to regulatory compliances and inefficient database reconciliation between financial institutions should consequently incentivize banks to overhaul their infrastructure to reduce these costs. Most of these tasks related to regulation have been done in-house by banks and other financial institutions. However, a new trend has been to outsource these operations.

FinTech entrants are now offering these services more efficiently and at a reduced cost, consequently fragmenting operating parts involved in regulation (Nicoletti, 2017). Outsourcing introduces both opportunities in banking business models and risks in the financial infrastructure. First, outsourcing parts of operating procedures allows banks to focus on core activities. This could reduce operating costs and introduce new value-added services. However, risks involved in outsourcing constitutes opaque routines and difficulties for regulatory authorities to keep track of involved parties.

There is a fine line between technological innovation and regulation. First, Arner et al. (2015) suggests regulatory authorities should resist taking an active role in regulating technological innovation and start-ups, as this is a waste of resources. A number of new ideas and products will fail before launch, consequently self-filtering new products. Consequently, regulation should act reactively to new innovation taking hold in the industry. Second, regulatory authorities should keep an interest in technological developments, especially by start-ups. Start-ups launching new products may not be fully compliant with current regulatory requirements but should regardless be incentivized to facilitate innovation (Arner et al., 2015). This is backed up by interviewee #10:

"...Regulation needs to adjust in light of technological innovation, but I believe start-ups will push innovation to a significantly larger degree than incumbent financial institutions."

Blockchain technology has been suggested by several informants to facilitate a new solution in Know-Your-Customer and Anti-Money Laundering procedures.

KYC and AML

Know-Your-Customer (KYC) involves screening personal information to verify and identify investors (Low, 2017). Related operating costs has increased significantly recent years and is expected continue in the coming years. On average, an financial institution spends $60M annually to meet Know Your Customer and Customer Due Diligence (CDD) obligations (Harrop & Mairs, 2016)

Current operations in KYC and CDD involves significant processing delays, lack of skilled labor to conduct regulatory compliances tasks and a changing regulatory landscape are challenges financial institutions face today. Ultimately, this creates unnecessary frictions.

During our interviews, a majority of our informants brought up regulation as one of the key points that blockchain could untangle and streamline processes. This holds especially in KYC and Anti-Money Laundering and Counter Terrorist Financing (AML/CTF).

"A number of banks are looking into blockchain technology and KYC. Currently, if firms have several banking relationships, firms may have outstanding loans in several places. Consequently, you need to submit new KYC information regarding changes in the board or annual reports to every involved bank because it is not currently standardized. Banks might ask for different things. Hence it is an excessive amount of work. However, by submitting this

information on your KYC profile residing on a blockchain could banks agree to submitted information."

- Interviewee #10

Using blockchain technology to initiate a global standard of KYC procedures could potentially reduce operating costs drastically. As information necessary for verification and identification needs only to be submitted once, financial institutions do not have retrieve the same information over again. Other financial institutions are subsequently allowed to call on information from the registry with customer consent. Moreover, blockchain reduces costs in reconciliation of databases. It follows from an informant that a standard is essential in applying blockchain technology to deal with KYC registries.

"…if we are able to agree on a national and international standard in KYC platforms where each entity submits their clients' credentials on an open KYC platform."

- Interviewee #12

Finally, blockchain technology could have significant impact on AML (Phillips, 2017). Combining new technology and data analytics, could facilitate real-time screening in suspicious transaction activity. This could also increase probability of discover potential misconduct by analysing data on call requests through irregular patterning. Further, hashing and timestamping consequently decrease risks in tampering information residing on the blockchain, ensuring trust by other financial institutions and regulatory authorities.

6.3.5 Accounting and Audit on Blockchain

Blockchain technology has been mentioned as a tool to provide higher quality of auditing. One of our interviewees suggest that blockchain technology may facilitate real-time accounting transactions, enhancing and streamlining cumbersome processes involved in auditing today. Further, he suggests that the role of accountants will change significantly. Using data analytics to increase the probability of finding patterns to reveal fraud, money laundering and spot illicit related party transactions has been suggested. This is in line with Deloitte (2016) and EY (2016), claiming blockchain has several use-cases in auditing and would free up time for auditors to offer other value-added services in auditing.

Depending on blockchain design, timestamping and cryptographic hashing of transactions could mitigate problems related to tampering. It is evident that transactions and other entries may be necessary to adjust in light of legislation, accounting standards and other

circumstances. However, using blockchains could trace proposed updates in accounting ledgers to ensure fair conduct. Enabling blockchain technology to increase trust in auditing may provide an opportunity for companies, regulatory authorities, and accounting firms to decrease the number of auditing incidents.

A number of accounting incidents has occurred recent years, exemplified by the related-party transaction scandal in Enron and EY missing Toshibas wrongdoings (Bratton, 2002; Uranaka & Wada, 2015). Reducing potential asymmetric information and moral hazard issues may be possible using blockchain technology combined with robust governance and read-access design (Yermack & National Bureau of Economic Research, 2017). To conclude, auditing may potentially change drastically in businesses processes and job roles of auditors. This does not spell the death of auditing however, only changes in business models of accounting.

6.3.6 Capital Raising

Crowdfunding

As we have discussed in decentralization, there seems to be a tendency of decentralizing economic activities facilitated by information technology in response to complexity and interconnectedness in the financial system. The infrastructure and processes of banking and finance have not been subject to drastic changes, until recent years. Just as industries of entertainment, media and more recently transportation and accommodation have faced changes in structural industry changes the last decades, banking and finance now face the same disruptive changes.

One of these changes occur in the rise of new financing platforms. Crowdfunding involves aggregating funds from a large number of individual investors (and institution) using social networks or crowdfunding platforms. Firms and individuals pitch their funding needs with financial information such as credit history and “soft” information such as business plans. Further, investors are compensated depending on type of crowdfunding; debt-based, equity-based, reward-based or donation-based. Crowdfunding have seen an increased interest recent years, followed by a significant increase in funding volumes

In times where low interest rates have been consistent and a number of potential revolutionary innovations of information technology, we face several changes in corporate finance. First, we present different types of crowdfunding and their operational functionality. Next, we identify drivers in demand and supply of capital and discuss advantages and disadvantages of these

platforms. Lastly, we identify economic agents of novel financing market to clarify incentives, regulatory concerns and changes in mechanisms to deal with asymmetric information which banks have been solving for a few hundred years.

Banking is in the market of information, connecting economic agents with excess supply of funds to those in demand (Haldane, 2013). Asymmetric information problems described by Akerlof (1970) are mitigated by financial intermediation in reducing market failures and allocates capital to "edible" lemons through monitoring and screening, aggregating information and experience over time and financing investments with tools of risk management such as duration matching and time transformation (i.e. short-term funding with long-term investments (in this case, supply of loans)). Historically, banking and financial intermediation has been effective way to facilitate economic growth by enabling reducing transactions costs and "optimal" allocation of capital in the economy. Moreover, commercial banks and other financial institutions holds a unique role in the financial system as creators of money in the issuance of new loans. However, a number of incidents as decline of public trust and inefficient credit supply post-financial crisis have seen novel financing platforms arise. Due to the scope of the thesis, we introduce debt and equity crowdfunding because of potential effects on banking and financial intermediation as we know it.

Debt crowdfunding emerged with Zopa[27] in the UK in 2005. In crowdfunding, it can further be split into peer-to-peer lending which involves consumer loans and peer-to-business lending as an alternative to traditional bank loans. Currently, debt crowdfunding makes up the largest share of capital in the crowdfunding space. Platforms based on crowdfunding involves two matching lenders and borrowers directly in a two-sided market. Borrowers pitch prospects which potential investors thus evaluate and compare with other alternatives. Depending on crowdfunding platform, rates are based on auctions or a credit assessment by the platform itself. Moreover, borrowed funds are usually success by an "All-in or Nothing" approach which returns funds back to investors should the project fail to fully raise wanted/required funding.

Further, equity crowdfunding involves more-or-less the same platform design, however it constitutes a mere 5% of outstanding crowdfunding capital and is fundamentally different

[27] https://www.zopa.com/

from debt crowdfunding in classification of financial asset. Equity crowdfunding can be seen as a financing alternative to traditional players as angels and venture capital funds. Moreover, there are hybrid versions of equity crowdfunding such as profit and revenues-sharing shares compared to pure equity. Due to regulatory compliances and financial regulation to protect investors, equity crowdfunding has been fairly limited so far. However, there are a number of regulatory changes which aims to open up possibilities and facilitate equity crowdfunding platforms.

In light of these new financing platforms, a number of questions needs to be discussed. What does these new platforms offer which traditional commercial banking does not? Moreover, with the advantages of banking such as screening & monitoring, risk management and accumulation of experience and knowledge of industries and borrowers?

Recent years have seen a significant increase in academic research on this field. First, (Tasca et al. (2016) finds that adjusting for credit risk in debt crowdfunding, interest rates offered to firms are comparable to interest rates of commercial banks. Further, Roure, Pelizzon, & Tasca (2016) and Blaseg & Koetter (2015) finds that debt crowdfunding increases in periods where access to credit by commercial banks tightens. Moreover, both studies find debt crowdfunding platforms to serve a part of the consumer market in high-risk, small-sized loans neglected by traditional commercial banks. In order to explain why these are rejected by traditional banks, authors suggest reputation costs linked to having a significant part of portfolio being non-performing loans, increased loss provisions as a result of increase in risky loans and the complex and inefficient lending procedures in extending loans.

Crowdfunding platforms may be able to pass down lower interest rates because of increased efficiency in infrastructures. By reducing operating costs with modern infrastructure to facilitate online platforms, it can compete with traditional commercial banks which incurs significant costs in operating physical retail branches and degrading IT infrastructure. Moreover, crowdfunding platforms introduces new tools from data analytics to provide credit and quality assessments based on several sources of information. Hard data based on an estimated financial plan with revenue sources and repayments of the project, meanwhile “soft” data such as personal information of the issuer, description of project and proposed business models.

However, debt and equity crowdfunding poses several problems. First, a significant number of start-ups fails. Crowdfunding platforms may fail to inform investors of the risk involved in financing start-ups in the event of delinquency. Hence, US regulation requires crowdfunding platforms to limit the amount investors can invest during a 12-month based on annual income and net worth (Comission, 2017). Moreover, equity issuances involve significant financial regulation, disclosing financial and accounting reports to protect investors. Start-ups and firms needs to provide an annual report to SEC, but it does not have the scope as listed firms. Consequently, financial regulation imposes limits on maximum amount in fundraising by start-ups and established firms, before requiring these to list shares on public exchanges (Comission, 2017).

Further, equity crowdfunding may have problems in liquidation. Early investors such as angels and venture capital funds are heavily involved in start-ups to assist with strategy and conduct financing rounds based on the start-up meeting certain thresholds. This does not necessarily hold for start-ups financed by crowdfunding. Consequently, the lack of exit options might make it harder for crowdfunding investors to liquidate their investments.

Finally, banks and other intermediaries has business models solely relying on having better information and experience in financing to achieve a competitive advantage. Moreover, they have unique roles in the financial system to provide credit and efficient capital allocation among alternative investments. Hence, it seems reasonable for banks to have netter information and industry experience than individual investors. However, Hockett & Omarova (2016) argues that the aggregate knowledge of an significant large number of investors should be able to provide better price discovery than an single intermediary.

Despite these problems, Haldane (2013) welcomes these new types of disintermediated finance as a response to the increased “financialization”, increased complexity, and interconnectedness of the financial system. In the event of a platform default, this should not have a direct impact on other crowdfunding platforms (Tasca et al., 2016). Further, P2P and crowdfunding platforms does not create new money as commercial bank loans do, and should thus not have an significant impact on financial stability (Lipton, 2017). However, in the case of loan default of unsecured, investors need to understand the risks of not being able to claim

any repayment on the firm (Boel, 2016). Crowdfunding platforms such as MoolahSense[28] have put in place mechanisms which holds firms' directors to be held personally accounted for issued loans. Clearly, as research identify firms and projects in debt crowdfunding as opaque and risky while simultaneously deemed unprofitable for commercial banks, investors have to be informed and educated the investments. This is stressed by regulatory authorities such as Financial Conduct Authority which imposes strict KYC and AML regulation on these platforms to mitigate the highlighted risks (FCA, 2015).

To conclude, disintermediation of finance has both its perks and drawbacks. It seems reasonable to to be a viable alternative in smaller investment projects and projects which are not deemed profitable by commercial banks.

Initial Coin Offerings

Initial Coin Offering (ICO) offers a fully decentralized crowdfunding on a blockchain. An ICO is a privately issued cryptocurrency (token) representing a claim in a decentralized organization residing on a blockchain. Decentralized Autonomous Organization (DAO) are based on smart contracts, which specifies its governance model and purpose in the functions of production and value creation in the cryptoeconomy, similarly to peer-to-peer production (Benkler, 2006; Mougayar, 2015). Further, smart contracts in DAOs governs shareholder rights, ownership structure and profit distribution.

The issuance of tokens is essential to bootstrap these types of organizations. First, tokens could theatrically represent any type of claim, such as equity, debt or a hybrid. Simultaneously, it functions as a container of value acting as a reward and payment vehicle in the cryptoeconomy. Mougayar (2017) defines these tokens as, "*a unit of value that an organization creates to self-govern its business model, and empower its users to interact with its products while facilitating the distribution and sharing of rewards and benefits to all of its shareholders".*

According to Loizos (2017), the process of an ICO starts when a decentralized business model has been formalized and achieved a robust code base. Next, it submits an announcement of token pre-sales with relevant business information such as purpose, roles and features (Mougayar, 2017). Further, the Proof-of-Concept white paper of the ICO is published to be

[28] Marketplace lending platform connecting SMEs and investors, based in Singapore

assessed and peer-reviewed by potential users and investors. This requires users to engage in discussions and come up with suggestions in improving the concept before the ICO is set in motion. Finally, the DAO is launched on top of a public blockchain, such as Ethereum. Tokens are issued by investors exchanging private cryptocurrencies, such as Ether or Bitcoin, into the issued tokens. Prices are initially set the by issuing DAOs, subsequently allowing market dynamics to decide price development after issuance (Kastelein, 2017).

The success and failures of ICOs have been mixed. Some projects have returned investors several thousand percent while others have failed miserably, practically scamming fund of investors. An example is Monero, a (controversial) cryptocurrency focusing on in transaction privacy and scalability, achieved returns close to 2800% in 2016 (Greenberg, 2017). Another example is Ethereum. In 2014, the project raised $18,4M in 42 days, holding a top 10 placing in the funding amount achieved by crowdfunding. At the time of writing this thesis, ICOs have already raised $180M in 2017, close to doubling the total amount raised in 2016 at $101M (A. Levy, 2017). Clearly, there seems to be a hype in ICOs, by looking at published articles in mainstream media and interest from individuals not necessarily engaged in the ideological aspects of the cryptoeconomy (Hackett, 2017; Kaminska & Murphy, 2017; Vigna, 2017).

According to Kastelein (2017), an ICO brings several benefits in terms of innovation and increased decisional freedom for start-ups compared to traditional equity funding. Innovation in cryptoeconomy needs to simultaneously find new business opportunities while finding mechanisms to enforce terms in smart contracts and transparent monitoring to protect investor funds (Davidson, De Filippi, & Potts, 2016). This facilitates a loop of iteration, which may increase innovation exponentially. This is in line with an interviewee, stating that everything is “tried out” in the space of ICOs, cryptocurrencies and the cryptoeconomy. As these organizations can operate outside jurisdictional boundaries of the real economy, the test-and-failure approach can spur innovation immensely. Moreover, ICO bypasses the traditional venture capital and angel investors, essentially removing third parties to obtain funding. Consequently, business decisions are solely based on terms written in code and stakeholder voting. Despite the potential benefits of an ICO, several issues of concerns emerge.

First, risks related to scam and malicious conduct seems to be a pressing issue. A number of ICOs has been involved in stealing funds, not delivered on their contract terms, nor provided any real use-case utility (Mougayar, 2017; Suberg, 2015). Second, ICOs are completely unregulated and non-enforceable in legal jurisdictions. Naturally, ICOs have been called the

"Wild West" of finance (Kastelein, 2017). ICOs constitute a legal loophole as it is not deemed a financial security subject to regulation. However, regulatory authorities are looking into the matter of ICO as we speak. According to Chavez-Dreyfuss (2017), the increased popularity has provoked a statement from the Securities and Exchange Commission (SEC), which emphasizes the need for investor protection in these financing schemes. Human incentives and risks of moral hazard, seems to be a significant obstacle in facilitating trust in ICOs. This follows by an informant,

"By its very nature it feels kind weird not to scam it. So that is what I think is the interesting bit, how to make sure that the transparency is maintained. And the people who are kind of becoming investors and taking part in it, are not victims of some sort of scam".

- Interviewee #6

Hence, embedded mechanisms and governance models needs to enforce contracts, facilitate precise and robust code writing, securing investors and stakeholders of scams and recanalization and detection of undesirable actions by the DAO. These issues are resolved in the real economy by regulation, law and corporate governance. In an economy where contracts and property rights are no longer enforceable by law, other mechanisms need to step in. The same interviewee as above suggest to rely on innovation in self-enforcing and self-governing mechanisms as pointed out by Davidson et al. (2016),

"One way of doing it is that you kind of involve your own users, or you involve your own community […] The moment you get external funds and external people investing, suddenly the price goes up or whatever, then you have this injection of foreign capital, and then it usually falls apart. […] I think this concept of self-organizing and self-validating and self-reinforcing is kind of fundamental here. So, it's just not the economics, not just the technology, but it's kind of the mechanisms. You know, because in normal society we do have those regulatory mechanisms."

There are initiatives trying to facilitate increased legitimacy of ICOs. External rating agencies, such as ICOrating.com, aggregates information regarding business models, anticipated future development and developer team to provide an independent and prognostic review on ICOs. This could potentially reduce some of the asymmetric information problems, especially relevant for investors which are not heavily involved in computer science and cryptography. Moreover, this forces DAOs considering an ICO to be transparent and detailed in their ICO proposal to establish trust and credibility. Having an anonymous development teams, clearly

lacking purpose and goals in the business model and opaque source code would not be a desirable investment by the community.

Moreover, there are blockchains being developed to facilitate digital jurisdictions with mathematical verification techniques proving robustness of the code governing transactions and a decentralized court system to solve human disputes.[29] Hence, a DAO can launch their organization on top of blockchains with digital jurisdictions, such as Tezos and Aragon, which themselves are built on-top of platforms as Ethereum. This allows interoperability and transactions between DAOs while facilitating self-enforcing and self-governance in the cryptoeconomy.

However, considering these solutions several issues needs to be addressed. First, it requires solid understanding of programming and computer science to evaluate the robustness of a DAO. Even if rating agencies and advisory companies might be able to reduce some of the problems related to asymmetric information, these are themselves not regulated not monitored. Consequently, reducing asymmetric information by centralizing investment advice ironically oppose the very foundation of the cryptoeconomy, namely decentralization. Investors and stakeholders lacking knowledge and skills in programming will have to trust DAOs to conduct fairly and rating agencies offering investment advice. Hence, a solution needs to be found in the lack of monitoring the ones responsible for monitoring in an unregulated environment (T. Stamland, personal communication, June 13, 2017). This is also in line with interviewee #6's view:

"*I think several regulatory aspects are very immature yet. There is progress, some companies are trying to be transparent, they are trying to show how money flows, how the voting is happening and so on and so forth. But, you know, it is still kind of a space for manipulation for those early entrants, and they usually keep quite a big stake in the venture so they can maneuver the system for their own benefit."*

To summarize, ICOs and decentralized autonomous organization may have great potential and possibly present new ways in organizing economic activity. However, ICOs are still in its

[29] Examples of blockchains with a digital jurisdiction are Tezos (https://www.tezos.com) and Aragon (https://aragon.one)

infancy and the lack of real business applications needs to be addressed in order to mitigate potential hype cycles and loss of trust by investors.

TheDAO

TheDAO was a DAO designed as an investment fund without human managers, launched on the Ethereum platform in 2016 ("The DAO of Accrue," 2016). In hindsight, we can call it an ambitious experiment in completely decentralized governance, with important consequences for later projects. The entire organization was run by smart contracts which enabled holders of tokens to vote for investment projects.

The ICO of TheDAO still holds the record of funding, raising over $150M with 11,000 individual investors in a 28-day window from 30th of April 2016. However, during the funding period, some vulnerabilities were uncovered and it was raised concerns regarding the security of the source code. While developers were addressing these issues, an unknown hacker exploited these vulnerabilities, stealing an estimated $60M from the fund. In light of this hacking, a controversial governance decision was made by the Ethereum Foundation.

In order for investors to have their funds returned a decision were made by the developer team of Ethereum to reverse the timeline of blocks, consequently “starting over” at the block preceding the time of attack. The decision to reverse the blockchain were done by voting allowing stakeholders in Ethereum vote in a defined time-window. A significant majority voted in favour of reversing the blocks, but not without a controversial debate in the cryptocurrency community. A group of opposing participants did not follow suit and rejected the updated protocol by continuing the chain of the hacking incident. This blockchain is now under the name of Ethereum Classic (ETC). The decision to continue was based on ideological and technical differences of opinions within the community. At the point of writing this thesis, the market value of Ethereum compared to Ethereum Classic is $384,45 higher.[30] We interpret this as the market supports the decisions made, having confidence in the governance-model of ETH. In sum, however ambitious TheDAO proved to be, it emphasizes the need for a tire-kicked system. The incident exemplifies the risk of failure and loss of funds by investors.

[30] 12th of June 2017

7. Conclusion

In this thesis, we provide an assessment of the blockchain technology and its potential future applications. Blockchain is a decentralized distributed database, offering a tamper-proof record, cryptographically secured in which all participants in the network shares the same information. The most known application today is Bitcoin, a money and payments system designed to circumvent intermediaries. In the last couple of years, blockchain technology has caught the attention of the very intermediaries it was designed to bypass. By designing an explorative case-study, we conducted 20 in-depth interviews and carried out a broad literature search. We arrived at highlighting two main topics, namely the future of money and the future of finance.

Cryptocurrencies have evolved from being a payment solution to a series of specialized applications using the underlying blockchain technology. By downloading a client, everyone can participate in permissionless blockchains, either/both by maintaining the network or utilizing it as a means of transaction. Some blockchains are designed to run complex smart contracts, consequently, offering a whole new decentralized economic system known as the "Cryptoeconomy". Cryptocurrencies is not solely a medium of exchange, but an instrument enabling a self-governing network to function. Additionally, we find that these networks need to have a sound governance design to not be ousted by competing currencies. There are conflicts of interest within the Bitcoin network, where some want Bitcoin to be a speculative investment vehicle while others aims to use Bitcoin as an alternative money system.

Furthermore, we discussed how Central Bank issued Digital Currency (CBDC) could be a complement or replacement of physical cash. We find that such a solution is not necessarily dependent on blockchain technology. However, if the responsibility of updating and maintaining a CBDC network is spread across financial institutions, blockchain technology pose as a viable and robust solution implementing CBDC. There are key differences between a private cryptocurrency and CBDC, where the latter would require central bank guidelines and regulatory compliance. CBDC introduces new toolkits in fiscal and monetary policy. Moreover, it may be a viable means of fighting tax evasion and the shadow economy. Conversely, the implications of the public having an account in a central bank could pose profound consequences for commercial banking.

We argue that traditional financial institutions may be standing in front of a wave of competition by new entrants. Technological giants and Financial Technology (FinTech) start-ups are providing new, efficient and less costly solutions to old problems. The banking industry may risk lagging behind due to outdated core banking systems and traditional banking business models may be at risk.

Blockchain technology may facilitate a number of applications in banking and finance. Several initiatives are trying to optimize and streamline cumbersome processes. Programmable agreements which automates cumbersome processes, called smart contracts, are the most prominent aspect of blockchain technology. We observe that the technology is still in an early stage and there are several challenges which need to be solved, such as human interpretation and enforceability issues.

Moreover, blockchain could streamline Know Your Customer and Anti-Money Laundering processes, potentially reducing compliance costs. Further, accounting and auditing could benefit from higher quality data in combination with data analytics, finding irregularities automatically. Microfinance and banking the unbanked could be facilitated through mobile applications based on blockchain architecture. Lastly, blockchains introduce disintermediation in finance without centralized platforms. Capital raising through Initial Coin Offerings, is a new way of funding projects based on blockchain in the cryptoeconomy. Several projects have seen extreme returns, but it is not without drawbacks. This funding scheme is not regulated and is heavily reliant upon the cryptoeconomic community to avoid scams.

Blockchain has a wide range of applications. From facilitating a cryptoeconomy as a new decentralized economic system by public blockchains, to the financial intermediaries interested in cost savings and efficiency gains utilizing private blockchains. Private blockchains are heavily reliant upon a common agreement of standards to compete with established systems. We draw a parallel between the Internet in the early 1990s and the current technological maturity of blockchain. The most promising aspect of the technology is the possibility to create smart contracts with a range of applications, from decentralized autonomous organizations to simple settlements.

Financial Technology (FinTech) has gained an increased attention over the last couple of years with innovations such as Robo-Advisory and Mobile Banking.

Ultimately, we aimed to raise awareness and reflection upon the potential changes introduced by blockchain technology and cryptocurrencies.

This thesis is limited both in time and the depth of topics covered. Several suggestions could be made with regards to recommendations for further research. We discussed a range of topics regarding the implications a cashless society would face with an introduction of CBDC. The macroeconomic implications of CBDC and how banking business models may change is still an area that need further research.

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Appendix A: Interview request

Interview request

Master thesis, Norwegian School of Economics
Topic: Blockchain and financial sector

Hi!

We are two students from the Norwegian School of Economics who currently are writing a master's thesis about blockchain. Our main motivation is investigating what this technology represents in terms of potential changes in the financial sector, and we would really appreciate getting in touch with you to conduct an interview, where we would like to know how you and your organization views.

Following is a list of topics we would like to discuss:

- Technological innovation
- Knowledge of blockchain technology
- Blockchain – what the technology represents
- Application areas of blockchain
- Opportunities and threats

We sincerely hope that you wish to contribute both with your expertise and points of view. The interview is expected to last nothing more than one hour and where we are not able to conduct it face-to-face, Skype/Google Hangouts/phone is an alternative. Following below are our contact information – and we hope that you are as enthusiastic as we are and don't hesitate for a pleasant conversation!

Best regards

Geir Iversen
Phone: [redacted]
E-mail: [redacted]

Runar Alvseike
Phone: [redacted]
E-mail: [redacted]

Note: Directly identifiable personal information will be anonymized in published material, but indirect information relevant for the analysis may be published. Collected data material will be secured during the process of analysis, and anonymized by the projects end.

Appendix B: Interview guide

Semistructural Interview guide: Technology Innovation & Strategy - Blockchain

Factual questions and introduction

- *Motivation: Try to get an overview on the interviewee and their role at the company/entity they are employed by*
    - **What does your company/entity do in the financial ecosystem?**
    - **What is your role in the company?**
      What kind of trends and changes have you observed within your industry in recent times?

Questions with regards to innovation and overall blockchain technology

- *Motivation: Try to get an overview on how the interviewee and company/entity understand and their views and opinions on the blockchain technology*

  General Technology
    - **How does your company/entity view technical innovation?**
        - Probe: *Short- vs. long-term implications of new technology changing business practices*
        - Probe: *Experiences with changing business practices*
    - **How does your company/entity work with technological innovation?**
        - Probe: Technological innovation strategy, target areas, rethinking or optimizing

- *Blockchain Technology*
    - **What is your relationship to blockchain technology – are you aware of any applications of blockchain solutions today in your industry?**
        - Probe: *First point of interest*
        - Probe: *Accumulated knowledge about the technology*
        - Probe: *Genuine interest or pressures of competition (push or pull)*
    - **What is your standpoint and opinion on blockchain technology?**
        - Probe: *Positive or negatively biased – influences from BTC scandals*
    - **Is your institution/company currently involved in any blockchain project?**
        - Probe: *Internal development/collaborations*

    - **What kind of consequences (if any) will blockchain technology bring for your industry?**
        - Probe*: Long-/short-term implications for current business models – openings for new models*
        - Probe: *Potential benefits, gains, overall market and for company/entity*
        - Probe: *Potential drawbacks, limitations, challenges*

    - **What kind of hurdles must be sorted out before you see your industry adopting blockchain technology full-scale?**
        - Probe: *Security issues – permissioned vs. permissionless systems*
        - Probe: *Regulation implication – fintech sector*

- Probe: *Existing vs. new technology developing side by side – streamlining vs. disruptive changes*
- Probe: *Immutable record – garbage in/garbage out*

- **Given the current hurdles/drivers of cost in your transaction processes – how do you reckon future solutions would look like? Is your industry exposed to drastic change within 2-5 years?**
  - Note: Modify for specific interview (Stakeholders in industry, transaction cost drivers)
  - Probe: *Regulation, drivers of change in business models*
  - Probe: *Short-/long-term optimism/pessimism*

- **What is your view on Open-Source development of technological innovation – advantages & disadvantages with this type of organization of development?**
  - Probe: *High requirements in cryptography and mathematics (security)*
  - Probe: *Application development → In-house vs. collaborative*

- **In light of emerging several strategic alliances and consortium, what are your thoughts on collaboration with development of blockchain tech?**
  - Probe: *Consortium, in-house development, strategic alliances*
  - *Eksempel på First Mover vs. Follower på teknologisk innovasjon. Vipps vs. MobilePay vs. mCash*
  - *Here is a lot of examples of collaborations and consortium trying to develop applications with blockchain technology – why do you think we see this form of organization instead of in-house development?*

- **Other reflections with regards to blockchain technology?**
  - Note: Sector/industry specific customization
  - Probe "Regulations": *Financial supervisory, AML: anti money laundering, KYC: know your customer, financial crisis, technology disruptions, transparency*
  - Probe: *Intellectual property rights*
  - Probe: *Smart contracts*
  - Probe: *Applications; (trade finance, B2B/P2P cross border, repos, derivatives)*