Consequences of the implementation of blockchain technology

A grounded theory study to develop a conceptual framework on the perceptions of actors on the consequences of implementing blockchain technology.

(This page is intentionally left blank)

Consequences of the implementation of blockchain technology

A grounded theory study to develop a conceptual framework on the perceptions of actors on the consequences of implementing blockchain technology.

Master thesis submitted to Delft University of Technology
in partial fulfilment of the requirements for the degree of
Master of Science Systems Engineering, Policy Analysis, Management

To be defended on the 20th of April 2017

D.B. (David) Meijer
Student number: 4081617

Graduation committee
Chairperson: Prof.dr.ir. M.F.W.H.A (Marijn) Janssen (section Information and Communication Technology)
First supervisor: Drs. J. (Jolien) Ubacht (section Information and Communication Technology)
Second supervisor: Dr. A.F. (Aad) Correljé (section Economics of Technology and Innovation)
External Supervisor: Ir. F.A. (Floris) Schoenmakers (oneUp.Company)

"Constantly seek criticism"
Elon musk

I. Foreword

Sometimes, everything just comes together

Although this research started in October 2016, the foundation of this research was built in the April 2016. I had finished all my courses for my master, without a clue what to do for my master thesis. This piece "great" time management was fortunately solved by oneUp.Company, who gladly directly involved me in their day to day business as an intern. Five months later I've had more responsibilities than most people have had in their first years on a job. The incredible amount guts to trust a student with so much responsibilities still astonishes me, and is something I will not forget. Many, many thanks to everyone at oneUp who has helped me during my internship, you know who you are, but especially: Mark, Joris, Floris, Jef, Jan and Thi Nga.

Sometimes, everything just comes together.

After this internship, my thesis could no longer be postponed. As one of the main subjects I dealt with at oneUp was blockchain, we discussed the possibilities. Quickly, I could include Jolien into this process. Jolien happened to be my supervisor for the Thesis Preparation course, happened to be one of the blockchain experts at TPM and happened to be an expert in the Grounded Theory approach.

Sometimes, everything just comes together.

Jolien, throughout this thesis you've been an invaluable source of information, encouragement and guidance. Without you this research would not have been possible. Also, many thanks to the rest of my committee, Marijn, Aad and Floris, were also indispensable to this research. Your academic insights helped me improve the scope, focus and importance of this research.

Sometimes, everything just comes together.

Finally, this research could not have been made possible by an incredible number of people; family, friends, acquaintances and even some strangers, I think that I've either complained, or asked for guidance from most of you. I'm certain however, that I talked "a bit" too much at one time or another about my thesis... Again, it is impossible to list everyone, but: Mark, Lotte, Maaike, Niels, Jan-Wouter, Maurits, Emma, Iris, Peter, Bente, Peter. I owe you guys, and hope to repay the favour one time!

Sometimes, everything just comes together.

In the end, I hope to have contributed to the current blockchain madness that is going on. Thanks to everyone mentioned above, I strongly believe that in the end:

Everything just came together.

David Benjamin Meijer
April 2017

PS. Many thanks to everyone who kept my spirits up as the days went on: Thomas & Paul, Jeremy, Barry & Robin & Maurice, Adam & David & Charlie & Dan & David & Jim & Millard, Nicky & Mark & Shane & Kian & Bryan, Walter & Donald, Don & Glenn & Bernie & Joe, Stijn & Bert, and many many more.

II. Summary

Blockchain technology, the technology underlying the cryptocurrency Bitcoin, has attracted the interest of a multitude of actors since its invention in 2009. As a part of the 4th industrial revolution, "characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres"(Schwab, 2016b), it has the potential to significantly impact society.

A blockchain is a shared and secure database, which is not controlled by a single user but by the network as a whole. Thus, a blockchain represents a "distributed database or ledger, which uses a secure protocol where a network of computers collectively verifies a transaction before it can be recorded and approved. Therefore, blockchains can be used to create trust, by enabling people who do not know each other (and thus have no underlying basis for trust) to collaborate without going through a central authority" (Schwab, 2016a, pp. 22,23). Blockchain technology was first seen in the digital currency Bitcoin, where it was used to verify and store transactions of this digital currency. This enabled a *decentralization* of digital value exchange, which was impossible before blockchain technology. Digital transactions before Bitcoin and blockchain were always conducted using a trusted third party, or intermediary, such as retail banks.
As blockchains are a special kind of databases, the term blockchain refers to an underlying database structure, and they can do more than store transactions. Developments in blockchain technology have expanded the possibilities to a "world computer" based on blockchain technology. This blockchain world computer (called Ethereum) can run decentralized computer-code on a blockchain database. This enables a decentralized computing network, without a central authority. A blockchain computer can thus be used to program anything, while being computed on a blockchain. Blockchains can therefore be used to transact physical assets, created binding contracts and even create organizations through corporate bylaws captured by smart contracts. Howard (2015, para. 18) summarizes the characteristics of blockchain technology as follows:

- "As a public ledger system, blockchain records and validates each and every transaction made, which makes it secure and reliable;
- All the transactions made are authorized by validators, which makes the transactions immutable and prevent it from the threat of hacking;
- Blockchain technology discards the need of any third-party or central authority for peer-to-peer transactions;
- Decentralization of the technology"

Under the effects of the growth and hype of blockchain technology, an unclear image has been created on the possible consequences that blockchain technology might have. Incumbents, as banks and governments, and new entrants, as Bitcoin and Arcade City, take distinctly different approaches to these consequences. Incumbents view blockchain technology in light of *enhancing* their business models, while new-entrants see completely new *disrupting* business models. To help structure the discussion on the consequences of blockchain technology, a conceptual framework is needed.
As there are currently no such frameworks in scientific literature, the goal of this research is to create *a conceptual framework that provides an overview of the perceived effects, functions and issues of blockchain technology, to help structure the discussion by actors on the consequences of implementing blockchain technology.*
Therefore, this research answers the following research question:

"What effects, issues and functions can be discerned and conceptualized that capture the consequences of the implementation of blockchain technology?".

In this research project, blockchain technology is defined as a *distributed, shared, encrypted, chronological, irreversible and incorruptible database and computing system (public/private) with a consensus mechanism (permissioned/ permissionless), that adds value by enabling direct interactions*

between users. This research focusses on the perceived consequences of the implementation of *applications* using blockchain technology.

This research question is answered by using the Straussian Grounded Theory research approach (Corbin & Strauss, 1990). This research approach is most suited for this research, as it allows the emergence of a new conceptual framework on the consequences of implementing blockchain technology that is grounded in empirical data. Such a framework is not yet found in scientific literature.

This research resulted in a conceptual framework that describes the current discussions by actors (as corporates, new entrants and critical journalism) on the possible consequences of blockchain implementation, which is presented in Figure I.

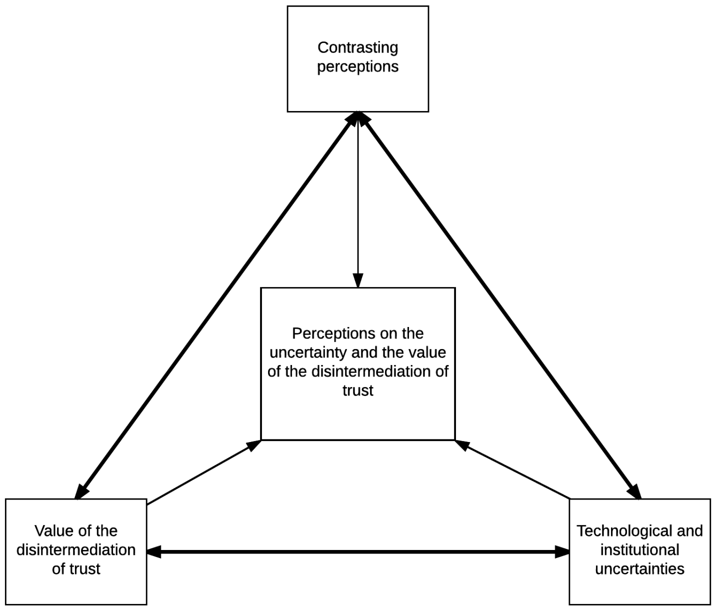


Figure I – Conceptual framework on blockchain implementation consequences

The discussion on blockchain technology is centered around three categories:

- *The Value of the Disintermediation of Trust:*
  The cost and benefits of implementing blockchain technology
- *Technological and Institutional Uncertainties:*
  The technological immaturity, lack of institutional framework and reaction to blockchain technology causes high uncertainties
- *Contrasting perceptions:*
  Highly different perceptions of involved actors on the value and technological and institutional uncertainties related to the consequences of implementing blockchain applications.

Furthermore, the blockchain discussion is focused around *environments with highly institutionalized values*. These are sectors, actors, processes or arrangements with highly institutionalized values, either through an institutional framework or through history. Examples include governments, the financial sector or trade in valuables. In this research, these characteristics were conceptualized into our empirical core category as "*Disintermediation of trust in environments with highly institutionalized values", which was argued step-by-step in chapter 5.*

This empirical core category was compared to existing literature in other scientific fields to refine and strengthen it. Due to the importance *of* trust we firs related our core category to Trust research.

We use the conceptualization of Trust by Nooteboom (2002). Nooteboom conceptualizes Trust as part of a higher-level concept *Reliance. Reliance* says that a trustor can rely that a trustee behaves as expected. Nooteboom conceptualizes reliance in two concepts: Trust and Control. Trust considers the intentions and competences of the trustee. Control considers the ability of the trustor to *control* the behavior of the trustee, through deterring the trustee to behave in contrast to the trustors expectations. Examples of deterrence include controlling opportunisms by lowering the possible actions of a trustor, and controlling incentives by providing positive or negative incentives to the trustee to behave as expected.

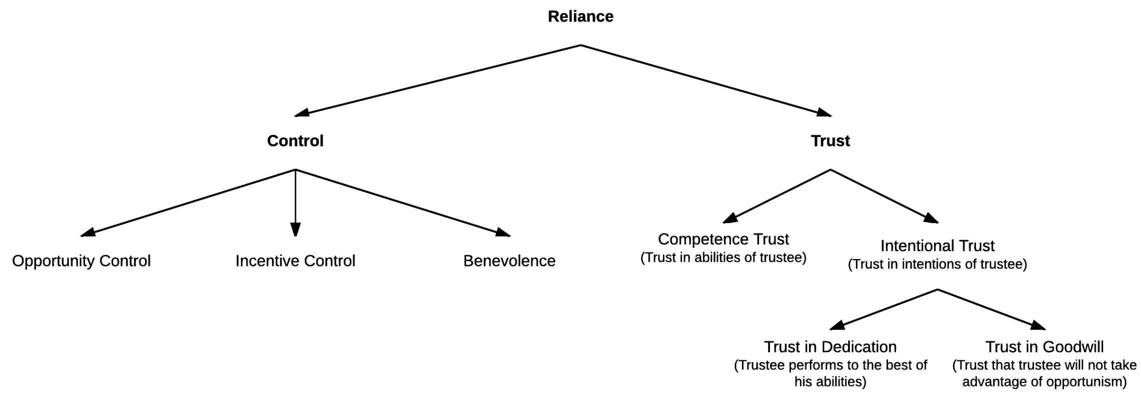


Figure II - Conceptualization of trust by Nooteboom (2002)

Using this conceptualization on blockchain technology we conclude that blockchain increases the possibilities for control, as blockchains ensure that contracts are performed as prescribed. Furthermore, blockchains offer high incentives to behave per expectations. However, due to incomplete contracts, complete control (even in blockchains) is impossible. Trust therefore still plays a role in blockchains. For example: Users trust the competence of the developers of blockchain technology, users trust other users not to create contracts that are advantageous to the trustor, and users trust the validators in the network to run an honest and fair blockchain. This conceptualization therefore helps us to conclude that previous uses of the **term *trust* in this research therefore actually refers to *reliance*, as trust in blockchains often are more aimed at *control* than *trust*. However, blockchains are unable to provide complete control.** Therefore, blockchain cannot completely replace trust, whereas this is a dominant view in our empirical data. Currently, the actors in the discussion are not aware of this conceptual, semantic difference, which is at the core of the lack of structure and overview in this discussion

Thus, blockchain technology increases control between counterparties in a transaction. However, due to the decentralized nature of blockchain technology, the control from a systems-perspective decreases. According to literature on decentralized decision making, a loss of control over the outcomes and system is expected in every decentralized decision making processes.

The current blockchain discussion is therefore best captured by incorporating the two previous conclusions: The tension between increasing control between actors in a transaction, and decreasing control on the complete system explains the discussion on blockchain technology. Incumbents, such as large banks or insurers, are interested in the possibilities of increasing control within the system, but are hesitant to give up control over the complete system. This contrasts with the views of the new entrants, such as Arcade City and Bitcoin, which are interested in both the increasing control over other actors in the system, and decreasing the control of incumbents over the complete system.

To fully capture these conclusions, we have to redefine our empirical core category *disintermediation of trust in environments with highly institutionalized values.* The tension between increasing control of counterparties in a transaction and decreasing control from a systems-perspective, is characterized by an increase in *power* of end-users, and a decrease of *power* of incumbents. As both an increase and a decrease of power emerged, this is best captured by *"a power transfer"*. Thus, this leads us to present our final core category as ***power transfer in environments with highly institutionalized values.*** This final core category captures the essence of the implementation of blockchain technology, thereby structuring the discussion and helping actors with the decision whether to implement blockchain technology.

Together, the insights presented in this summary answer the research question of this research:
"What effects, issues and functions can be discerned and conceptualized that capture the consequences of the implementation blockchain technology?"

The conclusions presented in this summary have both societal and scientific relevance. The *Scientific Relevance* of this thesis is three-fold. First, it presents a first scientific, empirical overview of the discussion on blockchain implementation, which was not yet available in scientific literature. Second, the explanatory power of our core concept enables new research into essential blockchain foundations, as *Trust* and *Decision making.* Finally, our comparison to decentralized decision making literature showed the importance of using social sciences into this field dominated by computer scientists and acknowledging the importance of governance structures in blockchains.

Our core concept is closely related to the *societal relevance* of this thesis. First, the overview presented in our framework provides holistic, understandable insights into the blockchain trade-off for actors, such as incumbents and new entrants. Second, our core category provides a clear representation of the core discussion on the implementation of blockchain applications, which further helps to *structure* the discussion on blockchain technology. Third, our literature comparison to trust research identified an important, semantic difference in Trust, Reliance and Control. The introduction of these differences into blockchain research is paramount to further develop the understanding of blockchain technology in practice. Together, these three notions, form the societal relevance of this research. A strong conceptualization of blockchain technology helps to create understanding of the possibilities of the technology and enables actors to discuss the *essence* of blockchain consequences, thereby structuring this discussion and helping actors with the decision whether to implement blockchain technology.

This research provided a starting point for further research, as it provided a strong basis to start from. Most important future research could focus on a further (quantitative) refinement of *Environments with highly institutionalized values,* to present decision-makers with clear criteria or factors (even decision making tools or frameworks) on when to use blockchain technology. Also, *further comparison of our core category to Trust research and Decision making literature* could further improve the conceptualization of blockchain technology in scientific literature. Finally, the *formalization of our substantive theory* on blockchain technology consequences is paramount to further develop understanding of blockchain technology from an economic perspective.

III. Table of Contents

IV. List of Figures

V. List of Tables

VI. Glossary of Terms

Axial Coding

A) "In the Axial coding phase, categories are related to their sub-categories, and the relationships tested against data" (Corbin & Strauss, 1990 p.13)
B) Coding process aimed at creating *dimensions* by grouping *properties* into higher-level concepts

BitCoin

A) The first implementation of Blockchain technology
B) The BitCoin blockchain
C) The BitCoin Currency used on the Bitcoin Blockchain

Blockchain

A) "A" blockchain refers to the underlying database in blockchain implementations
B) "The" Blockchain should only be used to refer to a specific blockchain implementation (the Bitcoin blockchain, the Ethereum Blockchain).

Blockchain Technology A distributed, shared, encrypted, chronological, irreversible and incorruptible database and computing system (public/private) with a consensus mechanism (permissioned/ permissionless), that adds value by enabling direct interactions between users

Categories A group of *dimensions* that are grouped and interrelated. Emerge in the Selective Coding phase

Classical Grounded Theory (CGT) Original Grounded Theory approach by Glaser & Strauss (1967)

Coding Describing an issue or interest in a short manner (Allen, 2003)

Empirical Data The 56 documents used in this research project

Dimensions A group with *properties* that are grouped on common interest, or subject. Emerge in the Axial Coding phase

Ether The digital currency used in the *Ethereum* blockchain

Ethereum A world computer based on blockchain technology, able to run smart-contracts

Formal Theory Theory based on "validated, generalizable conclusions across multiple studies" (Dwivedi, 2009, p. 55)

Grounded Theory "a qualitative strategy of inquiry in which the researcher derives a general, abstract theory of process, action, or interaction grounded in the views of participants in a study" (Creswell, 2009 p. 14)

Open Coding

A) "the interpretive process by which data is broken down

	analytically, [which is aimed at providing] new insights by breaking through standard ways of thinking about or interpreting phenomena reflected in the data" (Corbin & Strauss, 1990 p.12) B) Coding process aimed at creating a *long-list of properties*, which are found in sources, which are linked together using a variety of codes
Properties	Codes used in the Open coding phase, which describe a quote
Selective Coding	A) "the grounded theorist writes a theory from the interrelationship of the categories in the axial coding model" (Creswell, 2002, p. 426). B) Coding phase aimed at interrelating and grouping *dimensions* into *categories*
Sensitizing Concepts	A) "sensitizing concepts merely suggest directions along which to look (Blumer, 1954 p.7) B) Used in Grounded Theory to "[structure or] framework analysing empirical data and, ultimately, for developing a deep understanding of social phenomena." (Bowen, 2006, p. 20)
Smart contracts	Computer code that can be ran on a blockchain
Straussian Grounded Theory (SGT)	Adapted Grounded Theory approach by Strauss & Corbin (1990) in which the main changes that were "incorporated were to the coding structure adding more procedures on how to code and structure the data"(Evans, 2013, p. 43). Process included the Open, Axial and Selective coding phases
Substantive Theory	Theory "that provides a "working theory" of action for a specific context" (Dwivedi, 2009, p. 55)
Theoretical Sampling	during the open coding phase, the sampling of new literature/ empirical data based on theoretical grounds that emerged from the properties (Corbin & Strauss, 1990)
Theoretical Saturation	The moment where the addition of new data does no longer lead to new insights (Creswell, 2002)

1 Introduction to blockchain technology and research approach

"We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before"(Schwab, 2016b, para. 1). According to Schwab, the fourth industrial revolution is currently in progress, with far reaching consequences for the way we live.

The first industrial revolution started in the 18th century and started the evolution from manpower to mechanical power and the world we know today(Schwab, 2016a). The construction of railroads and the steam engine enabled the widespread implementation of *mechanical production*. The second industrial revolution, characterized by the invention of electricity and the assembly line enabled a further shift from *mechanical production* to *mass production.* Finally, the third industrial revolution, usually called the *digital* or *computer revolution*, was enabled by the invention of semiconductors, personal computing and the internet.

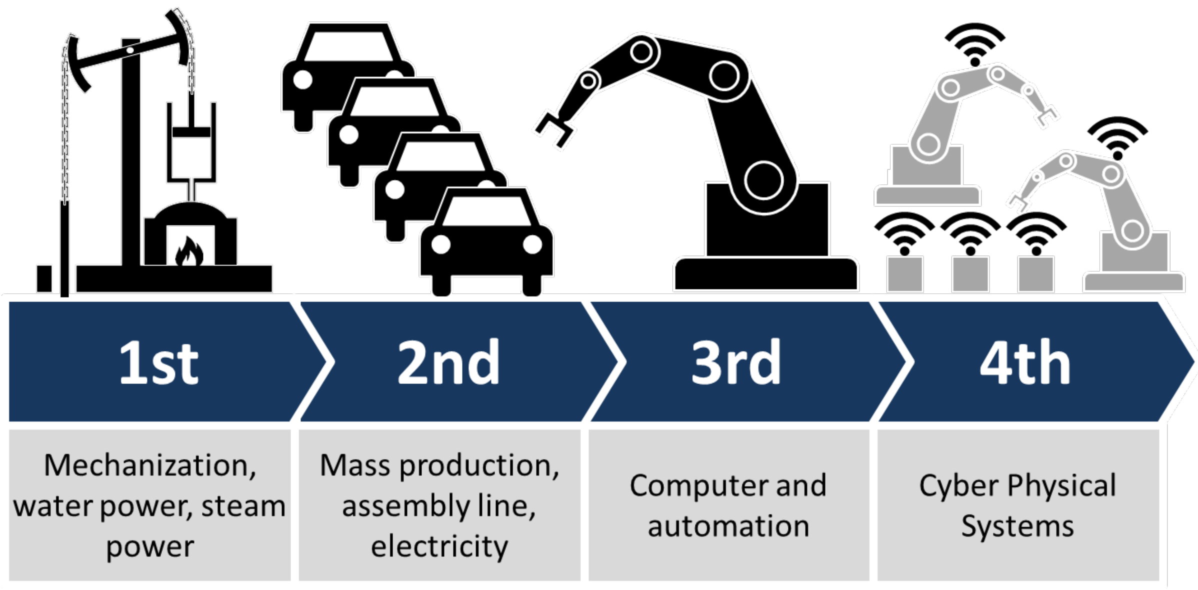


Figure 1.1 The four industrial revolutions by Roser (2015)

Now, we are facing the fourth industrial revolution: the integration of cyber-physical systems. It is "characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres"(Schwab, 2016b, para. 3). It encompasses technologies as artificial intelligence, big data, the Internet of Things, nano-technology, platforms and 3-d Printing, which could have a significant impact on the foundations of society through the power of digitization and information technology. This fourth revolution is distinctly different from the third revolution due to three factors (p.8):

- **Velocity**
  The fourth revolution is characterized by an exponential instead of linear adoption pattern.
- **Breadth and depth**
  By building on top of the third revolution, this revolution enables the combination of technologies, which leads to unprecedented paradigm shifts. It is not only changing "what" we do and "how" we do it but also "who" we are.
- **Systems complexity**
  The transformation is found throughout systems, countries, industries and society.

One of the technologies that is at the heart of this industrial revolution is *Blockchain technology*. It has been called one of the most important trends to watch by *Harvard Business Review* (Webb, 2015) and one of the 10 strategy trends in technology for 2017 by Gartner (Cearley, Walker, & Burke, 2016). The following paragraph introduces blockchain technology from a *decentralization perspective*, by looking at recent changes in a specific sector: The Taxi-industry.

The taxi-industry used to be highly *centralized*. Taxi companies, for example Taxi Centrale Amsterdam (TCA), oversaw both *production (*in this case the taxis and trips) and *settlement* (payment for the trip). Thus, both the *production* and *settlement* were *centralized* into one corporate entity. The end-user interacts only with the TCA, and the TCA is responsible for validating the complete transaction; they check if a trip has taken place, and if funds are transferred.

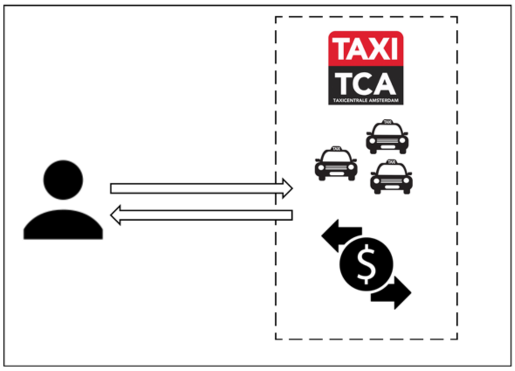


Figure 1.2 Centralized Taxi Industry

The next step in decentralization was provided by *Uber*. This platform[1] enabled the *decentralization of production.* Uber no longer had a centralized fleet of taxis, but used a decentralized network of taxis to perform trips. It thus enabled the end-user to directly interact with the source of *production,* the taxi. However, *settlement* was still centralized in Uber, which means that funds were still transferred through the central entity Uber. Thus, Uber is still responsible for validating the complete transaction.

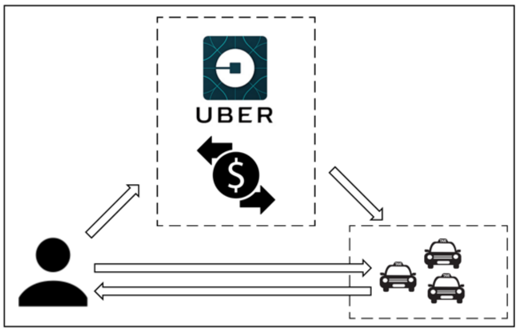


Figure 1.3 Semi-Decentralized taxi industry

The next step is to *decentralize settlement*. A new start-up, called Arcade City, does this. Arcade city only *enables* the transaction to take place, but is no longer responsible for the validation of the transaction. Instead, a *network* of taxis and users validates[2] the complete transaction. Only if the network agrees that the trip was completed, and funds were exchanged, the transaction is validated. Thus, in this system both *settlement* and *production* are decentralized.

To enable these digital systems, special software is needed to validate these transactions and create these networks. This software is called *Blockchain Technology.*

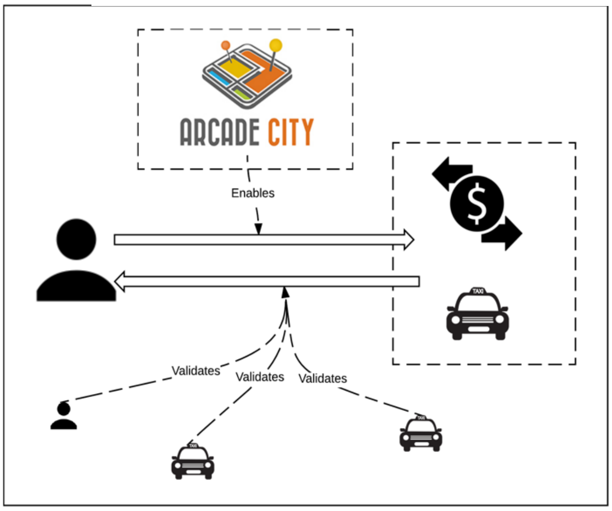


Figure 1.4 Fully decentralized taxi industry

[1] More on platforms in section 2.2

[2] The computer (or phones) of the taxis and end-users are automatically validating these transactions. The users themselves do not have to check the transactions, the blockchain algorithms do this automatically.

From a more technical perspective, a blockchain is a shared and secure database, which is not controlled by a single user but by a network. Thus, a blockchain represents a "distributed database or ledger, which uses a secure protocol where a network of computers collectively verifies a transaction before it can be recorded and approved. Therefore, blockchains can be used to create trust, by enabling people who don't know each other (and thus have no underlying basis for trust) to collaborate without going through a central authority" (Schwab, 2016a, pp. 22,23).

Blockchain technology was first seen in the digital currency Bitcoin (Nakamoto, 2009), where it was used to verify and store transactions of this digital currency. This enabled a *decentralization* of digital value exchange, which was impossible before blockchain technology. Digital transactions before Bitcoin and blockchain were always conducted using a trusted third party, or intermediary, such as retail banks.

The term *blockchain technology* refers to the underlying database structure used in these transactions. However, blockchain technology can do more than store transactions. Developments in blockchain technology have expanded the possibilities to a "world computer" based on blockchain technology. This blockchain world computer (called Ethereum) can run decentralized computer-code on a blockchain database. These pieces of computer codes are called smart contracts (Buterin, 2013). This enables a truly decentralized network for value exchange. To further clarify what the possibilities of blockchain technology are, three examples are introduced.

- *Bitcoin*
  The first implementation of blockchain technology. BitCoin used blockchain technology to track the exchange of digital coins. The blockchain database is used to store transactions, balances and identities. This back-end is used to transact *Bitcoins,* an online currency. Bitcoins decentralizes value exchange and banking.

- *Everledger*
  Everledger is also an implementation that uses blockchain technology to track value exchange. In contrast to Bitcoin, valuable *physical* assets are exchanged and tracked. For example, diamonds are tracked throughout their lifecycle. A complete history of the asset is thereby created, providing users with the possibility to check the provenance of their diamonds. As a consequence, illegally traded or obtained diamonds, or diamonds illegally mined in war-zones (Blood diamonds) could come to an end. This application of blockchain technology decentralizes the authentication of valuable assets, which used to be done by notaries or trusted intermediaries.

- *The DAO*
  The DAO[3] was one of the most ambitious implementations of blockchain technology. By using smart contracts that describe *corporate bylaws*, a truly decentralized investment fund was created. This company has no management, as all decisions are made by the shareholders as described in the corporate bylaws. The DAO was an investment fund, in which the shareholder could decide on every business interaction by voting on proposals of other shareholders. They could change the bylaws, split into sub-DAOs and invest in proposals that they thought were profitable. The DAO removed the need for trust in organizations and disintermediated the "corporation".

Blockchain is thus a highly disruptive technology with potential significant effects on digital currencies, value exchange, and the way we organize transactions in society. We therefore take *a complex multi-actor systems perspective*, defined by Pruyt (2010) as systems in which both systems

[3] Not an abbreviation. Name derived from the term used for organizations run on the blockchain using smart contracts: Decentralized Autonomous Organizations. "The DAO" is the official name of the company however, and is not an abbreviation.

complexity and multi-actor complexity play a role. Systems complexity arises in a "very large system of connected parts/components/data or the interaction of system parts/components resulting in emerging time-evolutionary behavior" (Pruyt, 2010, p.510). Actor complexity arises when a multitude of actors interact with "different world-views, (cultural) value systems, roles, interests, perspectives, positions, perceptions, leverage, strategies and behavior"(Pruyt, 2010, p. 511).The combination of multi-actor complexity and systems complexity, with the high complexity in the technology itself, causes high uncertainty about the implementation and effects of blockchain technology.

The following section further analyzes these uncertainties of blockchain technology from these perspectives.

1.1 Blockchain as a complex multi-actor system

The previous section introduced blockchain technology, and the *complex multi-actor systems*-perspective. This section first discusses the *systems complexity* of blockchain technology, and then discusses the *multi-actor complexities*. It concludes with the knowledge gap of this research.

1.1.1 Systems complexity

To analyze the systems complexity of blockchain technology we performed a literature review on the expected effects of blockchain technology. This section presents an overview of the results of this literature review. Due to the novelty of the technology and a current lack of Blockchain implementations, scientific literature on blockchain so far is scarce. However, two approaches are presented in a series of papers by (Davidson, De Filippi, & Potts, 2016a, 2016b; MacDonald, Allen, & Potts, 2016), Blockchain from a Neo-Classical Economics perspective, and Blockchain from a New-Institutional Economics perspective.

Literature Review on (economic) blockchain effects

A literature study was performed into the economic effects of blockchain technology. Using Google Scholar, Scopus and the SSRN database and keywords; Blockchain Technology, Blockchain, Economic, Economy, Institutions, Effects the articles presented in 1.1 were found. Furthermore, we used non-scientific sources, such as corporate reports, which were found using search engine Google. These sources were used to provide insights into the views of non-scientific actors in blockchain environments.

Blockchain from a Neo-Classical perspective

This perspective focusses on economic gains of blockchain technology from a Neo-Classical Economics (NCE) perspective. Davidson et al. (2016b) argue that from "a general-purpose technology-focused Schumpeterian economic analysis of blockchain will emphasize the gains in total factor productivity (TFP) to existing economic operations, as well as its creative-destructive effect on firms, markets, industries and jobs" (p.3). Thus, blockchains would increase efficiency of economic operations through a process of creative destruction (Schumpeter, 1942), by lowering production costs. Blockchain could therefore have far reaching consequences on governments, corporations and markets, as blockchain can be seen as a General Purpose Technology (GPT) in the line of *electricity* and the *computer in previous decades* (Bresnahan & Trajtenberg, 1995). A GPT is a technology with many uses, spill over effects and is widely used. "The benefit of adoption of electricity or computers does not just accrue to the owners of those technologies, but under competition accrues to *all factors* that use those technologies because their marginal productivity has been enhanced. This, in essence, is the standard economic explanation of why technological change drives economic growth as generalized prosperity and why economic growth is equivalently measured as total factor productivity" (Davidson et al., 2016b, p. 12).

In non-scientific literature, this is a popular view. Most books on blockchain technology use this perspective, and focus on efficiency gains in economic operations (e.g. Chuen, 2015; Swan, 2015;

Tapscott & Tapscott, 2016). Furthermore, most reports on blockchain technology by incumbents, corporates and governments, use this approach. Corporates like McKinsey and Credit Suisse primarily see efficiency gains for existing corporations, from faster transaction times to improved auditing (Credit Suisse, 2016; McKinsey & Company, 2015). From an innovation perspective, this approach is characterized by the *enhancement of business models,* described by March (1991) as Incremental innovation (*Exploitation).* Exploitation "entails change within the compass of basic design logic, principles or architecture. This entails the maintenance of meanings, roles, tasks and goals." (Nooteboom, 2013, p. 106).

However, it is also argued that blockchain technology can be analyzed from a New Institutional Economics (NIE) perspective (Davidson et al., 2016a, 2016b; MacDonald et al., 2016), which is discussed in the next section.

Blockchain from a New Institutional Economic perspective

This perspective takes a New Institutional Economics approach to analyze blockchain technology. Davidson et al. (2016b) argue that this is the perspective which should be used to analyze blockchain technology. They argue that analyzing blockchains from a production cost perspective, and thereby a NCE perspective, is incorrect as "It is not that the electrons now move faster, or that the processing engines are more efficient" but that "Blockchains economize on production costs by changing the organizational form by which value is created, often stripping out layers of activity that are no longer needed because trusted third-parties are no longer required" (p.14). Thus, in this case technological change does not lower production costs, but technological change lowers transaction costs. This implies that blockchain technology is able to provide much more than just production efficiency gains, it can be seen as an "institutional technology for coordinating people —i.e., for making economic transactions— which competes with firms and markets" (MacDonald et al., 2016, p. 12).

Within non-scientific literature, this NIE approach is also found. However, it is far less common than the NCE-approach. Only one book, "The Business Blockchain", by Mougayar (2016) discusses these consequences of blockchain technology as more than providing efficiency gains.

Furthermore, new entrants, as start-ups, take this perspective. For example, "Transactive Grid", an American initiative in the electricity markets, uses blockchain technology to create peer-to-peer electricity markets by enabling households to trade electricity without an intermediary. From an innovation perspective, this approach is characterized by the *disruption of business models*, described by March (1991) as Radical Innovation (*Exploration),* which "entails a breaking through these limits, which requires room for ambiguity of meanings and roles, and a loosening of principles and architecture." (Nooteboom, 2013, p. 106).

As blockchain technology indeed lowers transaction costs, instead of production costs, a New Institutional Economic perspective provides a more suitable framework. We thus follow the argument presented in this section and take a New Institutional Economics Perspective on blockchain technology (Davidson et al., 2016a, 2016b; MacDonald et al., 2016). The next section provides an in-depth view on this perspective to further develop this perspective.

New institutional economics

Institutions are defined by North (1990) as "the rules of the game", which shape individual and collective behavior. These can be both formal and informal rules, as the following overview of the four types of institutions shows (Williamson, 1998). In each level, an example is given how blockchain technology could influence institutions:

- The first level are informal institutions, such as norms, customs and values. Blockchain technology was created out of a strongly decentralized, disintermediated world view. This contrasts with most current norms and values that are highly centralized, such as governments and hierarchical corporates
- The second level are formal institutions, the legal rules and regulations of the system. Within our current systems, for example banking in our financial system should adhere to rules on responsibility, market influence and auditing. These rules and regulations are not yet clear for blockchain technology.
- The third level are arrangements between actors, such as contracts. Within the financial sector, users currently have contracts with retail banks to be able to transact money. Within blockchains it is possible to create these contracts directly with counterparties. Changes in this layer mostly represent changes as described in the NIE perspective.
- The fourth level are interactions by actors, such as resource allocation. Changes in this layer are predominantly concerned with efficiency and are thus connected with the NCE perspective.

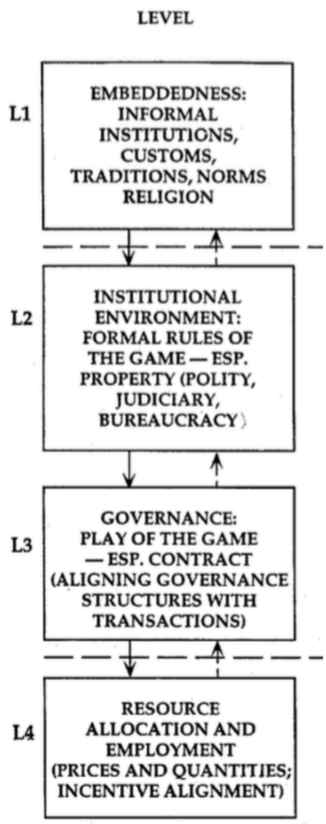


Figure 1.5 Williamson's (1998) four layer model of institutions

Blockchain technology, thus has the possibility to change institutions in all layers. As described by Koppenjan and Groenewegen (2005), technological systems can influence institutional arrangements. Throughout the layers, institutions, values and actors are at stake. However, the papers by MacDonald et al. provide no overview of how blockchain might influence these arrangements, and thereby provide no overview of the effects of blockchain technology.

In conclusion, blockchain technology has potential significant effects on the way we organize transactions, on institutional arrangements and on values, but these effects are still debated in both scientific and non-scientific literature. Thus, we conclude that blockchain technology is highly complex from a systems-perspective. The next section discusses the actor complexities in blockchain technology.

1.1.2 Actor complexity

As described in the previous sections, complex multi-actor systems also have high multi-actor complexity, which arises when "different world-views, (cultural) value systems, roles, interests, perspectives, positions, perceptions, leverage, strategies and behaviour"(Pruyt, 2010, p. 511).

Blockchain Technology has attracted the interest of many actors over the last years. When blockchain was first used in the BitCoin currency in 2009, it was only known by software developers.

However, due to the potential significant effects on organizations, institutional arrangements and efficiency, other actors became interested.

The different approaches (NCE and NIE) presented in the previous section already show that there are multiple positions and perceptions on blockchain technology, probably caused by a different world view of incumbents, new entrants and original blockchain technology developers.

Furthermore, the high technological complexity and technological immaturity of blockchain technology causes a large knowledge difference between actors in the system.

Thus, a high number of actors, with different world views, perceptions, strategies and knowledge levels are currently active in the blockchain environment, which shows that blockchain technology is highly complex from an actor perspective as well.

In conclusion, blockchain technology is highly complex from both a systems and multi-actor perspective, and is thus a complex multi-actor system. This causes extreme uncertainties, which were discussed in these sections. Actors have little knowledge on blockchain technology, are possibly facing shifting institutional arrangements, and are debating the effects of the technology from their own world views and perceptions. In this this research project, we explore these effects to provide the involved actors with an overview of the consequences of blockchain technology implementation.

1.2 Research problem

Under the effects of the growth of blockchain technology, an unclear image has been created on the possible consequences that are evoked using blockchain technology. To help structure this discussion on the consequences of blockchain technology, a conceptual framework is needed.
As there are currently no such frameworks in scientific literature, the goal of this research is to develop *a conceptual framework that provides an overview of the perceived effects, functions and issues of blockchain technology, to help structure the discussion by actors on the consequences of implementing blockchain technology.*
The focus will be on a theoretical conceptual framework, however the practical use of this research by actors that want to use blockchain technology is also highly important. For example, companies in the utilities and electricity sectors are currently all considering the implementation of blockchain technology in their business processes. However, they do not have a full overview of the true possibilities, the consequences of these possibilities and how to implement blockchain technology. The combination of theoretical and practical use leads to the societal and scientific relevance of this study.

1.2.1 Societal relevance

First, this research has societal relevance as it provides structure to the ongoing blockchain discussions. By creating a conceptual framework, actors can quickly see the possible effects, issues and functions that blockchain technology might have in their situation. Combined with the identified issues, this research can provide a holistic, high-level, conceptual view on advantages and disadvantages of blockchain technology to streamline the discussions implementing blockchain technology. It can therefore become a powerful communication tool, as structures the discussion on blockchain technology implementations. Furthermore, this research can provide actors with a conceptual overview of the possibilities of blockchain technology, thereby helping actors with the decision whether to implement blockchain technology.

1.2.2 Scientific relevance

Second, this research has scientific relevance as it provides a first attempt at creating a conceptual framework of the perceived economic effects of blockchain technology on society, and the issues that hinder these effects. Current scientific literature is unable to capture the ambiguity of the discussion on the consequences (effects, issues and functions) of blockchain technology. Furthermore, these scientific approaches (presented in the previous section) are primarily focused on theoretical principles, without an empirical connection with the true development of blockchain technology in society. A gap between theory and practice has therefore been created. This research bridges that gap, by using a bottom-up approach that starts with perceptions of actors, instead of established theory. This perspective calls for a highly explorative qualitative research approach, in which an empirical conceptual framework is formed.

1.2.3 Research questions

To research this problem, the following main research question will be answered:

"What effects, issues and functions can be discerned and conceptualized that capture the consequences of the implementation of blockchain technology?".

In this research, we use the Grounded Theory approach (Glaser & Strauss, 1967). Grounded theory is a highly explorative research method, which is aimed at forming a theory based on empirical, qualitative and quantitative data. Creswell (2009, p. 14) defines Grounded Theory as "a qualitative strategy of inquiry in which the researcher derives a general, abstract theory of process, action, or interaction grounded in the views of participants in a study." This allows us to use empirical data as an input for a conceptual framework that captures the consequences of implementing blockchain technology. In the following research questions, sub-questions two, three and four represent the stages of the Grounded Theory approach that we will explain in section 1.3 and section 3.1.

This research question is divided in five sub-questions.

1. How can the concept "blockchain technology" be described?
2. How can the research approach Grounded Theory be applied in this research?
3. Which dimensions can be discerned of effects, issues and functions of blockchain technology?
4. How can relations between the effects, issues and functions of blockchain be integrated into a conceptual framework and explained by a core category?
5. How does our core category relate to existing literature?

1.3 Research design

In this research, we use the following research design, which is visualized in Figure 1.6. This section elaborates on this research design.

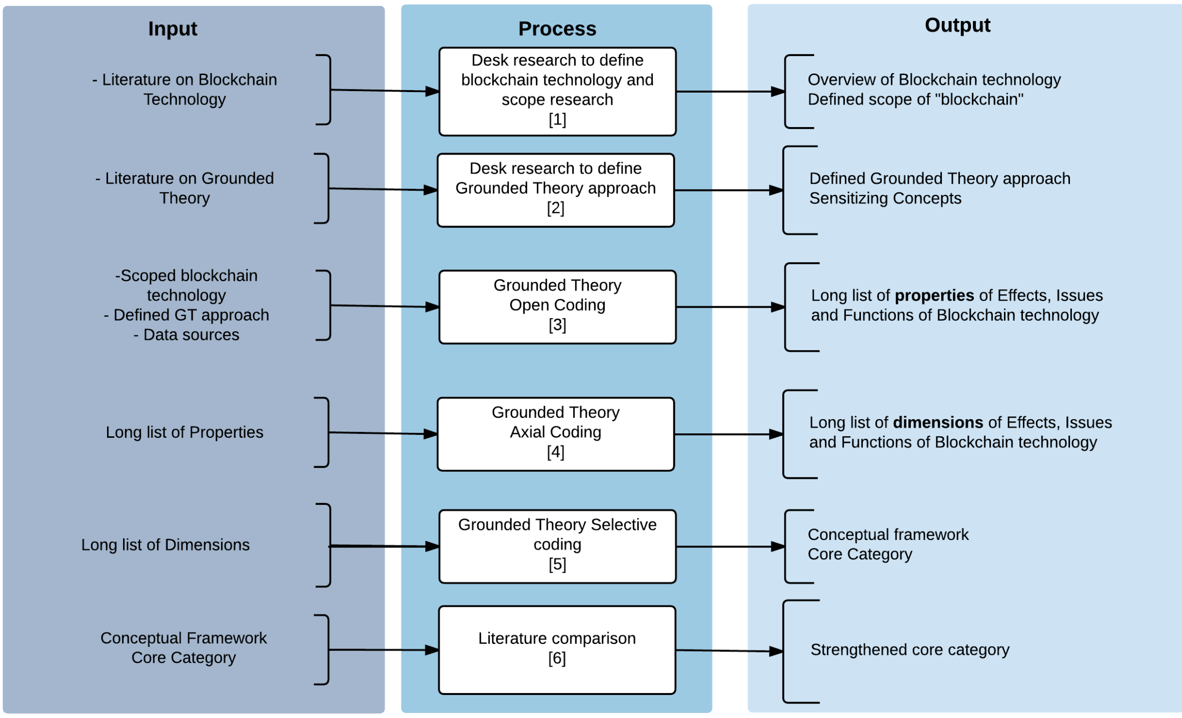


Figure 1.6 Research flowchart

Phase one – Desk research to define blockchain technology and scope research

The first phase of this research is aimed at answering the first sub-question: "How can the concept "blockchain technology" be described?". Using desk research, an overview of the literature on blockchain technology is presented. Both scientific and non-scientific literature is used during this phase, which will be found primarily using Google Scholar and Scopus. Furthermore, Google is used when scientific literature fails to provide enough practical implications. In this phase, blockchain technology is further explained by presenting a clear definition of blockchain technology that will be used in this research. In addition, the implications of blockchain are discussed, by grounding blockchain technology in state-of-the-art research on for example platforms and distributed computing.

As a result, this phase provides a clear overview of what blockchain technology is, and scopes blockchain technology for the following phases.

Phase two – Desk research to define Grounded Theory approach

The second phase of this research is aimed at answering the second sub-question: "How can the research approach Grounded Theory be applied in this research?". Using desk research and a literature review, the specific Grounded Theory approach is determined and defined. Due to the highly explorative nature of this research approach it is paramount to clearly define the exact research design to provide more structure to this research project.

As a result, this phase provides an overview of the Grounded Theory research approach that is used in this research.

Phase three and four – GT approach open/axial

The third and fourth phase of this research is aimed at answering the third sub-question "Which dimensions can be discerned of effects, issues and functions of blockchain technology?"

This sub-question is answered using a part of the Grounded Theory approach (Glaser & Strauss, 1967). In contrast with other scientific methods, Grounded Theory does not start with a literature study to form a hypothesis, which is tested throughout the research. Grounded Theory is instead characterized by an explorative constant comparison of qualitative empirical data that leads to emerging dimensions of properties and the sampling of different groups of involved actors to maximize similarities and differences of information. In practice this means that a researcher uses (qualitative) data (any publication, article, interview or discussion) to find words or phrases that highlight issues, or interests of the study. These issues or interests are labelled in a short manner, which is called coding (Allan, 2003). Using these codes, a bottom-up theory on the issue at hand emerges, which is as close to practice as possible. Because of this approach, Grounded Theory is highly effective when current theories about phenomena are either inadequate or non-existent (Creswell, 2002), as it "systematically generate[s] a theory that explains, at a broad conceptual level, a process about a substantive topic" (p. 423)

Grounded Theory is chosen in this research, as the perceptions in section 1.1.1 on effects and issues are the closest thing to a theory on the effects, issues and function of blockchain technology. This lack of formal theory and the novelty of the phenomenon blockchain technology is the primary reason to choose a Grounded Theory approach. Furthermore, Grounded Theory is highly flexible and forces the researcher to look at the data through multiple lenses. This is useful as blockchain technology is highly complex from a multi-actor and systems perspective. Finally, the practical bottom-up approach is valuable, as this research focuses on the <u>perceived</u> effects, issues and functions by practitioners. This results in a conceptual framework that is useful for both the scientific community and practitioners.

Within Grounded Theory several different approaches have emerged, with a main divide between the Classical Grounded Theory (CGT) approach by Glaser and the Straussian Grounded Theory (SGT) approach by Corbin and Strauss (1994). For this chapter, it suffices to mention that the main difference is found in the procedure. Straussian Grounded Theory provides a structure with different coding phases to help the researcher. Classical Grounded Theory does not provide such a rigid structure as it would influence the outcome of the research too much (Evans, 2013).
This research follows the Straussian approach because it is more suited for novice researchers, as it provides more structure to the process. Furthermore, by focusing on effects, issues and functions we are using a *preconceived theoretical grounding,* which is part of the SGT approach.

The Straussian approach uses three distinct coding phases: the open coding phase, the axial coding phase, and the selective coding phase. To answer our third research question, we use the Open and Axial coding phases. The Open coding phase is aimed at creating a long-list of properties, which are found in sources, which are linked together using a variety of codes. This is our third research phase.

Sensitizing concepts are used to provide an early structure to the analysis. Sensitizing concepts differ from definitive concepts as "definitive concepts provide prescriptions of what to see, sensitizing concepts merely suggest directions along which to look"(Blumer, 1954, p. 7).These sensitizing concepts are: Actors, Effects, Issues and Functions. These concepts are further explained in Chapter 3. During the Axial coding phase, these properties are further compared and dimensions are formed, which are used to group the properties. A better overview of the underlying concepts thus emerges. This is the fourth research phase.

The result of the open coding phase is a long list of actors, effects, issues and functions. These long lists are used in the axial coding phase, which results in a list of dimensions of actors, effects, issues and functions.

Phase five – Selective coding Grounded Theory
The fifth phase of this research is aimed at answering the fourth sub-question: “How can relations between the effects, issues and functions of blockchain be integrated into a conceptual framework and core category?”

This sub-question is answered using the *Selective Coding* phase of the *Grounded Theory* approach. Using the list of dimensions found in the previous phase, relations between the dimensions are found and conceptualized into categories. These categories are then integrated into a conceptual framework that provides an overview of the complete blockchain discussion. Furthermore, an empirical *core category* emerges in this research phase. This is a category that explains the conceptualized framework.

The result of this phase is a visualized, conceptual framework of related dimensions (*categories)*, and a core category that has explanatory power. This framework *describes* the current state of blockchain discussion by conceptualizing the main interests that emerge during this research.

Phase six – Comparison with existing literature
The sixth research phase is aimed at answering the fifth sub-question: “How does our core category relate to existing literature?”.

This sub-question is answered by comparing our emerged empirical core category with existing literature. Our core category is thus strengthened and refined with concepts from this literature.
The result of this phase is a strengthened theoretical core category, as it uses concepts found in existing literature in other fields.

1.4 Conclusion

This first chapter introduced blockchain technology, explained our research problem and elaborated on the research approach used in this research. The next chapter presents the outcomes of the first research phase, by providing an in-depth description of blockchain technology.

2 Describing blockchain technology

The first chapter introduced blockchain technology and the research problem at hand. This chapter presents the results of a literature study that aims to further scope this research, describing blockchain technology and grounding blockchain technology in other state-of-the-art research, thereby answers the first sub question: *How can the concept "blockchain technology" be described?* Throughout this chapter, a definition of blockchain technology emerges. Each section is concluded with an update to the definition. This chapter thereby presents the results of the first research phase (Figure 2.1).

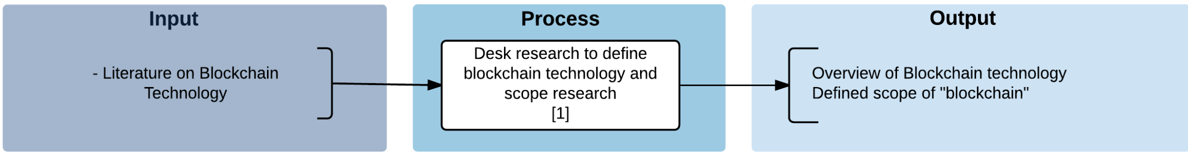


Figure 2.1 Research flow of the first phase

First, section 2.1 describes the emergence and workings of blockchain technology, by explaining blockchain transactions and smart contracts. Then, section 2.2 describes blockchains as a platform. Section 2.3 provides an overview of the users involved in blockchain transactions and the methods for maintaining the blockchain. Section 2.4 discusses different blockchain technology typologies. Then section 2.5 compares blockchain technology to distributed systems. These sections provide this research with a theoretical grounding of blockchain technology, and a comparison to state-of-the-art concepts. In section 2.6 a practical definition of blockchain technology emerges, which is compared to the theoretical grounding presented in the previous sections. Finally, section 2.7 presents an overview of the current state of the blockchain landscape using a layered model.

2.1 How blockchain technology works

Blockchain technology was first seen in Bitcoin, a digital currency, which was made public through the whitepaper "Bitcoin: A peer-to-peer electronic cash system" by an organization, or person using the alias Satoshi Nakamoto (Nakamoto, 2009). This whitepaper described two new technologies: *The Blockchain protocol* and *The Bitcoin Protocol* (this difference is further explained in the textbox below).

The Blockchain protocol described a new technology that empowered users to create a true decentralized transaction network, that could process transactions. Using computing power of all users (so called *miners*), a public, *decentralized ledger* was built and kept up to date. The network thereby generated *consensus* on the status of this decentralized ledger. This decentralized ledger was called *the Blockchain*.

The blockchain was aimed at creating an "*electronic* payment system based on *cryptographic proof instead of trust*, allowing any two willing parties to *transact directly* with each other without the need for a *trusted third party* [by proposing] a solution to the *double spend problem*" (Nakamoto, 2009, p. 1).

The double spend problem is inherent to digital, electronic assets. In contrast to physical assets it is incredibly hard to verify that the digital assets you are

The differences between blockchain and bitcoin

Bitcoin and blockchain are sometimes used as interchangeable terms. However, blockchain technology and bitcoin are distinctly different. *Bitcoin* is a digital currency that enables users to transfer funds without an intermediary, which *uses* a special distributed database that is called the *blockchain*. The Bitcoin protocol therefore primarily describes the inner workings of a currency, where the blockchain protocol described the underlying database system. Therefore, this research focusses on *blockchain technology* instead of *Bitcoin technology,* as the latter is only one implementation using *blockchain technology.*

buying are not copied, or sold already.

Physical assets can be easily exchanged: two people could easily trade a physical Euro coin[4]. Both people are physically there, both know what has been exchanged, and the seller cannot trade the coin again as he no longer physically owns it. However, considering we are currently able to trade digital coins, how can we make sure that you did not spend the coin earlier? Before blockchain technology the only option was to use a *centralized ledger:* a book in which all transactions of digital coins were written down. This creates a *trusted third party*; the retail banks we are currently using to transfer money. This process is visualized in Figure 2.2.

The sender of the transaction broadcasts the transaction to a trusted third party, a bank in the case of a financial transaction. The bank verifies that the sender of the transaction can send the coins to the receiver, thereby validating the transaction. This transaction is written into the *centralized ledger* of the bank and the coins are transacted to the receiver of the transaction.

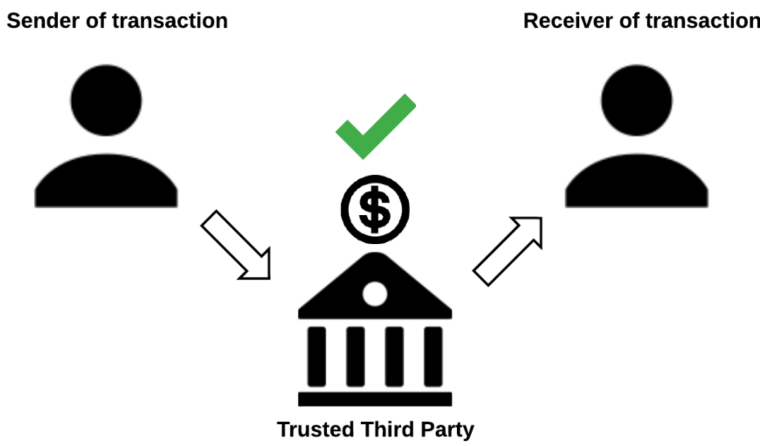


Figure 2.2 A centralized transaction

In a blockchain, this trusted third party is no longer needed, as it does not centralize this ledger, but decentralizes it. This means that all users of the digital coins have access to this ledger. The transaction process of a blockchain transaction is visualized in Figure 2.3, and explained below.

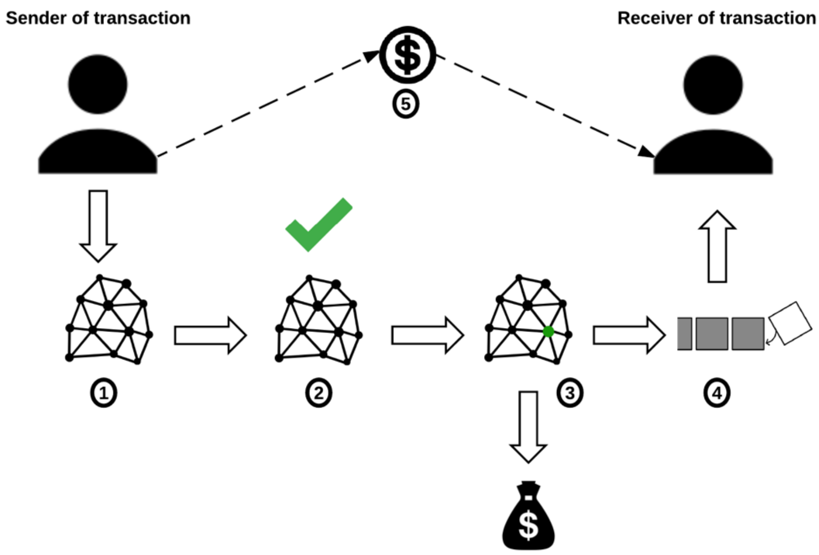


Figure 2.3 A decentralized blockchain transaction

[4] Explanation based on Custodio (2013)

1) The sender of the transaction broadcasts the transaction to all the nodes in the network.
2) These nodes all check all the transactions made in the network and make sure that the assets are not double spent. Only when there is *consensus* within the network, the transaction is validated by the network.
3) As this process of validating needs computing power, an incentive is needed to power this validating process. The nodes that are validating the transactions are trying to combine all validated transactions into one package by solving a *cryptographic puzzle.* The winner of this competition is rewarded with by receiving several coins. This process is called *mining* and provides cryptographic proof in blockchains.
4) This node then places this package of transactions, *a block*, into the blockchain.
5) This updates the *decentralized ledger* and transacts the coins from the sender to the receiver.

Currencies that use a blockchain (and thereby these cryptographic algorithms) are referred to as *Cryptocurrencies.* After the introduction of blockchain technology in Bitcoin, other cryptocurrencies emerged, such as *DogeCoin* and *Litecoin* (Coinmarketcap, 2016). These were highly similar to the Bitcoin cryptocurrency. This changed when *Ethereum* was introduced by Vitalik Buterin (Buterin, 2013). Ethereum is not just a ledger of transactions, it is a *world computer* that can compute computer code on a blockchain-database using *smart contracts*.

Smart contracts are in essence pieces of computer code that are run on this distributed world computer based on blockchain technology. A smart contract is defined by Buterin as "a mechanism involving digital assets and two or more parties, where some or all of the parties put assets in and assets are automatically redistributed among those parties according to a formula based on certain data that is not known at the time the contract is initiated."(Buterin, 2014a, para. 2). Put simply, smart contracts distribute assets based on rules written down in the smart contract. Smart contracts are therefore pieces of computer-code, small programs, that can be programmed to do anything, while being computed on the blockchain. An example of what a simple smart-contract could do is presented by Swan (2015, p. 22):

> *"The simplest smart contract might be a bet between two parties about the maximum temperature tomorrow. Tomorrow, the contract could be automatically completed by a software program checking the official temperature reading (from a pre-specified external source or oracle (in this example, perhaps Weather.com), transferring the Bitcoin [or Ether] amount held in escrow from the loser to the winner's account."*

This simple example shows a bet (or more general a transaction) between two individuals on the weather tomorrow. By using smart contracts, a decentralized, betting-agency without a middleman acting as intermediary has been created.

Another example of a decentralized implementation is *The DAO*, the world's first decentralized investment platform, built using smart contracts that run on the Ethereum blockchain (Jentzsch, 2015). Investors used *Ether,* the currency of the Ethereum blockchain, to purchase *DAO-tokens* by transacting to a smart contract. The Ethers were locked into this smart contract, and using the DAO-tokens the investors could vote what projects they wanted to fund. These projects could be proposed by anyone who had bought DAO-tokens. The voting- and proposal-procedure were both established in smart contracts. The worlds' first decentralized investment platform, completely run by its shareholders was created.

An overview of the examples of blockchain implementations used in this section is presented in Figure 2.4.

Blockchain implementation	Description
Bitcoin	First implementation of blockchain technology Decentralized payments
Ethereum	First blockchain implementation computing platform Decentralized computing power Introduced smart contracts
The DAO	Built using smart contracts on the Ethereum blockchain Decentralized investment platforms Tokenholders (shareholders) vote on investment decisions

Figure 2.4 Examples of blockchain implementations

These examples show, in a small way, the possibilities that blockchain technology and smart contracts offer: a decentralized, distributed world. Howard (2015, para. 18) summarizes the characteristics of blockchain technology as follows:

- As a public ledger system, blockchain records and validates each and every transaction made, which makes it secure and reliable;
- All the transactions made are authorized by miners, which makes the transactions immutable and prevent it from the threat of hacking;
- Blockchain technology discards the need of any third-party or central authority for peer-to-peer transactions;
- Decentralization of the technology.

2.2 Blockchain as a platform

In short, blockchain technology enables direct interaction between two parties, without the need for a trusted third party or middleman. This seems to be closely related to *multi-sided platforms,* like Uber and Airbnb, as described by Hagiu and Wright (2015). Multi-Sided Platforms have two key features:

- "They enable direct interactions between two or more distinct sides;
- Each side is affiliated with the platform" (p. 5)

Blockchain technology also enables direct interactions between two or more sides, and both parties are affiliated with the platform. However, concluding that blockchain therefore is a platform is incomplete. First, platforms as Uber and Airbnb still act as a central intermediary that govern the marketplace. Within blockchain environments this intermediary is no longer there. Furthermore, blockchain technology is a base protocol that enables not just a single interaction. Through smart contracts users can shape any interaction, from simple money transactions to the creation of organizations.

From a platform perspective Blockchain technology therefore enables the creation of a multitude of decentralized platform-like entities, which enable direct interaction between two or more distinct sides. This is closely related to the *platform of platforms*-classification as presented in a TNO report (Van Eijk et al., 2015). These "are platforms or ecosystems on which other platforms work" (p.18). Blockchain technology can therefore be seen as a decentralized platform of platforms, that does not predefine the interaction that takes place.

2.3 Users and consensus in a blockchain transaction

This platform perspective provides insight into the importance of the "sides" or users that are involved in the blockchain. Following from the explanation of a blockchain transaction in section 2.1 and Figure 2.3, three types of users can be identified in blockchains:

- *Users that read data*
  Users that have access to view the (blockchain data
  Also called: -

- *Users that write data*
  Users that send and receive transactions via the blockchain
  Also, called: users, transaction users

- *Users that validate data*
  Users that validate the transactions that are send onto the blockchain
  Also, called: Miners, full nodes/users, validator nodes/users. This research further uses validator nodes as term, as this best describes their task.

These three core-users together form a network in which transactions are send, received and validated. The validation of these transactions is a unique capability of blockchain technology. The validator nodes use a so called *consensus mechanism* to determine which transactions should be approved. This process was earlier mentioned as steps 2, 3 and 4 in Figure 2.3.

Defining users in a blockchain

While researching this classification of users in a blockchain transaction it became clear how ill-defined blockchains currently are. Terms like, miners, full-nodes and validator nodes are used interchangeably by one application, but are clearly different in other applications. Bitcoin for example has a clear divide between miners (validator nodes as described in this conceptualization) and full-nodes (users that do not validate transactions, but have a copy of the blockchain on their computer).

These problems are found more often when dealing with definitions of aspects of blockchain technology, which further increases the need for a better description of the technology.

The purpose of a consensus mechanism, as defined by (Buterin, 2014b) is "to allow for the secure updating of a state according to some specific state transition rules, where the right to perform the state transitions is distributed among the economic set. The economic set can be users which are given the right to collectively perform transitions through an algorithm" (para. 2). Put simply, the consensus mechanism allows the blockchain to be updated to a new state when certain conditions are met. In most blockchain applications this means that a majority of the validator nodes should approve the transaction to create a new block. The determination of the majority is the specific *consensus mechanism* of that blockchain.

A multitude of *consensus mechanisms* are currently being published, all with distinct advantages and disadvantages. As this research focusses on consequences of blockchain technology and not on the exact working, we will not further discuss these considerations. However, to increase the understandability of this research, two widely used consensus mechanisms are discussed: *Proof of Work and Proof of Stake.*

Proof of Work is the most used *consensus mechanism* and is used by both Bitcoin and Ethereum, and was used in all examples so far. The computer of the *validator node* tries to solve a cryptographic puzzle, which means that voting power is determined by computing power of the user. More computing power provides more voting power in the system, which in turn provides the user with a bigger chance to win the *cryptographic puzzle* to gain validating rewards (step 3 Figure 2.3) in the form of the currency of the blockchain (for example Bitcoins or Ethers).

Proof of Stake is another popular consensus mechanism. The *validator node's* voting power is simply determined by the amount of currency it currently has available. This can be compared to *voting rights* in a normal election. This especially provides useful implementations in more closed blockchain scenarios where you would prefer only a few *validator nodes* that determine the state of the blockchain, all with predetermined voting power.

Consensus mechanisms are thus one of the design choices that should be made in blockchain technology. Blockchain technology is not a "one-size-fits-all" implementation. The following section discusses another important design choice for blockchain technology: the overall network layout, or blockchain typology.

In conclusion, we can update our definition of blockchain technology with the addition of the consensus mechanism: a decentralized platform of platforms <u>with a consensus mechanism</u>, that does not predefine the interaction that takes place.

2.4 An introduction to blockchain typologies

An important design choice for blockchain technology is the overall blockchain typology. These typologies determine what parts of the blockchain or actions are restricted to users of the blockchain. Multiple definitions of these types are found in both scientific and non-scientific literature. The Table 2.1. presents an overview of these interpretations.

Table 2.1 Definitions of blockchain typologies

Author	Terminology	Definition
(Buterin, 2015a)	Public	"a blockchain that anyone in the world can read, anyone in the world can send transactions to and expect to see them included if they are valid, and anyone in the world can participate in the consensus process" (para. 2)
	Private	"A blockchain where write permissions are kept centralized to one organization. Read permissions may be public or restricted to an arbitrary extent." (para. 2)
	Consortium	"a blockchain where the consensus process is controlled by a pre-selected set of nodes. The right to read the blockchain may be public, or restricted to the participants." (para. 2)
(BitFury Group, 2015)	Public	"a blockchain, in which there are no restrictions on reading block-chain data (which still may be encrypted) and submitting transactions for inclusion into the block- chain." (p.10)
	Private	"a blockchain, in which direct access to blockchain data and sub-mitting transactions is limited to a predefined list of entities." (p.10)
	Permissioned	"a blockchain, in which transaction processing is performed by a predefined list of subjects with known identities." (p.10)
	Permissionless	"a blockchain, in which there are no restrictions on identities of transaction processors (i.e., users that are eligible to create blocks of transactions)." (p.10)
(Walport, 2016)	Permissionless	"A ledger that allows anyone to contribute data to the ledger and for everyone in possession of the ledger to have identical copies." (p. 17)

	Permissioned	"May have one or many owners. The ledger's integrity is checked by a limited consensus process. This is carried out by trusted actors." (p.17)
	Distributed Ledger	"Are a type of database that is spread across multiple sites, countries or institutions, and is typically public." (p.17)
	Shared Ledger	"to any database and application that is shared by an industry or private consortium, or that is open to the public. spectrum of possible ledger or database designs that are permissioned at some level." (p.18)

These definitions provide two basic axes:

- Permissions for users that can read/write data to the blockchain
- Permissions for users that can be a validator node and take part in the consensus process.

The distinction between users who can read and write data that was made in the previous section is not used in practice and thus combined into one group. Buterin does not make the distinction between different users at all and just uses public and private blockchains. Walport does the same, but only looks at permissioned and permissionless blockchains. Definitions by BitFury largely cover discussion and cover both axes.

Based on these definitions, it can be concluded that there are two key attributes that group blockchain technology. These are:

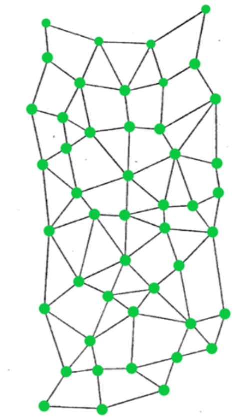
- Public – private. This axis determines which users can view the blockchain, or submit transactions or programs to the blockchain.
- Permissioned – Permissionless. This axis determines which users take part in the consensus mechanism of the blockchain and become a validator node

These two axes are used to present an overview of the classifications of blockchain technology in Figure 2.5. The grey quadrants are currently used in practice; the white is not.

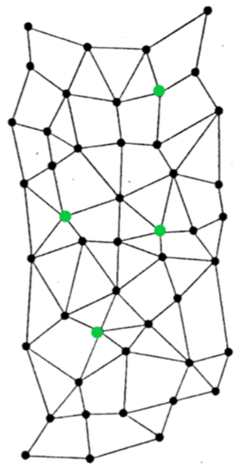
	Permissionless	**Permissioned**
Public	- No restrictions on who can read data - No restrictions on who can submit transactions or program - No Restrictions on who can take part in the consensus mechanism	- No restrictions on who can read data - No restrictions on who can submit transactions or programs - Restrictions on who can take part in the consensus mechanism
Private	- Restrictions on who can read data - Restrictions on who can submit transactions or programs - No Restrictions on who can take part in the consensus process	- Restrictions on who can read data - Restrictions on who can submit transactions or programs - Restrictions on who can take part in the consensus mechanism

Figure 2.5 Overview of blockchain technology classification

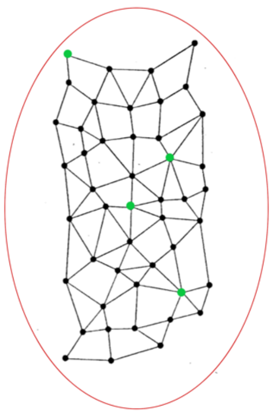
The following paragraph presents a further explanation of the four types of blockchains presented in the previous figure. The figure next to the explanations visualize the design choices. Green nodes represent validator nodes that take part in the consensus mechanism, black nodes represent read/write nodes. A red ring represents the border of the blockchain system for a private blockchain.



First, public permissionless blockchains. These are blockchains in the purest form, where there are no restrictions on reading and submitting transactions, and there are no restrictions who can take part in the consensus process. Examples include Bitcoin and Ethereum.

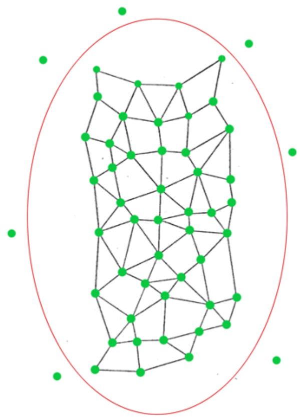


Second, public permissioned blockchains. These blockchains offer no restrictions on who can read data or submit transactions or programs, however they do restrict who can take part in the consensus process. These blockchains provide a more controlled environment, which might be of interest for institutions like banks or registries. An example of a public permissioned blockchain is Ripple (Schwartz, Youngs, & Britto, 2014). Ripple is a blockchain implementation for cross-border payments that can be used (and is being tested) by banks around the world to improve the transaction speed of transactions. The blockchain itself is public, but only the participating banks can take part in the consensus process.



Third, private permissioned blockchains. These are completely restricted blockchains, owned by one institution or combination of institutions. Both the decentralized and trustless properties of blockchain are largely diminished, but these are used by companies as Rubix by Deloitte, or Bluemix by IBM, to offer Blockchain as a Service (BaaS) to corporations.

Fourth, permissionless private blockchains. These are not used in practice as they provide a combination of properties that do not complement each other. These would put restrictions on who can use the blockchain to transact or read data, but open the consensus up to anyone.



This overview of blockchain types raises an important question: should all of these implementations be considered as *blockchain technology?* Or is a highly private and permissioned blockchain just a distributed database? In this research, we consider all of these implementations as blockchain technology, as this research focusses on the current *perceptions* of blockchain technology. If there are actors that perceive an implementation of blockchain technology as useful and expect certain consequences, these blockchains should also be considered in this research. Even though private blockchains were not the intention of its inventor, the practical and empirical uses form the basis of this research. Private permissioned blockchains are therefore considered in this study if they have a consensus mechanism, otherwise it is a distributed database. The distinction between blockchain technology and distributed databases are made in the following section.

Following the conclusions in Section 2.3, we can update our definition of blockchain technology further: a decentralized platform of platforms (public/private) with a consensus mechanism (permissioned/permissionless), that does not predefine the interaction that takes place.

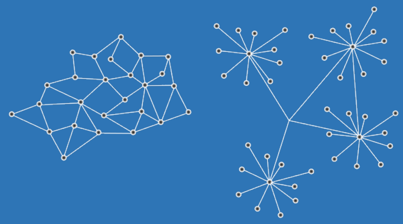
2.5 Comparing Distributed systems and blockchain technology

The previous section touched upon *Distributed computing* and compared blockchain technology with this field in computing systems. This section discusses the differences between distributed databases and blockchains, to further scope the term blockchain technology as used in this study.

Distributed databases are part of the larger field of *distributed computing systems*. Distributed computing systems are defined as "A collection of independent computers that appears to its users as a single coherent system" (Tanenbaum & Van Steen, 2007, p. 2). This definition is further explored by Özsu and Valduriez (2011) as "a number of autonomous processing elements (not necessarily homogeneous) that are interconnected by a computer network and that cooperate in performing their assigned tasks"(p. 2). Blockchain technology adheres to both definitions, as it appears as single system to its users and cooperate in performing an assigned task in a network. Therefore, blockchain is a form of a distributed computing system.

Distributed or Decentralized?

A clear distinction between distributed systems and decentralized systems is made by Baran (1964). In a distributed system there are no central nodes, in a decentralized system there still are some central-hierarchical nodes. In the figure below, the right is a decentralized network, the left is distributed.
As there are no central nodes in a blockchain network, these are distributed networks.



Furthermore, Özsu and Valduriez (2011) define a *distributed database* as "a collection of multiple, logically interrelated databases distributed over a computer network" (p. 3), a *distributed database management system* as "the software system that permits the management of the distributed database and makes the distribution transparent to the users" (p. 3). The combination of these two terms is called a Distributed Database System.

Blockchain clearly is a collection of multiple, logically interrelated databases distributed over a network. Furthermore, it adds a layer of software that manages these databases. Therefore, blockchain is also a form of a Distributed Database System.

Blockchain is therefore a combination of a distributed computing system and a distributed database system, with special features that set it apart from standard distributed systems implementations. This should therefore be added to the previous definition (section 2.4) [*a decentralized platform of platforms (public/private) with a consensus mechanism (permissioned/permissionless), that does not predefine the interaction that takes place*].

To improve readability, we've chosen to rewrite this definition and redefine the notion of a platform as "an organization that creates value primarily by enabling direct interactions between two (or more) distinct types of affiliated customers" (Hagiu & Wright, 2015, p. 1). In this case, direct interactions are any interactions without a middleman. By combining these notions, the new definition is formed as: a blockchain is a distributed database and computing system (public/private) with a consensus mechanism (permissioned/ permissionless), that adds value by enabling direct interactions between users.

2.6 An overview of blockchain technology definitions used in practice

The definition described in the previous section is primarily grounded in scientific literature and existing concepts as multi-sided platforms and distributed systems. However, this research is focused on the perceived, empirical consequences of practical implementations of blockchain technology. Therefore, we also need to look at current practical definitions found in (non)-scientific literature. This definition should provide a further scope on how blockchain is seen in practice and provide us with clear criteria to distinguish blockchain technology from distributed database systems, distributed computing systems and platforms. In this section, we form a practical definition of blockchain technology which is then compared to the theoretical definition that emerged in the previous section. The following table gives an overview of the definitions of blockchain technology found in practice.

Table 2.2 Overview of definitions of blockchain technology

Blockchain definitions	
(Walport, 2016)	"A type of database that takes several records and puts them in a block. Each block is then 'chained' to the next block, using a cryptographic signature. This allows block chains to be used like a ledger, which can be shared and corroborated by anyone with the appropriate permissions. There are many ways to corroborate the accuracy of a ledger, but they are broadly known as consensus" (p.17)
(Mougayar, 2016)	"Technically, the blockchain is a back-end database that maintains a distributed ledger that can be inspected openly. Business-wise, the blockchain is an exchange network for moving transactions, value, assets between peers, without the assistance of intermediaries. Legally speaking, the blockchain validates transactions, replacing

	previously trusted entities." (p. 4)
Vermont (US, Legislative Code) *Rule of Evidence* 902 §1913 (2016)	""Blockchain technology" means a mathematically secured, chronological, and decentralized consensus ledger, or database, whether maintained by internet interaction, peer-to-peer network, or otherwise." (p. 1)
(Buterin, 2015b)	"A blockchain is a magic computer that anyone can upload programs to and leave the programs to self-execute, where the current and all previous states of every program are always publically visible, and which carries a very strong crypto economically secured guarantee that programs running on the chain will continue to execute in exactly the way that the blockchain protocol specifies." (para. 8)
(Wright & De Filippi, 2015)	"a distributed, shared, encrypted database that serves as an irreversible and incorruptible public repository of information" (p.2)
(Kim & Laskowski, 2016)	"a distributed database that maintains a continuously-growing list of data records secured from tampering and revision. It consists of blocks, holding batches of individual transactions. Each block contains a timestamp and a link to a previous block" (p. 2)
(Norta, 2015)	"The blockchain is a distributed database for independently verifying the chain of ownership of artefacts in hash values that result from cryptographic digests" (p. 1)

Currently the definition by Wright and De Filippi "a distributed, shared, encrypted database that serves as an irreversible and incorruptible public repository of information" provides a good starting point. Using this as a basis we can further define key characteristics of a blockchain implementation, as some characteristics that belong to blockchain technology are not covered in this definition. The following list gives an overview the characteristics most often found in the definitions above. Furthermore, this list argues whether these characteristics should be incorporated into the definition by Wright and De Filippi:

- <u>Information in database or ledger</u>
  This is already in the definition by Wright and De Filippi
- <u>Chronological</u>
  Is not part of the definition by Wright and De Filippi, but is a characteristic of blockchain technology because of the constant additions of *blocks* into the *blockchain*, which creates a chronological overview of transactions. This should be added to the definition.
- <u>Distributed</u>
  This is already in the definition by Wright and De Filippi
- <u>Decentralized</u>
  Is not a part of the definition by Wright and De Filippi, however a blockchain is not a decentralized system, it is a distributed system (section 2.5).
- <u>Consensus/Crypto-economic</u>
  One of the most important missing parts of the definition by Wright and De Filippi. A consensus mechanism that determines the state of the distributed database system is one of the characteristics of a blockchain implementation. This should therefore be added to the definition.
- <u>Chain</u>
  Is not part of the definition by Wright and De Filippi, but is already covered by the *chronological* addition.
- <u>Shared</u>

This is already in the definition by Wright and De Filippi

- Irreversible and Incorruptible
  This is already in the definition by Wright and De Filippi
- Publically available
  This is already in the definition by Wright and De Filippi, but should be removed as this statement only considers public blockchains. As argued in the previous sections, private blockchains are also considered in this research, which are not publically available.

This gives us the following revision of the Wright and De Filippi definition: a distributed, shared, encrypted, chronological database with a consensus mechanism that serves as an irreversible and incorruptible ~~public~~ repository of information.

Some additions to this might be made from characteristics that are found in some definitions, but that might be highly important:

- Without the assistance of intermediaries (Mougayar)
  Although this might be one of the most important consequences of blockchain technology, we argue that this should not be added to a definition. Although blockchain technology enables a distributed information database without intermediaries, intermediaries can easily be incorporated into blockchain technology. If the existence of an intermediary would disqualify implementations as blockchain technology, every implementation of current corporate banking (which are private/permissioned) blockchains would not be considered blockchain technology, as they create a new form of intermediation. Therefore, this is not added to the definition.
- Peer to peer network (Vermont)
  Peer to peer is often connected with blockchain technology. This is certainly the case for permissionless blockchains, but not in permissioned blockchains where certain nodes have more power than others. Therefore, this is not added to the definition.
- Magic world computer (Buterin)
  An important addition to the current definition, as the current definition implies (*repository of information)* that only information can be stored. However, blockchain is also a distributed computing network that can execute programs. This should therefore be added as *repository of information or executable programs*.
- Ownership of artefacts (Norta) and moving transactions, value, assets between peers (Vermont)
  These are important functions of blockchains, but not characteristics of every blockchain. Therefore, this is not added to the definition.

By combining these insights, the following practical definition of blockchain technology forms: a distributed, shared, encrypted, chronological database with a consensus mechanism that serves as an irreversible and incorruptible public repository of information and executable programs.

This definition can now be compared with the definition that was formed earlier in section 2.5. This definition defined blockchain as *a distributed database and computing system (public/private) with a consensus mechanism (permissioned/ permissionless), that adds value by enabling direct interactions between users.*

By combining these definitions, we can find the following definition of blockchain technology in this research: a blockchain is a distributed, shared, encrypted, chronological, irreversible and incorruptible database and computing system (public/private) with a consensus mechanism (permissioned/ permissionless), that adds value by enabling direct interactions between users.

This means that the term blockchain technology from now on refers to the underlying database structure of the technology. We propose to use this term solely when referring to the underlying technology. However, there is more to blockchain technology than just the underlying database structure. A complete blockchain architecture is emerging which is described in the following section.

2.7 Defining the blockchain architecture and applications

The previous sections explained and defined blockchain technology. The inner workings of blockchains, different types of blockchains and properties of blockchains were discussed. This section now provides an overview of what we can do with this technology. This section therefore has two goals. First, the introduction and explanation of the three-layer model by Mougayar (2016). Second, using this model and examples a definitive scope for this study is provided.

The three-layer model by Mougayar is used to describe the blockchain architecture. It is presented in his book on blockchain technology and a returning issue in his blogs (Mougayar, 2015). The examples used in this sections all come from these blog posts, which provide an overview of the current state of financial blockchain landscape. The model identifies three layers, which are visualized in Figure 2.6:

- *Infrastructure and Base protocols*
  The base protocols of the blockchain architecture are described in this layer, which acts as a foundational base for the other two layers. Both the blockchain protocol and implementations of this protocol, such as Bitcoin and Ethereum, are found in this layer. Furthermore, the (hardware) infrastructure is described in this layer. For example, computers designed specifically for *validating transactions,* i.e. dedicated mining units, are found here. When compared to the internet, one could imagine protocols like TCP/IP, HTTP and SMTP here.
- *Middleware and services*
  This layer describes the services and middleware that is built on top of the base infrastructure and protocols. They extend the functionality of the protocols or make it easier to build applications. Services are primarily aimed at providing insight, consultancy or easier access to blockchain technology. Examples here include the Rubix platform by Deloitte or an influential blockchain-consultancy firm as Consensys, and APIs that make connecting to the underlying protocols easier. The middleware layer consists of implementations to make things easier for final applications. Examples include file sharing systems like the InterPlanetary File System (IPFS).
- *Applications and solutions*
  Finally, the applications and solutions layer describes the implementations that end-users use. Examples include the earlier mentioned initiatives as "The DAO", a decentralized trading platform, and Arcade city, the blockchain-taxi company in the introduction. However, applications by established corporates are also found here. Examples include NASDAQ Private Market efforts to create a blockchain based capital markets system.

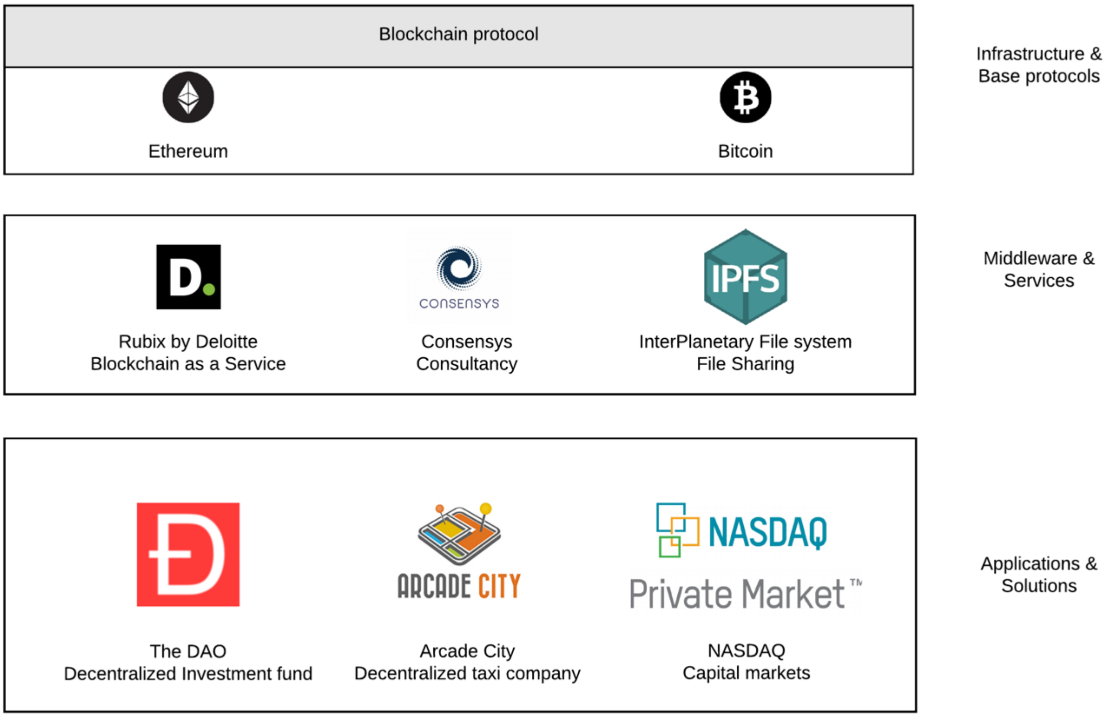


Figure 2.6 Model based on the Three-layers identified by Mougayar

This research focusses on the third and final layer of this model, the applications and solutions layer. We argue, by drawing a comparison to the emergence and implementation of internet technology, that the most important consequences are found in this layer. As Castells (2014) argues: "The Internet, as all technologies, does not produce effects by itself." The decentralization of communications caused by the internet enabled the emergence of social media, online retails and multi-sided platforms. Those applications and solutions have had the most important consequences. Therefore, this research also focusses on those implementations, and will step away from a discussion on blockchain protocols and middleware layers.

2.8 Conclusions

This chapter introduced blockchain technology more in depth to answered the first research question: "How can the concept "blockchain technology" be described?". A literature review provided us with the following description: *Blockchain technology is a distributed, shared, encrypted, chronological, irreversible and incorruptible database and computing system (public/private) with a consensus mechanism (permissioned/ permissionless), that adds value by enabling direct interactions between users.* This research focusses on the perceived consequences of the implementation of *applications* using blockchain technology. This chapter thus provided a clear overview of what blockchain technology is, and scoped blockchain technology as a term which will be used in the following chapters.
The next chapter introduces the research approach that is used in the remainder of this research.

3 Defining the Grounded Theory Approach

The term blockchain technology was defined in the previous chapter, which provided the starting point for this research into the consequences of the implementation of blockchain technology. To further define this research, the research design should be further described. The aim of this chapter is to further elaborate on the exact research design, the second phase of this research (Figure 3.1). Chapter one already introduced the main research approach: Grounded Theory. Due to the highly explorative nature of this research approach it is paramount to clearly define the exact research design to provide more structure. This chapter therefore answers the second research question: "How can the research approach Grounded Theory be applied in this research?".

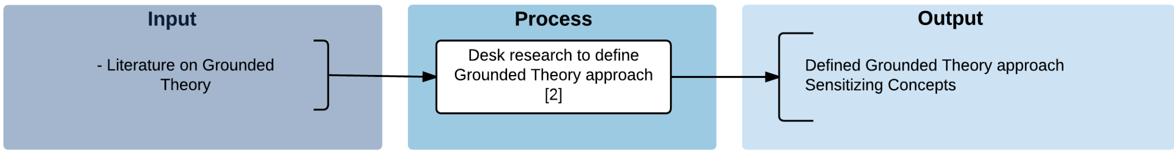


Figure 3.1 Research flow of the second phase

This chapter is structured as follows: the first section discusses the Grounded Theory research approach and why it was chosen in this research. Furthermore, it elaborates on two Grounded Theory approaches, Classical Grounded Theory and Straussian Grounded Theory (SGT), and argues the decision for a SGT approach. Section 3.2 further explains the three distinct phases in this approach; open coding, axial coding and selective coding. Then section 3.3 discusses the use of sensitizing concepts in this research. Section 3.4 then elaborates on the practical research setup by describing the data sources and coding approach used in this research. Finally, section 3.5 introduces the validation efforts of this research.

3.1 An introduction to the Grounded Theory approach

The goal of this research was defined in chapter one as *providing a conceptual framework that provides an overview of the perceived effects, functions and issues of blockchain technology, to help structure the discussion by decision makers in organizations on the trade-offs of implementing blockchain technology.* This calls for an explorative approach that focuses on the perceptions of actors. This section argues why the *Grounded Theory* approach should be used in this research.

3.1.1 Deciding on Grounded Theory methodology

Grounded Theory highly explorative research approach, which is aimed at forming a theory based on empirical, qualitative and quantitative data (Glaser & Strauss, 1967). Creswell (2009, p. 14) defines Grounded Theory as "a qualitative strategy of inquiry in which the researcher derives a general, abstract theory of process, action, or interaction grounded in the views of participants in a study." In contrast with deductive scientific methods, Grounded Theory does not start with a literature study to form a hypothesis, which is tested throughout the research.

Grounded Theory is instead characterized by an explorative constant comparison of data that leads to the inductive emergence of dimensions of properties and the sampling of different groups of involved actors to maximize similarities and differences of information (Strauss & Corbin, 1990). In practice this means that a researcher uses (qualitative) data (any publication, article, interview or discussion) to find words or phrases that highlight issues, or interests of the study. These issues or interests are described in a short manner, which is called coding (Allan, 2003). Using these codes, a process of *theoretical sampling* is started, in which "the process of data collection for generating theory whereby the analyst jointly collects, codes, and analyses his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges" (Glaser & Strauss, 1967, p. 45). During this process, a bottom-up core category or conceptual framework on the issue at hand emerges, which is as close to practice as possible. Because of this approach Grounded Theory is highly effective when current theories about phenomena are either inadequate or non-existent (Creswell, 2002), as it "systematically generate[s] a theory that explains, at a broad conceptual level, a process about a substantive topic" (p. 423)

Grounded Theory is chosen in this research, as there currently are no theory or conceptual framework on the effects, issues and function of blockchain technology. This was concluded in section 1.2 on the research problem, based on the literature review presented in section 1.1 on the consequences implementing blockchain technology. This lack of formal theory and the novelty of the phenomenon blockchain technology is the primary reason to choose a Grounded Theory approach. Furthermore, Grounded Theory is highly flexible and forces the researcher to look at the data through multiple lenses. This is useful as blockchain technology is highly complex from a multi-actor and systems perspective. Finally, the practical bottom-up approach is valuable, as this research focuses on the *perceived* effects, issues and functions by actors. This results in a conceptual framework that presents an overview of the discussion on the consequences of implementing blockchain technology, which helps practitioners and decision makers structure the trade-offs of implementing blockchain technology.

3.1.2 The specific Ground Theory approach

Since the discovery of Grounded Theory by Glaser and Strauss (1967) several distinct approaches for the application of Grounded Theory were started. Two main approaches are often discerned (e.g., Allan, 2003; Breckenridge et al., 2012; Evans, 2013), and especially for novice researchers it is recommended not to mix-and-match between the approaches (Breckenridge & Jones, 2009). Although there is an ongoing lively debate on the differences[5], these approaches still adhere to the main principles as described in the previous section, and the following characteristics:

- "Categories must not be forced on the data, they should *emerge* instead in an ongoing process of data analysis" (Kelle, 2010, p. 193)
- "In developing categories, the sociologist [researcher] should employ *theoretical sensitivity*, which means the ability to see relevant data and reflect upon empirical data material with the help of theoretical terms" (Kelle, 2010, p. 193)
- The use of coding to describe issues or interests in a short manner (Allan, 2003)
- Constant comparison of data, theoretical sampling and emergence (Heath & Cowley, 2004)
- A common objective: Theory-development

Classical Grounded Theory[6]

The Classical Grounded Theory (CGT) was defined in the first developed and presented by Glaser and Strauss in 1967 and further defined by Glaser in (1992) and (1978) after a division between Glaser and Strauss on how to use the approach. CGT is the most *emergent* approach and starts *without* preconceived notions on the topic of research. This helps the researcher keep an *open-minded view* on the empirical data. However, the lack of structure is often perceived as difficult by novice Grounded Theory researchers (Kelle, 2007).

Two coding types are used, *substantive and theoretical coding*. Holton (2007) describes *substantive coding* as: "In substantive coding, the researcher works with the data directly, fracturing and analysing it, initially through open coding for the emergence of a core category and related concepts and then subsequently through theoretical sampling and selective coding of data to theoretically saturate the core and related concepts" (p.265). *Theoretical coding* is described by Glaser (1978) as: "to conceptualize how the substantive codes may relate to each other as hypotheses to be integrated into the theory" (p. 55).

[5] Melia (1996) argues that it is not even clear if these approaches are actually different, or just similar ideas described in different ways.

[6] Strongly based on Onions (2006, pp. 8,9)

Straussian Grounded Theory[7]

The Straussian Grounded Theory (SGT) was described in work by Corbin and Strauss(Strauss & Corbin, 1990). It contrasts with CGT mainly in two ways. It presents a *coding paradigm* and accepts *preconceived theoretical grounding* (Evans, 2013) . Both provide more structure to the research, however opponents of the SGT argue that this shifts focus from *emerging* the theory from the data into *forcing* the theory from the data*,* as this structure leads to more preconceptions about the formed theory.

The *coding paradigm* consists of three distinct coding phases, that primarily helps to structure the research. These are the *open, axial* and *selective* coding phases(Corbin & Strauss, 1990). The *open coding phas*e is aimed at creating a *long-list of properties*, which are found in sources, which are linked together using a variety of codes. During the *Axial coding phase*, these codes are further compared and grouped and *dimensions* are formed, which are used to group the codes. A better overview of the underlying concepts thus emerges. The *selective coding phase* uses these dimensions and *relates* them with each other in *categories*, thus a complete overview of the issue at hand emerges.

The academic debate on the approaches is still ongoing and this research does not aim to provide any contribution to that discussion. Therefore, this research follows one approach, without further going into the methodological discussion. This research follows the *Straussian Grounded Theory* approach, because of the following reasons:

- As a novice researcher, the provided structure through the coding paradigm is helpful in structuring the research. This is a notion found in research, for example Kelle (2010, p. 211) argues that a paradigm could help not to drown in data. It provides more help on what to do in each coding phase, when coding phases are finished and how to verify and validate the research.
- This research clearly is focused on effects, issues and functions of blockchain technology. These can already be seen as a *preconceived theoretical grounding* as described by Strauss. By focusing so clearly on these consequences, the researcher automatically goes against CGT. Furthermore, this theoretical grounding allows to pay attention to the broader environmental and contextual factors, which might be highly important in this research.

This section discussed the main research approach of this thesis: Straussian Grounded Theory. Grounded Theory is chosen as it allows the emergence of a new conceptual framework on the consequences of implementing blockchain technology, which is grounded in empirical data. The specific approach (SGT), which is described in the following section, was chosen as it provides more structure for novice researchers.

3.2 Phases of Straussian Grounded Theory

The previous section introduced the Straussian Grounded Theory approach, this section further describes the three main phases of this approach. These three main are: the *open, axial* and *selective* coding phases.

3.2.1 Open coding

The first phase as outlined by (Corbin & Strauss, 1990) is called the *open coding* phase and described as “the interpretive process by which data is broken down analytically, [which is aimed at providing] new insights by breaking through standard ways of thinking about or interpreting phenomena reflected in the data”(p.12). These insights are coded (Allan, 2003) and as a result, long lists of properties emerge from the data. The researcher can, during the open coding phase, sample new literature based on theoretical grounds that emerged from the properties (Strauss & Corbin,

[7] Strongly based on Onions (2006, pp. 8,9)

1990), which is called *theoretical sampling*. During the coding phases the researcher can write *memos*; "notes the researcher writes throughout the research process to elaborate on ideas about the data and the coded categories."(Creswell, 2002, p. 438). These memos can be hunches, ideas and thoughts, but are also used as a logbook to create a verifiable research process. Through the constant comparison of data, the researcher immerses himself in the subject until *theoretical saturation* has been achieved. Theoretical saturation is the moment where the addition of new data does not longer lead to new insights (Creswell, 2002). The result of our open coding phase is a long list of perceived consequences (effects, functions and issues) of implementing blockchain technology.

3.2.2 Axial Coding

The next phase is described by Corbin and Strauss (1990) as "In the Axial coding phase, categories are related to their sub- categories, and the relationships tested against data"(p.13). The properties that emerged in the open coding phase are combined into higher level concepts, thereby further conceptualizing the properties into *dimensions*. Again, theoretical sampling might be used to find new data sources. More insights are generated through the overview of the higher-level concepts and the constant comparison of properties to be combined into a dimension. These *dimensions* are thus the result of this coding phase.

3.2.3 Selective Coding

The third and final coding phase is the selective coding phase(Corbin & Strauss, 1990). In this phase "the grounded theorist writes a theory from the interrelationship of the categories in the axial coding model"(Creswell, 2002, p. 426). The dimensions are thus categorized together, while relationships between the dimensions, and the dimensions and the environment emerge. These patterns provide the basis for a theory, visualized in a framework. Throughout these phases, a conceptual framework "grounded" in the data emerges. This theory is often a visual representation of a so called "core category", a category that explains most the research data.

This theory is a *substantive theory.* A substantive theory is a theory "that provides a "working theory" of action for a specific context" (Dwivedi, 2009, p. 55). The context in this research is formed by the definition of blockchain in chapter 2 and the focus on perceived consequences of the implementation of this technology.

The theory will therefore only be applicable to the specific context that is studied in this research. For example, when blockchain technology is implemented and has reached a certain level of maturity, these perceived consequences will no longer provide useful insights as there are measurable consequences. Substantive theories contrast to *Formal Theories* which are based on "validated, generalizable conclusions across multiple studies" (Dwivedi, 2009, p. 55). The outcome of this research therefore is a substantive conceptual framework on the perceived consequences of implementing blockchain technology.

3.2.4 Straussian Grounded Theory in practice

The previous sections presented a theoretical overview of the steps in a Straussian Grounded Theory approach. This section provides a short overview of how SGT is used in practice, and therefore translates the concepts presented in the previous section in practical terms. Figure 3.2 visualizes the coding approach. In the Open coding phase, we highlight quotes in our qualitative empirical data and code these interests. This combination is called a *property.* Then, in the Axial coding phase, we group these properties together, based on a common interest, subject or theme. For example, all *properties* concerning types of costs (properties as *exploitation costs*, *energy cost* and *switching costs*) are grouped together under the *dimension* Costs. Then, in the Selective coding phase, we interrelate these *dimensions* and form *categories.* Finally, we create a *Core Category* that further conceptualizes these categories, creating one category that explains all or most of the data. In essence, each step of the SGT approach conceptualizes the empirical data by grouping it together or interrelating emerged concepts.

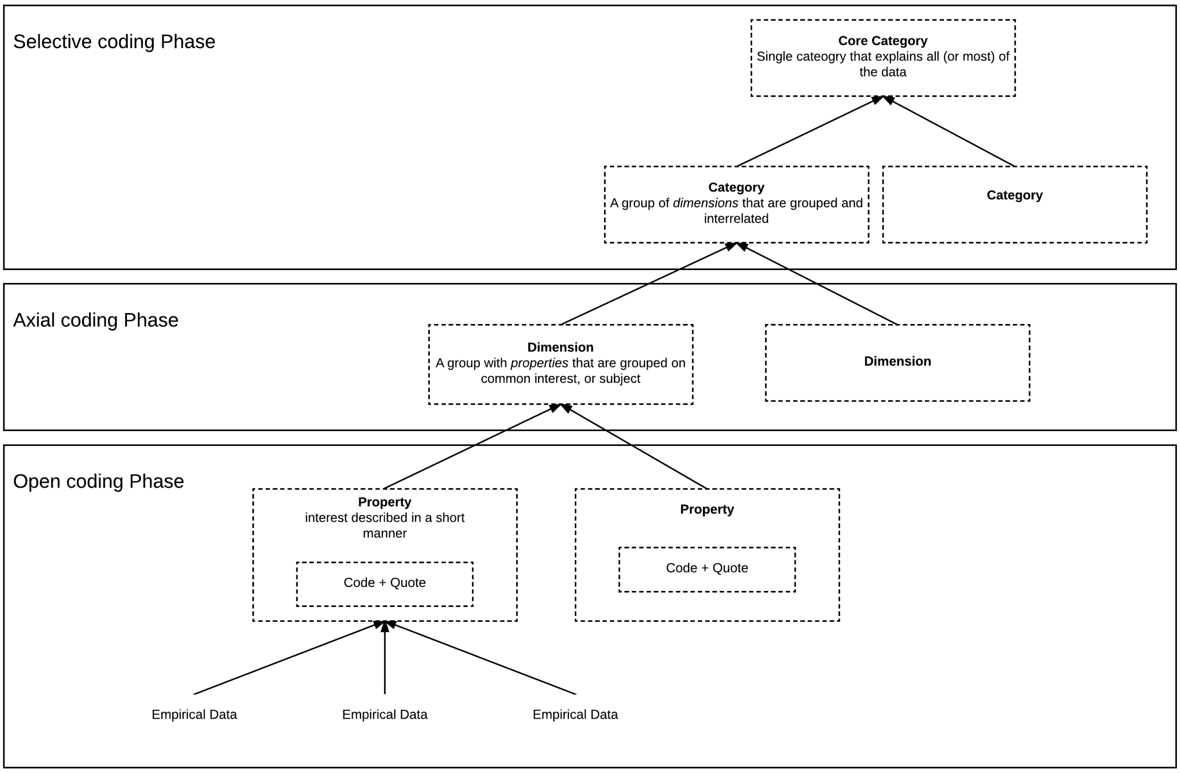


Figure 3.2 Straussian Grounded Theory in Practice

This section elaborated on the different phases in Straussian Grounded Theory: the open, axial and selective coding phases. It further defined the deliverable of this research: a substantive conceptual framework on the perceived consequences of implementing blockchain technology. To further provide structure in the coding phases, these "consequences" must be defined using Sensitizing Concepts.

3.3 Sensitizing Concepts

This section discusses the use of Sensitizing Concepts in this research. Sensitizing concepts are used to provide more structure to the coding phases and provide starting points for the analysis of the data.

Sensitizing concepts differ from definitive concepts as described by Blumer (1954, p. 7): "definitive concepts provide prescriptions of what to see, sensitizing concepts merely suggest directions along which to look". Sensitizing concepts can be used in a Grounded Theory study to provide a "[structure or] framework analyzing empirical data and, ultimately, for developing a deep understanding of social phenomena." (Bowen, 2006, p. 20)
It was argued in chapter 1 that there are three main concepts that are currently of interest in the discussion on the perceived consequences of the implementation of blockchain technology: *Effects, Issues and Functions*.

A trade-off between *effects* and *issues* is made by actors to decide if they should implement blockchain technology in organization. As these effects are strongly linked to what blockchain technology can do, *functions* are also considered to be highly important. Therefore, they were all three mentioned in the research question of this research. Furthermore, as blockchain technology is likely not yet implemented these effects are merely perceptions of the consequences by *actors.* These four concepts *(functions, issues, effects and actors)* will thus be used as sensitizing concepts.

Functions are defined by the Oxford Dictionary as “an activity that is natural to or the purpose of a person or thing”(Functions, n.d.). Furthermore, functions are defined in the book *Engineering Design* by Dym and Little (1994) “things a designed device or system is supposed to do”(p.72) .This sensitizing concept therefore refers in this research *to the intended activities, or purposes of implementing blockchain technology*. Functions and characteristics are distinctly different. Characteristics of blockchains as described in the following chapter are top-down *things that qualifies or characterizes a blockchain as a blockchain,* functions are the *activities or purposes of a blockchain.* Examples include *trading* or *voting.*

Effects are defined by the Oxford Dictionary as “A change which is a result or consequence of an action or other cause.”(Effects, n.d.). Hybertson (2016) defines Effects in his *Systems Engineering Handbook* as “result, actual or interpreted, of system behavior on an environment” (p.72). In this research this sensitizing concept refers to *the changes that are a result of the function of the implementation of blockchain technology*. Both economic effects and changes to institutions are considered in this research. Examples include *faster settlement* or *improved transparency.*

Issues are defined by the Oxford Dictionary as “An important topic or problem for debate or discussion”(Issues, n.d.). Furthermore, problems or issues are defined by Sage and Armstrong (2000) in the book *Introduction to Systems Engineering* as “the occurrence of an undesired aspect of the current situation that creates a gap between what is occurring and what we would like to have occur.” (p. 87). In this research, *issues* are therefore described as the *occurrence of an undesired aspect of the implementation of blockchain technology*.

As blockchain technology is often not yet implemented and in development, issues can also arise before implementation, for example *lack of understanding of blockchain technology.*
During the data analysis, it will become clear if issues are found more as an unwanted effect of the implementation of blockchain technology or during the implementation of blockchain technology. Examples therefore include the *lack of understanding of blockchain technology* and *the irreversibility of blockchain.*

Actors are defined by the Oxford Dictionary as “A participant in an action or process”(Actors, n.d.). More specifically, when looking at actors from a policy analysis perspective, actors are defined as “a social entity, person or organization, able to act on or exert influence on a decision”(Enserink et al., 2010, p. 79). In this research, this sensitizing concept refers to *the social entities, persons and organizations that want to implement blockchain technology, or influence the implementation and decision making of blockchain technology.* All social entities, persons or organizations that are presented in the third layer of the three-layer model by Mougayar (2016) described in section 2.7 are considered in this research.

This section described the four sensitizing concepts (Effects, Functions, Issues and Actors) that were used to structure the analysis of the data through the three phases of Straussian Grounded Theory. The next section discusses the research setup that was used to structure the research in practice.

3.4 Research Setup

This section further elaborates on the exact research setup that was used to find and analyze the data. The first paragraph describes how data was gathered. Furthermore, it discusses the filtering of this data, into the data that was finally used in this research. The second paragraph discusses the use of qualitative analysis tool, ATLAS.ti, and the coding procedure that was followed in this software package.

3.4.1 Gathering data for Grounded Theory approach

This research focusses on grey and non-scientific literature, to provide an overview that is as close to empirical data as possible to capture the real-life debate. Scientific sources already provide a "colored" image of the views presented in non-scientific literature and are therefore not used in this research phase. The sources that were used include, but are not limited to:

- Corporate reports
- Governmental reports
- White papers within blockchain technology
- Opinion articles in media, such as HBR/Coindesk/Medium/Newspapers
- Web-sites by start-ups

The non-scientific sources are found primarily using *Google* with the keywords: Blockchain, Distributed Ledger Technology, Report, Use case, Effects, Issues, Functions.

The combination of these search results, and the process of theoretical sampling, provided a long list of 73 articles. A final list of 56 relevant articles was created based on this long list and the following set of criteria:

- Only articles that followed the definition of blockchain technology, as presented in section 2.6 and 2.7, were used in the shortlist.
- Articles with explanations and in-depth overviews were preferred over short, summarizing articles that provided little more insights than a list of consequences of implementing blockchain technology.
- Highly technical whitepapers were omitted, as they present little to no data on the expected effects, issues ore functions of the implementation.

These 56 articles include articles that were added through the process of *Theoretical Sampling.* In this process new articles were added when new properties emerged that provided the researcher with new insights. These insights were new application domains, new actors, new consequences or another viewpoint on existing insights. This process is further explained in section 4.1.1. An overview of the final list of 56 articles is presented in Appendix 1.

3.4.2 Coding the data using ATLAS.ti

The data was coded by the researcher using the qualitative analysis tool ATLAS.ti version 1 for Mac[8]. ATLAS.ti is a qualitative research tool that enables a researcher to code quotations, group codes and relate codes and grouped codes with each other. ATLAS.ti was primarily used in the open and axial coding phase. Several Grounded Theory experts do not recommend using software to help the coding efforts (Glaser, 1998; Holton, 2007), as it would force a certain structure on the researcher and that software could not replace human thinking. However, Friese (2016) argues that software does not have these effects as this software is only used for documentation and not for analysis,

[8] The MAC and Windows versions are essentially the same program; however, some changes were made in terminology. This research will follow the MAC terminology. To my knowledge these are the differences (Friese, 2016):
Code Family (Windows) = Code Group (Mac)
Super Families (Windows) = Smart Group (Mac)
Super Codes (Windows) = Smart Codes (Mac)

thereby not replacing human thinking: “I can hardly imagine how one would handle the potentially anticipated material data manually, and, in particular, how to keep track of it.”(p.20).

3.5 Validation

The validation of qualitative research, and especially emergent techniques as Grounded Theory can be challenging. In contrast to the often used (quantitative)-positivist approach to research, Grounded Theory does not form hypotheses that are tested. Grounded Theory can therefore be sometimes described as “a nice story” (Urquhart, 2012, p. 153) or the result of the researchers´ “self-delusion” and therefore be unreliable and invalid”(Carcary, 2009 in; Sikolia et al., 2013, p. 1). Both the evaluation of the research, and the research design (Wester, 2005) are therefore paramount to the success of a persuasive and convincing outcome. The evaluation methods are presented in this section; the importance of a good research design is discussed in the text-box.

A qualitative research design by Wester (2005)

The presentation of the research design is highly important for qualitative research. Wester argues that these paragraphs are generally lacking. He therefore proposed a checklist that was used to write this chapter. The main elements are

1. Research goal
2. Research design
3. Selection of data
4. Generation of Data
5. Process for analyzing data

In an article on the validation of Grounded Theory research Lazenbatt and Elliott (2005) present an overview of possible validation techniques for research. The table below presents an overview of qualitative and Straussian Grounded Theory evaluation criteria.

Table 3.1 Overview of evaluation criteria for research by Lazenbatt and Elliot (2005, p.51)

Qualitative Research(Lincoln & Guba, 1985)	**Straussian Grounded Theory (Corbin & Strauss, 1990)**
- Credibility - Transferability - Dependability - Confirmability	- Research process - Empirical grounding of findings

The validation criteria of Qualitative Research as presented in the left column are general criteria that any qualitative study should adhere to. In a review of Grounded Theory research by Sikolia et al. (2013) these four criteria are made specific:

Trustworthiness dimension	Steps to improve Trustworthiness
Credibility (Internal validity)	• Prolonged engagement with participants(Brown et al. 2002; Jacelon and O'Dell 2005; Morrow 2005) • Triangulation of data (data from interviews, observations, documents etc.)(Bowen 2009; Brown et al. 2002; Jacelon and O'Dell 2005) • Thick descriptions of data and sufficiency of data assessment or saturation(Morrow 2005) • Respondent validation of interview transcripts and emerging concepts and categories (participant checks) (Brown et al. 2002; Jacelon and O'Dell 2005; Morrow 2005) • Participant guidance of inquiry (theoretical sampling)(Cooney 2010) • Use of participant words in the emerging theory(Cooney 2010) • Negative case analysis(Brown et al. 2002; Morrow 2005) • Peer debriefers(Brown et al. 2002; Jacelon and O'Dell 2005; Morrow 2005)
Transferability (External validity)	• "Thick descriptions" of the research, the participants, methodology, interpretation of results and emerging theory.(Bowen 2009; Brown et al. 2002; Cooney 2010; Morrow 2005)
Dependability (Reliability)	• Examination of a detailed audit trail by an observer(Brown et al. 2002; Morrow 2005)
Confirmability	• Examination of a detailed audit trail by an observer(Brown et al. 2002; Morrow 2005)

To improve the trustworthiness of this research, several steps are taken:

- Credibility is considered by using a *wide range of data sources* as input for this research. Furthermore, by staying as close as possible to used phrases and terms in these sources, we *stay as close to the data as possible*. Second, we use *thick descriptions* of the data and assessment in chapter 4, 5 and 6. Finally, *negative case analysis* was used by including critical journalism in our data.
- Transferability is considered by means of a strict use of the *article short list*, which describes why sources were used in this research. Furthermore, the use of memos throughout the coding procedure automatically creates a logbook, which should provide a clear audit trail that can be followed. Also, this current chapter is specifically written in the main text, not in an appendix, to provide a *thick description of the research design and methodology.*
- Dependability and Confirmability are both ensured *through the supervision of this thesis*. As this research is part of a master thesis, the supervisors form an automatic observing community that follows this research process

The general qualitative validation criteria are thereby described. However, Strauss and Corbin have presented two lists of criteria to assess the quality of Grounded Theory studies; the *research process* criteria and the *empirical grounding of findings* criteria. Both consist of 7 criteria (Corbin & Strauss, 1990, pp. 17,18).

Research process criteria

- *"Criterion 1:* How was the original sample selected? On what grounds (selective sampling)?
- *Criterion #2:* What major categories emerged?
- *Criterion #3.* What were some of the events, incidents, actions, and so on that indicated some of these major categories?
- *Criterion #4.* On the basis of what categories did theoretical sampling proceed? That is, how did theoretical formulations guide some of the data col- lection? After the theoretical sample was carried out, how representative did these categories prove to be?

- *Criterion #5:* What were some of the hypotheses pertaining to relations among categories? On what grounds were they formulated and tested?
- *Criterion #6:* Were there instances when hypotheses did not hold up against what was actually seen? How were the discrepancies accounted for? How did they affect the hypotheses?
- *Criterion #7:* How and why was the core category selected? Was the selection sudden or gradual, difficult or easy? On what grounds were the final analytic decisions made? How did extensive "explanatory power" in relation to the phenomena under study and "relevance" as discussed earlier figure in the decisions?"

Empirical grounding of findings criteria

- *"Criterion #1:* Are concepts generated?
- *Criterion #2:* Are the concepts systematically related?
- *Criterion #3:* Are there many conceptual linkages and are the categories well developed? Do the categories have conceptual density?
- *Criterion #4:* Is there much variation built into the theory?
- *Criterion #5:* Are the broader conditions that affect the phenomenon under study built into its explanation?
- *Criterion #6:* Has "process" been taken into account?
- *Criterion #7:* Do the theoretical findings seem significant and to what extent?"

These criteria are considered during the execution of this research. Furthermore, at the end of this research, in Appendix 5, the criteria are all checked to ensure a good process and findings that are grounded in empirical data.

3.6 Conclusions

This chapter further explained the precise research design, which answered the second research question: "How can the research approach Grounded Theory be applied in this research?". Elaborating on the research design was primarily needed as Grounded Theory is a highly explorative and inductive approach, which means that the research process provides the needed structure. Furthermore, we argued that the *Straussian Grounded Theory approach* is most suited for this research, as it allows the emergence of a new conceptual framework on the consequences of implementing blockchain technology, which is grounded in empirical data. The specific approach was chosen as it provides more structure for novice researchers. It furthermore discussed the three phases of coding within Grounded Theory: Open coding, Axial coding and Selective coding. Finally, we then elaborated on the research setup, by explaining the data gathering and data analysis approaches. Finally, it discussed the validation criteria used throughout this research.

4 Open and Axial Coding – Emerging variables and dimensions of the Issues, Effects and Functions of blockchain technology

The previous chapter introduced the research approach used in this research. The research phases were explained in section 3.2 (theoretically) and section 3.2.4 (practically). This chapter describes the emergence of the first results of this research. First, it discusses the third phase of this research, the Open Coding phase. This phase is aimed at the emergence of a long list of *properties*, perceived effects, issues and functions of implementing blockchain technology. Then, this chapter elaborates on the fourth stage of this research, the Axial Coding phase (Figure 4.1). This phase is aimed at the emergence of a long list of *dimensions*, these are *properties* combined into higher level concepts by a common theme. Thus, the aim of this chapter is to answer the third research question: "Which dimensions can be discerned of effects, issues and functions of blockchain technology?". These research phases use the three sensitizing concepts, Effects, Issues and Functions, to provide structure to this process.

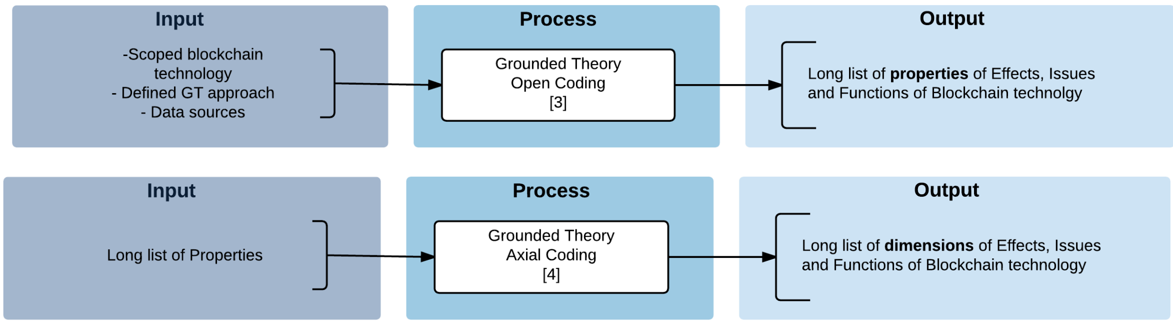


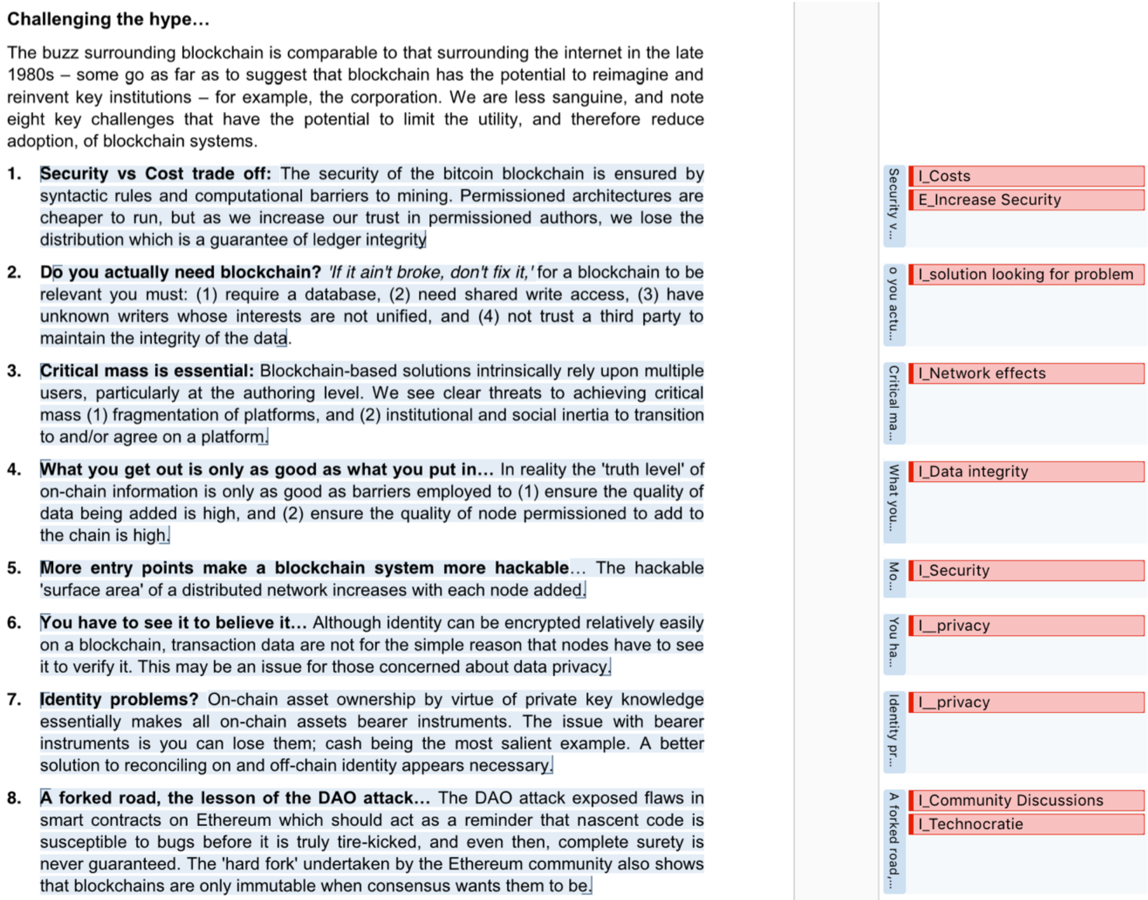
Figure 4.1 Research flow of the third and fourth phase

4.1 Structuring the data using Open Coding

This section discusses the results of the Open Coding phase. As described in section 3.2.1, the result of our open coding phase is a long list of perceived consequences (effects, functions and issues) of implementing blockchain technology, called *properties*. This section first provides a short overview process and discussion on how theoretical saturation was reached. Then, this section elaborates on some examples of properties and quotations, to provide an insight in the coding process.

4.1.1 An overview of the open coding phase

At the end of the Open Coding phase 56 documents were coded. This resulted in a total of 539 quotes over 415 properties in total over the three sensitizing concepts Effects, Issues and Functions.
Figure 4.2 provides an example of the open coding phase in ATLAS.TI. Examples of properties are presented in section 4.1.2. Finally, an overview of all properties and the coding scheme used is presented in Appendix 2.



Challenging the hype…

The buzz surrounding blockchain is comparable to that surrounding the internet in the late 1980s – some go as far as to suggest that blockchain has the potential to reimagine and reinvent key institutions – for example, the corporation. We are less sanguine, and note eight key challenges that have the potential to limit the utility, and therefore reduce adoption, of blockchain systems.

1. **Security vs Cost trade off:** The security of the bitcoin blockchain is ensured by syntactic rules and computational barriers to mining. Permissioned architectures are cheaper to run, but as we increase our trust in permissioned authors, we lose the distribution which is a guarantee of ledger integrity
2. **Do you actually need blockchain?** *'If it ain't broke, don't fix it,'* for a blockchain to be relevant you must: (1) require a database, (2) need shared write access, (3) have unknown writers whose interests are not unified, and (4) not trust a third party to maintain the integrity of the data.
3. **Critical mass is essential:** Blockchain-based solutions intrinsically rely upon multiple users, particularly at the authoring level. We see clear threats to achieving critical mass (1) fragmentation of platforms, and (2) institutional and social inertia to transition to and/or agree on a platform.
4. **What you get out is only as good as what you put in…** In reality the 'truth level' of on-chain information is only as good as barriers employed to (1) ensure the quality of data being added is high, and (2) ensure the quality of node permissioned to add to the chain is high.
5. **More entry points make a blockchain system more hackable**… The hackable 'surface area' of a distributed network increases with each node added.
6. **You have to see it to believe it…** Although identity can be encrypted relatively easily on a blockchain, transaction data are not for the simple reason that nodes have to see it to verify it. This may be an issue for those concerned about data privacy.
7. **Identity problems?** On-chain asset ownership by virtue of private key knowledge essentially makes all on-chain assets bearer instruments. The issue with bearer instruments is you can lose them; cash being the most salient example. A better solution to reconciling on and off-chain identity appears necessary.
8. **A forked road, the lesson of the DAO attack…** The DAO attack exposed flaws in smart contracts on Ethereum which should act as a reminder that nascent code is susceptible to bugs before it is truly tire-kicked, and even then, complete surety is never guaranteed. The 'hard fork' undertaken by the Ethereum community also shows that blockchains are only immutable when consensus wants them to be.

Figure 4.2 Example of Open Coding phase in ATLAS.TI

Theoretical Sampling during the Open coding phase

During this open coding phase a continuous process of *theoretical sampling* was used to provide the research with new literature based on emerging knowledge. First, the research started with reports by corporates as McKinsey & Company, IBM and Oliver Wyman as it was assumed that they presented a more holistic view on blockchain technology, instead of one single application. The first emerging pattern was that there was a primary focus on the Financial, Supply Chain, Government and Health sectors with the first being the most important. Other corporate sectors seem to be lagging in publishing about blockchains.

Therefore, we decided to focus more on these sectors when considering the start-up scene in blockchain literature. With this sector focus, a better comparison between established corporates and start-up could be made. A long list of start-ups was created by searching on Google for “Blockchain [Sectors]” and using Angel.Co, a website that presents an overview of start-ups. Whitepapers and direct copies of web-pages were also used to create the start-up documentation. Using these documents, we could stay as close to empirical data as possible. At the end of these coding phases a highly positive image of blockchain technology emerged. This corresponds with expectations, as both the corporates and the start-ups are pushing blockchain technology. Therefore, we decided to add critical journalism to the documents to create a more balanced view of blockchain technology. These included:

- Quality (international) newspapers articles: The Economist, The Wall Street Journal, Forbes, NRC[NL], de Volkskrant[NL]
- Opinionated pieces in these newspapers
- Books

These sources provided a more balanced, outsider view. For example, new properties as *Hype* and the negative effects of the current *community discussions and technocracy* emerged. Both are important pieces of the current blockchain technology discussion, but were not mentioned in documents by “blockchain believers”.

Reaching Theoretical Saturation

The open coding phase is finished if *theoretical saturation* is reached. Theoretical Saturation was earlier defined in section *3.2.1* as the moment where the addition of new data does not longer lead to new insights (Creswell, 2002). To verify whether theoretical saturation was reached, one document per emerged actor-category (Corporate, Start-up and journalism) was not coded during normal coding. When we had the feeling that adding other documents started to add little to no new information, these articles were coded to verify our theoretical saturation.

- Corporate
  A report by the Bank Credit Suisse was used in the corporate category. Only two new properties were added, which were highly similar or interconnected with existing properties. Therefore, no new insights emerged.
- Start-ups
  Start-ups were heavily focused on their own small blockchain implementation, so we determined that three start-ups in different sectors should be checked for saturation. These were: Uport in Identity/Government, BlockchainHealth in Health and Bittunes in Music/Supply chain. Again, only 2 new properties were added, which were highly similar to the existing properties. Therefore, no new insights emerged.
- Journalism
  A critical chapter in Tapscott & Tapscott’s book *The Blockchain Revolution* was used for the critical journalism parts. In this chapter, no new properties were added, so no new insights emerged.

In view of the limited number of added properties we concluded that theoretical saturation was reached.

4.1.2 Examples of properties and quotes in the open coding phase

This section presents three examples of quotes and properties, to further clarify the results of the open coding phase. The first is the Effect in the Financial Sector Cost “Savings”, the second is the Function in the Financial Sector “Verify Transactions”, and the third the Issue “Hype”.

Effect in Financial Sector: Cost savings

Oliver Wyman

“Many clients (particularly on the buy side) will expect to accrue the most benefit, from the reduction in costs of capital markets dealing and securities servicing. Retail and wholesale investors may transact more among themselves, now with guaranteed execution on open markets.”

World federation of exchanges

“Broadly speaking, respondents highlighted cost savings (for the responding entity and the industry more broadly), efficiency enhancement and risk reduction as their main reasons for investigating the application of DLT to the use cases which are set out above. “

IBM

“The cost effectiveness of such an infrastructure would also be critical to underpin a future ‘internet of things’, he adds. “With the number of devices connected to the internet exploding and them all becoming potential users of banking services, this technology may enable us to offer services at much lower cost,” he says. “Real distributed ownership enabling machine to machine interactions – that is

going to be really transformational," agrees Julio Faura, Head of R&D, Banco Santander. "A use case for this could be payments in the context of the internet of things." "

Function in Financial Sector: Verify Transactions

Credit Suisse

"The blockchain is increasingly recognized as the most significant technical innovation of bitcoin. Google search data reflects this trend and we have noted a rapid recent increase in our clients' interest in blockchain's disruptive potential, particularly its impact on the payments space. Most simply, the blockchain protocol is a cryptographically secure system of messaging and recording in a shared database. Working in tandem, these systems enable the secure record, verification and confirmation of transactions without the need for a central counterparty to administer the system."

Cognizant

"The lure of blockchain was its method of verifying and tracking transactions. Instead of a trusted third-party or a central bank, it relies on consensus among a peer-to-peer network of computers based on complex algorithms."

Kynetix

"With a centralised ledger that publicly records the movement of every asset, along with proof of ownership and the authenticity of assets protected by a coded secure cryptographic framework and with confirmations of new trades identifiable by a unique crypto stamp, there is a significant reduction in manual processes.

Hype issues

Credit Suisse

"On the streets of Davos this year there are only three discussions being had. One: robots are going to take over our jobs. Two: blockchain is amazeballs and three: FinTech is like blockchain amazeballs, but with even more possibilities to control and mould the behaviours of the common man."

Bloomberg

"Part of the answer is that the blockchain vogue has a certain universality right now, at least among financial- technology types, that makes it an appealing pitch across markets. "We need to find a way to reduce processing time in syndicated loan markets" is a pretty niche pitch, perhaps appealing to the back-office guy who handles syndicated loans. "We want to use the blockchain to trade syndicated loans" might get you a higher-level audience, perhaps with the chief technology officer or the head of loan trading. And "we want to use the blockchain to trade syndicated loans and Treasury repos and private company shares and whatever else you've got" could get you in front of the CEO."

de Volkskrant (translated from Dutch)

"The internet sector is shocked by the theft of 50 million dollars at "The DAO", an online investment fund without staff, managers or direction. The DAO uses a technology called blockchain. The theft heavily undermines one of biggest tech hypes of this moment. The most well know application of blockchain technology is currently bitcoin, a virtual coin that enables transactions that is not traceable or forgeable."

ZDnet

" "I haven't seen anything as hyped in such a short period of time as blockchain ... The answer to every question seems to be 'blockchain'," said Peter Williams, chief edge officer at Deloitte's Centre for the Edge. "I expect that at the next Miss World, 'What do you want to do?' 'I want to solve world peace by using a blockchain, and end poverty and world hunger as well," he told the APIdays conference in Melbourne on Wednesday. Williams said we have an "irrational exuberance" for blockchain, the distributed ledger at the heart of Bitcoin and other cryptocurrencies. He's right. Just follow the Twitter account @bitcoin_txt for some of the more ludicrous comments from its fans. But as I've written previously, Bitcoin is an ideology, and it's unlikely to ever be workable for everyday transactions."

This section discussed the *Open Coding Phase*, which resulted in 415 properties. An overview of these properties can be found in Appendix 2.

4.2 Creating dimensions in the data using Axial Coding

This section discusses the results of the Axial Coding phase. As described in section 3.2.2 the result of our axial coding phase is a list of *dimensions*: properties combined into higher level concepts by a common theme. This section first provides an overview of the coding process and how the dimensions were created. Then, this section presents some examples of dimensions, by elaborating on their underlying properties and quotes. Finally, an overview of the dimensions is given, which will serve as input for the selective coding phase.

4.2.1 Overview of axial coding phase

The 415 properties that emerged during the open coding phase were grouped together in dimensions during the Axial Coding phase. This coding phase eventually resulted in a total of:

- 14 dimensions in the sensitizing concept Issues
- 13 dimensions in the sensitizing concept Functions
- 12 dimensions in the sensitizing concept Effects

For a total of 39 dimensions. A more detailed overview of all dimensions and explanations are found in appendix 3, 4 and 5. In the following paragraphs, they are discussed per Sensitizing Concept.

4.2.2 Examples of dimensions that emerged during the Axial coding phase

A total of 39 dimensions emerged during the axial coding phase. To provide more insight in this process, this section presents two of these dimensions. The first dimension is relatively straightforward and is the *Issue "Cost"* (sensitizing concept: Issues). Properties that discuss the high costs of blockchain technology were grouped here. The second dimension is an example of a dimension that was less straightforward: *User Empowerment* (sensitizing concept: Effects). This dimension groups all effects that empowered the end-user in the blockchain system.

Costs (Sensitizing Concept: Issues)

The costs related with running a blockchain are high. Some implementations require a large amount of computing power and electricity. Validating blockchain transactions in a Proof-of-Work consensus mechanism (as described in section 2.1) requires large amounts of computing power, and therefore increases electricity usage and costs. Furthermore, there are large switching costs that are considered with blockchain technology, as new software and new hardware is needed to implement blockchain technology. Table 4.1 presents an overview of the *dimension* Cost, with the underlying *properties,* below this table a series of quotes is presented to provide insights into the coding process. Each quote is presented with the author of the quote, and the *property* [in brackets] that was attached to this quote.

Table 4.1 Overview of Cost dimension including underlying properties

Costs		
Exploitation Costs	Energy Usage	Computing Power
Switching Costs	Risk Investments	

Deloitte [Exploitation Costs]

"The speed and effectiveness with which blockchain networks can execute peer-to-peer transactions comes at a high aggregate cost, which is greater for some types of blockchain than others. This inefficiency arises because each node performs the same tasks as every other node on its own copy of the data in an attempt to be the first to find a solution. For the Bitcoin network, for example, which uses a proof-of-work approach in lieu of trusting participants in the network, the total running costs associated with validating and sharing transactions on the public ledger are estimated to be as much as $600 million a year and rising. This total does not include the capital costs associated with acquiring specialist mining hardware"

McKinsey & Company [Computing Power]

"Computing power: Computational power required by blockchain hashing algorithms is substantial in the Bitcoin application, a potential impediment to applications in financial markets, which have considerably higher transaction volumes. Although computational difficulty is a feature of the Bitcoin blockchain by design, energy consumption may remain a concern."

Berkeley [Switching Costs]

"Bootstrapping: Moving the existing contracts or business documents/frameworks to the new Blockchain based methodology presents a significant set of migration tasks that need to be executed. For example in case of Real Estate ownerships/liens, the existing documents lying in County or Escrow companies need to be migrated to the equivalent Blockchain form. This may involve time and cost."

Credit Suisse [Exploitation Costs]

"Security vs Cost trade off: The security of the bitcoin blockchain is ensured by syntactic rules and computational barriers to mining. Permissioned architectures are cheaper to run, but as we increase our trust in permissioned authors, we lose the distribution which is a guarantee of ledger integrity"

User Empowerment (Sensitizing Concept: Effects)

Blockchains can lead an empowerment of the end user. Users can influence the rules of the game, which are transparent, of corporations, institutions and governments. Blockchain further improves access to anything; capital, financial inclusion etc. This is linked with the access to real-world-objects, or a sharing economy. All in all, users are empowered with more control over the rules that govern the system, or are less dependent on intermediaries. Table 4.2 presents an overview of the *dimension* User Empowerment, with the underlying *properties.* Below the table we present quotes to provide insights into the coding process. Again, the author of the quote and the property [in brackets] is presented before every quote.

Table 4.2 Overview of User Empowerment dimension including underlying properties

User empowerment			
Protect against domination	Self-governance	Enable Sharing economy	Fairness increase
Access to financial services	Globalization	Customer engagement	Personalization
Access to capital	Increase control	Lower entry barriers	

IBM [Self-Governance]

"As blockchain-based transactions become more sophisticated, the business network as a whole will achieve greater levels of autonomy, reducing the need for human governance and ultimately evolving into self-governing, cognitive business networks. These autonomous organizations will stretch our definition of what it means to be a dynamic enterprise."

United Kingdom Government Office for Science [Enable Sharing Economy]

"Example 1: A tractor that operates as an autonomous unit can authorise access to multiple farmers in an area, enabling a pay per use model. It has the ability to discover and pay for climate data, and communicate with its manufacturer for maintenance and repairs."

Ujo [Increase Control]

"We believe the machinery required to make the music industry move for creative rights is the blockchain, and it's important that we have a shared understanding of what that means and what it's going to take to get there. It's our hope that by combining a handful of these next generation technologies, we can bring about a new type of collective in the music industry — one that enables creators to retain more control of their rights, to receive fair and transparent compensation for their creations, to have leverage in the marketplace, and reduces the costs of licensing content and paying royalties."

BitShares [Self Governance]

"BitShares is a technology supported by next generation entrepreneurs, investors, and developers with a common interest in finding free market solutions by leveraging the power of globally decentralized consensus and decision making. Consensus technology has the power to do for economics what the internet did for information. It can harness the combined power of all humanity to coordinate the discovery and aggregation of real-time knowledge, previously unobtainable. This knowledge can be used to more effectively coordinate the allocation of resources toward their most productive and valuable use."

4.2.3 An overview of the results of the axial coding phase

The results of the axial coding phase are presented in **Error! Reference source not found.**, Table 4.4 and Table 4.5, which provide an overview of the dimensions that emerged for the three sensitizing concepts. Notice that *dimensions* are properties combined into higher level concepts by a common theme, and that these tables do not include *relations* between the *dimensions.* Relating dimensions to each other is done in the selective coding in the next chapter. For a more in-depth discussion of these dimensions, which includes an explanation of the dimension and an overview of all underlying properties per dimension, see appendix 3,4,5.

Table 4.3 Overview dimensions in Effects sensitizing concept

Effects			
Accuracy	Costs	Enable New Markets and Organizational Forms	Trust
Auditability	Disintermediation	Risk	User Empowerment
Automation	Efficiency	Security	Value Creation

Table 4.4 Overview dimensions in Issues sensitizing concept

Issues			
Adoption Strategy	Corporate and Personal Privacy	Immutability	Standardization
Anonymity	Costs	Institutional Framework	Technocracy
Automation	Customs and Culture	Integration	
Centralization vs Decentralization	Immaturity	Performance	

Table 4.5 Overview of dimensions in Functions sensitizing concept

Functions			
Corporate	Governmental Services	Regulatory Reporting	Voting
Create and Execute Immutable Rules	Identity Services	Single Source of Truth	
Data	Immutable Recording of transacted assets	Standardization	
Digitize Assets	Market Making	Tokenization	

4.3 Conclusions

This chapter presented an overview of the Open and Axial Coding phase, thereby answering our third research question: “Which dimensions can be discerned of effects, issues and functions of blockchain technology?”, using the Open and Axial Coding phase of the Straussian Grounded Theory approach. First, it discussed the open coding phase, which resulted in a total of 415 *properties*. Then, it discussed the emergence of higher-level concepts from these *properties,* called *dimensions*. This resulted in fourteen Issue dimensions, thirteen Function dimensions and twelve Effect dimensions. These dimensions are used in the next chapter in the Selective Coding phase, the development of a conceptual framework and as well as the core category that describe and encompass the blockchain discussions.

5 Selective Coding – A conceptual framework of blockchain consequences

In this chapter, we discuss the fifth phase of this research, the Selective Coding phase. In the Selective Coding phase, the *dimensions,* which emerged in the Axial coding phase (section 4.2), are interrelated into *categories* that are used to conceptualize a conceptual framework (Figure 5.1). First, in this chapter, we argue that our sensitizing concepts should be revised to three other categories. Then, we present the conceptualization of the conceptual framework on the blockchain discussions. Finally, we discuss the emergence of our *empirical core category,* a category that explains all (or most of) the data in this research. Thus, this chapter answers the fourth research question: "How can relations between the effects, issues and functions of blockchain be integrated into a conceptual framework and core category?"

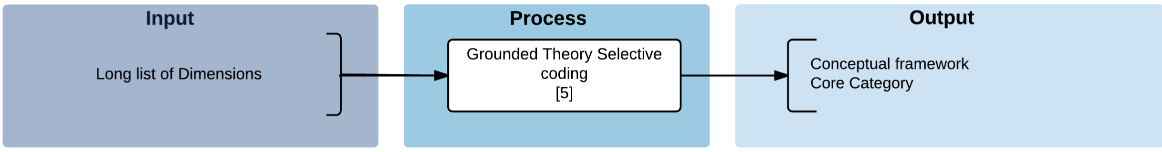


Figure 5.1 Research flow of the fifth phase

This section is structured as follows: first, section 5.1 discusses the development and refinement of our sensitizing concepts into definitive concepts in the form of categories. Then, section 5.2, 5.3 and 5.4 discuss our categories: The value of disintermediation of trust, Technological and institutional uncertainty, and Contrasting perceptions. This results in a conceptual framework on the consequences of blockchain implementation. This framework is then analyzed in section 5.5, in which our Core Category emerges.

5.1 The development of sensitizing concepts

The sensitizing concepts, Effects, Issues and Functions, were used to provide structure to the Open and Axial coding phase. In this chapter, the sensitizing concepts are revised into *definitive concepts* , in the form of categories in conceptual framework. Blumer (1954) describes this difference as: "Whereas definitive concepts provide prescriptions of what to see, sensitizing concepts merely suggest directions along which to look" (p.7). Thus, sensitizing concepts are only used to provide early structure and to inspire the researcher, and can therefore be changed throughout the research. This coincides with the highly iterative and emergent nature of the Grounded Theory approach. This chapter argues the emergence in the Selective Coding phase of three definitive categories:

- The value of disintermediation of trust
- Technological and institutional uncertainty
- Contrasting Perceptions.

5.2 Value of the disintermediation of trust

This section describes the emergence of the category *value of disintermediation of trust*. In this category, dimensions from all three sensitizing concepts are used.

First, we use the sensitizing concept *Functions.* In this sensitizing concept, which consists of the 13 dimensions mentioned in Table 4.5, one dimension is most important. The *immutable recording of transacted assets* is the core function of blockchain. The other functions are secondary functions, or functions that are made possible by the immutable recording of transacted assets. Thus, the Dimension *Immutable Recording of Transacted* Assets has full explanatory power over all dimensions in the Sensitizing Concept *Functions.* This is visualized in Figure 5.2, which shows the dimension *Immutable Recording of Transacted Assets* that explains or enables all other dimensions in this sensitizing concept.

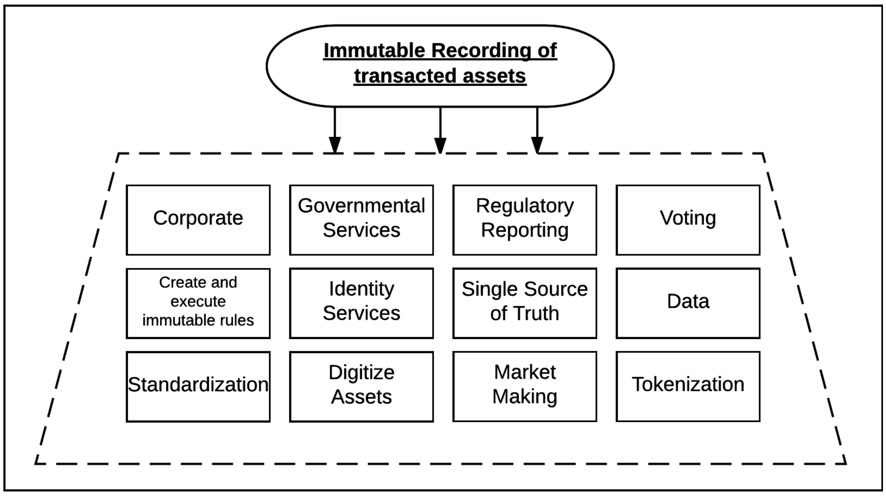


Figure 5.2 Overview of the dimensions in sensitizing concept Functions

The *Immutable Recording of Transacted Assets* is also linked to the sensitizing concept Effects, as it enables the most important effect of blockchain technology. The *Immutable Recording of Transacted Assets* creates a *Single Source of Truth (*also a dimension in the Functions Sensitizing Concept); *i*t creates a database which all participants can agree on. Whether it is an asset transfer in the form of (digital) money or rules and bylaws of corporations, blockchain technology enables to cooperate with unacquainted, and thereby untrusted, parties without the need for a (trusted) intermediary. Thus, this single source of truth enables the transfer of assets without an intermediary. The ability to transfer assets without a (trusted) intermediary is strongly linked to an often-used phrase in blockchain literature and discussions: The Disintermediation of Trust. Blockchain enables users in a system to interact, cooperate and transact with untrusted parties *without* the need for a trusted intermediary. This is visualized in Figure 5.3.

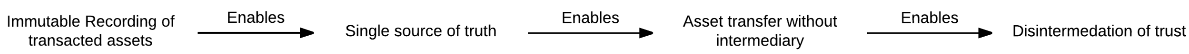


Figure 5.3 Overview of blockchain enabling a disintermediation of trust

The second part of this category, value, emerged from the dimensions in the *effects*-and *issues* sensitizing concepts. The dimensions in the sensitizing concept *Effects* describe positive consequences of implementing blockchain technology. Dimensions in de sensitizing concept *Issue* described *negative consequences* and *uncertainties*. By combining these *positive consequences* and *negative consequences* we can create an overview of the costs and benefits of blockchain technology. This overview represents the *costs and benefits* of implementing blockchain technology and therefore the *value* of blockchain technology, or the *value of the disintermediation of trust.* Table 5.1 presents an overview of the *Costs* and *Benefits*, in which *dimensions* from both the sensitizing concepts *Issues* and *Effects* are used. The *uncertainties* are discussed in the following section.

Table 5.1 Overview of the Cost and Benefits (value) Category, based on a selection of dimensions from the two separate sensitizing concepts Issues and Costs

Costs and Benefits			
Accuracy	Corporate and Personal Privacy	Enable New Markets and Organizational Forms	Security
Anonymity	Costs (Issue)	Immutability	Standardization
Auditability	Costs (Effect)	Integration	Trust
Automation (Issue)	Disintermediation	Performance	User Empowerment
Automation (Effect)	Efficiency	Risk	

We combine these two notions, *Value* and *Disintermediation of trust,* as it captures the complete costs and benefits, and functions, of blockchain technology as described in our data. The *value of the disintermediation of trust* therefore creates a starting point for the emergence of our conceptual framework on blockchain technology (Figure 5.4).

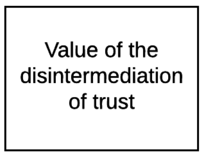


Figure 5.4 Emergence of Conceptual Framework - Value of Disintermediation of Trust

5.3 Technological and institutional Uncertainty

This section further develops the descriptive framework by adding the category of *Technological and Institutional Uncertainty.*

Actors perceive uncertainties when discussing the implementation of blockchain technology. This means that costs and benefits in category *the value of disintermediation of trust* are uncertain. Furthermore, not only the extent of the costs and benefits are uncertain, it is uncertain whether these costs and benefits exist. Both are primarily caused by the immaturity and novelty of blockchain technology. These uncertainties emerged from several dimensions in the sensitizing concept *Issue*. Table 5.2presents an overview of the category *Uncertainties*.

Table 5.2 Overview of dimensions in Uncertainty-category

Technological and Institutional Uncertainties	
Adoption Strategy	Technological Immaturity
Centralization vs Decentralization	Institutional Framework
Customs and Culture	Technocracy

The category *Technological and Institutional Uncertainties* represents two of the biggest uncertainties concerning blockchain currently: Technological uncertainties and Institutional uncertainties.

- Technological uncertainties are described in the dimension *Technological Immaturity* in table 5.3, which creates uncertainty on the extent to which the *value of the disintermediation of trust* is achieved as expected. Includes the *properties*:
    - Insecurity of promise
    - Unknown costs and benefits
    - Lack of expertise
    - User unfriendliness
- Institutional uncertainties are described by the following dimensions:
    - The *institutional framework* is currently not well developed. Both regulatory and legal frameworks on blockchain technology are not in place, which creates uncertainty.
    - The interaction between people and technology creates uncertainty. How are *customs* and *cultures* impacted and is blockchain technology *accepted* by people? How do people react to the current *technocratic* nature of blockchain technology?
    - The interaction between decision-makers and the technology also creates uncertainty. This dimension considers the encapsulation efforts by current (centralized) corporates, and the lack of successful *adoption strategies* for blockchain technology.

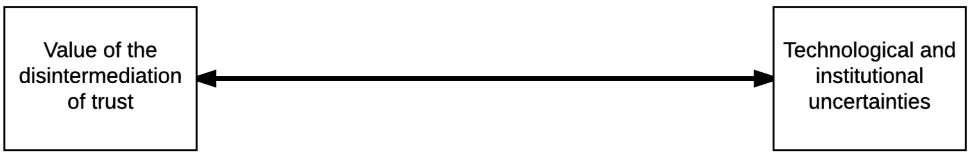


Figure 5.5 Emergence of Conceptual Framework - Technological and Institutional Uncertainties

5.4 Contrasting perceptions

The third and final category emerged from the dimensions is *Contrasting Perceptions.* Actors that are involved in the discussion on blockchain technology implementations perceive the technology differently. These perceptions influence how the *value of the disintermediation of trust* and the Technological and Institutional *uncertainties* are perceived by actors.

Actors have contrasting perceptions on the desirability of the consequences of implementing blockchain technology. For example, people involved in fraudulent activity, such as criminals or creators of fake goods, will perceive the transparency of a blockchain in another way than regulators. A less obvious example is the effort of currently highly centralized corporates, which claim to incorporate blockchain technology. A serious blockchain implementation would disintermediate and disrupt their own business model. In decentralized electricity systems, for example, a full blockchain implementation would enable true peer to peer electricity exchange, in which everyone can exchange their produced electricity without an intermediary. Electricity companies would thus, if decentral electricity production becomes sufficient, disrupt their own business model by creating a blockchain implementation. Therefore, even the desirability of the core of blockchain technology (*disintermediation of trust)* is disputed. Finally, a contrast between perceived effects and actual effects is already emerging. Blockchain should have a great effect for regulators and auditors, due to the highly transparent, anti-fraudulent and trust-increasing properties of the blockchain. However, BitCoins are currently often used for criminal activity as the high cryptographic safety makes BitCoins harder, or nigh-impossible, to track. The question whether blockchains increase the trust and transparency of interactions is at the heart of this part of the conceptual framework.

Furthermore, actors have contrasting perceptions on the uncertainties and the associated impact of the uncertainties. Established corporates and journalists, contrast with start-up initiatives in this respect. Uncertainties are handled with a more "hands-on" approach by start-ups, meaning they either ignore current institutional frameworks or assume that the frameworks will change as they move on. Established corporates and journalists are more reluctant and see the absence of an institutional framework as highly influential and highly troublesome.

By adding these contrasting perceptions to the conceptualization, the following framework emerges:

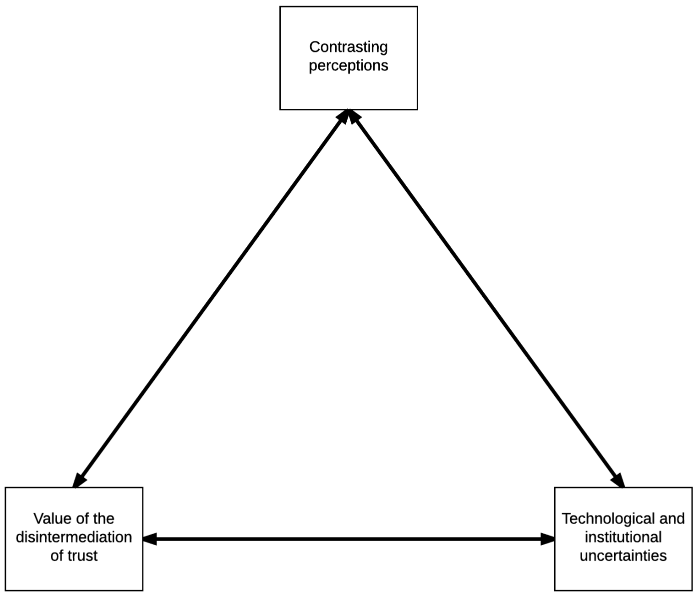


Figure 5.6 Emergence of Conceptual Framework - Contrasting Perceptions

This framework is finalized by the addition of the actors. These actors are currently trying to position themselves within this framework, dealing with uncertainties, contrasting perceptions and determining their value of the disintermediation of trust. Therefore, we add the notion of *perceptions on the uncertainty and the value of disintermediation of trust.* Thereby finishing the development of our conceptual framework on the discussion in blockchain technology (see figure 5.5).

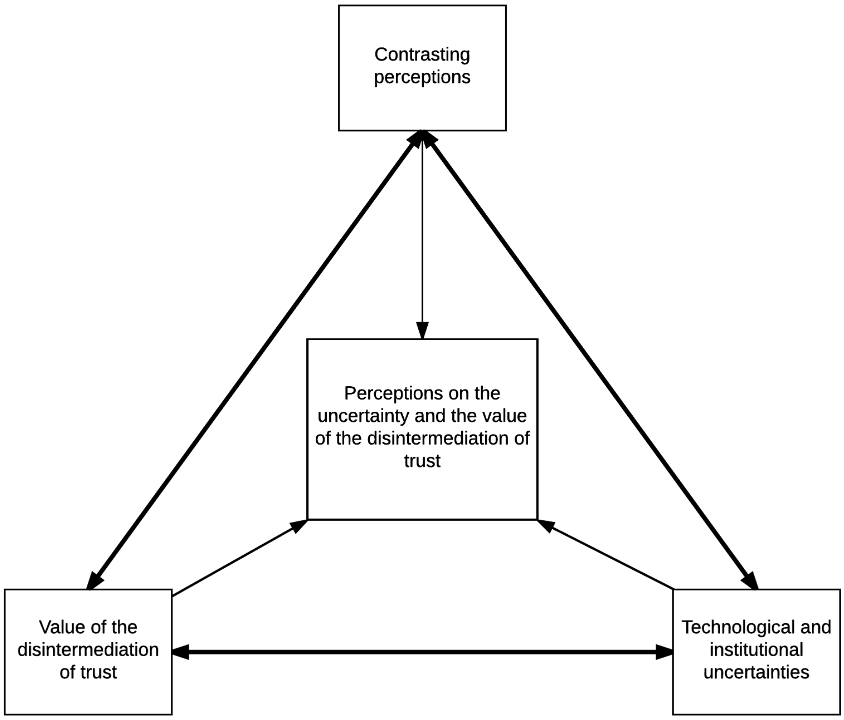


Figure 5.7 Conceptual Framework on the blockchain discussion

This section discussed the emergence of a conceptual framework on the discussion on blockchain technology. In conclusion, actors are deciding under high technological and institutional uncertainty on contrasting perceptions and the value of the disintermediation of trust. This framework provides an overview of the current discussions on blockchain technology. However, it does not yet explain on a higher level why this is the case. By analyzing this framework and the underlying data in the next section, we discuss the emergence of our core category.

5.5 Core category development

This section elaborates on the emergence of our *core category,* a category that explains all (or most of) the data in this research. This core category is developed using the *empirical description* of the blockchain discussion presented in the previous section, deciding under high technological and institutional uncertainty on contrasting perceptions and the value of the disintermediation of trust. We argue that this "value of the disintermediation of trust" especially effects a certain *environment*. Analyzing the sectors of the publications that were used in this research, the following overview emerges of sectors in which blockchain is most discussed:

- Finance
- Health
- Government
- Insurance
- Internet of Things
- Music
- Organizational
- Advisory (aimed at Financial, Insurance and Government)

Most of these sectors are highly reliant on values, such as trust, customs and culture, which are institutionalized through a legal or institutional framework, or history. Blockchain technology is

perceived as most effective in these sectors as it enables decentralization in these sectors, which was previously not possible through other recent innovations, such as the Internet and Platforms.
The notion sector does not completely cover this overview though. Especially organizational concepts, organizations on the blockchain, are not a sector. Instead, "organizations" are an important institutional arrangement, like "markets", "governments" and "hierarchies". These arrangements themselves are highly institutionalized. If consequences of blockchain include the disruption of these arrangements, a wider notion than "sectors" should be part of our core category. We decide to call this wider notion *environments.* Current data suggests that the *sector* is one of the most important environmental factors to be considered, as most applications clearly focus on sectors with highly institutionalized values.

In conclusion, we combine our notion of *deciding under high technological and institutional uncertainty on contrasting perceptions and the value of the disintermediation of trust* and *environments with highly institutionalized value* into our empirical core category: <u>*The disintermediation of trust in environments with highly institutionalized values*</u>.

5.6 Conclusions

This chapter presented an overview of the Selective Coding phase, thereby answering the fourth research question: "How can relations between the effects, issues and functions of blockchain be integrated into a conceptual framework and core category?". First, it discussed the emergence of a conceptual framework of the current discussion on the perceived consequences of implementing blockchain technology. This resulted in our framework, as presented in section 5.4, consisting of three categories: *Contrasting Perceptions, Value of Disintermediation of Trust* and *Technological and Institutional Uncertainties.* Then, using this framework our empirical core category emerged. By analyzing the *environments* in which blockchain technology is used, we concluded that these are *environments with highly institutionalized values*. Our empirical core category, which conceptualizes the current blockchain technology discussion, therefore is: *Disintermediation of trust in environments with highly institutionalized values.* The next chapter relates this empirical core category with existing literature in other fields to further strengthen and define this core category.

6 Literature comparison – Relating our core category to existing literature

This chapter discusses the sixth (and final) phase of this research, a literature comparison. In this literature comparison, our *core category the disintermediation of trust in environments with highly institutionalized values* , which emerged in the Selective Coding phase (section 5.5), is compared to existing scientific literature (Figure 6.1) in order to strengthen our core category. First, in this chapter we compare our core category to existing *trust research*, to provide an in-depth view of how trust is conceptualized. We then compare our core category to existing research on *decentralized decision making*, as blockchain technology also has implications for both decentralization and decision making. Thus, this chapter answers the fifth research question: "How does our core category relate to existing literature?"

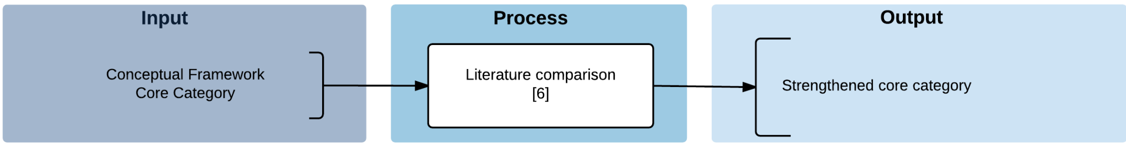


Figure 6.1 Research flow of the sixth phase

6.1 Comparison to trust research

Our empirical core category presented in the previous chapter, *the disintermediation of trust in environments with highly institutionalized values*, is centered around the notion of *trust*. This section further conceptualizes trust, by relating our empirical core category to existing trust research. This conceptualization is then used to strengthen our core category

Providing an overall definition of trust is hard, due to a great variety of conceptualizations and operationalizations, being hard to quantify and differences between inter-personal and inter-organizational trust (Seppänen, Blomqvist, & Sundqvist, 2007). In their literature review of empirical trust research, Seppanen et al conclude that there are still major conceptual challenges in measuring trust. To overcome part of these challenges they advise that "authors should be very clear on the roles of the trustor and the trustee" (p.261). As this research is not aimed at providing an overview of these conceptualizations, this research follows one conceptualization that helps with the first steps in relating trust research and our empirical core category. This research follows a conceptualization by Nooteboom, which was chosen because it provides an informative high-level overview of trust, including both personal and organizational trust, mitigation measures, and is based in Transaction Cost Economics/Institutional Economics.

Nooteboom (1996, 2002)[9] provides a high-level overview of trust, which is visualized in Figure 6.2. Nooteboom conceptualizes trust in two types: *Competence trust* and *Intentional Trust*. The former being the trust that one (trustor) has in the abilities of a counterparty (trustee). This includes for example technical, organizational, cognitive abilities. The latter involves the trust one has in the intentions of a counterparty, especially how he might deal with opportunism. This *Intentional Trust* is then divided into two concepts: *Active Intentional trust* and *Passive Intentional trust*. Here, passive intentional entails a dedication to perform to the best of your abilities, and is therefore also called *Trust in Dedication. Active intentional Trust* is concerned with "Interest seeking with

[9] Klein Woolthuis, Hillebrand, and Nooteboom (2005, pp. 814-817) provide a full overview of the conceptualization of trust by Nooteboom (1996,2002) and is used as a basis for this section.

guile"(Williamson, 1975), the belief that a counterparty will not take advantage by lying, stealing or cheating, and is therefore called *Trust in Goodwill/Benevolence*.

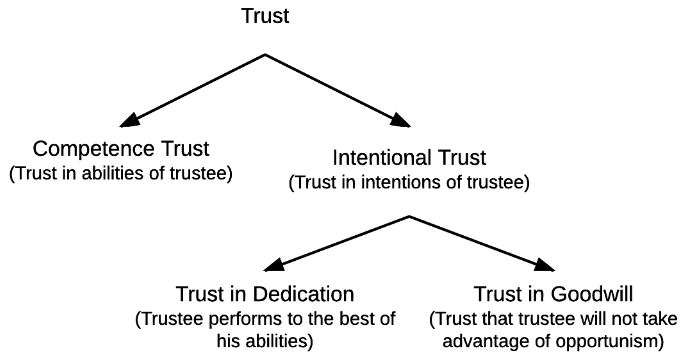


Figure 6.2 Conceptualization of Trust by Nooteboom (2002)

Nooteboom (1996) also conceptualizes mitigation measures, or measures to *control* a counterparty. Three main categories are conceptualized (and visualized in Figure 6.3): *Opportunity control, Incentive control* and *Goodwill*/*Benevolence. Opportunity Control* entails controlling the opportunism that the counterparty, or trustee, has. The trustor restricts the possible actions that the trustee can make, thereby limiting opportunism. *Incentive control* entails incentivizing the trustee to refrain from opportunistic behavior due to dependency on the trustor, for example "hostages", relational consequences (stopping an advantageous business-relation between counterparties) or material consequences (for example fines). *Goodwill/Benevolence* limits the inclination towards opportunistic behavior by using norms, values or relations.

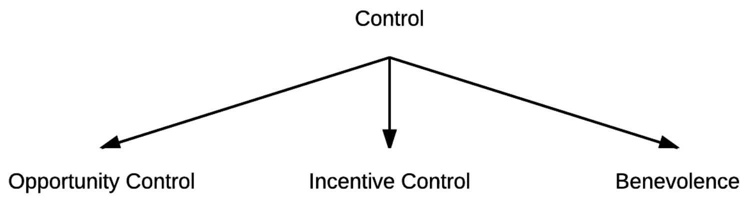


Figure 6.3 Conceptualization of Control by Nooteboom (2002)

Finally, (Nooteboom, 2002) suggests to use the term *reliance* as an overarching term that includes on the one hand *control* and on the other hand *trust* (visualized in Figure 6.4).

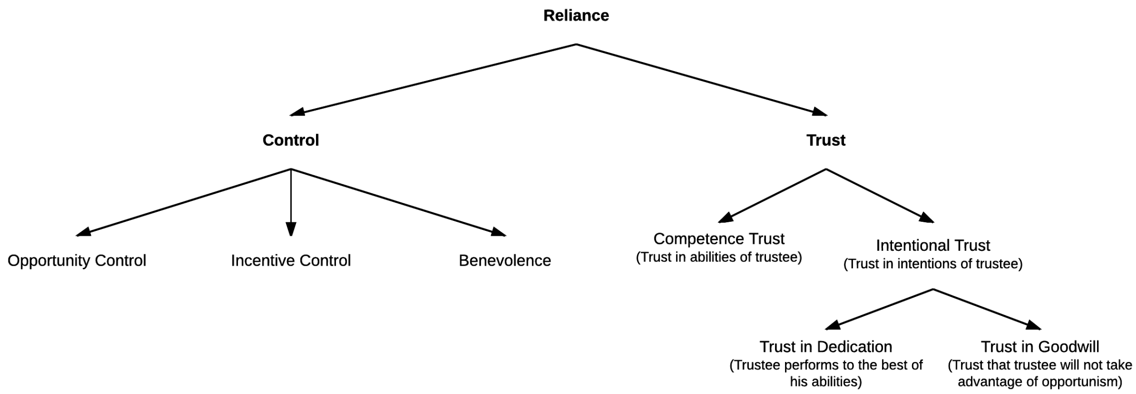


Figure 6.4 Conceptualization of Reliance by Nooteboom (2002)

Using this conceptualization, Klein Woolthuis et al. (2005) researched whether trust and control are substitutes or complements. Based on a literature review they conclude that there are three approaches to the relationship between trust and control (in the form of contracts):

- Contracts/control and trust are positively related
  "TCE and contract theory see contract as a basis for trust since it limits the opportunities and incentives for opportunism. Here contract and trust are positively related, with contract as a prerequisite for trust." (p.817)
- Contracts/control conflict with trust
  "social scientists often envisage contract as 'in conflict' with trust. Contracts can be detrimental to trust development since contracts can be interpreted as a sign of distrust" (p.818)
- Contracts/control and trust are negatively related
  "negatively related, with trust preceding and 'embedding' relationships, thereby decreasing or eliminating the need for formal control or contracts. […] In this view, trust precedes contracts, and contracts can as a result become unnecessary" (p.818)

Furthermore, based on a case study of four cases, they conclude that trust and control (in the form of contracts) can be both <u>substitutes</u> and <u>complements</u> and that *generally* trust precedes contracts. This contrasts with the first approach, the TCE approach, which sees contracts as a basis for trust. This is mainly caused by taking a calculative approach to trust, which does not include benevolence or goodwill and argues that trust does not go beyond calculative self-interest. For this type of control contracts are indeed highly effective to deter opportunism.

This section discussed the conceptualization of trust, reliance and control by Nooteboom. This conceptualization is used in the next section to further strengthen our core category, *the disintermediation of trust in environments with highly institutionalized values*.

6.1.1 Reliance, Trust and Control in blockchain technology

In this section, we use the conceptualization of reliance, trust and control by Nooteboom as presented in the previous section to further strengthen our core category, *the disintermediation of trust in environments with highly institutionalized values*. By providing insights into the consequences of blockchain technology on these reliance arrangements, and determining if blockchains are affecting trust (as mentioned in the conceptual framework and empirical core category), reliance or control, we aim to determine if using the concept *trust* in our core category is the right concept. First, we look back at the empirical data that was used in this research, and analyze how the notion *trust* was used and conceptualized in this data. Then, we use a practical example to show how blockchain technology affects reliance arrangements.

6.1.2 Analyzing our empirical data on reliance arrangements

We argued, in the previous section, that the conceptualization of Trust by Nooteboom, as Reliance, Trust and Control, can be used to further develop the core category of this research, which is centered around *trust*. To further define our core category with these notions, we look back at our empirical data, the 56 documents used in the Open, Axial and Selective Coding. First, we determined if articles mentioned Trust, Reliance and Control. Then, we looked at what these articles meant by using these terms, to determine if they were using these terms as conceptualized by Nooteboom.

This analysis was conducted separate from the open coding phase, as the insights provided by the core category were only available after the open coding phase. We therefore did not chose to code this during the open coding phase. Based on this analysis we find the following: more than 50% of articles use the term *Trust* in the text. This is still comparatively low, due to the importance of trust in this research. However, when we disregard technical whitepapers, highly specialist implementations and critical journalistic pieces this number becomes much higher (70%). This is much higher than either control (10%), or reliance (5%). This was expected, as our current core categories mentions trust instead of control or reliance.

Examples of the quotes concerning trust are as follows:

Credit Suisse

"Disintermediates trusted third party solving prisoners dilemma
To transact, you must trust that the:
- Value transfer commitment between parties will be met;
− Other party has ownership over the value they agreed to transfer;
− The value transferred is legitimate."

IBM

In business, trust is incredibly hard to engineer and impossible to guarantee. Until now, we've relied on instruments and institutions to be surrogates for our trust. With blockchains, trust can be embodied in the transaction itself. A far greater assurance of trust is now possible.

The DAO

Whatever a private contract or public law require: (1) people do not always follow the rules and (2) people do not always agree what the rules actually require.

These quotes provide an example of how the notion *trust* is mostly used in empirical data. However, discovered that most actually refer to the concept of *Control* instead of *Trust.* The Credit Suisse quote provides the best example of this phenomenon. Although they mention *Trust*, they argue that you need to be sure that you can be sure that the other party behaves as expected, through measures of *control*.

Therefore, we conclude that actors in our empirical data often *use* the notion of *trust* in their reports. However, as our analysis of these notions show, actors often mean *control* instead of *trust.* This semantic difference is an important explanatory factor in the lack of structure in the blockchain discussion, as it shows that actors have no common conceptualization of trust, which is one of the most important consequences of blockchain technology. The importance of this semantic difference is further argued in the following section, by analyzing reliance arrangements in blockchain environments.

6.1.3 Analyzing reliance-arrangements in blockchain environments

We argued in the previous section, by looking back at our empirical data, that actors are often focused on the term *trust,* while *control* might be more applicable. In this section, we further explore this argument by analyzing reliance arrangements in blockchain technology, from an end-user perspective.

Table 6.1 Reliance arrangements in blockchains

Arrangement between Trustor and Trustee	Effects on Control	Effects on Trust
End-User and End-User (simple transaction)	Complete control is possible	No trust needed
End-User and End-User (Complex Transaction)	Complete control is impossible High opportunity and incentive control	Intentional trust needed Competence trust needed
End-User and Validators	Complete control is impossible High opportunity control High incentive control	No trust needed unless a 51% attack is possible No trust needed as long as the system "works" as expected (Mollering, 2006)
End-User and Developers	Complete control is impossible Medium opportunity and incentive control	Competence trust needed Intentional trust needed
End-User and Technology	Complete control is possible if developers can be relied on	Trust is not needed if end-users can rely on developers.

End-Users and End-users (simple transaction)

This transaction is based on a simple crypto-currency transaction in a blockchain environment, such as bitcoin, or a repeatable transaction as the taxi-example in the introduction. In this example one end user (trustor) transacts coins to another end-user (trustee). As the transaction is completely predefined and end-users cannot influence this transaction, the transaction itself is completely controlled, thereby eliminating the need for trusting the counterparty of this transaction.

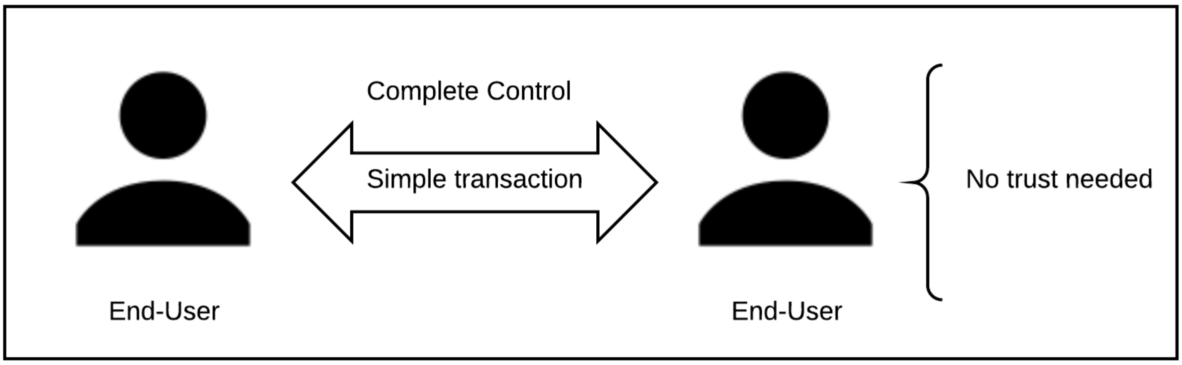


Figure 6.5 Reliance between End-Users in a simple transaction

End-User and End-User (Complex Transaction)

This transaction is based on a complex blockchain transaction. Examples of a complex transaction include notary transactions of assets such as houses or diamonds, or transactions involving real world actions, such as investing in t-shirts or building a real house. In these transactions, both incentive and opportunity control are high as the contracts are always performed as presented. This would suggest that, again, this transaction no longer requires trust. However, as these contracts are personalized and highly complex this is not the case. In the case of a notary transaction, the trustee can easily create a contract that somehow enables the transaction to take place for just one dollar. T

Intentional trust is therefore still highly important as complete contracts are impossible. Futhermore, the lack of an intermediary and institutional frameworks creates the need for benevolence (in the sense of control), as there are little norms or values that force the trustee to behave in the interest of the trustor. Even more difficult are transactions involving real world actions. A blockchain contract that describes the construction of a new house is highly controlled. However, competence is an important issue here. How can I trust the competence of my trustee? How do I know that the trustee can actually build this house? Therefore, complex blockchain transactions still require some form of trust between End-Users, especially competence and intentional trust.

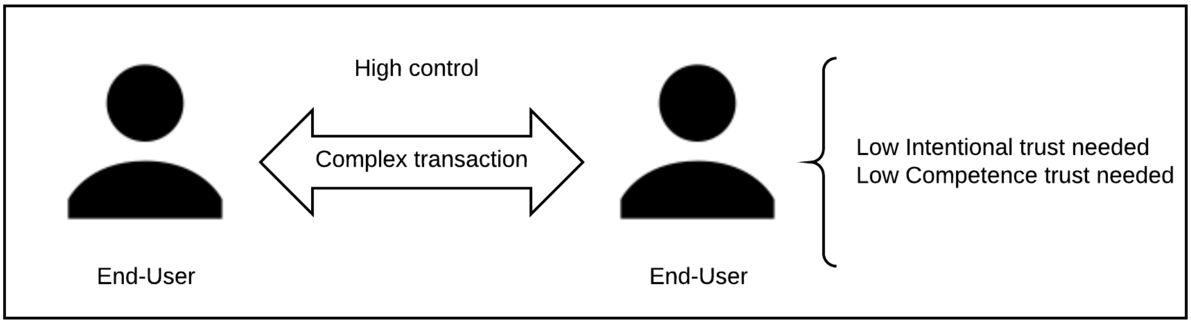


Figure 6.6 Reliance between End-Users in a complex transaction

End-User and Validator

When a blockchain transaction is send to the network, the validators check this transaction using predefined algorithms. Validators have strong opportunity and incentive control. Opportunity control is strong due to the predefined algorithms, so there are little chances to mess with these algorithms. Incentive control is strong due to the incentive structure in blockchains as the coins (Bitcoins, Ethers etc) are only worth as much as a market is willing to pay for it. If no one trusts the validators to do the correct thing, the price drops. This provides validators with incentives to adhere to the system. However, complete control cannot be ensured as validators have decision making power in the system. If more than half of the validators accept a change in the algorithms, these changes become accepted by the system. A so called "51% attack" is therefore possible, which assumes that if you can get 51% of the validators to accept malicious changes you can control the blockchain. In large networks as Bitcoin this is highly unlikely. Mollering (2006) concluded (separate from blockchains) that through direct experience and through mediated demonstrations that institutions 'work', trust in systems grows. As long as the system does what it is supposed to be doing, trust becomes less of an issue.

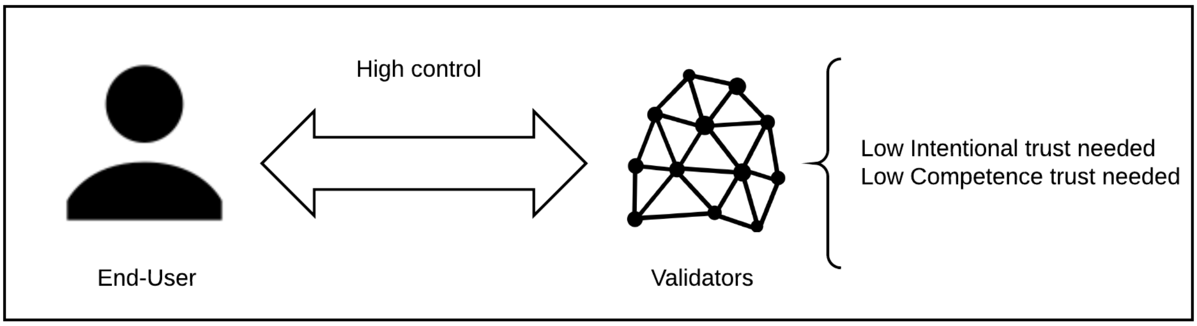


Figure 6.7 Reliance between End-User and Validator

End-User and Developers
End-users should also rely on the developers. Are they competent? Have they put in a clause that gives them infinite coins? Again, developers face some incentive control and opportunity control through the same mechanisms as validators face. However, as the developers create and program the system, their power to act maliciously is much greater. Therefore, the incentive and opportunity control on them is smaller than on validators. Furthermore, competence trust becomes an issue here. Even though the changes that are proposed by developers should be accepted (or rejected) by validators, end-users cannot assume that every line of code is therefore perfect. Furthermore, if these lines of code are not perfect, end-users cannot assume that there are no deliberate parts of the code that enriches these developers. Therefore, competence and intentional trust are still important.

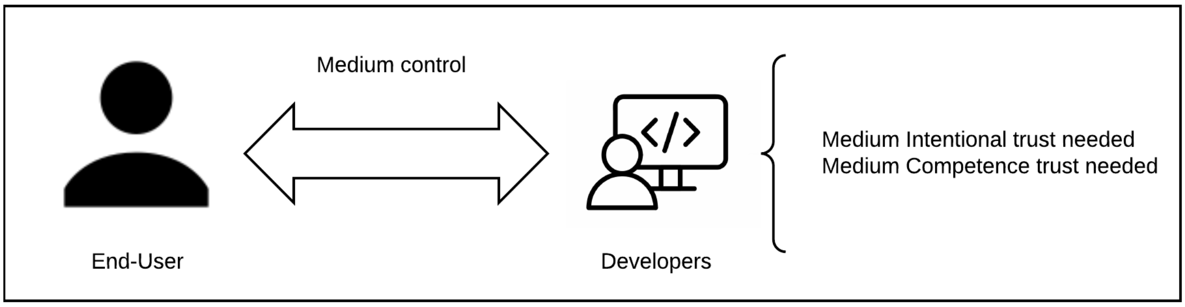


Figure 6.8 Reliance between End-Users and Developers

End-Users and Technology
Relying on the algorithms that run the blockchain is primarily based on control. The algorithms only do what they are programmed to do, so complete control is possible. Trust in the technology itself is therefore not needed, but trust in developers is!

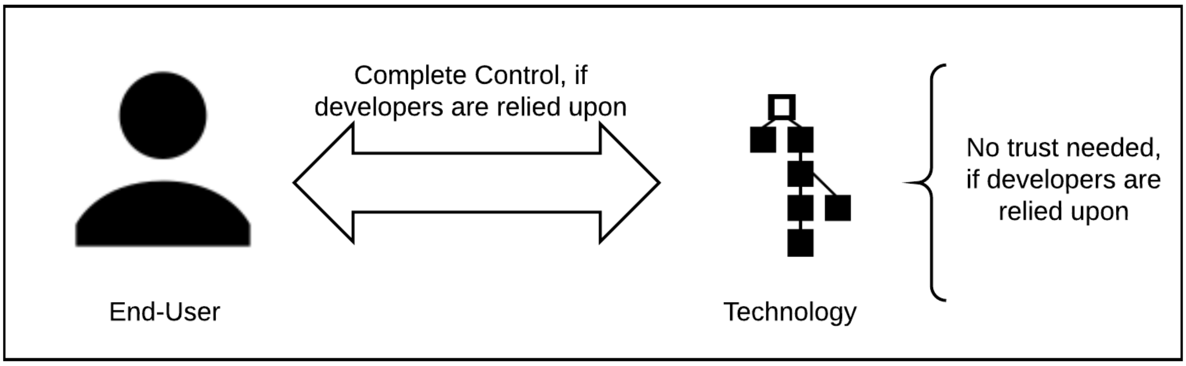


Figure 6.9 Reliance between End-Users and Technology

6.1.4 Practical examples of control and trust in blockchain technology
Based on the notions of reliance found in our data and used in the previous analysis of reliance arrangements, we conclude that this approach is also taken by most current literature on blockchain technology. This approach contrasts with the notion of *Deep trust,* which is primarily based on (interpersonal) care, concern and benevolence (Klein Woolthuis et al., 2005). Furthermore, in contrast to the conclusions by Klein Woolthuis et al. (2005) current blockchain discussions are centered around the notion that *contracts can precede trust*, instead of *trust preceding contracts.* This notion is not found in current literature, as "Complete, that is, unconditional or blind trust, is ill advised, and where trust ends one needs control. Vice versa, complete control is impossible, and trust is needed where control ends"(Nooteboom, 2013, p. 107). This would require complete control in a (blockchain) environment, thereby making trust truly obsolete. Researching the ability of blockchains to provide such an environment is needed to provide more insight. However, our

analysis on reliance arrangements in blockchain environments concludes that this is not the case in current blockchain implementations ,as multiple interactions in blockchain environments still require trust, instead of control. This analysis is strengthened by two practical example:

The DAO, the decentralized investment fund earlier mentioned in this research, was hacked in June 2016 (Coindesk, 2016). Someone found an error, or exploit, in the smart contracts that run this investment fund and could drain 50 million worth of Ether out of this investment fund. The smart contracts were run as they were programmed; however, there was a discrepancy in the intention of the programmer and the program/smart contract itself. The blockchain still worked as intended, but a programming running on the blockchain not. This example shows that although complete control seems to be possible in complex blockchain environments, the contrary is true. Complete contracts are nigh-impossible to create. So even though blockchain increases control in this example, as all smart contracts ran exactly as they were programmed, complete control is impossible due to incomplete contracts. Without complete control, trust is still needed.

ZCash, is one of the many cryptocurrencies invented after Bitcoin and is a classic example of a so called "Pump and Dump"(Coinmarketcap, 2017). It followed a classical scheme of inflated expectations, mainly generated by the inventors and programmers behind it, claiming it was better than BitCoin and would have huge gains for early investors. Investors boosted price per coin of ZCash to almost 6000 dollars. The inventors quickly dropped their assets and made huge profits, after which the coin has been stable around 40 Dollar per coin. This is another example of the importance of trust in blockchains. Can we trust the creators of a blockchain? Because, even *if* complete control was possible, we might not be sure what the intentions of the creators are.

Following this analysis and conceptualization by Nooteboom, we can conclude the following: although blockchains are usually related to trust, as we did in our empirical core category "*disintermediation of trust in environments with highly institutionalized values*", blockchains should be much more related to control than trust. Therefore, **we conclude that previous uses of the term *trust* in this research actually refers to *reliance*, as *trust* in blockchains often primarily aimed at *Control*.** This is a highly important conclusion, as it provides further explanatory power on the blockchain discussions. A strong conceptualization of the term *trust* (reliance), is needed to analyze and explain the consequences of blockchain technology. Currently, the actors in the discussion are not aware of this conceptual, semantic difference, which is at the core of the lack of structure and overview in this discussion. Although blockchain is often referred to as "the trust-machine", we therefore propose to start referring to the blockchain as "the control-machine".

This conclusion also strengthens our choice, which made in the introduction, to take a New Institutional Economics/Transaction Costs Economics approach in this research. Blockchain Technology is a technology to control *opportunism* in transactions, as described by Williamson (Williamson, 1985, pp. 64-67). According to Williamson (1979, p. 234): "opportunism is a central concept in the study of transaction costs". Furthermore, Williamson argues that, the need to control the opportunism of a counterparty in a transaction increases the economic efficiency of hierarchies and relational contracting over markets. Blockchain Technology could thus impact these arrangements, and enable more transactions to take place in a market than in hierarchies or with relational contracting. In this section, we have shown that Blockchain Technology is probably not able to provide complete control in all cases, and therefore not eliminate opportunism completely due to (amongst others) incomplete contracts. However, the ability to almost eliminate opportunism is still an important notion from a TCE perspective and further calls for analyzing blockchains from this perspective. As Davidson et al. (2016a) argue: "So, if the Williamson model of firms and markets is correct, and effective cooperative economic activity and investment is stymied by both threats and engagement of opportunism, blockchains will be a revolutionary institutional innovation." (p.17)

6.2 Conclusions on Trust in blockchain technology

In this section, we argued, using the conceptualization of Reliance, Trust and Control by Nooteboom, that blockchain technology is more connected to *Control* instead of *Trust.* In our empirical data, and our empirical framework (Figure 5.7), *Trust* was discussed much more often than *Control.* This (semantic) difference is at the core of the unstructured nature of the discussion on blockchain technology. We can thus strengthen our empirical core category (*disintermediation of trust in environments with highly institutionalized)* using these notions. As we have used literature outside of our empirical data, this is no longer an *empirical core category*. Our strengthened core category is thus *disintermediation of* <u>*control*</u> *in environments with highly institutionalized values.*

Blockchain is thus a technology that strengthens control between counterparties in a transaction, as described in this section. However, it is unclear how control is affected in blockchain technology from a systems-perspective. Due to the decentralized nature of blockchain environments, we suspect that blockchain technology decreases control from a systems-perspective. To further develop this notion, and thereby our core category, we also compare our strengthened core category to *decentralized decision making* literature in the following section.

6.3 A comparison to decentralized decision making literature

The previous section discussed the reliance arrangements in a blockchain environments. We concluded that blockchain increases the control between counterparties in a transaction, and suspect that blockchain technology decreases control from a systems perspective. This is caused by the decentralized vision of blockchain technology, which calls for *decentralized decision making.* We therefore use decentralized decision making literature to further explore this concept to strengthen our core category.

6.3.1 The decentralized nature of blockchain environments

The decentralization of decision making power in blockchain is two-fold. First, decision making power on the rules in a blockchain. The validating nodes democratically determine how the blockchain is ran, therefore deciding in a decentralized way on these rules. For example, the BitCoin validators determine which updates or patches they want to run to the algorithms determining the rules of the bitcoin blockchain. Only if more than 50% accepts an update, the blockchain can accept these new rules, thereby creating a democratic, decentralized system.

Second, a blockchain enables the creation of organizations entirely based on blockchain technology. In these organizations, all corporate actions are decided upon by the shareholders directly, which creates a decentralized corporate decision making process for organizations on the blockchain. For example, in the DAO investment fund, shareholders could vote on proposals how the funds were invested or how the corporate rules were updated.

6.3.2 Control in decentralized blockchain environments

We use Bonabeau (2009) to further characterize and develop *decentralized decision making*. Bonabeau was chosen because he is an export on collective intelligence from a complex systems perspective, and provides a full overview of issues concerning *decentralized decision making.*

Bonabeau (2009) identified five main issues within decentralized decision making networks:

- **Control**
  Centralized entities in decentralized decision making networks are bound to lose control. Bonabeau concludes that “common to all forms of collective intelligence, is a loss of control” (p.48).
- **Diversity versus Expertise**
  A diverse group of decision makers might sound beneficial but “no amount of diversity will help if the participants are completely ignorant of the issues” (Bonabeau, 2009 p.48).

- **Engagement**
  In a decentralized decision making system participants are only as valuable as their vote. Keeping them engaged in the decision making is thus paramount to the success of these networks.
- **Policing**
  Oversight into the behavior of participants is needed, Bonabeau (2009) argues that "when people are allowed to contribute to decisions, the likelihood that some will misbehave increases with groupsize" (p.49).
- **Intellectual property**
  Intellectual property presents an issue that is two-fold in decentralized decision making processes. First, existing intellectual property should be known to all participants in the decision-making process. Second, the decision-making process might create new intellectual property. Who is the owner of this Intellectual property?

Control

Bonabeau concludes that "common to all forms of collective intelligence, is a loss of control" (p.48). A loss of control could be manifested by, for example, *unwanted and undesirable outcomes, unpredictability,* and *unassigned liability.* Blockchain environments are highly decentralized, as explained in the previous section, thus loss of control from a systems-perspective is expected. Thus, our suspicion that blockchain technology decreases control from a systems-perspective, while increasing the control between users in a transaction, is correct. The tension between this increase and decrease provides further explanatory power in our research. Especially existing corporates, governments and incumbents are highly interested in the possibilities to increase the control over a counterparty in a transaction. However, due to their highly centralized paradigms they do not want to lose control to other parties in their systems. For new-entrants, that have no control over the system to begin with, this down-side of blockchain technology implementation is much less of an issue. Most blockchain initiatives from new-entrants are created with decentralization in mind, and are aimed at providing the end-users more control. Market-share, efficiency and profits are thus less important in the blockchain paradigm of new-entrants. Thus, from a Neo-Classical Economics perspective the devide in approach for implementing blockchain technology between incumbents and new entrants can be explained. However, from a New Institutional Economics perspective it can also be explained. Cognitive Dissonance can be used in NIE to explain irrational behavior in economic systems (Nooteboom & Six, 2003). Cognitive Dissonance is explained as: "A person's perceptions of another will be determined not only by the information he receives from his direct experiences or from what others tell him, but also by his need to absorb this information in such a way as to prevent disruption of existing perceptions, cognitions, or evaluations to which he is strongly committed"(Deutsch, 1973, p. 159). Incumbents in blockchain environments are strongly committed to their centralized paradigm. Even though convincing evidence is presented that blockchain technology might disrupt this paradigm, they try to push this technology into their own paradigm. This could further explain the divide seen in blockchain discussions between incumbents, who simply do not want to accept that their paradigm is being disrupted, and new-entrants.

The other four issues identified by Bonabeau (2009) are also linked to blockchain technology. These issues are more considerations or design rules, which should be considered when implementing any decentralized decision making network. Therefore, they should also be considered when implementing blockchain technology. In this research, they further operationalize how to deal with the decentralized nature, and loss of control in blockchain technology implementations. As this is not the main goal of this research project though, they are not further discussed than the short descriptions above.

6.4 Conclusions on Decentralized Decision Making in blockchain technology

The core category presented in section 6.2 "*disintermediation of control in environments with highly institutionalized values"* provided insight into the importance of the increase of control between counterparties in a transaction by blockchain technology. However, we argued in this section that control from a systems-perspective decreases due to the decentralized nature of blockchain technology. The tension between increased control of counterparties transactions, and decreased control from a systems-perspective is another important insight that helps to structure the ongoing blockchain discussions. It should therefore be incorporated into our core category. The increased control over transactions provides users with an increase in *power.* However for existing centralized entities, blockchain technology lowers control over the system, thereby decreasing their *power* over the system. The aforementioned tension between increased control of counterparties in transactions and decreased control from a systems-perspective is thus captured by *changing power arrangements* in systems in which blockchain is implemented. As both an increase and decrease of power is seen, we conclude that blockchain technology enables <u>*a power transfer*</u>. Thus, our core category should be further refined to incorporate this argument. We therefore update our final core category to: <u>**power transfer in environments with highly institutionalized values.**</u>

6.5 Conclusions from our literature comparison

This chapter presented an overview of the Literature comparison and answered the research question: How does our core category relate to existing literature? By using the conceptualization of Nooteboom we conclude that blockchain technology is primarily a technology that increases control between actors in a system. This conclusion contrasts with our core category, based on empirical data, which is *disintermediation of trust in environments with highly institutionalized values*. This core category is thus focused on trust instead of control. Furthermore, we conclude that although blockchain increases control between counterparties in a transaction, it is impossible to provide complete control in blockchain environments. Also, control from a systems-perspective decreases because of decentralized decision making.

Finally, to fully capture these conclusions, we should redefine our current core category *disintermediation of trust in environments with highly institutionalized values.* The tension between an increase in control of counterparties and a decrease of control from a systems, is best captured by *"a power transfer"*. Thus, this leads us to present our final core category as ***power transfer in environments with highly institutionalized values*.**

7 Conclusions and discussion

This chapter presents an overview of this research and discusses suggestions for further research. First, in section 7.1 the answers to the research questions are presented. Then, section 7.2 provides suggestion for further research, which emerged during this thesis. Finally, section 7.3 reflects on the research process and outcomes of this research in the form of a discussion.

7.1 Answering our research questions

This section presents an overview of the conclusions per research question, which are then used to answer the main research question of this research.

Research question 1

1. How can the concept “blockchain technology” be described? [Chapter 2]

In chapter two blockchain technology was introduced and throughout the chapter a definition and scope for this research emerged. Using a literature review, which included a comparison to Platforms, Distributed Computing, and an overview of current blockchain literature we formulated the following definition for blockchain technology in this research project : *Blockchain technology is a distributed, shared, encrypted, chronological, irreversible and incorruptible database and computing system (public/private) with a consensus mechanism (permissioned/ permissionless), that adds value by enabling direct interactions between users.* This research focusses on the perceived consequences of the implementation of *applications* using blockchain technology.

Research question 2

2. How can the research approach Grounded Theory be applied in this research? [Chapter 3]

In chapter three the Grounded Theory approach was introduced and a specific Grounded Theory approach was chosen. A thorough elaboration on the research design was primarily needed as Grounded Theory is a highly explorative and inductive approach, which means that the research process provides the needed structure. We argued that the *Straussian Grounded Theory approach* is most suited for this research, as it allows the emergence of a new theoretical framework on the consequences of implementing blockchain technology, which is grounded in empirical data. This specific approach was chosen as it provides more structure for novice researchers. We furthermore discussed the three phases of coding within Grounded Theory: Open coding, Axial coding and Selective coding. Finally, it was determined that this research uses the following sensitizing concepts to provide our research with structure: Effects, Issues, Functions and Actors.

Research question 3

3. Which dimensions can be discerned of effects, issues and functions of blockchain technology? [Chapter 4]

In chapter four the results of the Open and Axial coding phases of the Straussian Grounded Theory were presented: an overview of dimensions in the sensitizing concepts Effects, Issues and Functions emerged. The open coding phase resulted in a total of 415 *properties.* These properties were then used in the emergence of higher-level concepts, called *dimensions.* This resulted in fourteen Issue dimensions, thirteen Function dimensions and twelve Effect dimensions. These dimensions provide an overview of the Functions, Effects and Issues of blockchain technology. An overview is presented in Table 7.1, Table 7.2, Table 7.3. Notice that *dimensions* are properties combined into higher level concepts by a common theme, and that these tables do not include *relations* between the *dimensions.* Relations are presented in the following sub-question.

Table 7.1 Overview dimensions in Effects sensitizing concept

Effects			
Accuracy	Costs	Enable New Markets and Organizational Forms	Trust
Auditability	Disintermediation	Risk	User Empowerment
Automation	Efficiency	Security	Value Creation

Table 7.2 Overview dimensions in Issues sensitizing concept

Issues			
Adoption Strategy	Corporate and Personal Privacy	Immutability	Standardization
Anonymity	Costs	Institutional Framework	Technocracy
Automation	Customs and Culture	Integration	
Centralization vs Decentralization	Immaturity	Performance	

Table 7.3 Overview of dimensions in Functions sensitizing concept

Functions			
Corporate	Governmental Services	Regulatory Reporting	Voting
Create and Execute Immutable Rules	Identity Services	Single Source of Truth	
Data	Immutable Recording of transacted assets	Standardization	
Digitize Assets	Market Making	Tokenization	

Research question 4:

4. How can relations between the effects, issues and functions of blockchain be integrated into a conceptual model and core category? [Chapter 5]

In chapter five, we presented an overview of the Selective Coding phase. First, we discussed the emergence of a conceptual framework of the current discussion on the perceived consequences of implementing blockchain technology. This resulted in our framework, as presented in section 5.4, consisting of three categories *(*Figure 7.1*).*:

- *Value of Disintermediation of Trust*
- *Technological and Institutional Uncertainties*
- *Contrasting Perceptions*

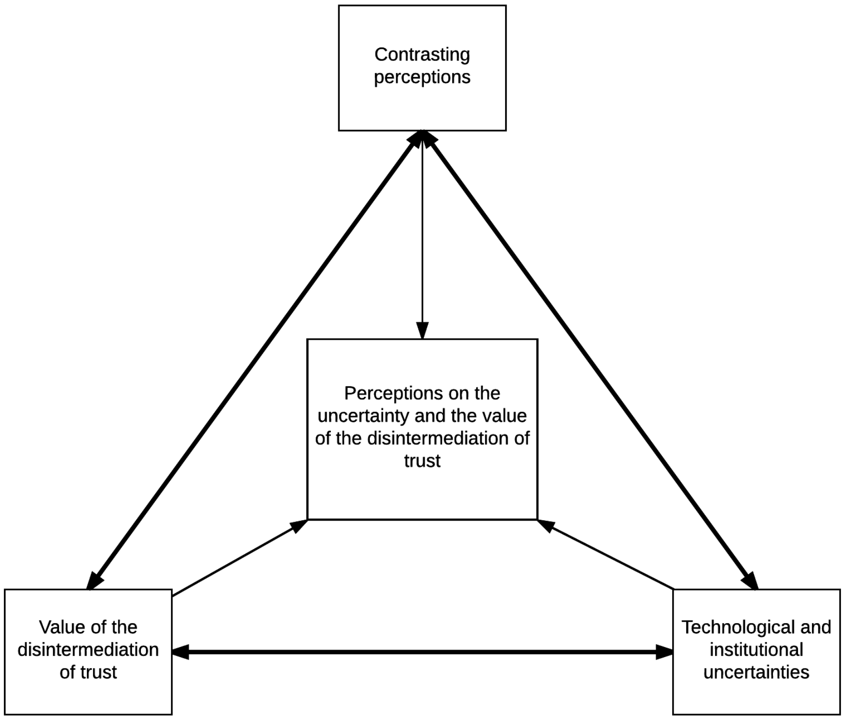


Figure 7.1 Conceptual framework on blockchain implementation consequences

Then, using this framework our empirical core category emerged. By analyzing the *environments* in which blockchain technology is used, we concluded that these are *environments with highly institutionalized values*. Our core category, which conceptualizes the current blockchain technology discussion, therefore is: *Disintermediation of trust in environments with highly institutionalized values.* It captures both the uncertainty of the value of the disintermediation of trust and the specific environments in which blockchains are primarily used.

Research question 5:

5. How does our core category relate to existing literature? [Chapter 6]

In chapter six, we related our core category to existing research. Due to the importance of trust in our empirical core category, we first used *trust* research to strengthen our core category. Using a conceptualization of trust by Nooteboom, as Reliance, Trust and Control, we concluded that blockchain technology is primarily a technology that increases control between counterparties in a transaction. This conclusion contrasts with our empirical core category, which is "the disintermediation of trust in environments with highly institutionalized values", as this empirical core category focusses on *trust* instead of *control.* This (semantic) difference is at the core of the unstructured nature of the discussion, and empirical misunderstanding of blockchain technology. Furthermore, our empirical data shows that it is often assumed that blockchain technology can provide complete control over a counterparty. We argued that this is not the case, mainly due a lack of control over validators and blockchain developers, and the lack of *complete contracts* in practice. Thus, blockchain is a technology that increases control over a counterparty in a transaction, but not completely.

Furthermore, using literature on Decentralized Decision Making we argued that control from a systems-perspective decreases due to the decentralized nature of blockchain technology. A loss of control over the system was identified as a core consideration of *decentralized decision making.* We therefore conclude that although blockchain increases control between counterparties in a transaction, control from a systems-perspective decreases because of decentralized decision making.

The current blockchain discussion is therefore best captured by incorporating these two notions: an increase of control between counterparties in a transaction and decrease of control from a systems-perspective. The tension between these two concepts explains the discussion on blockchain technology. Incumbents are interested in the possibilities of increasing control over counterparties in a transaction, but are hesitant to give up control from a systems-perspective. This contrasts with the views of the new entrants, which are interested in both the increasing control of counterparties in a transaction, and decreasing the control of incumbents from a systems-perspective.

Finally, to fully capture these conclusions, we should redefine our empirical core category *disintermediation of trust in environments with highly institutionalized values.* The tension between increasing control of counterparties in a transaction and decreasing control from a systems-perspective, is characterized by an increase in *power* of end-users, and a decrease of *power* of incumbents. As both an increase and a decrease of power emerged, this is best captured by *"a power transfer"*. Thus, this leads us to present our final core category as ***power transfer in environments with highly institutionalized values*.** This final core category captures the essence of the implementation of blockchain technology, thereby structuring the discussion and helping actors with the decision whether to implement blockchain technology and providing a much-needed empirical basis of blockchain implementation consequences on which further research can start.

Together these research questions are used to answer our main research question:

"What effects, issues and functions can be discerned and conceptualized that capture the consequences of the implementation of blockchain technology?".

We conclude that the current blockchain discussions are centered around three categories: *Contrasting Perceptions, Value of Disintermediation of Trust* and *Technological and Institutional Uncertainties.* Furthermore, we conclude that blockchain technology is primarily used in *environments with highly institutionalized values*. Our core category was defined as: *disintermediation of trust in environments with highly institutionalized values*. Using our literature comparison, we related our core category to Trust research and Decentralized decision making literature. We concluded that blockchain cannot completely replace trust, although this is a dominant view in blockchain literature. Blockchains are thus more connected to *Control* than *Trust,* which is why we actors should consider blockchain from a *control-perspective* instead of a *trust-perspective* to fully understand this technology.

Furthermore, in our comparison with *decentralized decision making* we conclude that blockchain technology decreases the control from a systems-perspective. The tension between the increased control between counterparties and decreased control from a systems-perspective is thus incorporated into our core category.

Finally, by combining these notions we conclude that our core category should be refined to: ***power transfer in environments with highly institutionalized values*.** This category has explanatory power in the blockchain discussion, as it explains why new-entrants and incumbents approach blockchain differently. Incumbents, often highly centralized with a lot of power in their systems, are reluctant to give up this systems-power, even though they are highly interested in the possibilities of increasing power in single transactions. Furthermore, our core category provides structure to the discussion, as it enables actors to grasp the consequences of blockchain technology in one single conceptualization, thereby helping actors with the decision whether to implement blockchain technology. Finally, this substantive theory on blockchain technology provides a new starting point for further research on the consequences of blockchain technology. The relevance of these conclusions is further discussed in the following section.

Scientific and societal relevance
The conclusions presented in the previous section have both societal and scientific relevance, as was the aim of this research.

The *Scientific Relevance* of this thesis is two-fold. First, it presents a first scientific, empirical overview of the discussion on blockchain implementation, which fills a gap in literature, as presented in the introduction. Second, the explanatory power of our core concept enables new research into essential blockchain foundations, as *Trust* and *Decentralized Decision making.* Third, our comparison to decentralized decision making literature showed the importance of using social sciences in this field dominated by computer scientists and acknowledging the importance of governance structures in blockchains. Especially the four issues of decentralized decision making issues mentioned in section 6.3 provide an interesting starting point for creating design rules for blockchain systems. Finally, this research strengthens the choice (and argument by (Davidson et al., 2016a)) to analyze blockchains from a New Institutional perspective. As discussed in section 6.1, blockchains are a technology for controlling *opportunism* (as described by Williamson (1979)), which is a central concept in Transaction Cost Economics and New Institutional Economics. Also, this lens enables us to look at blockchain technology from a broader perspective than "just" an efficiency enhancer, and analyze effects of concepts like *Cognitive Dissonance (*section 6.3). Cognitive dissonance helps us explain the encapsulation efforts by incumbents, who simply do not want to accept that their paradigm is being disrupted, even though they are presented with evidence. This provides us with a more interesting analysis than a Neo-Classical explanation centered around market shares and efficiency.

Our core concept is closely related to the *societal relevance* of this thesis. First, our framework provides holistic, understandable insights into blockchain technology for actors that might implement it. Second, our core category provides a clear representation of the core of a blockchain, which further helps to *structure* the discussion on blockchain technology by actors. Third, our literature comparison to trust research identified an important, semantic difference in Trust, Reliance and Control. The introduction of these differences into blockchain research is paramount to further develop the understanding of blockchain technology in practice. Together, these three notions, form the societal relevance of this research. A strong conceptualization of blockchain technology helps to create understanding of the possibilities of the technology and enables actors to discuss the *essence* of blockchain consequences, thereby structuring this discussion and helping actors with the decision whether to implement blockchain technology.

7.2 Further research and development of our substantive blockchain theory

From a scientific perspective, the goal of this research was to create a starting point for blockchain literature: a strong foundation on top of which new research can begin. Therefore, there are a multitude of new research possibilities that arise from this research. This section discusses the most important ones.

Further refinement of Environments with highly institutionalized values
Blockchains are most useful in *environments with highly institutionalized values,* such as the financial or government sectors. Unfortunately, this research is not able to pinpoint the exact combination of environmental factors that make blockchain technology successful, because the empirical data used in this research mainly considers the *perceived consequences* of blockchain technology, in contrast to *real consequences.* Without data, and quantitative analysis, on the actual consequences of blockchain technology, such an assessment cannot be made. This research suggests that these *environments* are largely centered around *sectors* with highly institutionalized values, but might include actors, processes, arrangements or other factors. Further research is needed to define these

environments, and which criteria or factors qualify *environments* as “blockchain environments”. This future research is valuable as it presents decision-makers with clear criteria or factors (even decision making tools or frameworks) on when to use blockchain technology.

Further comparison of our core category to trust research

Our analysis that combined Trust research and Blockchain technology provided one of the most important conclusions of this research: Blockchain is more about *Control* than *Trust.* However, as mentioned in section 6.3, we used just one conceptualization of *Trust*, by Nooteboom. More research into the effects of blockchain on Reliance, Control and Trust is needed to further analyze how blockchain affects Trust arrangements in practical settings. We therefore call upon researchers in this field to start bridging the gap between Blockchains and Trust research, as changes in reliance arrangements are one of the most important consequences of blockchain implementation

Further comparison of our core category to decision making literature

In section 6.3, we compared our core category to decentralized decision making literature. We showed that standard decentralized decision making problems arise in blockchain technology implementations, which is usually not considered by blockchain developers. Further research on decentralized decision making of blockchains systems is therefore needed, as blockchains add further complications like the lack of a central entity for policing, liability and anonymity. Furthermore, a balance between the problems of decentralized decision making and the decentralized vision of blockchains might be able to be achieved, but more research is needed to see if this is the case. Together, they could present a starting point for *design rules* of blockchain systems.

Removing uncertainties

In our framework presented in chapter 5.4, we concluded that there is *high technological and institutional uncertainty*. Further research on these two important factors is therefore needed. First, research into the true technological potential of blockchains is needed to be able to conclude more definitively what they can do in terms of capacity, speed and throughput. An expected time-line of these factors would greatly improve decision-making. Second, the lack of a comprehensive legal and institutional framework is a problem. Especially the legal status of cryptocurrencies, digitized assets and regulatory oversight is unclear, which leads to great uncertainty for stakeholders. If both technological and institutional uncertainties are at least diminished, proof of concepts are easier to implement.

Further developing a Formal Blockchain theory

This research presented a substantive blockchain theory. Together with important pieces of literature (Allen, 2017; Davidson et al., 2016a; Wright & De Filippi, 2015), which were mentioned in the introduction, future research should be dedicated to further formalize these theories. More research into specific blockchain applications is therefore needed to create a formal theory on (economic) effects of blockchain technology.

7.3 Reflection on research

This section reflects on this research. It discusses the process and outcomes of this research and presents five factors that should be considered while assessing this research. Part of this reflection are the 14 research criteria presented in chapter 3, these are discussed in Appendix 5.

Researcher bias

Research bias is always an important topic of reflection in Grounded Theory studies. We tried to lower this risk as much as possible through various approaches.

First, as indicated by Glaser and Strauss (1990), a grounded theory approach is best performed by multiple researchers at the same time. By comparing properties, dimensions and categories between researchers one can ensure that the findings are validated. As this research is part of my Master Thesis project, this could not be done. However, bi-weekly in-depth discussions on both the process and the outcomes were conducted with my first supervisor Jolien Ubacht. Although we cannot say that these discussions are as effective as coding with multiple researchers, we reduced this risk.
Second, throughout the research we stayed as close to the empirical data as possible in a process of constant comparison. Thereby reducing the risk of our own ideas or notions becoming more powerful than the empirical data.
Finally, we performed a negative case analysis by using critical journalism articles. These were used to present a balanced view and combat the risk of researcher bias.

Focus on perceived effects
As blockchain technology is still immature, all data used in this research is empirical data on *perceived effects, issues and functions*. These are perceptions of consequences, instead of real consequences. Therefore, this research should be seen as a substantive theory on these perceived consequences, instead of a substantive theory on real consequences. This research mapped these current discussions, and not the real consequences of implementing blockchain technology.

No practical validation
Due to the highly theoretical nature of this research, a practical validation was not performed. This was part of my first proposal, but could not be done after the decision to take a more theoretical approach to this study. We can therefore not verify that our core category and framework truly structures discussions amongst decision makers. Validity in this research was captured by a strong line of argumentation and the criteria presented in the previous sections. This should provide this research with enough “trustworthiness”, but practical validation of this research would improve this.

Data Reflection
Four notions are important when discussion the data used in this research.
First, all data that was used was either English or Dutch. Although there is a lot of activity in China regarding blockchain development, these were not included into our empirical data due to a language barrier. We cannot be certain of the effects this has on our results. However, there are two important notions to make.

Firstly, due to the highly conceptual nature of this research, we argue that the addition of these articles would not have made a significant difference to our empirical framework (Figure 5.7). The conceptualization from more than 500 quotes into three categories would not be significantly impacted by the addition of Chinese articles.

Secondly, although we can argue that our empirical framework would not significantly be affected by the addition of this literature, our understanding of highly sociological and cultural factors as Trust and Control might have influenced the further conceptualization into our empirical core category and refined core category might have been influenced by other cultural viewpoints.

Second, in the current blockchain discussion, a lot of articles are written that do not truly understand blockchain technology. These articles were omitted during the first selection of our empirical data. In hindsight, these articles could have provided us with interesting insights on how blockchain is perceived by actors that do not understand it. Although these insights would have been interesting, they would probably be omitted later in the research to create a conceptualization that is correct, over a conceptualization that is empirically correct. Thus, significant effects are not expected on the outcome.

Third, our data is strongly focused around several sectors. Blockchain technology is most often used in these sectors, so our analysis and data gathering was also focused on these sectors. Again, due to the highly conceptual nature of this research, the effects of this are not expected to be significant. However, important differences between the sectors did emerge on the precise application and implementation of blockchain technology. Blockchain technology is thus not a “one-size-fits-all” solution that magically solves all problems in all sectors. The design of a blockchain should suite the problem that it is trying to solve.

Finally, we were unable to identify a central piece of literature in our Grounded Theory approach. There was not one article that completely covered the discussion, or provided an overview of all viewpoints.

Reflection on the MSc. Systems Engineering, Policy Analysis and Management and this research

Finally, we reflect on the connection between our MSc. program SEPAM and this research. In short, the SEPAM MSc program is centered around the *analysis and design of complex socio-technical systems in which both systems- and multi-actor complexities arises.* This thesis is thus strongly linked to the core of this Masters-program. We analyzed a highly complex (both from a systems-, and multi-actor perspective) technological system, that has possible significant effects on values in both the public and private domain. We analyzed the technical issues of blockchain technology, but also addressed the institutional difficulties of implementing blockchain technology. Furthermore, the design of our framework combined both systematic and creative ways to analyze a complex engineering system, blockchain technology. Although this thesis was primarily aimed at analyzing the macro-effects and conceptual nature of blockchain technology, this thesis also has a design component. We designed a framework and conceptualization of blockchain technology to help actors with the decision whether to implement blockchain technology. Furthermore, both our technical assessment of blockchain technology in chapter 2, and the literature comparison into decentralized decision making provided much-needed first steps into creating *design rules* for blockchain technology systems.

8 Literature

Actors. (n.d.). Oxford English dictionary online. Retrieved from (01-11-2016): https://en.oxforddictionaries.com/definition/actors

AD. (2016). Blockchain gaat de wereld veranderen. Retrieved from (01-09-2016): http://www.ad.nl/nieuws/blockchain-gaat-de-wereld-veranderen~a4697f98/

Allan, G. (2003). A critique of using grounded theory as a research method. *Electronic journal of business research methods, 2*(1), 1-10.

Allen, D. W. (2017). Discovering and developing the blockchain cryptoeconomy. *Available at SSRN 2815255.*

Ascribe. (2015). Towards An Ownership Layer for the Internet. Retrieved from (01-09-2016): https://bravenewcoin.com/assets/Whitepapers/ascribe-whitepaper-20150624.pdf

Backfeed. (2016). Backfeed: Explore in-depth. Retrieved from (01-09-2016): http://backfeed.cc/explore-in-depth

Baran, P. (1964). On distributed communications networks. *IEEE transactions on Communications Systems, 12*(1), 1-9.

Berkeley. (2015). BlockChain Technology:Beyond Bitcoin. Retrieved from (01-09-2016): scet.berkeley.edu/wp-content/uploads/BlockchainPaper.pdf

BitFury Group. (2015). Public versus Private Blockchains Part 1: Permissioned Blockchains [Whitepaper] Retrieved from (01-11-2016): http://bitfury.com/content/5-white-papers-research/public-vs-private-pt1-1.pdf

BitNation. (2016). Bitnation Whitepaper. Retrieved from (01-09-2016): https://docs.google.com/document/d/1ZiIZ-rmI79HPNbfJ1AXwcgoe8TKMoUMatDf7YfO5LZw/edit

BitShares. (2015). What is BitShares. Retrieved from (01-09-2016): http://docs.bitshares.org/bitshares/whatis.html

Bittunes. (2016). An independent digital music market. Retrieved from (01-09-2016): http://www.bittunes.org/general-explanation/

BlockchainHealth. (2016). Blockchainhealth. Retrieved from (01-09-2016): https://blockchainhealth.co/

Blockverify. (2016). Blockverify. Retrieved from (01-09-2016): http://blockverify.io/

Bloomberg. (2016). Blockchains for banks probably can't hurt. Retrieved from (01-09-2016): http://origin-www.bloombergview.com/articles/2015-09-01/blockchain-for-banks-probably-can-t-hurt

Blumer, H. (1954). What is wrong with social theory? *American sociological review, 19*(1), 3-10.

Bonabeau, E. (2009). Decisions 2.0: The power of collective intelligence. *MIT Sloan Management Review, 50*(2), 45.

Bowen, G. A. (2006). Grounded theory and sensitizing concepts. *International journal of qualitative methods, 5*(3), 12-23.

Breckenridge, J., & Jones, D. (2009). Demystifying theoretical sampling in grounded theory research. *The Grounded Theory Review, 8*(2), 113 -126.

Breckenridge, J., Jones, D., Elliott, I., & Nicol, M. (2012). Choosing a methodological path: Reflections on the constructivist turn. *Grounded Theory Review, 11*(1), 64-71.

Bresnahan, T. F., & Trajtenberg, M. (1995). General purpose technologies 'Engines of growth'? *Journal of Econometrics, 65*(1), 83-108.

Buterin, V. (2013). A Next-Generation Smart Contract and Decentralized Application Platform [White paper]. Retrieved from (01-09-2016): https://github.com/ethereum/wiki/wiki/White-Paper

Buterin, V. (2014a). DAOs, DACs, DAs and More: An Incomplete Terminology Guide. Retrieved from (01-09-2016): https://blog.ethereum.org/2014/05/06/daos-dacs-das-and-more-an-incomplete-terminology-guide/

Buterin, V. (2014b). Proof of Stake: How I Learned to Love Weak Subjectivity. Retrieved from (01-09-2016): https://blog.ethereum.org/2014/11/25/proof-stake-learned-love-weak-subjectivity/
Buterin, V. (2015a). On public and private blockchains. Retrieved from (01-09-2016): https://blog.ethereum.org/2015/08/07/on-public-and-private-blockchains/
Buterin, V. (2015b). Visions, Part 1: The Value of Blockchain Technology. Retrieved from (01-09-2016): https://blog.ethereum.org/2015/04/13/visions-part-1-the-value-of-blockchain-technology/
Carcary, M. (2009). The research audit trial–enhancing trustworthiness in qualitative inquiry. *The electronic journal of business research methods, 7*(1), 11-24.
Castells, M. (2014). The impact of the internet on our society: A global perspective. In M. Castells, D. Gelernter, J. Vázquez, & E. Morozov (Eds.), *Change: 19 Key Essays on How Internet Is Changing our Lives*: Turner House Publications.
Cearley, D. W., Walker, M. J., & Burke, B. (2016). Top 10 Strategic Technology Trends for 2017. Stamford: Gartner.
Chuen, D. L. K. (2015). *Handbook of digital currency: Bitcoin, innovation, financial instruments, and big data*. London: Academic Press.
CIO. (2016). Blockchains: Hype or Reality. Retrieved from (01-09-2016): http://www.cio.com/article/3058266/security/blockchain-technology-hype-or-reality.html
CIO [Security]. (2016). Is blockchain good for security? Retrieved from (01-09-2016): http://www.cio.com/article/3050995/security/is-the-blockchain-good-for-security.html
Cognizant. (2016). Blockchain in Banking: A Measured Approach. Retrieved from (01-09-2016): https://www.cognizant.com/whitepapers/Blockchain-in-Banking-A-Measured-Approach-codex1809.pdf
Coindesk. (2016). Understanding The DAO Attack. Retrieved from (01-02-2017): http://www.coindesk.com/understanding-dao-hack-journalists/
Coinmarketcap. (2016). Crypto-Currency Market Capitalizations. Retrieved from (01-09-2016): https://coinmarketcap.com/
Coinmarketcap. (2017). ZCash Charts. Retrieved from (01-02-2017): http://coinmarketcap.com/currencies/zcash/
Colony [2]. (2016). Collin Vine, co-founder Colony | Dutch Blockchain Conference #dbc16s. Retrieved from (01-09-2016): https://www.youtube.com/watch?v=ROC3jpV94n8&t=579s
Colony-io. (2016). Colony.io. Retrieved from (01-09-2016): https://colony.io/
Corbin, J., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative sociology, 13*(1), 3-21.
Corbin, J., & Strauss, A. (1994). Grounded theory methodology. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 273-285).
Correspondent. (2015). Hoe Bitcoin de oude idealen van het internet nieuw leven inblaast. Retrieved from (01-09-2016): https://decorrespondent.nl/70/hoe-bitcoin-de-oude-idealen-van-het-internet-nieuw-leven-inblaast/12911778880-ecc7c2e7
Credit Suisse. (2016). Blockchain: The trust disruptor. Retrieved from (01-09-2016): https://plus.credit-suisse.com/researchplus/ravDocView?docid=iPvkYN
Creswell, J. (2002). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research*. Saddle River, NJ: Prentice Hall.
Creswell, J. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks: Sage publications.
Custodio, N. (2013). Explain Bitcoin Like I'm Five. Retrieved from (01-09-2016): https://medium.com/@nik5ter/explain-bitcoin-like-im-five-73b4257ac833 - .bsnv08mgh
Davidson, S., De Filippi, P., & Potts, J. (2016a). Disrupting Governance: The New Institutional Economics of Distributed Ledger Technology. *Available at SSRN 2811995*.
Davidson, S., De Filippi, P., & Potts, J. (2016b). Economics of blockchain. *Available at SSRN 2744751*.

De Morgen. (2016). De stille revolutie van Blockchain, de 'notaristechnologie' die onlinetransacties veilig moet maken. Retrieved from (01-09-2016): http://www.demorgen.be/technologie/de-stille-revolutie-van-blockchain-de-notaristechnologie-die-onlinetransacties-veilig-moet-maken-b14b8e79/
Deloitte [Banking]. (2016). Blockchain in Banking. Retrieved from (01-09-2016): https://www2.deloitte.com/uk/en/pages/innovation/articles/blockchain.html
Deloitte [Insurance]. (2016). Blockchain in Insurance. Retrieved from (01-09-2016): https://www2.deloitte.com/uk/en/pages/innovation/articles/blockchain.html
Deloitte [Main]. (2016). Blockchain: Enigma Paradox Opportunity. Retrieved from (01-09-2016): https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/Innovation/deloitte-uk-blockchain-full-report.pdf
Deloitte [Public]. (2016). Blockchain in Public sector. Retrieved from (01-09-2016): https://www2.deloitte.com/uk/en/pages/innovation/articles/blockchain.html
Deutsch, M. (1973). *The resolution of conflict: Constructive and destructive processes*: Yale University Press.
Dwivedi, Y. K. (2009). *Handbook of research on contemporary theoretical models in information systems*: IGI Global.
Dym, C. L., & Little, P. (1994). *Engineering design*. Hoboken: Wiley & Sons.
Economist. (2015). The next big thing, Or is it? Retrieved from (01-09-2016): http://www.economist.com/node/21650295/print
Effects. (n.d.). Oxford English dictionary online. Retrieved from (01-11-2016): https://en.oxforddictionaries.com/definition/effect
Enserink, B., Hermans, L., Kwakkel, J., Thissen, W., Koppenjan, J., & Bots, P. (2010). *Policy Analysis of Multi-Actor Systems*. The Hague: Lemma.
Evans, G. L. (2013). A novice researcher's first walk through the maze of grounded theory. *Grounded Theory Review, 12*(1).
Everledger. (2016). Everledger. Retrieved from (01-09-2016): https://www.everledger.io/
Filament. (2016). Foundations for the Next Economic Revolution. Retrieved from (01-09-2016): https://filament.com/assets/downloads/Filament Foundations.pdf
Follow the Money. (2015). De grote Bitcoin-vooroordelen-debunksessie. Retrieved from (01-09-2016): https://www.ftm.nl/artikelen/de-grote-bitcoin-vooroordelen-debunksessie
Forbes [Bitcoin]. (2016). Theft And Mayhem In The Bitcoin World. Retrieved from (01-09-2016): http://www.forbes.com/sites/francescoppola/2016/08/06/theft-and-mayhem-in-the-bitcoin-world/print
Forbes [Eth]. (2016). Ethereum And The 'Old Catholics'. Retrieved from (01-09-2016): http://www.forbes.com/sites/francescoppola/2016/07/26/ethereum-and-the-old-catholics/print/
Forbes [LessonsEth]. (2016). A Painful Lesson For The Ethereum Community. Retrieved from (01-09-2016): http://www.forbes.com/sites/francescoppola/2016/07/21/a-painful-lesson-for-the-ethereum-community/print/
Frauenfelder, M. (2016). Bitcoin is the Sewer Rat of Currencies. Retrieved from (01-09-2016): https://medium.com/institute-for-the-future/bitcoin-is-the-sewer-rat-of-currencies-b89819cdf036
Friese, S. (2016). Computer-assisted grounded theory analysis with ATLAS. ti. *10.14279/depositonce-5079*.
Functions. (n.d.). Oxford English dictionary online. Retrieved from (01-11-2016): https://en.oxforddictionaries.com/definition/function
Garp. (2016). Blockchain Critique: For 2016, Questions of Risks and Rewards. Retrieved from (01-09-2016): http://www.garp.org/ - !/risk-intelligence/all/all/a1Z400000031aX7EAI
Gem. (2016). Gem Complex Data Sharing Made Simple. Retrieved from (01-09-2016): https://gem.co/

Glaser, B. G. (1978). *Theoretical sensitivity: Advances in the methodology of grounded theory.* Mill Valley: Sociologicy Press.

Glaser, B. G. (1992). *Basics of grounded theory analysis*. Mill Valley: Sociology Press.

Glaser, B. G. (1998). *Doing grounded theory: Issues and discussions*. Mill Valley: Sociology Press.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. London: Weidenfeld and Nicolson.

Hagiu, A., & Wright, J. (2015). Multi-sided platforms. *International Journal of Industrial Organization, 43*, 162-174.

Heath, H., & Cowley, S. (2004). Developing a grounded theory approach: a comparison of Glaser and Strauss. *International journal of nursing studies, 41*(2), 141-150.

Holton, J. A. (2007). The Coding Process and Its Challenges. In A. Bryant & K. Charmaz (Eds.), *The Sage handbook of grounded theory* (pp. 265-289). Thousand Oaks: Sage publications.

Howard, G. (2015). Blockchain Technology Is Our Chance To Rebuild The Internet In A Way That Benefits Creators. Retrieved from (September 13, 2011): http://www.forbes.com/sites/georgehoward/2015/08/12/blockchain-technology-is-our-chance-to-rebuild-the-internet-in-a-way-that-benefits-creators/ - 63bd3ac9610f

Hybertson, D. W. (2016). *Model-oriented systems engineering science: a unifying framework for traditional and complex systems*: CRC Press.

IBM. (2016). Fast forward: Rethinking enterprises, ecosystems and economies with blockchains. Retrieved from (01-09-2016): https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=GBE03757USEN

IBM [Banking]. (2016). Banking on Blockchain: Charting the progress of distributed ledger technology in financial services. Retrieved from (01-09-2016): https://www.finextra.com/finextra-downloads/surveys/documents/32e19ab4-2d9c-4862-8416-d3be94161c6d/banking on blockchain.pdf

Issues. (n.d.). Oxford English dictionary online. Retrieved from (01-11-2016): https://en.oxforddictionaries.com/definition/issue

Jentzsch, C. (2015). Decentralized Autonomous Organizations to automate governance. Retrieved from (01-09-2016): https://download.slock.it/public/DAO/WhitePaper.pdf

Kelle, U. (2007). " Emergence" vs." forcing" of empirical data? A crucial problem of" Grounded Theory" reconsidered. *Historical Social Research/Historische Sozialforschung. Supplement*, 133-156.

Kelle, U. (2010). The development of categories: Different approaches in grounded theory. In A. Bryant & K. Charmaz (Eds.), *The Sage handbook of grounded theory* (pp. 191-213). Thousand Oaks: Sage publications.

Kim, H. M., & Laskowski, M. (2016). Towards an Ontology-Driven Blockchain Design for Supply Chain Provenance. *Available at SSRN 2828369*.

Klein Woolthuis, R., Hillebrand, B., & Nooteboom, B. (2005). Trust, contract and relationship development. *Organization studies, 26*(6), 813-840.

Koppenjan, J., & Groenewegen, J. (2005). Institutional design for complex technological systems. *International Journal of Technology, Policy and Management, 5*(3), 240-257.

Kynetix. (2016). 7 Ways Blockchain Technology Could Disrupt The Post-Trade Ecosystem. Retrieved from (01-09-2016): http://www.kynetix.com/news-and-insights/whitepaper/7-ways-blockchain-technology-could-disrupt-the-post-trade-ecosystem/

Lazenbatt, A., & Elliott, N. (2005). How to recognise a'quality'grounded theory research study. *Australian Journal of Advanced Nursing, The, 22*(3), 48.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Newbury Park CA: Sage publications.

MacDonald, T. J., Allen, D., & Potts, J. (2016). Blockchains and the Boundaries of Self-Organized Economies: Predictions for the Future of Banking. *Available at SSRN 2749514*.

March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization science, 2*(1), 71-87.

McKinsey & Company. (2015). Beyond the Hype: Blockchains in Capital Markets. Retrieved from (01-09-2016): http://www.mckinsey.com/industries/financial-services/our-insights/beyond-the-hype-blockchains-in-capital-markets

McKinsey & Company [Insurance]. (2016). Blockchain in insurance: Opportunity or Threat. Retrieved from (01-09-2016): http://www.mckinsey.com/industries/financial-services/our-insights/blockchain-in-insurance-opportunity-or-threat

Melia, K. M. (1996). Rediscovering glaser. *Qualitative health research, 6*(3), 368-378.

Mollering, G. (2006). Trust, institutions, agency: towards a neoinstitutional theory of trust. In R. Bachmann & A. Zaheer (Eds.), *Handbook of trust research* (pp. 355-371). Cheltenham: Edward Elgar.

Mougayar, W. (2015). The Global Landscape of Blockchain Companies in Financial Services. Retrieved from (01-12-2016): http://startupmanagement.org/2015/10/22/the-global-landscape-of-blockchain-companies-in-financial-services/

Mougayar, W. (2016). *The Business Blockchain: Promise, Practice, and Application of the Next Internet Technology*. Hoboken: Wiley.

Nakamoto, S. (2009). Bitcoin: A peer-to-peer electronic cash system [White paper]. Retrieved from (01-09-2016): https://bitcoin.org/bitcoin.pdf

Nooteboom, B. (1996). Trust, opportunism and governance: A process and control model. *Organization studies, 17*(6), 985-1010.

Nooteboom, B. (2002). *Trust: Forms, foundations, functions, failures and figures*. Cheltenham: Edward Elgar Publishing.

Nooteboom, B. (2013). Trust and innovation. In R. Bachmann & A. Zaheer (Eds.), *Handbook of advances in trust research* (pp. 106-123). Cheltenham: Edward Elgar.

Nooteboom, B., & Six, F. (2003). *The trust process in organizations: Empirical studies of the determinants and the process of trust development*: Edward Elgar Publishing.

Norta, A. (2015) Creation of smart-contracting collaborations for decentralized autonomous organizations. *Vol. 229. Lecture Notes in Business Information Processing* (pp. 3-17).

North, D. C. (1990). *Institutions, institutional change and economic performance*: Cambridge university press.

Oliver Wyman. (2016). Blockchain in capital markets: The Prize and the Journey. Retrieved from (01-09-2016): http://www.oliverwyman.com/content/dam/oliver-wyman/global/en/2016/feb/BlockChain-In-Capital-Markets.pdf

Onions, P. E. (2006). *Grounded theory applications in reviewing knowledge management literature.* Paper presented at the Leeds Metropolitan University Innovation North Research Conference, Leeds.

Özsu, M. T., & Valduriez, P. (2011). *Principles of distributed database systems*. New York: Springer Science & Business Media.

ProofOfExistence. (2016). ProofOfExistence. Retrieved from (01-09-2016): https://proofofexistence.com/about

Provenance. (2015). Blockchain: the solution for transparency in product supply chains. Retrieved from (01-09-2016): https://www.provenance.org/whitepaper

Pruyt, E. (2010). Multi-actor systems and ethics. *International transactions in operational research, 17*(4), 507-520.

Ripple. (2016). A Protocol for Interledger Payments. Retrieved from (01-09-2016): https://interledger.org/interledger.pdf

Robeco. (2016). Distributed ledger technology for the financial industry. Retrieved from (01-09-2016): https://www.robeco.com/images/201605-distributed-ledger-technology-for-the-financial-industry.pdf

Roser, C. (2015). A Critical Look at Industry 4.0. Retrieved from (01-03-2017): http://www.allaboutlean.com/industry-4-0/

Sage, A. P., & Armstrong, J. E. (2000). *Introduction to systems engineering*. New York: Wiley.

Schumpeter, J. A. (1942). *Capitalism, socialism, and democracy*: Harper & Brothers.
Schwab, K. (2016a). *The fourth industrial revolution*: Penguin UK.
Schwab, K. (2016b). The Fourth Industrial Revolution: what it means, how to respond. Retrieved from (01-03-2017): https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/
Schwartz, D., Youngs, N., & Britto, A. (2014). The Ripple Protocol Consensus Algorithm [white paper].
Seppänen, R., Blomqvist, K., & Sundqvist, S. (2007). Measuring inter-organizational trust—a critical review of the empirical research in 1990–2003. *Industrial marketing management, 36*(2), 249-265.
Sikolia, D., Biros, D., Mason, M., & Weiser, M. (2013). Trustworthiness of grounded theory methodology research in information systems.
Stampery. (2016). Stampery. Retrieved from (01-09-2016): https://stampery.com/
Strategy+Business. (2016). A Strategist's Guide to Blockchain. Retrieved from (01-09-2016): http://www.strategy-business.com/article/A-Strategists-Guide-to-Blockchain?gko=0d586
Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Newbury Park, CA: Sage Publications.
Swan, M. (2015). *Blockchain: Blueprint for a new economy*. Sebastopol: O'Reilly Media, Inc.
Tanenbaum, A. S., & Van Steen, M. (2007). *Distributed systems*: Prentice-Hall.
Tapscott, D., & Tapscott, A. (2016). *Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World*: Penguin.
Tierion. (2016). BLOCKCHAIN HEALTHCARE 2016: Promise & Pitfalls. Retrieved from (01-09-2016): https://tierion.com/blog/blockchain-healthcare-2016-report/
Ujo. (2016). What Does the "B" Word Mean for Music? Retrieved from (01-09-2016): https://blog.ujomusic.com/what-does-the-b-word-mean-for-music-9ca48533eb1b - .ymvrwbc7c
Ujo [2]. (2016). Ujo. Retrieved from (01-09-2016): http://ujomusic.com/
Uport. (2016). UPORT: A PLATFORM FOR SELF-SOVEREIGN IDENTITY. Retrieved from (01-09-2016): http://whitepaper.uport.me/uPort_whitepaper_DRAFT20161020.pdf
Urquhart, C. (2012). *Grounded theory for qualitative research: A practical guide*: Sage.
Van Eijk, N., Fahy, R., Van Til, H., Nooren, P., Stokking, H., & Gelevert, H. (2015). Digital platforms: an analytical framework for identifying and evaluating policy options. *TNO 2015 R11271*. The Hague: TNO.
Volkskrant. (2016). Miljoenenroof fnuikend voor techhype blockchain. Retrieved from (01-09-2016): http://www.volkskrant.nl/tech/miljoenenroof-fnuikend-voor-techhype-blockchain~a4323457/
Walport, M. (2016). Distributed Ledger Technology: Beyond Blockchain. *UK Government Office for Science, Tech. Rep, 19*.
Webb, A. (2015). 8 Tech Trends to Watch in 2016. Retrieved from (01-09-2016): https://hbr.org/2015/12/8-tech-trends-to-watch-in-2016
Wester, F. (2005). De methodeparagraaf in rapportages over kwalitatief onderzoek.
WFE. (2016). Financial Market Infrastructures and Distributed Ledger Technology. Retrieved from (01-09-2016): https://www.world-exchanges.org/home/index.php?option=com_dropfiles&format=&task=frontfile.download&catid=18&id=349&Itemid=1000000000000
Williamson, O. E. (1975). *Markets and hierarchies : analysis and antitrust implications : a study in the economics of internal organization*. New York: The Free Press.
Williamson, O. E. (1979). Transaction-cost economics: the governance of contractual relations. *The journal of Law and Economics, 22*(2), 233-261.
Williamson, O. E. (1985). *The economic intstitutions of capitalism*: Simon and Schuster.
Williamson, O. E. (1998). Transaction cost economics: How it works; where it is headed. *Economist, 146*(1), 23-58.

Wright, A., & De Filippi, P. (2015). Decentralized blockchain technology and the rise of lex cryptographia. *Available at SSRN 2580664*.

ZDNet. (2016). Let's quit the magic blockchain talk. Retrieved from (01-09-2016): http://www.zdnet.com/article/lets-quit-the-blockchain-magic-talk/

9 Appendix 1 Empirical Data used in Grounded Theory

Article Name	Grouped
Credit Suisse (2016)	Advisory, Corporate
Deloitte Main (2016)	Advisory, Corporate
IBM (2016)	Advisory, Corporate
McKinsey (2016)	Advisory, Corporate
Mckinsey Insurance (2016)	Advisory, Corporate
OliverWyman (2016)	Advisory, Corporate
Ripple (2016)	Start-up
TheDAO – Referenced as (Jentzsch, 2015)	Start-up
UK (2016) – Referenced as (Walport, 2016)	Government
WFE (2016)	Government
Bitnation (2016)	Start-up
Provenance (2015)	Start-up
Berkeley (2015)	Overview
Cognizant (2016)	Start-up
Deloitte [Banking] (2016)	Advisory, Corporate
Deloitte [Insurance] (2016)	Advisory, Corporate
Deloitte [Public] (2016)	Advisory, Corporate
IBM [Banking] (2016)	Advisory, Corporate
Robeco (2016)	Advisory, Corporate
Strategy + Business (2016)	Advisory, Corporate
Ascribe (2015)	Start-up
Bitshares (2015)	Start-up
Bittunes (2015)	Start-up
Blockverify (2016)	Start-up
BlockchainHealth (2016)	Start-up
Colony-io (2016)	Start-up
Everledger (2016)	Start-up
Filament (2016)	Start-up
Gem (2016)	Start-up
Kynetix (2016)	Start-up
ProofOfExistence (2016)	Start-up
Stampery (2016)	Start-up
TierionHEalth (2016)	Start-up
Ujo (2016)	Start-up
Ujo [2] (2016)	Start-up
Uport (2016)	Start-up
Colony [2] (2016)	Start-up

Backfeed (2016)	Start-up
AD (2016)	Journalism
Bloomberg (2016)	Journalism
CIO (2016)	Journalism
CIO [Security] (2016)	Journalism
Correspondent (2015)	Journalism
DeMorgen (2016)	Journalism
Economist (2015)	Journalism
Forbes [Bitcoin] (2016)	Journalism
Forbes [Eth] (2016)	Journalism
Forbes [LessonsEth] (2016)	Journalism
Frauenfelder (2016)	Journalism
Follow The Money (2015)	Journalism
Garp (2016)	Journalism
Volkskrant (2016)	Journalism
ZDNet (2016)	Journalism
Blockchain Revolution – referenced as (Tapscott & Tapscott, 2016)	Journalism

10 Appendix 2 Overview of Properties in Open Coding phase

This appendix provides an overview of all codes in the open coding phase. The main coding scheme that was used is as follows:

- E/F/I – Effect Function or Issue
- Sector – early assumption, which was valuable later on, was that sectors were highly important in blockchain environments. We therefore coded the sectors as well. These are:
    - Adv = Advisory
    - Fi = Finace
    - Gov = Governemnt
    - Hea = Health
    - Ins = Insurance
    - SC = Supply chain
    - Org = Orginzations on the blockchain
- E_Adv_Automation is thus the Effect in the advisory sector Automation

E_Adv_Automation	F_Fi_Voting Rights
E_Adv_Decrease Fraud	F_Gov_Asset Registration
E_Adv_Disintermidiation	F_Gov_Authorisation
E_Adv_Improve Regulatory compliance	F_Gov_Backup
E_Adv_Increase Auditability	F_Gov_Code as regulation
E_Adv_Increase Collaboration	F_Gov_collect taxes
E_Adv_increase security	F_Gov_Control own data
E_Adv_Increase Trust	F_Gov_Deliver benefits
E_Adv_Independence of continuity	F_Gov_Ensure Integrity
E_Adv_New organizational forms	F_Gov_Identity services
E_Adv_Prevent Selling of Fake goods	F_Gov_issue passports
E_Adv_Protect Against Domination	F_Gov_Record keeping
E_Adv_Real Time	F_Gov_Recording transactions
E_Adv_Reduce Dispute Resolution	F_Gov_Reputation
E_Adv_Self Governance	F_Gov_Validate transaction
E_Adv_Value Creation	F_Gov_Voting
E_Automation	F_GovAsset exchange
E_Back office	F_HEa_Audit Trail
E_Decentralized model of trust	F_Hea_Identity services
E_Decrease costs	F_Hea_Standardization
E_Disintermidiation	F_Hea_Transfer ownership of data
E_E_Decrease transaction costs	F_Hea_Validation
E_E_Increase simplicity	F_Immutable
E_E_Increase speed	F_Ins_Control own data
E_Enable Sharing Economy	F_Ins_KYC
E_Fairness increase	F_Ins_Peer to Peer
E_Faster Settlement	F_Ins_Personal Data verification
E_FI_ Disintermediation	F_Ins_Validate Authenticity

E_Fi_Access to capital	F_Ins_Validate transaction
E_Fi_Access to financial services	F_Ins_Verify Transactions
E_Fi_Alignment	F_KYC
E_Fi_Alternative Currencies	F_Licence Management
E_Fi_Asset trading	F_Mu_Asset Tracking
E_Fi_Auditability	F_Mu_Identity services
E_Fi_Automation	F_Mu_Renumeration
E_Fi_Cost savings	F_Mu_Tokenization
E_Fi_Data integrity	F_Mu_Transfer ownership
E_Fi_Decrease costs	F_Mu_Verify ownership
E_Fi_Decrease infrastructure costs	F_Mu_Verify Transactions
E_Fi_Delivery versus Payment	F_ORg_Coordination
E_Fi_Eliminate Back office	F_Org_Performance management
E_Fi_eliminate errors	F_Org_Renumeration
E_Fi_Eliminate Front office	F_Org_Reputation
E_Fi_Eliminate time delay	F_Org_Share Distribution
E_Fi_Faster Clearing	F_Org_Voting
E_Fi_Faster Settlement	F_Ownership history
E_Fi_Increase Efficiency	F_Pay per use
E_Fi_Increase Operational Efficiency	F_Prove Authenticity
E_Fi_increase security	F_Prove Authenticity in IOT
E_Fi_Increase simplicity	F_Regulatory requirements
E_Fi_Interfaces reduction	F_SC)Confidential Data Sharing
E_Fi_Less Fraud	F_SC_Asset Tracking
E_Fi_Lower Credit Risk	F_SC_Assign properties
E_Fi_Lower Entry barriers	F_Sc_Connect counterparties
E_Fi_Lower fraud	F_SC_Digitized assets
E_Fi_lower operational costs	F_SC_Follow rules
E_Fi_Lower Risk deposit and payments	F_SC_Link between digital and physical world
E_Fi_Lower Settlement Risk	F_SC_Ownership history
E_Fi_Lower Systemic Risk	F_SC_Prove Authenticity
E_Fi_Real Time	F_SC_Prove Origin
E_Fi_Reduce bid/offer spreads	F_SC_Reputation System
E_Fi_Reduce capital requirements	F_SC_Track Creation
E_Fi_reduce colleteral	F_SC_Track Usage
E_Fi_reduce commincation needs	F_sc_Transfer ownership
E_Fi_Reduce cost	F_SC_Unambiguously discver state of system
E_Fi_Reduce counter party risk	F_SC_Verify Certifications
E_Fi_Reduce time for transactions	F_SC_Verify ownership
E_Fi_Regulatory compliance	F_SC_Verify Standards
E_Fi_Remove clearing Houses	F_Transaction Confirmation
E_Fi_Replicability	F_Transaction Processing

E_Fi_Risk Reduction	F_Validate Identity
E_Fi_Streamlining of process	F_Verify Ownership
E_Fi_System Reslience	F_Verify Transactions
E_Fi_Third party	I__Current legal framework
E_Fi_Transparancy	I__privacy
E_Fi_Trust	I__Security
E_Globalization	I_Adding Identity
E_Gov_Eliminate Back office	I_Adv_Costs
E_Gov_Enable Competition	I_Adv_Cultural resistance
E_Gov_Improve quality	I_Adv_Fear of working together
E_Gov_Increase competition	I_Adv_Governance
E_Gov_increase security	I_Adv_Lack of awereness
E_Gov_Lower fraud	I_Adv_privacy
E_Gov_No central point of failure	I_Adv_Regulations
E_Gov_No central point of trust	I_Adv_Security
E_Gov_Reduce bribery	I_Adv_Standardization
E_Gov_Reduce cost	I_Automation
E_Gov_Reduce fees	I_Behavior change
E_Gov_Reduce politicization	I_Capacity
E_Gov_Remove trusted third party for recordkeeping	I_Centralization efforts
E_Gov_Resilience	I_Code Errors
E_Gov_Robustness	I_Community Discussions
E_Hea_Data Integrity	I_Comparison
E_Hea_Increase Control	I_Comparison to internet
E_Hea_increase security	I_computer vs human
E_Hea_Quality Data	I_Costs
E_Hea_Reduce Costs	I_Criminals
E_Hea_Regulatory compliance	I_Cultural resistance
E_Hea_Scalability	I_Cultural Resistance due to legacy
E_Increase Control	I_Data integrity
E_Increase Data Accuracy	I_Encapsulation by incumbants
E_Increase Efficiency	I_Energy usage
E_Increase Security	I_Fear for automation
E_Increase speed	I_Fi_adoption
E_Ins_Automation	I_Fi_Adoption of DVP
E_Ins_Credibility	I_Fi_Anonymity
E_Ins_Customer engagement	I_Fi_Block capacity
E_Ins_Data Accuracy	I_Fi_Capacity
E_Ins_Decrease handling costs	I_Fi_Centralized Ledgers
E_Ins_Disintermidiation	I_Fi_Combination with real life systems
E_Ins_Increase Efficiency	I_Fi_Commercial sensitivity
E_Ins_Personalization	I_Fi_Computing power

E_Ins_Reduce administration	I_Fi_Cultural resistance
E_Ins_Transparancy	I_Fi_Current legal framework
E_Ins_Trustworthy	I_Fi_Current Regulation
E_Institutional Technology	I_Fi_Digitized assets regulations
E_Mu_Disintermidiation	I_Fi_Digitized Assets vs Real Life assets
E_Mu_Increase Collaboration	I_Fi_Faster payment
E_Mu_Increase Control	I_Fi_Fiat cash movement
E_Mu_increase flexibility	I_Fi_Giving up control
E_Mu_Self Governance	I_Fi_immaturity
E_Mu_Transparancy	I_Fi_Insecurity on promis
E_New organizational forms	I_Fi_integration with current technical systems
E_Org_Collaborative	I_Fi_Interoperability
E_Org_Disintermidiation	I_Fi_Interoperability with existing ledgers
E_Org_Open	I_Fi_Lack of expertise
E_Org_Smarter	I_Fi_Legal framework currently not integrated
E_Permanent uptime	I_Fi_Legal status of digitised assets
E_Privacy	I_Fi_Loss of keys
E_Regulatory compliance	I_Fi_Low transactinon speed
E_SC_ Disintermediation	I_Fi_Network effects
E_SC_Anti-Counterfeit	I_Fi_No leverage
E_SC_Auditability	I_Fi_No trading in unowned assets
E_SC_Decrease missing paperwork	I_Fi_Privacy
E_SC_Ensure integrity of the system	I_Fi_Proof of Concept
E_SC_Improve forecasting	I_Fi_Publically available data
E_SC_Increae resellability	I_Fi_Regulation
E_SC_Increase product safety	I_Fi_Requires specified contracts
E_SC_Increase Security	I_Fi_Resolvability of errors
E_SC_Increase Trust	I_Fi_Risk investment
E_SC_Less Fraud	I_Fi_Risk of first mover
E_SC_Prevent Double Spending of certifications	I_Fi_Scalability
E_SC_Prevent Selling of Fake goods	I_Fi_Security
E_Self Governance	I_Fi_Slow confirmation
E_Transparancy	I_Fi_Standardization
E_Trust	I_Fi_Unkown in C/B
E_Value Creation	I_Gov_Cultural Resistance due to legacy
F_Access Control	I_Gov_Immaturity of ecosystem
F_Adv_Authentication	I_Gov_Privacy
F_Adv_Authorisation	I_Gov_Terminogoly unclear to public
F_Adv_Digitize Assets	I_Gov_User friendliness
F_Adv_Ensure transaction	I_Hacks
F_Adv_Immune to tampering	I_Hea_Data Control
F_Adv_Market Making	I_Hea_Deployment

F_Adv_Recording transactions	I_Hea_Insecurity on promis
F_Adv_Shared Ownership	I_Hea_Lack of expertise
F_Adv_Single Source of Truth	I_Hea_Lock-in effects
F_Adv_Tamper Proof	I_Hea_Security
F_Adv_Transaction Processing	I_Human failure
F_Adv_Validate Identity	I_Hype
F_Adv_Validate transaction	I_Immaturity
F_Adv_Verify ownership	I_Inaccessibility
F_Adv_Verify Transactions	I_Increased computing mining
F_Adv_Voting	I_infrastructure immaturity
F_Asset registration	I_Ins_Cooperation needed
F_Authentication	I_Ins_Current legal framework
F_Authorisation	I_Ins_Regulations
F_Confidential Data Sharing	I_Ins_Scalability
F_Data integrity	I_Ins_Security
F_Digitize Assets	I_Ins_Standardization
F_Digitized assets	I_Job security
F_DocumentTime Stamping	I_Killer App
F_Fi_Asset Tracking	I_Lack of circuit breakers
F_Fi_Audit Trail	I_Lack of standards
F_Fi_Authentication	I_latency
F_Fi_Book entry	I_Mu_adoption
F_Fi_Clearing and Settlement	I_Network effects
F_Fi_Connect counterparties	I_No disintermidiation
F_Fi_CrowdFunding	I_Not Immutable without PoW
F_Fi_Digitized assets	I_Open Data
F_Fi_Dividend Payments	I_Performance
F_Fi_Documentation	I_Permissioning
F_Fi_Enable Trade	I_Pseudonymity
F_Fi_Ensure transaction	I_Regulatory compliance
F_Fi_Escrow	I_Responsibility
F_Fi_Exchange services products	I_SC_Maintaining privacy
F_Fi_Identity services	I_Scalability
F_Fi_Interoperability	I_Security
F_Fi_KYC	I_Security in public open
F_Fi_Ledger Consolidation	I_Societal Change
F_Fi_Machine to Machine	I_solution looking for problem
F_Fi_Market Making	I_Standardization
F_Fi_Peer to Peer lending	I_Storage Limits
F_Fi_Reconcilliation	I_Switching costs
F_Fi_Record keeping	I_Technical solution for political problem
F_Fi_Regulatory Reporting	I_Technocratie

F_Fi_Securities issuance	I_Technological focus
F_Fi_Single Source of Truth	I_Trust in nodes
F_Fi_Standardization	I_Tyranny of the majority
F_Fi_Track spending	I_Unknown regulatory influence
F_Fi_Trade Confirmation	I_User friendliness
F_Fi_Trade Matching	
F_Fi_Transfer ownership	
F_fi_unbundling	
F_Fi_Verify ownership	
F_Fi_Verify Transactions	

11 Appendix 3 Overview of Dimensions in sensitizing concept *Function*

Corporate			
Crowdfunding	Dividend Payments	Remuneration	Coordination
Performance Management			
Explanation of dimension: Blockchains can be used for corporate actions, such as paying dividends, crowdfunding, remuneration for work and performance management.			

Create and Execute immutable rules			
Ensure integrity of system	Code as regulation	Follow rules	
Explanation of dimension: Blockchains create and automatically execute immutable rules in a system. A single source of truth is formed, in which the rules (or code) is law.			

Data			
Confidential Data sharing	Data integrity	KYC	Backup
Control own data	Transfer ownership of data	Validation	Personal data verification
Explanation of dimension: Dimension concerned with all data functions of blockchains, such as KYC, Data backup, data sharing, data validation and control of data.			

Digitize assets			
Digitize assets	Exchange services and products	Peer to peer lending	Peer to Peer
Pay per Use	Link between digital and physical world		
Explanation of dimension: Blockchains can be used to digitize assets. Assets that are usually not digital, or tradeable, become tradeable using blockchains as they combine physical assets with digital assets, with 100% proof. Dimension includes peer to peer trading of physical assets, pay per use etc.			

Governmental Services			
Collect taxes	Deliver benefits	Issue passports	
Explanation of dimension: Properties concerned with all governmental actions that could be performed on the blockchain as benefits (which are controlled to be spend on approved items only), identify services, passports etc.			

Identity services			
Access control	Validate identity	Identity services	Reputation
Explanation of dimension: Blockchain can be used as an identity manager, including reputation systems and the verification of identities.			

Immutable recording of transacted assets			
Authentication	Authorisation	Ensure transaction	Immune to tampering
Recording transaction	Shared ownership	Transaction processing	Validate transaction
Verify transaction	Verify ownership	Asset registration	Time stamping
Asset tracking	Audit trail	Clearing and settlement	Documentation
Escrow	Ensure transaction	Record keeping	Securities issuance
Track spending	Trade confirmation	Transfer ownership	Immutable
Licence management	Ownership history	Prove origin	Track creation
Unambiguously discover state of system	Verify certification	Verify standards	Transaction confirmation
Explanation of dimension: The core dimension of Blockchain functionality. Blockchains are used to create an immutable historical record of transactions which can be used to authenticate ownership of assets, trade assets and track assets. It is tamper proof, time stamped and tracks history of an asset			

Market Making			
Market Making	Connect counterparties	Trade Matching	
Explanation of dimension: Blockchains can be used to connect counter parties in a trade, therefore creating a market. Especially useful in the sense of the current financial market makers.			

Regulatory reporting			
Regulatory reporting	Regulatory requirements		
Explanation of dimension: Due to the openness of blockchains, blockchains are highly suited for regulatory reporting. All necessary information is in one place, already confirmed by all nodes.			

Single source of truth			
Single source of truth			
Explanation of dimension: A core characteristic of blockchain, which means that there is one state the system is currently in that is accepted by all participants. A "single source of truth" is created, without dispute on asset-ownership			

Single source of truth			
Single source of truth			
Explanation of dimension: A core characteristic of blockchain, which means that there is one state the system is currently in that is accepted by all participants. A "single source of truth" is created, without dispute on asset-ownership			

Standardization			
Interoperability	Ledger consolidation	Machine to machine	Standardization
Explanation of dimension: Blockchain present an opportunity to standardize and improve interoperability of back-end systems			

Tokenization			
Tokenization			
Explanation of dimension: Blockchain is often based on cryptocurrencies, or tokens, that could be used as currency for anything. Work-related coins, or voting coins.			

Voting			
Voting			
Explanation of dimension: Blockchains can be used for voting. This can be used in a governmental sense, to improve the auditability and trustworthiness of our current voting system. Voting for the president on the blockchain. However, also voting on actions of a decentralized organization is part of the blockchain functionality			

12 Appendix 4 Overview of Dimensions in sensitizing concept *Effects*

Accuracy			
Data Integrity	Eliminate Errors	Increase Data accuracy	Decrease missing paperwork
Improve forecasting			
Explanation of dimension: Blockchains can increase the accuracy of data within systems. This dimension covers all effects and subsequent effects that are connected to data accuracy. Due to the single source of truth, and constant checking and rechecking of the state of the blockchain data integrity is higher. This in turn can lead to better forecasting, eliminating errors and improving data quality. Proving that (scientific) data is uncorrupted and real in for example health trails is made easier. Finally, accuracy is also connected to automation, as human errors are removed.			

Auditability			
Decrease Fraud	Improve Regulatory Compliance	Increase auditability	Prevent selling of fake goods
Auditability	Replicability	Transparency	Reduce Bribery
Anti-Counterfeit	Increase product safety	Prevent double spending of certificates	
Explanation of dimension: Blockchains can lead to an increase in transparency, which in turn leads to an improved auditability of the system in general. The auditability and oversight of the ledger is improved for all actors; users, regulators and auditors. Through a "single source of truth" there is no longer a debate on the state of the system. In the end, blockchain's auditability is causes a decrease in Fraud. The complete historical auditable database is used to detect fraudulent activity by criminals, but also by regulators to oversee fraud by banks.			

Automation			
Automation	Eliminate Back Office	Eliminate front office	
Explanation of dimension: Blockchain can lead to automation, due to smart contracts execution without the need of a trusted party. This is both between organizations, such as securities trades, as within organisation, such as back-office processes.			

Costs			
Decrease Costs	Decrease Transaction costs	Cost savings	Decrease infrastructure costs
Lower operational costs	Reduce fees	Decrease handling costs	
Explanation of dimension: Blockchain can lead to a decrease in costs on several levels. Financial transaction costs, such as cross-border payments, can decrease due to higher automation, speed, risk, trust. Furthermore, lower operational costs are expected due to disintermediation of supply chains and necessary paper trails. In essence, the reduction of the necessity to trust counterparties significantly reduces transaction costs, and the increase of automation strongly reduces operational costs.			

Disintermediation			
Disintermediation	Independence of continuity	Remove Clearing houses	No central point of failure
No central point of	Remove trusted third	Unbundling	

trust	party		
Explanation of dimension: Blockchain can lead to Disintermediation. This was the fundamental goal of blockchain as presented by Nakamoto. The disintermediation of financial sector through the removal of for example clearing houses, or disintermediation of corporations by removing the middleman in the music industry (like Amazon or Spotify), or even disintermediation of governments is possible. Further effects, such as the independency of one actor on the continuity of the system, or the lack of a central point of trust are also part of this dimension.			

Efficiency			
Real time	Increase simplicity	Increase speed	Faster settlement
Alignment	Eliminate time delay	Faster clearing	Increase efficiency
Increase operational efficiency	Interfaces reduction	Reduce bid/offer spread	Reduce capital requirements
Reduce Collatseral	Reduce Communication needs	Reduce Transaction time	Streamlining of process
Scalability	Increase speed	Reduce administration	Permanent uptime
Explanation of dimension: Blockchains can increase efficiency of systems through several Blockchains can increase the simplicity of systems because of the single source of truth, automation and disintermediation of for example the settlement process. An example of this is simpler international payments. factors such as less interfaces (due to a more standardized system and one information highway), the reduction of capital requirements (because of less risk), the reduction of administrative and regulatory burdens and improved scalability. Blockchains can improve speed in several sectors through the near real-time nature of blockchains (a refresh time of 10 minutes is much faster than the now multiple days for international payments). Automation, and auditability also cause the speed of larger transactions than international payments to improve			

Enable new markets and organizations			
Increase collaboration	New organizational forms	Asset trading	Enable competition
Improve quality	Reduce politicization	Institutional technology	Increase flexibility
Open	Smarter	Increase resell ability of assets	
Explanation of dimension: Blockchain enables the creation of new markets and organizations. This effect is caused by the fact that blockchain enables trade of digital assets (bitcoins, music etc.), digitized assets (any physical object, traded online), and new types of corporations and governments. The creation of new government-type organizations (such as BitNation) creates competition and new markets for governments, which was not possible before the disintermediation of trust by blockchains. Furthermore, the digitization of assets creates new markets for physical objects that could not be securely traded before, like invoices or a "pay as you go" community tractor. Closely related are the new organizational forms, as Decentralized Autonomous Organizations. First, they enable truly other (decentralized) governing strategies for corporations through smart contracts, thereby enabling managementless corporations. This improves collaboration between peers. Following Coase, it can be argued that "friction" reduces within corporations, completely dismissing economies of scale (i.e. size no longer matter, the governance matters).			

Risk			
Delivery versus Payment	Lower Credit Risk	Lower risk deposits and payments	Lower settlement risk
Lower systemic risk	Lower counter party risk	Risk reduction	

Explanation of dimension:
Blockchain can lead to a decrease in Risk, especially in the financial sector. On a transaction level, settlement risk and counterparty risk are the predominant risks that are decreased, as blockchains ensure that the transaction takes place. On a systems level, systemic risk might be reduced due to better regulatory possibilities and the combination of the lower level transaction risks.

Security			
Increase security	System Resilience	Robustness	Privacy
Ensure integrity of the system			

Explanation of dimension:
Blockchains can increase the security of systems and databases. From a high-level risk reduction leads to a more secure system in general. Furthermore, the decentralized, open nature of blockchains increase security as they are harder to attack and hack because of both the multitude of nodes that need to be attacked and the fact that they are open and thus constantly under attack. In a paradoxical way, the fact that blockchains are open and able to be attacked makes them more secure. Finally, the public-private key structure increases the privacy of users, which also increases their security

Trust			
Increase trust	Decentralized model of trust	Credibility	Trustworthy

Explanation of dimension:
Blockchains increase trust between users of the system, and therefore the whole system. Blockchains disintermediate of codify trust in for example the financial sector by assuring that transactions take place. A central theme is "removing proxies for trust" such as rating systems and intermediaries and replacing them with codification of trust. The trustworthiness of both sellers and buyers therefore increase

User empowerment			
Protect against domination	Self-governance	Enable Sharing economy	Fairness increase
Access to financial services	Globalization	Customer engagement	Personalization
Access to capital	Increase control	Lower entry barriers	

Explanation of dimension:
Blockchains can lead an empowerment of the end user. Users can influence the rules of the game, which are transparent, of corporations, institutions and governments. Blockchain further improve access to anything; capital, financial inclusion etc. This is linked with the access to real-world-objects, or a sharing economy. All in all, users are empowered with more control over their situation.

Value Creation			
Value creation			
Explanation of dimension: Blockchains create value through all effects above.			

13 Appendix 5 Overview of Dimensions in sensitizing concept *Issues*

Adoption Strategy			
Adoption	Adoption of Delivery vs Payment	Deployment	Adoption
Explanation of dimension: The adoption strategy for blockchain is important. First, moving to a completely new technological infrastructure presents issues. Second, a good road map is needed to deal with other issues mentioned further.			

Anonymity			
Adding identity	Criminals	Anonymity	Pseudonymity
Explanation of dimension: Anonymity in blockchains present several key issues: First, a push to add formal identity from incumbents, towards a permissioned blockchain, which largely removes the decentralized aspects. Second, because of anonymity criminals use blockchain a lot to transfer funds. This touches upon an important distinction, how transparent is a blockchain? Most regulators probably won't say that bitcoin is easier to regulate than fiat currency			

Automation			
Automation	Fear of automation	Computer vs Human	Job security
Explanation of dimension: Automation of blockchains present several key issues: First, a completely automated system lacks circuit breakers if something goes wrong (combine with decentralized for more problems). Second, can computers take over task for humans like creativity etc.? Finally, and most important, automation threatens job security			

Centralization vs Decentralization			
Centralization efforts	Comparison	Comparison to internet	Encapsulation by incumbents
Centralized ledger	No disintermediation	Permissioning	(Technical) solution looking for (political) problem
Explanation of dimension: Dimension concerned with the comparison with current systems, encapsulation efforts by incumbents and centralized systems. Incumbents threaten blockchain by trying to encapsulate the essence and use it in their centralized world, which removes a lot of the advantages. However, centralization and intermediaries are not always bad, as they present a backup for when things go wrong. The comparison to current systems is also important as there are little implementations that truly need a blockchain implementation to be successful. A trusted third party, that is 100% open about their rules, with guards in place to ensure that those rules are being followed might be as good. And a lot easier. Finally, are we not trying to force a technical solution on a political problem? which usually ends badly			

Corporate and personal privacy			
Privacy	Security	Commercial Sensitivity	Giving up control
Loss of Keys	Publically available data	Hacks	Data Control
Lack of circuit breakers	Open daa	Trust in Nodes	Security in the open
Explanation of dimension: Privacy, both personal as corporate, is at risk in blockchains. They are highly open and therefore it is (if it really is this way or just perceived doesn't matter) hard to ensure privacy. Corporate :The openness of blockchains can be seen as an issue as corporations encounter commercial sensitivity, giving up control etc. Should people be in charge of their own data, and is an open network really more secure than a closed? Second, The security of blockchains is an issue. First, social engineering (phishing etc.) is still as effective as it was without blockchain, and the openness might even pose more of a security threat. Hacks are commonplace, and without a central agency stolen money is lost money			

Costs			
Exploitation Costs	Energy usage	Computing power	Risk investment
Switching costs			
Explanation of dimension: The costs of running a blockchain (especially a PoW) are high due to high energy demands. Furthermore, switching costs to a complete new back-end are also high.			

Customs and Culture			
Cultural resistance	Fear of working together	Behaviour change	Legacy
Faster payments	Fiat Cash movement	No leverage	No trading in unowned assets
Requires specified contracts	Cooperation	Societal change	
Explanation of dimension: Blockchains are in possibility highly disruptive which asks for changes in culture. Cultural change and changing current business standards are therefore expected to run in to resistance. Resistance from people losing jobs, companies having to work together to create a blockchain standard and shared data. Finally, current business customs (contract culture) is often based on paying as late as possible, leverage, trading unowned assets (short selling) and incomplete contracts. All are not possible in blockchain worlds.			

Immaturity			
Lack of awareness	Immaturity	Insecurity on promise	Network effects
Proof of concept	Unknown cost and benefits	Immaturity of ecosystem	Terminology unclear to public
Infrastructure immaturity	Killer app	Hype	Inaccessibility
User friendliness	Lack of expertise		
Explanation of dimension: The blockchain platform is currently very immature. Therefore, all promises are still just that: promises. This comes with insecurity. Second, a lack of expertise is viewed to contribute to this.			

Technical standards are unclear; the end cost benefits are unclear and there is not enough expertise. together with the hype that surrounds this technology..

Immutability			
Data integrity	Resolvability of errors	Not immutable without PoW	
Explanation of dimension: Immutability is one of the cornerstones of blockchain. However, sometimes this is an issue. First, garbage in, garbage out. The ingoing data MUST be correct, otherwise (through automation) bad stuff can happen. Second, accidental errors cannot be resolved easily (resolvability of errors)			

Institutional framework			
Current legal framework	Regulations	Current regulations	Digitized assets regulation
Digitized assets vs real life assets	Responsibility	Unknown influence of regulators	
Explanation of dimension: The legal framework concerning blockchain is immature at best. Cryptocurrencies are starting to become legally clear, but all innovations surround blockchains not defined by legal terms at all. Who is responsible for the actions of a DAO? What is the legal status of a digitized asset?.			

Integration			
Combination with real life systems	Integration with current technical systems	Interoperability	Lock-in effects
Explanation of dimension: Integrating blockchains into current, existing ledgers, physical systems and technical systems is highly complicated. This can be combined with a lock in effect, which makes implementing blockchain harder.			

Performance			
Capacity	Block capacity	Low transaction speed	Scalability
Slow confirmation	Latency	Performance	Storage limits
Explanation of dimension: The performance of blockchains is currently sub-par when compared to standard database systems. They have little capacity and can only handle a handful of transactions per second. This is closely connected to the speed of a blockchain, the speed of calculations is low, transaction speeds are not great, performance issues and storage limits. Finally, scalability is low, which makes systems hard to implement in real world systems.			

Standardization			
Standardization	Lack of standards		
Explanation of dimension: Standardization of blockchains is highly important, currently there are multiple competing standards which hampers innovation. Currently it is messy, with multiple standards that have a hard time communicating. Compare this to multiple competing internets.			

Technocracy			
Governance	Code errors	Community discussion	Human failure
Inaccessibility	Technocracy	Technological focus	Tyranny of the majority
Explanation of dimension: Blockchains are currently highly technocratic. Both the community itself is an issue and the technocratic "code is law" nature of blockchains. First, the community is currently a technocracy. Updates by the "Ethereum foundation" (the foundation behind the invention of Ethereum) are almost always accepted. Is this really decentralized or are the technocrats making the rules? Furthermore, in the current phase the community itself is unsure on how to respond to events. This leads to discussions and a split user base. This is strengthened by the inability of "normal" humans (non-geeks) to fully understand and use blockchain currently. Second, Code is law is an often-heard statement in blockchain communities. However, if there are coding errors, the law is broken and funds can be stolen. Furthermore, even correctly programmed security measures (like multi-sigs) can be used incorrectly, which leaves huge security risks.			

14 Appendix 5 Research criteria

The following criteria were presented in chapter three and are the basic criteria for Straussian Grounded Theory, as presented by Corbin and Strauss (1990, pp. 17,18). [10]

Research process criteria

- *"Criterion 1:* How was the original sample selected? On what grounds (selective sampling)?"

Covered by Section 3.4.1, Gathering data for Grounded Theory approach.
The first sources were mostly corporate reports as they presented a holistic overview of blockchain technology. After this, theoretical sampling was used to first select start-up sources as whitepapers or website pages, and then journalism to present a more balanced overview.

- *"Criterion #2:* What major categories [in this research dimensions] emerged?"

Covered by Section 4.2, Axial Coding
The dimensions emerged during the axial coding phase, are presented in (amongst others) Table 7.1, Table 7.2 and Table 7.3.

- *"Criterion #3.* What were some of the events, incidents, actions, and so on that indicated some of these major categories?"

Covered by Section 4.1, Open coding
The emergence of our properties was the main indication for the emergence of our categories and dimensions. Furthermore, we used the frequency of these properties, and the structure of the data as indicators for major categories. Properties with more theoretical saturation were deemed more important and served s a guideline for the emerging dimensions and categories. The structure of the data provided us with insights how practitioners were structuring the discussion. Often, reports were centered around "value" and "implementation issues" of blockchain technology. We used this as in indicator to form the dimensions and categories.

- *"Criterion #4.* On the basis of what categories did theoretical sampling proceed? That is, how did theoretical formulations guide some of the data collection? After the theoretical sample was carried out, how representative did these categories prove to be?"

Covered by section 4.1.1, Theoretical Sampling
The empirical data was found primarily using *Google* with the keywords: Blockchain, Distributed Ledger Technology, Report, Use case, Effects, Issues, Functions. The combination of these search results, and the process of theoretical sampling, provided a long list of 73 articles. A final list of 56 relevant articles was created based on this long list and the following set of criteria:

- Only articles that followed the definition of blockchain technology, as presented in section 2.6 and 2.7, were used in the shortlist.
- Articles with explanations and in-depth overviews were preferred over short, summarizing articles that provided little more insights than a list of consequences of implementing blockchain technology.
- Highly technical whitepapers were omitted, as they present little to no data on the expected effects, issues ore functions of the implementation.

The first sources were mostly corporate reports as they presented a holistic overview of blockchain technology. After this, theoretical sampling was used to first select start-up sources as whitepapers or website pages, and then journalism to present a more balanced overview. We tested for theoretical saturation to verify our theoretical sampling.

[10] All 14 criteria used in this section are from Corbin and Strauss (1990, pp. 17,18), but are only referred here to improve readability.

Finally, our literature for the literature comparison was found using Scholar. We first looked for a complete review of the literature on Trust to gain more grounding. We found this in the review by (Seppänen et al., 2007). In this overview, Nooteboom's conceptualization of trust is highly important. As it immediately provided us with more insights, we further used this conceptualization. Then, due to the apparent importance of Control, we found the article by (Bonabeau, 2005) that combined both Control and Decentralized decision making.

- *"Criterion #5:* What were some of the hypotheses pertaining to relations among categories? On what grounds were they formulated and tested?"

Covered by Chapter 5, Selective Coding

Three major categories emerged:

- Value of the disintermediation of trust
- Technological and institutional uncertainties
- Contrasting perceptions

These categories were constantly compared and tested against the data in this research. They were formulated through a comparison of the dimensions found in the axial coding.

- *"Criterion #6:* Were there instances when hypotheses did not hold up against what was actually seen? How were the discrepancies accounted for? How did they affect the hypotheses?"

Not specifically mentioned in this report

Our main hypotheses of empirical categories (the framework presented in Figure 5.7) are solely based on the data used in this research. External data (literature) was not used until these empirical hypotheses were set in stone, after the selective coding phase. Therefore, there are little to no instances of hypotheses which did not hold up to this data. The emergence of our core category did take time and went through multiple iterations, which are mentioned in criterion 7.

- *"Criterion #7:* How and why was the core category selected? Was the selection sudden or gradual, difficult or easy? On what grounds were the final analytic decisions made? How did extensive "explanatory power" in relation to the phenomena under study and "relevance" as discussed earlier figure in the decisions?"

Covered by Chapter 5, Selective Coding

Our core category then emerged as:

- *Power transfer in environments with highly institutionalized values*

Our core category was iteratively. First, our core category was defined as the core of our descriptive framework: actors deciding under high technological and institutional uncertainty on contrasting perceptions and the value of the disintermediation of trust. However, this provided little to no explanatory power. We therefore theorized further, and the notion of *Technology Replacing Trust emerged.* This concept was not covered in this report, as a discussion within this committee showed that this was not the case in blockchain technology. This argumentation is used in chapter 6 when comparing trust arrangements to blockchains. Therefore, it provided us with insights that although the current data *suggests* that blockchains are a trust replacement, this cannot be the case from a theoretical perspective. It was therefore invaluable to creating our final core category: *Power transfer in environments with highly institutionalized values.*

Empirical grounding of findings criteria

- *"Criterion #1:* Are concepts generated?"

Covered by Section 4.1 and 4.2, Open and Axial Coding and chapter 5, Selective coding

Concepts were generated throughout this research. Special care was taken to freeze each phase before going into the next research phase, thereby ensuring that our concepts were grounded in empirical data.

- *"Criterion #2:* Are the concepts systematically related?"

Covered in Chapter 5, Selective Coding.
Concepts are systematically related through the framework presented in chapter 5.

- *"Criterion #3:* Are there many conceptual linkages and are the categories well developed? Do the categories have conceptual density?"

Covered by Chapter 5, Selective Coding
The categories are developed in chapter five. These categories are all strongly based on the dimensions found in axial coding, all dimensions are used in this model and the categories all have dense conceptual linkages into data.

- *"Criterion #4:* Is there much variation built into the theory?"

Covered by Chapter 6, literature comparison and chapter 5, Selective coding
Our selective coding and literature comparison shows that the categories that are developed are theoretically dense, and varied. Different perceptions can be found in the categories, which can be compared to a large variety of scientific fields (i.e. Innovation, Trust and Decision making).

- *"Criterion #5:* Are the broader conditions that affect the phenomenon under study built into its explanation?"

Covered by Chapter 6, Literature comparison
Our literature comparisons strengthen our core concept by including notions from other literature into this core category. We used Trust literature by Nooteboom to conceptualize Trust as Reliance, Trust and Control. We also used Decentralized Decision Making to further develop Control in blockchain environments.

- *"Criterion #6:* Has "process" been taken into account?"

Not specifically mentioned in this report
Process has been taken into account in several ways. First, our focus in chapter 3 to present a good research design (as defined by (Wester, 2005)). Second, our decision to strictly follow the Straussian Grounded theory approach. Third, our decision to freeze research phases before continuing to the next research phase.

- *"Criterion #7:* Do the theoretical findings seem significant and to what extent?"

Covered in Chapter 6, Literature comparison and Chapter 7 Conclusions
Our theoretical findings seem significant, as they represent a new view on blockchain technology: A Power transfer in environments with highly institutionalized values. Furthermore, in our analysis using literature comparisons, this core category provided us with high explanatory power of the discussions on the perceived issues and consequences of blockchain applications. Finally, our notion that blockchains are more connected to Control than Trust is extremely important in blockchain literature, as it further structures the debate on blockchain implementation.