MASTER

Blockchain : a decision-making guide on use cases
a study into the factors underlying this technology, aimed at the insurance branch

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Blockchain: A decision-making guide on use cases

A study into the factors underlying this technology, aimed at the insurance branch

by

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Abstract

When a new technology rises, numerous expectations can rise around its potential. Blockchain has become one of the major promises for the future and there has been an increasing amount of research conducted in this area. Now, we are passing the peak of expectations; therefore, we finally arrive at seeing the technology for what it is worth and look for use cases. Blockchain can become a gamechanger in the business processes for numerous sectors. For this research, it is applied to the insurance branch and this study investigates the factors that contribute to the decision-making on good use case. By developing an expert system that includes all relevant factors, an objective analysis of use cases is possible to help guide this decision. Two main frameworks are used to build the expert system. Blockchain is investigated by using the BOAT-model by Grefen which explores the factors concerning its technology, business and architecture domains. The Technology Acceptance Model by Davis et al. is the academic foundation on which the technology is analysed. Together, these models provide an advice concerning the selection of a Blockchain use case. Furthermore, the expert system shows the strength of the use case on three established business domains, being: consolidation, flow transactions and single source of truth. Besides this, it provides an advice on the preferred Blockchain platform including Bitcoin, Ethereum and Ripple. These advices together help an organisation to select its best use case in this current phase of use case exploration.

Executive summary

This executive summary comprises the entire research in three pages. It consists of the parts introduction, research approach, results, and conclusions and recommendations.

Introduction

Blockchain is a new and exciting technology. Its potential differs, depending on one's perspective. It differs from a logical next phase in automation to a new radical foundational technology that could change the very nature of our economic, social, and political system. However, going back to its core characteristics, it can be regarded as a Distributed Ledger Technology. What makes it unique, is a smart combination of cryptography, a consensus mechanism and smart contracts that creates a new range of functionalities and establishes a peer-to-peer network, implying direct interaction between participants. An important facet is the addition of smart contracts. Smart contracts are computer scripts that can automate certain transactions and provide them with conditions on which they are triggered. an interesting possibility for Blockchain because these computer scripts can automate certain transactions and provide them with conditions on which they are triggered. In general, Blockchain is a tool that can either be used by the sector to help create transparency and efficiency or it could be a tool that disrupts its entire existence.

According to Gartner, the hype has surpassed its peak and according to McKinsey, the phase of use case exploration has just begun. The company involved, CGI, has a desire to create an artefact that can help CGI guide their clients, in the insurance branch, in their decision on which use case, possible application, to select. Artefact is a term in the literature of Information Systems and it implies a solution. To establish an objective analysis and to create a deeper understanding of the technology, an intelligent tool must be developed. The design problem in the format of Wieringa has been drawn after consultation with the relevant stakeholders:

'Improve the decision-making on Blockchain use cases for the insurance branch by developing an intelligent tool such that it can provide an objective analysis of possible use cases to help understand the factors underlying the appropriateness of Blockchain and to help guide clients of CGI in starting a Blockchain project'

From this design problem, the research questions are derived that form the basis of this report:

RQ-I What are the factors that determine the appropriateness of a Blockchain use case?

- RQ-I.I What are the factors underlying the Blockchain technology?
- RQ-I.II What are the factors that determine appropriateness of a new technology like Blockchain?

RQ-II What are the relations between the factors that determine the appropriateness of a Blockchain use case?

Research Approach

To guide this research to be a successful one, the framework by Wieringa is used to distinguish the iterations in their according phase. These phases are problem investigation, artefact design and artefact validation. Furthermore, each iteration is elaborated upon using the Information Systems Research Framework of Wieringa.

Figure 3.1 represents the Information Systems Research Framework applied to the research plan. To acquire academic knowledge, a structured literature research is performed in the field of Blockchain.

A semi-structured literature research is performed in the field of prototyping, Design Science Cycle, Technology Acceptance Model, expert systems and questionnaires. Also, two academic courses are followed at the University of Berkeley and the University of Princeton, respectively: 'Blockchain at Berkeley' and 'Bitcoin and Cryptocurrency Technologies'. To acquire business needs, 20 interviews are performed, 117 use cases are analysed, a focus group is held and 17 experts participated in the expert analysis. To verify and validate the produced artefact, anomalies are checked and validation is performed through the method of case testing.

Results

The results led to an expert system as an intelligent tool, which helps resolve the design problem and the research questions. The expert system is a model that objectively assesses a Blockchain use case through its researched factors and their relations. The first research question deals with the factors that contribute to the appropriateness of a Blockchain use case. As a basis for the factors underlying the technology, the BOAT-model is used. This framework explains the characteristics of a technology-push by specifying its characteristics related to the Business, Organisation, Architecture and Technology domain. The organisation domain is not included in this research. The scope had to be narrowed down and the other domains are prioritised in the given situation.

Through a systematic literature review on Blockchain, the main constructs of the technology, business and architecture domain are discovered. Trust for the technology domain, efficiency for the business domain and openness & generation for the architecture domain. For trust, the main components entails trustworthiness and immutability. For openness, it comprises public permissionless, public permissioned and private permissioned, which can be seen as different types of Blockchain. For generation, it includes only Blockchain 1.0 and Blockchain 2.0 where the main difference is the addition of smart contracts in the case of Blockchain 2.0. Through a document analysis on 117 use cases, the components underlying efficiency are established which are clustered into consolidation, flow transactions and single source of truth. Together, these form the basis of the Blockchain characteristics on which the use case is assessed.

The other important framework is the Technology Acceptance Model, also known as TAM. It uses two variables, perceived usefulness and perceived ease-of-use, to measure the user's attitude toward using a new computer technology. Both its robustness and its parsimony create a strong added value to relate to the BOAT-framework. Not only are these relations examined and is the result shown in a 2D classification scheme, also two other advices are established. First, the effect of a use case on the three different efficiency components are shown as a strength in a 3D business cluster. Secondly, a platform advice is provided such that the IT department receives proper input to start working on a specific use case with the advised platform. The input of the expert system is generated through a questionnaire filled in by the business department. In this way, both the business and the IT department can work better together through an automated advice on both the use cases, its strengths and its platform on which it should be build.

Conclusions and recommendations

In this research, an expert system is presented to help analyse Blockchain use cases. First, the relations between the constructs of Blockchain and the TAM are examined. Secondly, the relations between the constructs of Blockchain and the platform are established to provide technological advice. Thirdly, a relation between the constructs of Blockchain and the business clustering strength established to provide business advice.

The constructs of Blockchain are trust, efficiency, openness and generation. The first shows a positive relation with perceived usefulness and no relation with perceived ease-of-use. The second shows a rather positive relation with perceived usefulness and a balanced relation with perceived ease-of-use depending on its components. Openness is rather negatively related to perceived usefulness and rather positively related to perceived ease-of-use. Generation is rather positively related to perceived usefulness and has a balanced relation with perceived ease-of-use depending on its components.

The relation between the constructs of Blockchain and the platform construct is established. The combination of the constructs of the architecture domain provides scenarios that lead to a certain component of the platform construct, which can be Bitcoin, Ethereum or Ripple. Furthermore, the relation between the efficiency construct and the business clustering strength construct is established, which provides a deeper insight in the selected use case. This is a 1:1 direct relation between the components of the efficiency construct and the business clustering strength construct.

The expert system has also been verified and validated. The verification phase showed one anomaly which has been put in place deliberately and fulfils a different function. The validation phase seemed to show significant results on the output of the TAM. The expert system is therefore useable and applicable to solve the given design problem.

As a reflection, the frameworks used to guide this project are deemed to be vital to its success. The business needs are thoroughly explored and only the balancing of consultancy & insurance and IT & business could be enhanced. Important recommendations are made to a structured literature research on Distributed Ledger Technology and the TAM & comparable models. Other remarks concern the validation phase which is only a first test of the expert system and should be tested more thoroughly.

Also, there are limitations concerning internal validity like the validation phase, the statistical analysis upon the 117 use cases and the fact that only one researcher has overseen this project. A limitation concerning external validity is, for instance, that the use of the insurance-specific correction factors could not always be applied due to the number of participants in some data collection measures. Other limitations concern the infantile expert system, the inclusion of only three platforms in the platform advice, the use of TAM rather than TAM2 or TAM3 and the scope at the Western society excluding the organisation domain. These limitations not only exist because no previous version of the expert system exists and this version should be tested more thoroughly but also due to design choices made in the artefact that limit its possibilities.

Furthermore, a short recommendation to CGI is given. It is advised that the framework behind the expert system is discussed in a structural manner such that it can be extended and evaluated. The expert system should be used in preliminary conversations with clients and could be put online to attract the clients' interests. Experts, working horizontally across departments, should keep track of the developments of Blockchain and other technologies. Also, three insurance use cases are analysed and added in appendix G.

Finally, some implications for future research have been made. The maturity of the expert system should be improved. This should be done by including the organisation domain, further research into the underlying factors of the components, performing a structured literature research in the fields of Distributed Ledger Technologies and the TAM & comparable models. Also, the validation phase of the artefact should be extended as said before. Besides, to improve this first blueprint of an expert system, a technological substitution list could be built. This could help decide whether to use Blockchain or another technological solution to a given problem.

Preface

Cryptocurrencies, Bitcoin, Ethereum, Blockchain, these are all buzzwords originating from 2009 and, according to Gartner, at its peak in 2017. From Larry Summers to Al Gore, from Vladimir Putin to Elon Musk, all these people are already impressed by its potential and believe in the future of this technology. With all this buzz, it is hard to take a step back and evaluate what it is we have at hand. But if you allow yourself to do that, not only will you see its true potential but then together we can even start working on a connected future where privacy and data ownership is a civil right yet again.

Taking a step back is also what this preface is about. I started in 2010 at the University of Technology Eindhoven with my Bachelor Industrial Engineering and stepped into a rollercoaster ride called student life. The Master Innovation Management, that I started in 2015, unfolded a new chapter where new challenges arose from master's courses, the time abroad in Canada and finally this report as the concluding crown jewel. Uncertain about what would follow, I chose the path towards the research of a new technology. This adventure could not be done alone and therefore I would like to thank the support I received throughout this journey.

First, I want to thank Maryam Razavian and Paul Grefen. Maryam, my mentor, helped me decide which courses to follow, supported my choices abroad and introduced me to this opportunity concerning Blockchain. The first couple of months, she was my guide in the difficult start of a master thesis. Also, many thanks to Paul Grefen who stepped in as a second supervisor but took the responsibility of guiding me as a first supervisor when Maryam had to withdraw from the project. Our discussions really helped me deliver an academic piece rather than an industrial tool and I am very grateful for this input. Secondly, I want to thank Tom van Dijk and Mario in den Haak. Tom was my direct supervisor and has been my guide in the company. We had numerous fruitful discussions with different perspectives but most of all a thorough drive towards exploring this technology. I want to thank Mario in den Haak for his kind support of this thesis. I enjoyed our conversation and I felt motivated for following my instinct that led to a successful project.

Finally, I would like to thank the people who supported me throughout the entire ride. Let me start with my parents. Thanks for the never-ending support to drive ambition when it is necessary and understand the choices when it is needed. Many thanks to my two brothers of whom both share a sincere interest in my project, my study and my life. Furthermore, I would want to thank the people that made this journey awesome. A student life cannot only be lived inside the Paviljoen or Flux, but it should be celebrated with experiences and challenges off the beaten path. Therefore, many thanks to the batteraven, Oktopus, SSRE, AB '14-'15 and, most importantly, Pegasus!

Jelle van de Wall

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1. Introduction

This chapter introduces the subject of the research together with the company involved, which are respectively Blockchain and CGI. Furthermore, some problem context is given to conclude with the determination of the design problem.

1.1 Blockchain

To explore the possibilities Blockchain could offer, first an elaboration of Blockchain is provided. It starts with the explanation of Blockchain as a Distributed Ledger Technology and afterwards explains some technical features that makes it a unique Distributed Ledger Technology. Since this research is aimed at the insurance branch, a short link is established.

1.1.1 Distributed Ledger Technology

Blockchain is a ledger, also sometimes referred to as a(n) (asset) database (Yli-Huumo et al., 2016). The most common use of a ledger is for accounting. However, to keep track of information rather than money can be even more interesting to organisations nowadays. In general, the name arises from the fact that blocks contain several transactions which are added on the chain (Witte, 2016). A transaction consists of data transferred from A to B. This data can be anything like an amount of cryptocurrency, some information, a document or a reference to an asset. A cryptocurrency is a specific currency that is only digitally in possession. This entire chain of blocks of transactions is the ledger. Blockchain is merely the next push in the historic shift from paper to bytes in this phase of digitisation.

The ledger called Blockchain is distributed. A distributed ledger refers to a ledger that is shared with all the participants in the network (UK Government Chief Scientific Adviser, 2016). Thus, every participant that is included in the network from clients to departments to businesses is in possession of the complete ledger. More specifically, all the participants in the network receive an own identical copy of the ledger where changes will be updated to everyone instantaneously (UK Government Chief Scientific Adviser, 2016).

1.1.2 Unique characteristic

Blockchain is just another Distributed Ledger Technology but what makes it unique, is that it can operate on a peer-to-peer base. A peer-to-peer network requires that all participants share a part of their hardware resources like processing power and all have direct access to the shared content, which is the ledger in this case, without passing intermediary entities (Schollmeier, 2001). To enable such a peer-to-peer network, Blockchain uses an intelligent combination of (existing) technologies like cryptography, consensus protocol and smart contracts. Appendix H provides a more in-depth analysis of these characteristics and figure 1.1 on the next page provides an overview of the process.

1.1.3 Insurance

This research is aimed at the insurance branch; therefore, it is relevant to establish the most important link between the insurance and Blockchain. A highly relevant characteristic for the insurance branch, is the possibility of creating smart contracts. Appendix H provides a more in-depth explanation of this topic. In general, these are computer scripts that can be applied to any given data exchange. The easiest way to understand what this means, is to think about IF-THEN-ELSE logic carrying a condition that can be applied to a transaction. This implies that conditions can be applied to data exchanges, which can be a monetary transaction but also all other forms of data transactions.

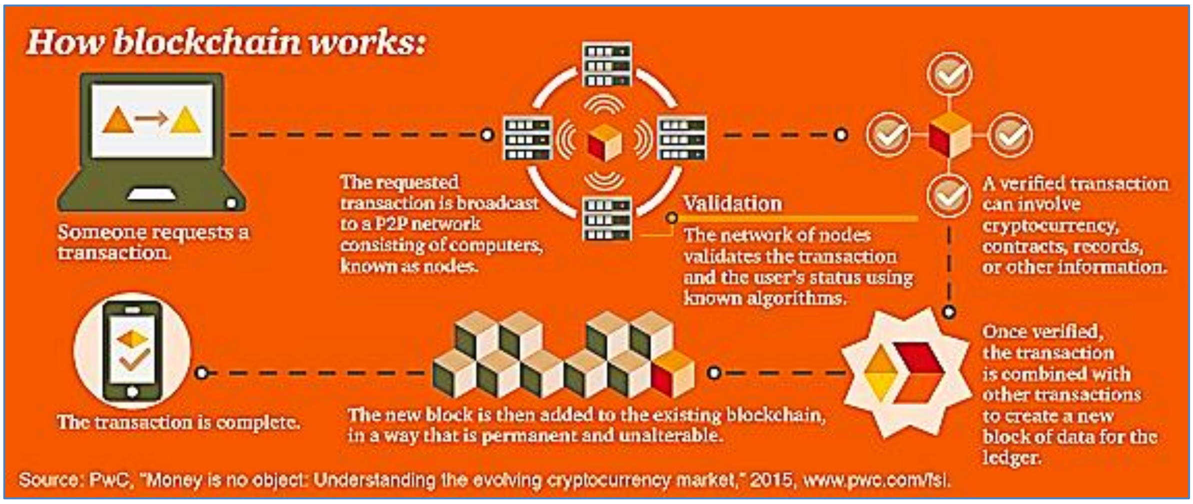

Figure 1.1: Blockchain as a process

To better understand this characteristic, some examples are given. If a certain transaction should only proceed after a certain period or at a certain interval, it is possible to automate that transaction and make it into a smart contract. More interesting, if one or more specific persons should digitally sign a transaction before it can be sent, it is possible to automate it. Imagine that a damage assessor and a mechanic must digitally sign a transaction to successfully pay out a certain claim, it will create a reliable transaction where the appropriate parties have agreed upon and this transaction will be put into Blockchain so that everyone can see that all parties have agreed upon the pay-out. There can also be set boundaries through smart contracts. Imagine a certain entity wants to claim a certain amount that is relatively high, the transaction does not have to be signed by only the damage assessor and the mechanic, but also by the manager to successfully complete the transaction. Create enough smart contracts that can automate certain transactions under established conditions and it is possible to create a peer-to-peer insurance environment in which the insurance company only provides the conditions and the participants share a peer-to-peer insurance environment.

The other characteristics that make Blockchain unique, which are discussed in appendix H, provides Blockchain with an immutability component. This means that it is not only possible to automate certain processes and put smart contracts on top of it, but it also provides an audit log that cannot be tampered with and includes the entire history of the transactions.

To give an example, a use case for Blockchain could be for claims handling (Mianelli & Manson, 2016). When a claim is made on a policy, there are several underwriters that are involved in the processing of it. Some underwriters may wish to be involved to monitor and review the process. Other underwriters can accept the process without actively participating in it through smart contracts. This could reduce the cost of administration, lower the amount of errors in the database and automate certain processes to achieve efficiency.

1.2 Company involvement

First some general information about the company, which is CGI, is described, followed by a customer research they performed last year, concluded with their roadmap based on those findings. The latter two are discussed linked to the investigated technology, Blockchain.

1.2.1 CGI Group

CGI Group, hereafter called CGI, is a Canadian multinational. It actively participates in the IT consulting with nearly 70.000 employees worldwide. Its vision is 'to be a global world class information technology and business process services leader helping our clients succeed' (CGI, 2017).

'In 2016, as part of our annual Voice of Our Clients program, CGI met face-to-face with more than 1000 business and IT leaders across ten industries and twenty countries to hear their perspectives on the trends impacting their organisations and the implications these trends have on their businesses' (CGI, 2016). Figure A.1 represents the top 5 global industry trends according to this research and figure A.2 shows the global business and IT priorities. As figure A.1 shows, the demands of customer are increasing in terms of new business models and digitalisation. They are becoming increasingly interested in collaboration to be able to use each other's expertise to make them both more competitive as figure A.2 shows. To successfully come to an age of collaboration within an ecosystem, there is a need of trust to achieve it. This trust can be generated using Blockchain. Also, other characteristics mentioned like real-time, end-to-end digital processing or enhancing the security through the decentralised structure perfectly fit in the possibilities Blockchain offers. Therefore, it is safe to say that this new technology has great potential not only in terms of its own characteristics but also in its link to global trends and priorities, according to last year's Voice of Our Clients of CGI.

A roadmap is established for the period until 2021 which can be found in figure A.3. Beside the fact that cybersecurity and insights are two important facets which can be linked to Blockchain, the most important contributing facet is the possibility to create an integrated ecosystem of partners through Blockchain.

1.2.2 Stakeholder goal

As a new technology emerges, a global IT partner should provide its clients with guidance and knowledge in terms of dealing with this new technology. Its desire is to create an artefact that can help it guide their clients of the insurance branch in their decision which use case for Blockchain is the most appropriate. To create this guidance, the artefact should help the stakeholder to understand the factors influencing the appropriateness of a Blockchain use case.

An artefact is a term used in academic literature of Information Systems and it regards a solution. The insurance branch wants to explore this technology from a technology-push perspective but needs guidance for selecting use cases. A use case is a possible application for a technology, not to be confused with a business case. This artefact could also help it understand the underlying factors contributing to the appropriateness of a Blockchain use case. Furthermore, it asks for expert knowledge which can be objectively applied to this specific challenge.

1.3 Problem context

In this section, the problem context is provided. The current situation of the technology is described together with its path in the near-future. The context helps clarifying what the stakeholder should do with Blockchain now and establishes the link between the artefact and the problem context.

1.3.1 Hype

As Blockchain rose throughout the years, more and more companies within the financial industry have been investigating this new technology. According to Gartner's Hype Cycle, the hype was just over its peak in the year 2017 as indicated in figure 1.2, implying that the expectations are already going downwards from its maximum and Blockchain almost enters its trough of disillusionment. At the time of the systematic literature review on Blockchain, which is further discussed in Chapter 2, the increase in scientific literature has a comparable curve as the increase of expectations on the Gartner Hype Cycle of 2016 as to be seen in figure A.4. The World Economic Forum argues that in 2027, 10% of global gross domestic product will be stored on this new technology (Global Agenda Council on the Future of Software & Society, 2015). It is important to realise its hype to objectively assess its potential.

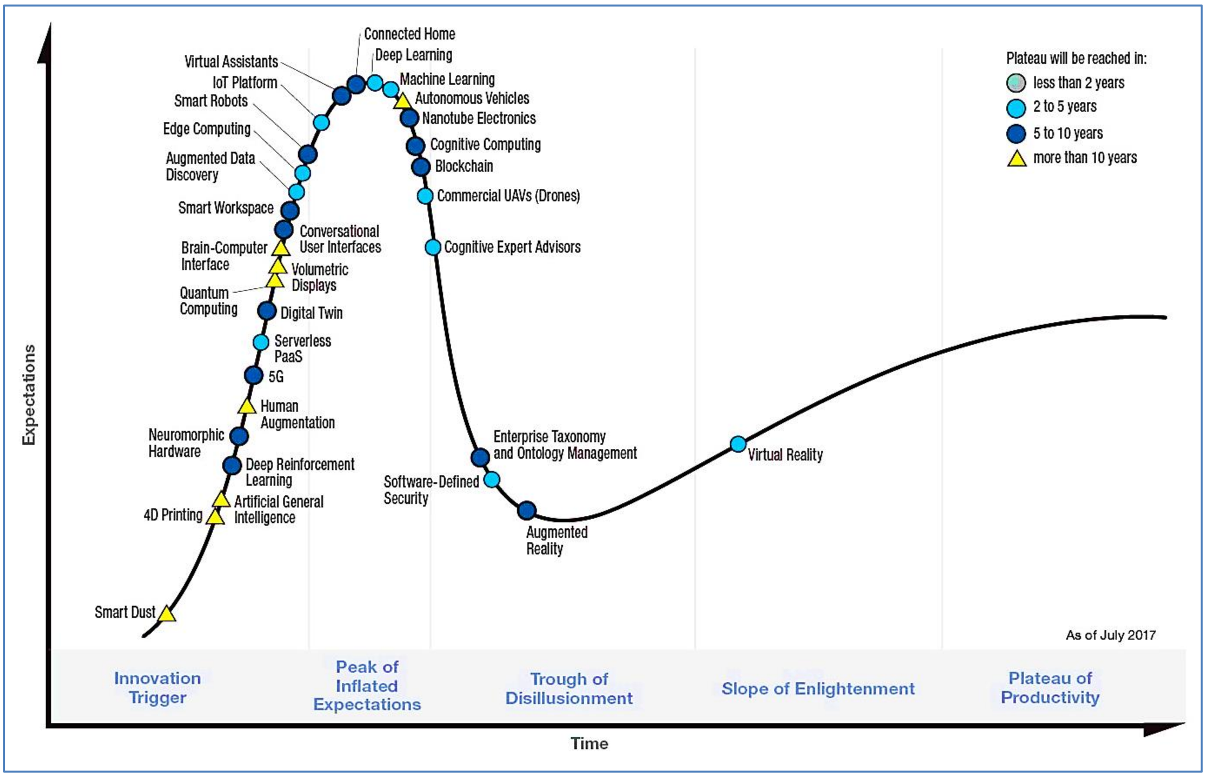

Figure 1.2: Gartner Hype Cycle of Emerging Technologies, 2017 (Panetta, 2017)

1.3.2 Long-term vision

McKinsey published a report of their quarterly meeting of the Federal Advisory Committee on Insurance called Blockchain Technology in the Insurance Sector (Federal Advisory Committee on Insurance, 2017). In this report, they produced a specific roadmap over time for Blockchain. Figure A.5 graphically provides an overview of the steps. It started with the Bitcoin age in 2009 in which only Bitcoin-based solutions have been developed. As discussed before, in 2013 the first peak at Blockchain-based solutions arose through by Vitalik Buterin but the platform only launched halfway 2015. After the hype, the current phase of use case exploration is now entered.

This vision emphasises the need to explore use cases in this current phase and it contributes to the given problem that it is unclear what an organisation should do with Blockchain now. This is exploring possible use cases, the designed artefact, and taking the current hype into account. Thus, to help the decision-making concerning selecting best possible Blockchain use cases, the artefact should provide guidance.

An important side note must be made. This vision is well-considered and provides an interesting perspective concerning future possibilities. However, it is not yet scientifically proven and is a tool for discussion.

1.4 Design problem

The formats derived from the article of Wieringa are used in this section to help establish the design problem and its associated research questions (Wieringa, 2014). Table 1.1 represents an overview of the design problem. For the design problem, four parts are needed, which are the problem context, the (re)designed artefact, the artefact requirements and the stakeholder goals.

Design problem	
Problem context	The decision-making concerning selecting best possible Blockchain use case, specifically aimed at the insurance sector, needs guidance
(Re)designed artefact	An intelligent tool
Artefact requirements	It should provide an objective analysis
Stakeholder goals	It should help understand the factors influencing the appropriateness of a Blockchain use case and the tool should guide clients of CGI to start with Blockchain

Table 1.1: Design problem

The design problem can therefore be written, in the format of Wieringa, as:

'Improve the decision-making on Blockchain use cases for the insurance branch by developing an intelligent tool such that it can provide an objective analysis of possible use cases to help understand the factors underlying the appropriateness of Blockchain and to help guide clients of CGI in starting a Blockchain project'

The research questions derived from this design problem are associated with the development of the designed artefact. The intelligent tool is an expert system, chosen after the interviews in which more than half the respondents deemed it to be very useful. Together with the academic stakeholders, the choice is made for an expert system. It fulfils the requirements of the industry stakeholders and the interviewees, while maintaining the feasibility aspects in terms of time and knowledge resources. From here on, the tool is addressed as an expert system. The basic idea behind expert systems is simply that expertise, which is the vast body of task-specific knowledge, is transferred from a human to a computer (Liao, 2005). An expert system consists of a knowledge base and an inference engine (Hendriks & Vriens, 1999). The knowledge base consists of relevant factors and the inference engine describes the relations between the factors influencing the appropriateness of a Blockchain use case.

RQ-I What are the factors that determine the appropriateness of a Blockchain use case?

- RQ-I.I What are the factors underlying the Blockchain technology?
- RQ-I.II What are the factors that determine appropriateness of a new technology like Blockchain?

RQ-II What are the relations between the factors that determine the appropriateness of a Blockchain use case?

1.5 Summary

This chapter introduced the concept of Blockchain. Some unique features are discussed as well as the link to the insurance branch, which is the aimed sector of this research. The involved company is introduced together with its link to Blockchain. After providing some context surrounding this technology, all the information was at hand to establish the design problem and its research questions. The next chapter describes the structured literature review on Blockchain.

2. State of the Art, Blockchain

In the preliminary phase of the research where the phase of problem discovery is entered, there is a need to summarise all existing academic information about Blockchain in a thorough and unbiased manner. By doing so, it provides a solid foundation for the rest of the research. To achieve this objective, it is suggested that a systematic literature review can fulfil this need and let the researcher draw more general conclusions about a certain phenomenon and it may be undertaken as a prelude to further research activities (Kitchenham & Charters, 2007).

In this chapter, the goals together with the theoretical framework are discussed. Only the findings relevant for this research are provided. Additional information concerning the study design, the analysis of the primary studies, several other frameworks, more in-depth knowledge and the discussion about the findings can be found in the complete systematic literature review (Van de Wall & Razavian, 2017). An important remark before reading this chapter, is that Blockchain in academic literature suggests a specific type of Blockchain which is the public permissionless type of Blockchain like Bitcoin. This is further explained in section 2.2.4.1.

2.1 Theoretical framework

When examining a technology, the focus cannot only be on technological aspects but it is argued that domains like business and organisation need to be included (Hoogervorst, 2004). Integration of the different domains is one of the most important aspects to successfully implement a new technology (Galliers & Baets, 1998; Kanter, 2001). The BOAT framework is chosen to help investigate interesting domains (Grefen, 2015). This framework assesses a technology through different domains that are Business, Organisation, Architecture and Technology, BOAT. This helps clarify different perspectives towards the technology and prioritises the domains in an early stage. This choice is made not only to analyse the characteristics of Blockchain in a structured manner but also to prioritise those domains and search for logical research gaps.

Blockchain is a technology-push, leading to market that seeks business opportunities linked to this technology. The launch of this technology is performed by Nakamoto, the writer of the first article about Bitcoin (Nakamoto, 2008). Since it is a technology-push, the technology-triggered perspective of the BOAT framework is applicable and can be found in figure B.1. The focus to business characteristics is the following step in understanding the *why* side of the aspects of an e-business. Since the architectural domain influences all other three domains, it is chosen to also highlight the most important architectural elements. The scope is narrowed down by not including the organisation domain. It is assumed that at this moment, the technological, business and architectural domain are the most important and that the organisation domain is an important recommendation for future research.

The main research goal is determined, which is an examination in academic literature on the three domains of the BOAT framework that are technology, business and architecture. The rationale is that the findings provide an objective overview of the existing elements.

2.2 Domains of the BOAT framework, technology-perspective

The three domains of the BOAT framework are discussed in order of importance. It is a technology-push therefore technology is discussed first, followed by business and architecture. The organisation domain is the logical next step but is left outside the scope due to a lack of information in academic literature. Every section starts with the definition of the domain, followed by the summary of the findings. After this, the constructs and components are shortly described.

2.2.1 Technology

The technology domain 'describes the technological realisation of the systems for which the architecture is specified in the A aspect… describes *from what ingredients* a networked e-business is built' (Grefen, 2015). Table 2.1 provides an overview of the key characteristics of the technology domain.

Key characteristics of the technology domain		
Construct	**Component**	**Opportunity/threat**
Trust	Trustworthiness	Opportunity
	Transparency	Opportunity
	Immutability	Opportunity
Security	-	Opportunity/threat
Usability	Latency	Threat
	Throughput	Threat
	Wasted resources	Threat
	Scalability	Threat
	Interoperability	Threat
Privacy	-	Threat

Table 2.1: Key characteristics of the technology domain

2.2.1.1 Trust

Trust has traditionally been difficult to define and measure (Rousseau et al., 1998). Some call it a 'confusing potpourri' (Shapiro, 1987) or even a 'conceptual morass' (Barber, 1983; Carnevale & Wechsler, 1992) but many agree now that trust is multidimensional (Mayer et al., 1995; Rousseau et al., 1998). The dimensions of trust, which are mentioned in academic literature, are trustworthiness, transparency and immutability. As proposed by Zhao et al.: 'the essence of blockchain lies in its ability to support trustworthy transactions' (Zhao et al., 2016). Participants are not only aware of the consensus protocol, they also accepted it and, in some cases, can even participate in this process, all leading to an increase of trustworthiness (Underwood, 2016). 'Because many parties have a copy of the ledger ... and many parties can verify every record …, a shared ledger has a high degree of transparency' (UK Government Chief Scientific Adviser, 2016) and 'the immutable nature of blockchain systems is a guarantee of its authenticity. That is, once a piece of information enters the system, it cannot be modified' (Guo & Liang, 2016).

2.2.1.2 Security

Security is the most controversial characteristic of the technology and is considered both an opportunity as a threat. When talking about security, this implies the number of practical attacks which leverages weaknesses in Blockchain (Karame, 2016). 'Security … [has] always sparked extensive debate in the process of each new financial innovation' (Guo & Liang, 2016). Because of the immutability and other features, like the distributive and decentralised characteristic of the technology, security of transaction is one of the top benefits perceived by early adopters (Underwood, 2016). By distributing the ledger, a possible hacker must rewrite at least half the ledgers to let it appear the right one. Thus, the distribution of multiple copies increases system reliability and security (Tsai et al., 2016). Also, the decentralised characteristic implies that there is no single point of failure (Azaria et al., 2016; Fanning & Centers, 2016). The most known security threats are more thoroughly discussed in the paper but it concerns 51% attack, Sybil attack, SYN Flood attack, timing & error attack, man-in-the-middle attack, key management and audit node/third party attack.

2.2.1.3 Usability

Again, usability is a broad threat concept which is further subdivided into latency, throughput, wasted resources, scalability and interoperability. Latency is the time it takes to complete one transaction and on the biggest Blockchain, called Bitcoin, the latency is set on 10 minutes to secure transactions, for instance, by outweighing the cost of double spending attacks (Yli-Huumo et al., 2016). Throughput, sometimes confused with bandwidth, is another key attribute to efficiency. The difference between throughput and bandwidth is that throughput is the perceived data that travels successfully, whereas bandwidth is the theoretical maximum amount. The throughput in a Bitcoin network is currently maximised to seven transactions per second and still growing, however, making it irrelevant to VISA (2000 transactions per second) and Twitter (5000 data transactions per second) (Yli-Huumo et al., 2016). Wasted resources refer to the significant amount of electricity is used unproductively to solve the Proof-of-Work algorithm (Watanabe et al., 2016). ‘It is challenging to extend blockchain systems and estimate the costs for such extensions’ (Wang et al., 2016), therefore scalability issues arise. As mentioned before, to ensure security on Blockchain, many full nodes are required (Beck et al., 2016), otherwise, one might end up in a less decentralised system. The last characteristic of usability which holds the implementation of Blockchain back is interoperability, implying the barrier between different and newer Blockchains (Collomb & Sok, 2016) and implying that Blockchain is evolving in many ecosystems like Ethereum, but the integration between those ecosystems is not possible (Underwood, 2016).

2.2.1.4 Privacy

Data privacy is one of the three key challenges, together with interoperability and scalability (Underwood, 2016). Underwood argues that ‘the privacy issue is about how much information needs to be exposed to verify a transaction’ and all the transactions happen in the open which could lead to pattern analyses (Konstantinos & Devetsikiotis, 2016). It is possible to see all transactions between different entities. However, the data of this transactions is encrypted, meaning that the sent and received data cannot be revealed other than to the participants of that transaction. Also, all participants are only known through its public key, but not to its true entity or entity credentials.

2.2.2 Business

The business domain ‘describes the business goals of networked e-business… answers the question *why* a specific e-business scenario exists or *what* should be reached by the collaboration in a scenario’ (Grefen, 2015). Table 2.2 provides an overview of the key characteristics of the business domain.

Key characteristics of the business domain		
Construct	**Component**	**Opportunity/threat**
Efficiency	Better documentation	Opportunity
	Fast multi-entity transactions	Opportunity
Cost saving	-	Opportunity
Intermediary	-	Opportunity/threat
Regulation	-	Threat
Other	Limits competitiveness	Threat
	Illegal activities	Threat

Table 2.2: Key characteristics of the business domain

2.2.2.1 Efficiency

Blockchain has the potential to improve existing processes, like documentation and fast multi-entity transaction, thus it increases efficiency. Through digitisation and verification of records, necessary procedures can be reduced, the follow-up process of trade agreements can be eased and the efficiency of execution can be boosted by helping link networks of recordkeeping (Nguyen, 2016). All these measures result in a less complex and more automated way of working. Also, they completely avoid the need for copious, often duplicated, documentation (Underwood, 2016) because everybody has access to the same ledger. Rather than having to duplicate information manually, all participants agree on the same ledger, which is automatically updated to each participant. Another business opportunity is the support of fast multi-entity transaction settlement and clearing (Tsai et al., 2016). Every time different entities must make a transaction; the transaction time can take several days to even several months to verify each party and each request. For these purposes, the efficiency of Blockchain is well enough to boost the speed of this process.

2.2.2.2 Cost saving

According to Nguyen, one third of the transaction fees could be saved for an estimation of 16 billion dollars for banking. McKinsey even made an estimation about the reduction of transaction costs in cross-border business which declines from 26 dollars to 15 dollars per transaction (Guo & Liang, 2016). But not only the user can profit from Blockchain, also the financial institutions can benefit from it. The back-end activities of loan trade are costly to financial institutions (Fanning & Centers, 2016). Also, worldwide capital requirements for banks could be reduced by 120 billion dollars (Nguyen, 2016).

2.2.2.3 Intermediary

The intermediary is a subject for debate. In principle, Blockchain can be used to eradicate intermediaries but opponents argue that this will never be fully possible. ‘Many of these early individuals involved with Bitcoin strongly wished to avoid dealing with third-party intermediaries such as financial institutions’ (Fanning & Centers, 2016). The peer-to-peer concept together with the consensus protocol in the network could lead to disintermediation. In general, intermediaries add cost and complexity (Wang, Chen, & Xu, 2016). However, there are some threats that make a transition to Blockchain less attractive. Therefore, just as Guo & Liang suggests, some form of safeguarding is needed and Blockchain probably still needs supervision from an intermediary during its early stage (Nguyen, 2016).

2.2.2.4 Regulation

A key issue to this technology is the incompleteness in terms of legal and regulation which prevents Blockchain technology from being widely applied (Nguyen, 2016). ‘Agencies, lawmakers, and legislatures should understand, investigate, and examine the mechanisms and impacts of blockchain technology and cooperatively develop and implement laws, policies, and regulations to govern the use of blockchain technology’ (Xu, 2016). It can be argued that this important hurdle is considered a part of the organisation domain.

2.2.2.5 Other threats

Two main threats are also mentioned in the papers. The first threat implies the limit on competitiveness. Because the Blockchain network is shared among all banks that participated in the system to improve the bank’s own system, it could have a negative impact on the level of competitiveness (Nguyen, 2016). Another threat is the rise of illegal activities using this technology. Problems like identity theft due to the anonymity in combination with the lack of security (Xu, 2016). Furthermore, it could become a venue for illegality like Silk Road using bitcoins or the facilitation of money laundering (Tsai et al., 2016).

2.2.3 Architecture

The architecture domain 'covers the conceptual structure or blueprint of automated information systems required to make the organisation defined in the O aspect work… describes *how* automated systems support the involved organisations in a conceptual, high-level fashion' (Grefen, 2015). Table 2.3 provides an overview of the key characteristics of the architecture domain. These are not regarded as threats and opportunities because they have dual effects as both opportunities as threats.

Key characteristics of the architecture domain	
Constructs	**Components**
Openness	Public permissionless
	Public permissioned
	Private permissioned
Generation	Blockchain 1.0
	Blockchain 2.0
	Blockchain 3.0
Consensus protocol	Proof-of-Work
	Proof-of-Stake

Table 2.3: Key characteristics of the architecture domain

2.2.3.1 Openness

Blockchain is characterised and explained through several features in the previous chapter. In general, academic literature only suggests a specific type of Blockchain that truly interacts peer-to-peer. However, some academic literature as well as people in the industry distinguish several types of Blockchain. Blockchain as discussed in this chapter is a specific type of Blockchain, called the public permissionless Blockchain. Bitcoin is the foremost example of it. However, there are some different types of Blockchain that are important to consider in this research. To understand the differences, there are two distinguishes that can be made.

First, there is a difference between permissionless and permissioned. Permissionless means that everyone can read & add new data to the ledger, can take part in the validation phase, called the consensus protocol, and where the participants in the consensus protocol, called miners or validators, remain anonymous (Van Hemelen & Winderickx, 2016). In a permissioned environment, only a determined list of peers can add new data as well as take part in the consensus protocol with miners that are identified (Van Hemelen & Winderickx, 2016).

Secondly, there is a difference between public and private. Public ledgers mean that everyone can read the Blockchain records and that the readers remain anonymous (Van Hemelen & Winderickx, 2016). Also, there is no single owner of the Blockchain records (UK Government Chief Scientific Adviser, 2016). Private ledgers are the opposite of public ledgers. A private ledger has the characteristic that not everyone can read the Blockchain records nor are the readers anonymous (Van Hemelen & Winderickx, 2016). Since a permissionless environment can only be a public Blockchain not a private one and a private Blockchain is always permissioned, there are three categories of Blockchain. If the specification of the openness is not written down, the public permissionless type of Blockchain is discussed.

2.2.3.2 Generation

Since the article of Nakamoto was published in 2008, academic literature suggests three distinct generations of Blockchain, that are Blockchain 1.0 for digital currency, Blockchain 2.0 for digital finance or smart contracts, and Blockchain 3.0 for digital society (Van Hemelen & Winderickx, 2016; Zhao et al., 2016). 'Interestingly, Blockchain 1.0 took a few years to mature starting from 2008, Blockchain 2.0 and 3.0 have emerged almost in parallel in an explosive manner around 2015' (Zhao et al., 2016). This distinction between smart contracts and digital currency is also elaborated upon in the previous chapter.

2.2.3.3 Consensus protocol

As discussed in the appendix H, the Proof-of-Work is the most used example of the consensus protocol. This concerns the solving of a computationally heavy puzzle by the peers who want to participate in the validation of transactions (Watanabe, 2016). It concerns a random guessing of a nonce, a certain value that solves the puzzle, by using one's computational power. This implies that an increasing amount of computational power leads to an increase in the likelihood of solving the puzzle. This is referred to as the proof, implying that a certain amount of effort is used and the winner receives some cryptocurrency for the effort. However, there is another important other method called Proof-of-Stake which is currently tested to be deployed.

In 2012, the Proof-of-Stake, PoS, method was proposed in a white paper and implemented in the Peercoin, another cryptocurrency (King & Nadal, 2012). The main difference between PoS and PoW is that the consensus protocol is based on cryptocurrency instead of computational resources. An important concept is launched by Nakamoto in 2010 that helps understanding PoS, namely coin age. Coin age is defined as the amount of cryptocurrency times the holding period, which is the period of inactivity of that amount (King & Nadal, 2012). The basic idea is that the more coin age a peer has, the more power it has in the network. To validate a block, a peer must use his own currency and give it back to himself, meaning the holding period drops to zero. In time, this amount can be reused and a percentage of the used amount is given to the peer as a reward for the validation. This process, which is called mining in PoW, is called minting in PoS. Also, the percentage of currency a peer has compared to the total amount of that currency is the maximum percentage of blocks a peer can mint. To add a block, the participant must give a certain amount of coins to himself leading to a coin age of zero for that amount. The more coin age consumed, the easier the block meets the hash target protocol that is the time that it takes to generate a new block (King & Nadal, 2012).

2.3 Summary

This systematic literature review explores the three domains of the BOAT framework that are technology, business and architecture. The organisation domain is the logical next step but is left outside the scope due to a lack of information in academic literature. The findings of each domain are used to create a solid academic ground to help solve the design problem, therefore each construct and component listed in table 2.1, 2.2 and 2.3 influences a use case for Blockchain.

Furthermore, there are some threats to validity assessed, both internal as external. For example, the selection bias, since only one person has performed this review, has an influence on the results gathered. Additional observations are made concerning the role of the government in this technology, the role of the intermediary and the rise of relevant white papers. Some challenges also have been established during this study like the validation of the results, the hype and real testing on Blockchain technology which all should be considered when reviewing this chapter. All these notions are elaborated upon more thoroughly in the entire document. This chapter only provides the relevant findings as a prelude to further research activities. For more in-depth information, it is advised to read the entire systematic literature review (Van de Wall & Razavian, 2017). The next chapter describes the methodology of this research.

3. Methodology

This chapter includes the methodology used to research the given design problem and its research questions. The frameworks of Wieringa are used that are based on the work of Hevner et al. (Hevner et al., 2004) and Van Strien (Van Strien, 1997).

3.1 Academic background

The development of an artefact is part of design science in information systems. The most profound and most used framework that helps building and evaluating an artefact is the framework developed by Hevner et al. (Hevner et al., 2004). It discusses two perspectives that are the behavioural-science and the design-science perspective, that both contribute to an iterative process of artefact building. However, the interaction of these iterations is not analysed by Hevner. Therefore, the work of Wieringa is chosen as an extension on this framework.

3.1.1 Design cycle

The regulative cycle forms the basis of the design cycle. It starts with a problem statement, followed by a diagnosis, a plan or design, an intervention or implementation and concludes with an evaluation (Van Strien, 1997). After the evaluation, it is possible to start again with a renewed problem statement that follows the same cycle. It is the general structure of a rational problem-solving process (Simon, 1955; March, 1994).

Wieringa adapted this regulative cycle for design science. Figure C.2 shows this design cycle. It consists of four stages which are problem investigation, artefact design, artefact validation and artefact implementation.

Problem investigation is regarded as a knowledge question because it asks for information about and understanding of the given problem without performing changes. Its goal is to describe the problem, to explain it, and possibly to predict what could happen (Wieringa, 2009). The artefact design is mostly a practical problem that helps to improve the world in a certain way for the stakeholder. The artefact validation phase is a knowledge tasks in which it is established if the design indeed helps the stakeholder reach its goal. The artefact implementation concerns a practical problem that executes the artefact design.

3.1.2 Information Systems Research Framework

Hevner developed a framework with two different perspectives, a behavioural-science and a design-science perspective. Where behavioural-science paradigm seeks to develop and justify theories, thus has its roots in natural science research methods, design science, having roots in engineering, is fundamentally a problem-solving paradigm that seeks to create innovations (Denning, 1997; Tsichritzis, 1998; Hevner et al., 2004). Based on this perspective, the Information Systems Research Framework is developed.

Figure C.1 represent the framework as developed by Hevner consisting of an environment and a knowledge base contributing to the Information Systems, also known as IS, research. The environment defines the problem space (Simon, 1996) in which the phenomena of interest resides. This environment is composed of people, organisations, and their technologies (Silver et al., 1995). All these characteristics contribute to their perspective towards the business need. ‘The knowledge base provides the raw materials from and through which IS research is accomplished’ (Hevner et al., 2004). It consists of foundations, indicating prior IS research and methodologies.

Wieringa distinguishes by defining knowledge problems and practical problems. Knowledge problems are defined as the 'difference between current knowledge of stakeholders about the world and what they would like to know' and practical problems as the 'difference between the way the world is experienced by stakeholders and the way they would like it to be' (Wieringa, 2009). Knowledge problems use analytical and empirical research methods whereas practical problems follow an engineering cycle. He argues that these two are mutually nested. Figure 3.1 represents the refinement of his framework on the work of Hevner.

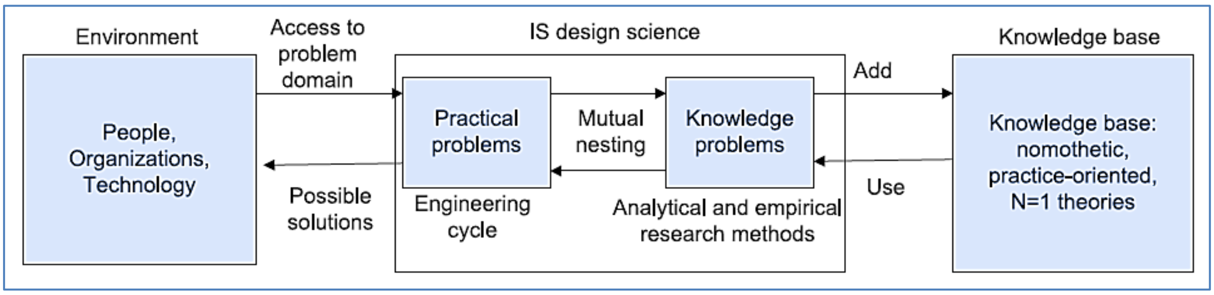

Figure 3.1: Information Systems Research Framework (Wieringa, 2009)

Wieringa argues that the framework he adapted from Hevner 'clarifies the interface of design science with its social environment and with the scientific knowledge base, and it makes clear that design and research are closely related activities' (Wieringa, 2009). Wieringa embraces this framework and has added an important part, which is the representation of the interaction of these activities, better known as the design cycle as described before.

3.2 Research plan

In this section, the research plan is described, starting off by describing the stages of the design cycle. Then, the Information Systems Research Framework of Wieringa is used to delve deeper into each artefact iteration of the artefact-design stage.

3.2.1 Design cycle

Figure 3.2 represents the design cycle of Wieringa (Wieringa, 2009). For a master thesis research, the last stage of the cycle, artefact implementation, is not included. There are several possibilities for problem investigation. In our case, it is a solution-driven investigation which is described as a 'technology [that] is in search of problems that can be solved with it' (Wieringa, 2009). Therefore, it starts with an investigation into the technology and its characteristics rather than start with a requirements-pull perspective for the artefact-design stage. A requirements-pull approach is applied during the second iteration of this artefact-design stage.

As a solid ground, a systematic literature review is undertaken in the problem-investigation stage. Because the development of this technology is at an early stage, a systematic literature review does not suffice to gain all possible knowledge. Hence, it is chosen to follow two additional academic courses. First, the 'Bitcoin and Cryptocurrency Technologies' course of Princeton University is chosen to be taken (Narayanan et al., 2016). Because this course was primarily focused on Bitcoin and cryptocurrencies, the 'Blockchain at Berkeley' course at Berkeley university is also followed. Through a systematic literature review and two academic courses, the knowledge questions concerning Blockchain can answered, thus, the problem investigation stage is finished.

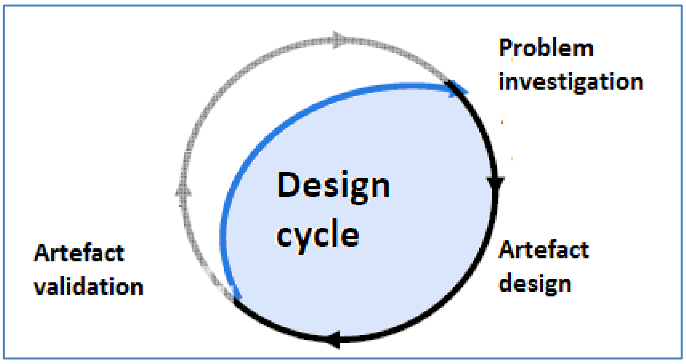

Figure 3.2: Design cycle

3.2.2 Information Systems Research Framework

This section is subdivided into the three different iterations of the artefact as to be seen in figure 3.3 on the next page. This figure represents the IS Research Framework of Wieringa (Wieringa, 2009), applied to the research plan. As seen, each iteration has an environment and a knowledge base influencing the IS research. The goal of each iteration is described in table 3.1.

Goals of each iteration		
Iteration	**Delivers**	**Goal**
1	RQ-I.I and (partly) RQ-II	Research the factors and their relations that influence a Blockchain use case
2	RQ-I.II and (partly) RQ-II	Research the factors and their relations that determine appropriateness of a new technology
3	RQ-II	Research the relations between all contributing factors that determine appropriateness of a Blockchain use case

Table 3.1: Goals of each iteration

3.2.2.1 Artefact iteration 1

The second stage of the design cycle is the artefact-design stage. The main practical problem is to find what kind of artefact should be developed and the main knowledge problem concerns how the artefact should be developed. The tools to help the practical problem include interviews and a document analysis whereas the knowledge problem is tackled through academic literature. Furthermore, the goal of this iteration is to research the factors and their relations that influence a Blockchain use case as described in table 3.1.

Interviews are planned to derive business needs from people with an expertise on Blockchain. It is chosen to have a qualitative rather than a quantitative method to create a deeper understanding of phenomena (Gill et al., 2008). ‘Interviews are, therefore, most appropriate where little is already known about the study phenomenon or where detailed insights are required from individual participants’ (Gill et al., 2008). Also, a document analysis is performed to acquire quantitative data.

Multiple research methods are chosen for several reasons. It is a major strength of information systems research, using a diversity in research methods (Lee, 1999; Robey, 1996; Sidorova et al., 2008). This proposed mixed method uses quantitative and qualitative research method, that is respectively the document analysis and the interviews, which helps to develop a deeper understanding of the phenomenon (Denzin, 1994; Jick, 1979; Mingers, 2001; Reichardt & Rallis, 1994). This is very helpful at this first iteration of artefact design.

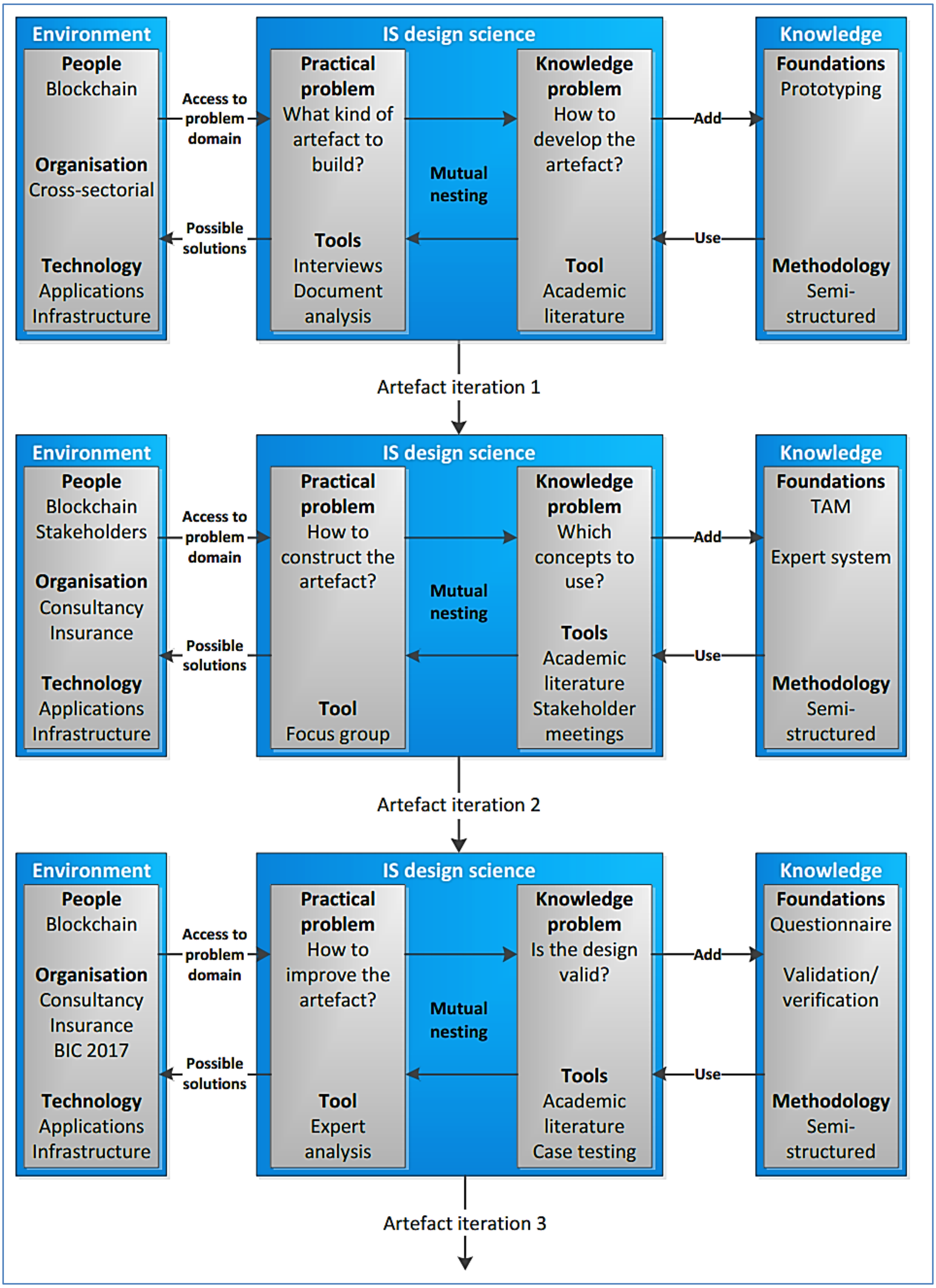

Figure 3.3: Information Systems Research Framework, applied to research

To enhance the knowledge base, a semi-structured literature research is performed towards several topics. The structured literature research together with the academic courses in the problem-investigation stage are used as the solid ground on which this research is built. However, there are several topics that consist of additional parts that are built on this solid ground rather than providing new foundational enrichment. From this iteration on, these topics are academically researched through a semi-structured literature research, providing additional resources in time to academically assess several areas of interest relevant to this research.

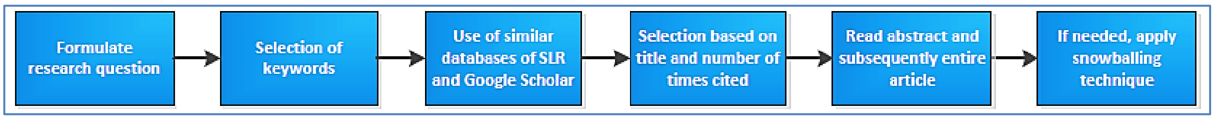

Figure 3.4: Strategy of the semi-structured literature research

A semi-structured research entails the following methodology as to be seen in figure 3.4. An important difference with a structured research is that the semi-structured literature review is ceased when the area of interest seems to be fully explored, thus a certain level of knowledge saturation is reached. This is based on a low number of times cited or no new relevant information is obtained after several articles.

At this iteration, the area of prototyping is researched which is the basis of the artefact-design stage. This academic knowledge guides the development of the artefact.

3.2.2.2 Artefact iteration 2

At the second iteration of the design stage, sufficient information is gathered to build a first prototype of the artefact. The main practical problem is to find how the artefact should be constructed and the main knowledge problem concerns which academic concepts should be used to assess the appropriateness of a new technology. The tool to help the practical problem includes a focus group whereas the knowledge problem is tackled through academic literature and stakeholder meetings. Furthermore, the goal of this iteration is to research the factors and their relations that determine appropriateness of a new technology as described table 3.1.

First, a semi-structured literature research is performed as drawn in figure 3.4. The area of interest includes several academic models that assess the factors contributing to the acceptance of Blockchain technology. After preliminary research, the Technology Acceptance Model of Davis et al. is chosen (Davis et al., 1989). Another area of interest is linked to the given design problem which concerns the intelligent tool. This is chosen to be an expert system after the interviews of the first iteration.

A first artefact prototype can be built after these knowledge domains are examined, which is artefact 2. To successfully evaluate this first built artefact, a focus group is chosen as evaluation tool. This focus group is an exploratory focus group as defined by Tremblay et al. in which the tool is particularly useful since little is known about the phenomenon (Stewart et al., 2007; Tremblay et al., 2010). Some key reasons for a focus group concerns flexibility, direct interaction, large amounts of rich data and building on other respondent’s comments.

3.2.2.3 Artefact iteration 3

This is the final iteration stage; therefore, this artefact is tested in the artefact-validation stage. The main practical problem is to find how the artefact can be improved and the main knowledge problem concerns the validation of the artefact. The tool to help the practical problem includes an expert analysis whereas the knowledge problem is tackled through academic literature and case testing. The choice of the case-testing method is discussed in Chapter 4 since it is derived from academic literature. Furthermore, the goal of this iteration is to research the relations of all contributing factors as discussed in table 3.1.

First, an expert analysis is performed to establish the last relations of the artefact. Also, general remarks concerning the improvement of the artefact are made. Secondly, a semi-structured literature research is performed as drawn in figure 3.4. The areas of interest include questionnaires and verification or validation measures in expert systems. Thirdly, the artefact is verified and validated, respectively through anomalies checking and case testing.

3.3 Report outline

Figure 3.5 provides an overview of the chapters in their relation to the Design Science Cycle whereas figure 3.6 graphically shows the chapters in accordance to their respective stakeholders. The second figure is made to clearly show the difference in importance to the different stakeholders such that they can prioritise the chapters to be read. An important note is that the chapters concerning the artefact are split up in process and product, whereas the stakeholder at the company is more interested in the product description and the stakeholder at the university puts more emphasis on the iterative process.

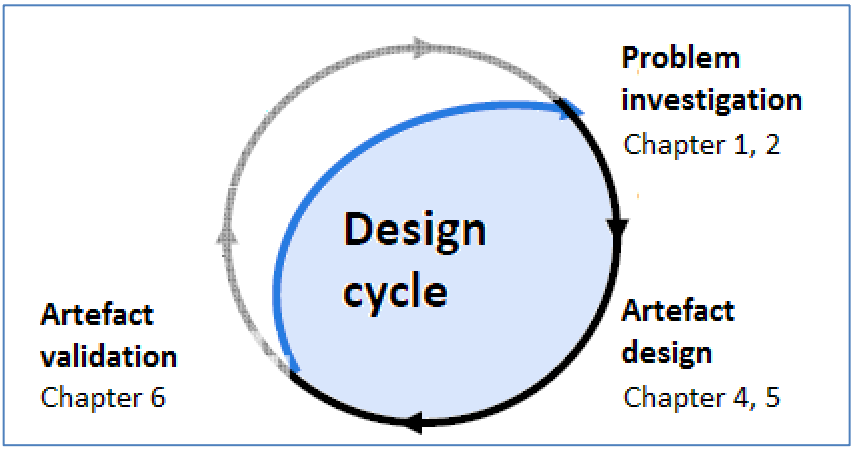

Figure 3.5: Design Cycle, applied to report outline

3.4 Summary

In this chapter, the methodology of this research is described. The framework of Wieringa is used to describe the different iterations of the artefact and the Design Science Cycle of Wieringa is used to describe the interactions of these iterations. Furthermore, these frameworks are applied to this research. A goal is given to each iteration together with the proposed plan how to achieve it. The next chapter describes the process in a more detailed manner.

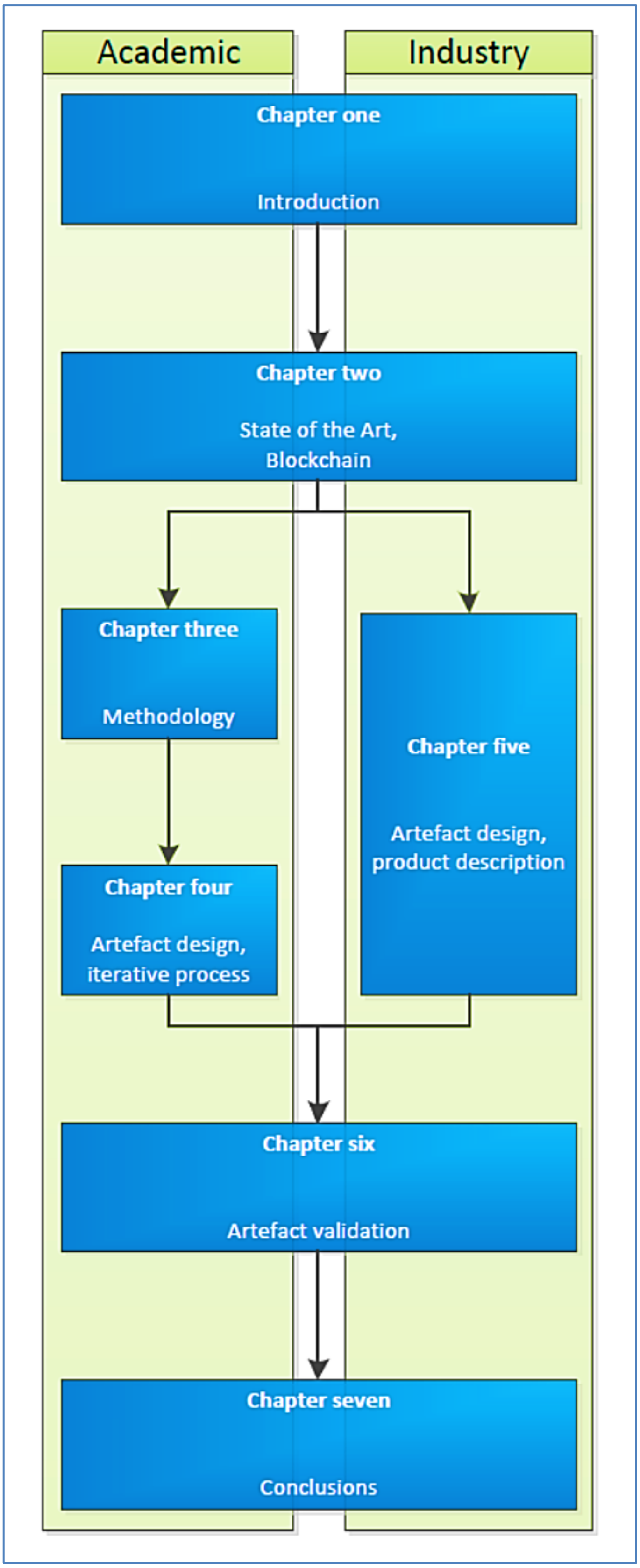

Figure 3.6: Diagram of the chapter layout

4. Artefact design, iterative process

Chapter 4 and 5 both regard the artefact-design stage. According to Walls et al., design is both a process, a set of activities, and a product, an artefact (Walls et al., 1992). Also, because the architecture of the artefact is discussed in this report, the two faces of architecture are both useful for the term 'design', which is design related to the structure of a product and design related to the structure of the process (Grefen, 2016). This chapter describes the process of the artefact design. This process is 'a sequence of expert activities that produces an innovative product (i.e., the design artefact)' (Hevner et al., 2004). Only the iterations on the final artefact are discussed. The next chapter only discusses this artefact with its parts without discussing its process of designing.

The structure of this chapter is comparable to the structure of the research design of the previous chapter. Each section refers to an artefact iteration as shown in figure 3.3. Each iteration concerns the its foundations, its tools and the concluding effects on the artefact. The goal of each artefact iteration is described in table 3.1.

The section concerning foundations has the following structure: the goal is described together with the definition and findings regarding this area of interest. The section concerning the tools has a comparable structure: the goal is described together with the overview of the participants and its findings. The process of the tools linked to the foundations are not discussed. This approach is already discussed in Chapter 3. Each iteration is concluded by the effects of the foundations and the tools on the product, i.e. the artefact.

To establish a link between the process and the product, which are discussed in this chapter and the upcoming chapter respectively, the concluded effects of the process are presented as the progress on the product. The product is an expert system that consists of three parts that are input, 'brain' and output. The 'brain' consists of the contributing factors to assess the appropriateness of a Blockchain use case and its relations, as referred to in the research questions. After each iteration, all the found factors are presented in the knowledge base of the brain and all the relations between those factors are presented in the inference engine. More information concerning the product is provided in Chapter 5.

4.1 Artefact iteration 1

This iteration has as a main goal to find the first relations between some of the factors and to add new factors or other parts to the artefact as discussed in table 3.1. Some of the factors are already established through the problem-investigation stage. Figure 4.1 provides the IS Research Framework of Wieringa of this iteration.

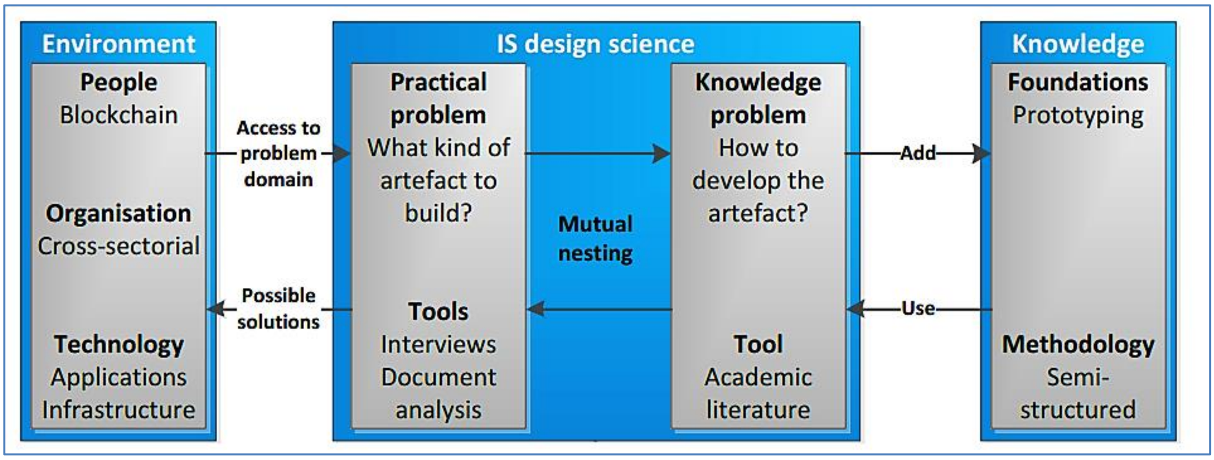

Figure 4.1: IS Research Framework, first iteration

4.1.1 Foundations

A research question is formulated in table 4.1 together with its keywords to find relevant information concerning the area of interest.

Foundations, first iteration	
	Prototyping
Research question	Which type of prototyping is best applicable to our designed artefact?
Keywords	Prototyping

Table 4.1: Foundation, first iteration

4.1.1.1 Prototyping

Prototyping is defined as 'a type of development in which emphasis is placed on developing prototypes early in the development process to permit early feedback and analysis in support of the development process' (Booth & Kurpis, 1993). Prototyping is chosen because it is successful in collecting criticisms and feedback for updated requirements but also to detect deviations from users' expectations early (Kordon, 2002). Furthermore, the two biggest benefits are an improved match with users' needs and improved 'ease of use' both leading to an increase in the likeliness to use the designed artefact (Gordon & Bieman, 1995).

According to Kordon, the two most common approaches towards prototyping are the throw-away versus the evolutionary approach. 'Prototypes can be developed either to be thrown away after producing some insight or to evolve into the product version' (Kordon, 2002). Throw-away prototyping is chosen to use due to several reasons. A throw-away prototype can be developed more quickly, works very well in isolation to verify relatively small parts of complex problems and is an effective way to move requirements from poorly understood to well understood (Davis, 1992). The time limit and the isolated scope of the research is particularly interesting since only the technology, business and architecture domains of a use case for a very complex new technology are used as a scope. This type of prototyping is very useful in a situation where quickly uncovering knowledge is important (O'Keefe & Preece, 1996). Figure 4.2 describes the throw-away prototyping approach based on Kordon (Kordon, 2002) and linked to the iterations.

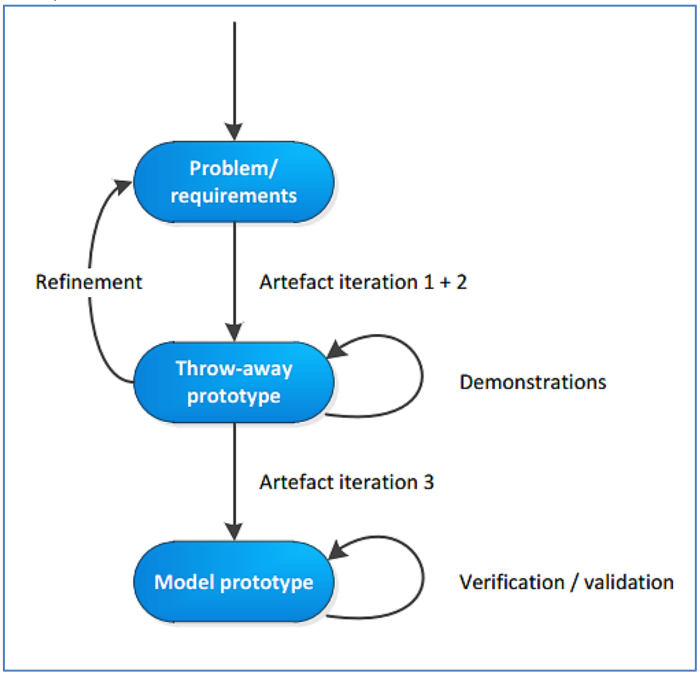

Figure 4.2: Prototyping, applied to research

4.1.2 Tools

The goals, their accompanying research question and the requirements are represented in table 4.2. The first are derived from table 3.1 and the requirements are discussed below.

Tools, first iteration		
	Interviews	**Document analysis**
Goal	Research the factors and their relations that influence a Blockchain use case	
RQ	RQ-I.I & RQ-II	
Requirements	The group of respondents should consist of insurance employees and Blockchain consultants	The number of use cases should range between the 100 and 200
	The two groups should preferably be equally presented, but the insurance employees should cover at least a quarter of the respondents	The number of use cases for the insurance sector should range between 25 and 50
	The number of respondents should range between the 10 and 30	

Table 4.2: Tools, first iteration

4.1.2.1 Interviews

To establish both an insurance perspective as a cross-sectorial expert perspective on Blockchain, the interviewees should be working in the insurance branch or as a consultant. An insurance employee sees Blockchain as a new possibility of enhancing their existing infrastructure whereas a consultant may look for new applications of this technology. The total of interviewees should preferably be equally distributed between these groups since general Blockchain knowledge is needed, but also insurance-specific information concerning Blockchain. However, the insurance employees should make up at least a quarter of the respondents. To make this viable within the given time limit, the number of respondents should be ranging between 10 and 30 respondents. Below this range, the influence of a single respondent is too big, above this range, too much time will be needed to perform this iteration. Table D.2 presents an overview of the characteristics of the participants. All the names and the companies have been anonymised due to confidentiality agreements; only an index number, the department and the kind of company are listed.

To successfully perform interviews, the best practices are gathered from two books (Seidman, 2006; Cohen et al., 2007). A semi-structured approach is used since through a predetermined sequence of questions, the comparability of responses is increased, the interviewer effects & bias are reduced and it facilitates organisation & analysis of the data (Cohen et al., 2007). The topics of the interview were the three different domains which are technology, business and architecture.

The findings of the interviews concerning the domains of technology and business can be found in table D.3 whereas table D.4 represents the domain of architecture and table D.5 summarises other interesting remarks, not directly related to the three domains. An important side note is that the performance and effort indicator of the Technology Acceptance Model (Davis et al., 1989) were not yet established, the indicators asked during the interviews were performance and complexity. Because perceived usefulness, one of the two variables of the TAM, is a performance indicator (Taylor & Todd, 1995; Venkatesh et al., 2003) and it concerns rough estimations by the interviews, these results are written down as perceived usefulness. Complexity is the opposite of ease-of-use (Taylor & Todd, 1995; Thompson et al., 1991; Venkatesh & Davis, 1996). To establish comprehensibility, the findings are presented in accordance to the two variables of the TAM.

An important other finding is that the participants want a simple representation of the performance and effort indicator on a two-dimensional classification scheme as an output. This creates a simple and easy way of understanding the appropriateness of a Blockchain use case. Also, an academic model that objectively assesses a Blockchain use case is very useful.

4.1.2.2 Document analysis

A document analysis is performed to acquire quantitative data. Therefore, the sample size should be large enough, implying a range between the 100 and 200 use cases to obtain data that can be assessed further using a statistical tool. It is important that the number of use cases concerning the insurance sector ranges between 25 and the 50 to make meaningful statements concerning the insurance branch, as opposed to other sectors.

The document analysis is chosen for two reasons. First, to generate quantitative data alongside the qualitative data from the interviews, which can be a major strength, especially in the early stage of the research where knowledge enrichment is a main goal (Venkatesh et al., 2013). Secondly, the factors of the business domain need to be examined, because they were not thoroughly researched in academic literature. The document analysis concerns use cases for Blockchain, already thought of by organisations. An overview of the semi-structured approach is provided in table 4.3.

Document analysis, semi-structured approach	
Research question	Which Blockchain use cases are already considered?
Keywords	Use Case Application Blockchain Insurance
Search engine	Google

Table 4.3: Document analysis, semi-structured approach

In total, there are 117 use cases found of which 27 are use cases for the insurance sector. The number of use cases as well as the part of the insurance branch is relatively low to perform a proper statistical analysis upon. Therefore, the results from the statistical analysis provides a guidance and an assumption that should be further researched in other research to verify this analysis. For now, we assume that the number of use cases is enough to perform proper statistical analysis in this early stage of the new technology. Table D.6 provides an overview of the articles that provide the use cases.

The findings of the document analysis can be found in table D.7. These findings are further analysed using IBM SPSS Statistics 23. To analyse a relation between the factors of the business domain, it is chosen that the level of analysis cannot be put on the level of the main construct of the business domain which is efficiency because this term is too broad. Also, it is not feasible in this study to analyse all the contributing factors in accordance to their performance and effort indicator. Therefore, it is chosen to cluster the given business factors.

A TwoStep Cluster Analysis is chosen for several reasons. First, the SPSS TwoStep clustering offers the possibility to handle categorical variables (Bacher et al., 2004) which in this case is a 0 or 1 for each factor for a given use case. Furthermore, the TwoStep clustering is reported to provide excellent results for the proposed algorithm to determine the number of clusters automatically (Chiu et al., 2001). Although there are also some drawbacks concerning the success rate of the right cluster structure, non-quantitative variables and it is preferred to use large data sets (Bacher et al., 2004), we assume that this clustering analysis suffices.

To tackle some of the possible errors of the TwoStep clustering, four scenarios are made. The first scenario of one-time clustering which results in two clusters as can be seen in table D.8. The second scenario uses another TwoStep cluster analysis on cluster two, providing three clusters as to be seen in table D.9. The third scenario uses another TwoStep clustering on cluster one, providing three clusters as to be seen in table D.10. The fourth scenario uses two more TwoStep clustering on both clusters, providing four clusters to be seen in table D.11. It is chosen not to continue since the difference between cluster sizes in scenario 2 and 3 is already large enough. Also, the clustering strength of the third and fourth scenario are considered poor according to IBM SPSS Statistics. Furthermore, it would represent a cluster with only one variable. Therefore, scenario 3 and scenario 4 are discarded from further analysis. Scenario 1 and scenario 2 are evaluated in a later iteration to select the most appropriate clustering for the business factors.

4.1.3 Concluding effects on the artefact

This iteration concerns the foundational knowledge that helps guide the development of the artefact, therefore the area of prototyping is explored. Figure D.1 represents the artefact so far after this iteration where the blue-coloured parts are the added parts of this iteration and the grey-coloured parts are obtained by previous research. Through the interviews, the first relations of the technology and architecture domain with a performance and an effort indicator are discussed. Since the business domain could not be researched thoroughly in the previous iteration, this domain is analysed again using a TwoStep clustering analysis based on the use cases obtained through the document analysis.

4.2 Artefact iteration 2

This iteration has as a main goal to find the desired in- & outputs, more constructs & components and some of the relations as indicated in table 3.1. Figure 4.3 shows the IS Research Framework of Wieringa of this iteration.

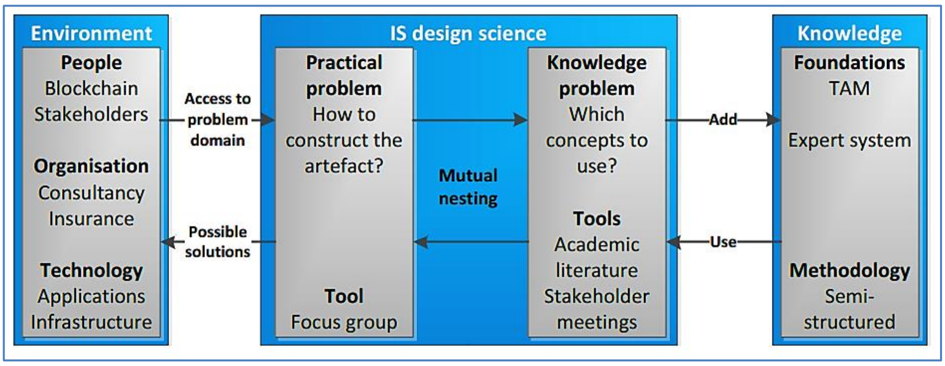

Figure 4.3: IS Research Framework, second iteration

4.2.1 Foundations

A research question is formulated in table 4.4 together with its keywords to find relevant information concerning the area of interest.

Foundations, second iteration		
	Technology Acceptance Model	**Expert system**
Research question	Is the Technology Acceptance Model appropriate for our design problem and what does it enclose?	Is an expert system appropriate for our design problem and which type of expert system is needed?
Keywords	Technology Acceptance Model Information Technology Acceptance Innovation Adoption	Expert System Knowledge Calculative Rule

Table 4.4: Foundations, second iteration

4.2.1.1 Technology Acceptance Model

Technology Acceptance Model, also known as TAM, is first published by Davis et al. and is added as figure D.2. This is an adaptation of the Theory of Reasoned Action (Fishbein & Ajzen, 1975) which is a well-researched intention model but not specifically for computer usage behaviour. 'The goal of TAM is to provide an explanation of the determinants of computer acceptance that is general, capable of explaining user behaviour across a broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified' (Davis et al., 1989). At the core of this relation, there are only two variables which are perceived usefulness, also known as PU, and perceived ease-of-use, also known as PEOU. The first is defined as 'the prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context' and the second as 'the degree to which the prospective user expects the target system to be free of effort' (Davis et al., 1989).

Other theoretical frameworks are also analysed to acquire the framework best suited for this research. One article that provides an overview of relevant frameworks is by Venkatesh. For instance, the Innovation Diffusion Theory which is grounded in sociology (Rogers, 1995) has been used since the 1960s to study very different kinds of innovation, like agricultural tools but also organisational innovations (Tomatzky & Klein, 1982; Venkatesh et al., 2003). Another researched framework is called the Organizational Innovation Adoption framework, which sees the adoption process as a 'sequence of stages a potential adopter of an innovation passes through before acceptance of a new product, service or idea' (Frambach & Schillewaert, 2002). This is also grounded in sociology and based on the work of Rogers.

It is chosen to use the TAM framework for several reasons. It is practical for usage in a technology-driven research (Venkatesh et al., 2012). Besides, it is considered a promising technique 'for those who wish to evaluate systems very early in their development, and cannot obtain extensive user experience with prototypes to assess its potential acceptability' (Davis et al., 1989). Also, the parsimony of TAM combined with its predictive power is a highly considered benefit of this model (Venkatesh, 2000). Furthermore, it is the most widely employed model of IT adoption and use (Adams et al., 1992; Venkatesh & Bala, 2008) and has received 'extensive empirical support through validations, applications, and replications … by researchers and practitioners, suggesting that TAM is robust across time, settings, populations, and technologies' (Venkatesh, 2000).

4.2.1.2 Expert system

The chosen artefact is an expert system. It remained an intelligent tool until the interviews and the stakeholders' meetings. 'The basic idea behind ES [expert system] is simply that expertise, which is the vast body of task-specific knowledge, is then stored in the computer and users call upon the computer for specific advice as needed. The computer can make inferences and arrive at a specific conclusion' (Liao, 2005). The expert system contains two separate parts. The knowledge base, which is 'an active database with some form of 'formal knowledge' about how the data may be used in practice', and the inference engine, which defines 'the ways in which the knowledge base may be put to use' (Hendriks & Vriens, 1999). The most important benefits for this research are the capturing and preservation of human expertise and the development of a system that is more consistent in its decisions (Hendriks & Vriens, 1999; Abraham, 2005).

To verify and validate an expert system, some suggestions are already made for the next iteration. Verification of a knowledge-based expert system has focused on attempts to demonstrate that such a system has been built in conformance with several well-defined properties, chiefly freedom from logical conflict, redundancy, and deficiency (Preece et al., 1992). Thus, verification should be done through looking for anomalies where an anomaly is 'an apparent instance of conflict, redundancy, or deficiency' (O'Keefe & Preece, 1996). In an ideal world, a verified expert system would be a naturally-validated expert system (Alavi & Wetherbe, 1991). However, this is of course hardly ever the case and therefore, validation must always be more than verification. 'By far the most prevalent method of validation is case testing, where the validator runs cases previously solved by an expert or experts through the system, and compares performance of the system to the experts' (O'Keefe & Preece, 1996).

4.2.2 Tools

The goals, their accompanying research question and the requirements are represented in table 4.5. The first are derived from table 3.1 and the requirements are discussed below.

Evaluation, third iteration	
	Focus group
Goal	Research the factors and their relations that determine appropriateness of a new technology
RQ	RQ-I.II & RQ-II
Requirements	The focus group should consist of six to twelve people and last about two hours
	The group of respondents should consist of insurance employees and Blockchain consultants
	The insurance employees should not have a minority share in the focus group

Table 4.5: Evaluation, third iteration

4.2.2.1 Focus group

According to Stewart et al., a focus group should consist of six to twelve people and last about two hours. These are the recommendations for the requirements. The environment should consist of people with Blockchain expertise who are working at the insurance company or the consultancy. Because of the key characteristic of building on other respondent's comments, the insurance sector should not have a minority share in the discussion.

The total number of participants in the focus group has been six of which four are currently working in the insurance branch and two in the consultancy sector. The two in the consultancy sector are the two main stakeholders of the project and are therefore invited to discuss important issues like in- & outputs. The duration of the focus group was approximately 2.5 hours. Table D.12 shows an overview of all participants and their characteristics.

To successfully perform the focus group, the best practices are gathered from two sources (Stewart et al., 2007; Tremblay et al., 2010). The requirements of these sources are fulfilled and the focus group is audio and video recorded. After the session, the transcript is written to objectively identify the important conclusions of the discussion. First, the most important topics are discussed to create meaningful qualitative data without time considerations. The discussed topics are both input, output, constructs and components as the completeness of the expert system.

The findings of the focus group can be found in table D.13. These are categorised per topic which are input, expert system (constructs & components), output and other remarks. For the input, the most important finding is that it should be a simple questionnaire to help the business unit select the best use case. For the expert system, the three domains are discussed again together with the advice they want to have. The advice should contain the appropriateness, a technological advice concerning the platform and a business advice concerning the strength of the business clusters of that use case. These should be delivered for the output.

4.2.3 Concluding effects on the artefact

The iteration concerns the foundational knowledge that is needed for the artefact, thus, the area of the Technology Acceptance Model and expert systems. Besides, the first artefact prototype is built and tested through a focus group. During this session, the domain of expert advisory is created, the input & output are discussed and some of the relations are established. Figure D.3 represents the artefact so far after this iteration where the blue coloured parts are the added parts of this iteration and the grey-coloured parts are already added in a previous iteration.

4.3 Artefact iteration 3

This iteration has as a main goal to establish the relation between the business domain and the Technology Acceptance Model. Also, it checks the model together with experts. Finally, this artefact is verified and validated. The IS Research Framework of this iteration is added as figure 4.4.

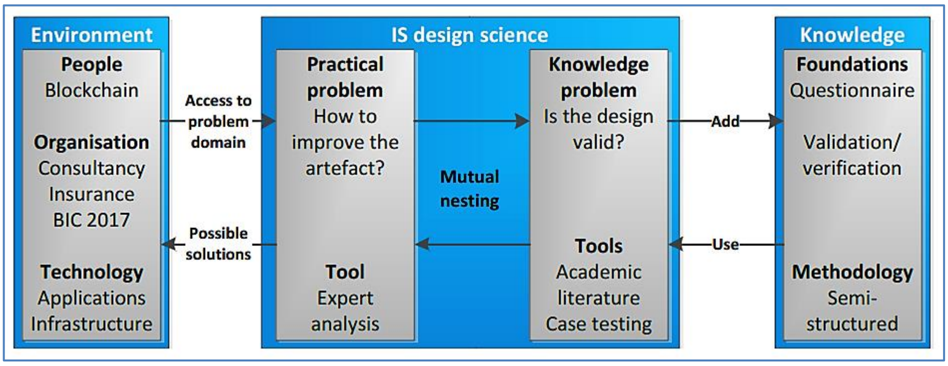

Figure 4.4: IS Research Framework, third iteration

4.3.1 Foundations

A research question is formulated in table 4.6 together with its keywords to find relevant information concerning the area of interest. The foundation concerning verification and validation is obtained in the previous iteration and is used in this iteration to validate the artefact.

Foundation, third iteration	
	Questionnaire
Research question	What are the best practices to be considered when making a questionnaire?
Keywords	Questionnaire Best Practices Design

Table 4.6: Foundation, third iteration

4.3.1.1 Questionnaire

As discussed in the previous iteration, a questionnaire should be a good mechanism to help the user group to use the expert system. It involves many, frequently iterative, steps of complex information processing.

'The process begins with the comprehension of the question and proceeds to the retrieval of relevant information from memory. Next, it involves a judgement and estimation process that is related to the respondent's motivation and preparedness to be truthful. Ultimately, the respondent's internally generated answer is matched to the response categories provided in the questionnaire'

(Lietz, 2010)

To minimize response errors, it is important to design questionnaire in accordance with best practices. These best practices are derived from experience and methodological research. Two main articles are used to summarise, evaluate and apply the best practices (Krosnick & Presser, 2010; Lietz, 2010). An overview of the best practices is shown in table D.14.

4.3.2 Tools

The goals, their accompanying research question and the requirements are represented in table 4.7. The goal and the research questions are derived from table 3.1 and the requirements are discussed below. The requirements of the case testing are derived from the academic literature of the second iteration.

Tools, third iteration		
	Expert analysis	**Case testing**
Goal	Research the relations between all contributing factors that determine appropriateness of a Blockchain use case	To verify and validate the model as a whole
RQ	RQ-II	-
Requirements	The group of respondents should consist of insurance employees and Blockchain consultants	Verification through anomalies
	The two groups should preferably be equally presented, but the insurance employees should cover at least a quarter of the respondents	Validation through case testing
	The number of respondents should range between the 10 and 30	

Table 4.7: Tools, third iteration

4.3.2.1 Expert analysis

The total number of participants in the expert analysis is seventeen of which seven are currently working in the insurance branch. An overview of the characteristics of the participants is presented in table D.15.

The findings of the expert analysis mainly concern the analysis of the business domain with the Technology Acceptance Model and the weights that each domain has on the Technology Acceptance Model. For the business domain, the two scenarios described in section 4.2.2.2 and shown in table D.8 & table D.9 are evaluated. Only one of the respondents preferred the scenario with two clusters, table D.8, and the others all preferred the three clusters of table D.9. The names given to each cluster are derived from the expert analysis and are in accordance with most of the participants. After this selection, the strength of the clusters on the two variables of the TAM are assessed. The overview is provided in table D.16. Furthermore, the weights of each domain on the TAM are assessed and provided in table D.17.

4.3.2.2 Simulation testing

As academic literature suggests in section 4.3.1.2, the verification could be done by logically searching for the anomalies (O'Keefe & Preece, 1996). This is done by testing the full range of each question of the questionnaire if its effect is calculative or by testing the full range of possibilities of combined questions of the questionnaire if its effect is rule-based, implying an IF-THEN-ELSE relation. The effect is shown both on each of the two variables of the TAM as on the other two constructs of the expert advisory, platform and business clustering strength.

The validation could be done through case testing as suggested by literature (O'Keefe & Preece, 1996). The validation on the two constructs of the expert advisory called platform and business clustering strength, is already validated through respectively literature from which the relations are derived and the 1:1 relation between efficiency & business clustering strength. Therefore, the validation only concerns the two variables of the TAM. To validate the perceived usefulness through case testing, several good use cases must be selected by experts and compared to a random set of normal use cases. To achieve this distinction, the use cases which are discussed at Europe's largest Blockchain conference, BIC 2017, are chosen as good use cases from experts in the industry. At this conference, several experts got the chance to show their most precious applications of Blockchain. A random set of the equal amount of use cases is chosen from the use cases gathered during the document analysis to evaluate the validity. To validate the perceived ease-of-use, it is chosen to also make two test sets. The same use cases are used to validate perceived usefulness as perceived ease-of-use. However, during the validation of perceived ease-of-use, the two sets are subdivided into difficult and easy to manage. Two experts with hands-on experience of a Blockchain platform subdivide these use cases into the two sets. With hands-on experience on a Blockchain platform, it is possible to assess the validity of perceived ease-of-use according to the expert system compared to the actual ease-of-use. The findings are thoroughly discussed in Chapter 6.

4.3.3 Concluding effects on the artefact

This iteration concerns the last foundational knowledge needed for the artefact, the area of questionnaires. The last relation between business and TAM is evaluated through an expert analysis and the artefact is built. This is furthermore verified and validated through simulation testing. Figure D.4 represents the artefact after the three iterations where the blue coloured parts are the added parts of this iteration and the grey-coloured parts are already assessed in previous iterations.

4.4 Summary

The overview of all participants is written as table D.18. In total 33 persons have participated in this research. Nine companies with a consultative function and six insurance companies were involved. The business/IT ratio has been 2:1. Some of the participants have participated in two of the three data collection measures, which are interviews, the focus group and the expert analysis, but none of them participated in all of them to get balanced results.

This chapter included a thorough description on the iterative process through which the information is collected to successfully build the artefact. Each artefact iteration is described by reporting its foundations and its tools. The goal, the requirements and the findings are provided of each iteration with a visual analysation of its effect on the designed artefact. The next chapter describes the artefact as a product, thus, explains the different parts of which it is created.

5. Artefact design, product description

The previous chapter explains the process perspective of the artefact whereas this chapter describes the artefact as a product. This chapter discusses the parts of the designed artefact without discussing its process which is described in Chapter 4. The artefact helps the business unit select the best possible use case for Blockchain. It is designed as an expert system. The basic idea behind expert systems is simply that expertise, which is the vast body of task-specific knowledge, is transferred from a human to a computer (Liao, 2005). First, the requirements, divided into functional requirements, user requirements, boundary conditions and design restrictions are listed in table E.2 (Van Aken et al., 2012). All assumptions and design choices made in the artefact are listed in respectively table E.3 and table E.4.

Design Choice 1: The expert system is partly calculative and partly rule-based

The calculative part is chosen for variables that contain a certain weight and therefore must be calculated. The rule-based part is chosen for variables that receive a classification and therefore has a more complex rule-based design.

Design Choice 2: The artefact can be subdivided into three distinct parts: being the input, 'brain' and the output

It is chosen to subdivide the artefact in three parts because it concerns three different interactions of components. The input is an active interaction with the user, in this case the business unit. The ´brain´ is an automated interaction of the expert system. The output is a passive interaction with the user, only showing results.

The artefact can be split up in three components as to be seen in figure 5.1, whereas the second component 'the brain' consists of the knowledge base and the inference engine. This chapter is described in accordance to these parts, using a forward chaining approach. This starts with the facts and works forward to the conclusions (Sydenham & Thorn, 2005), in our case from input to output. 'The forward chaining strategy is especially appropriate in situations where data are expensive to collect but few in quantity' (Sydenham & Thorn, 2005).

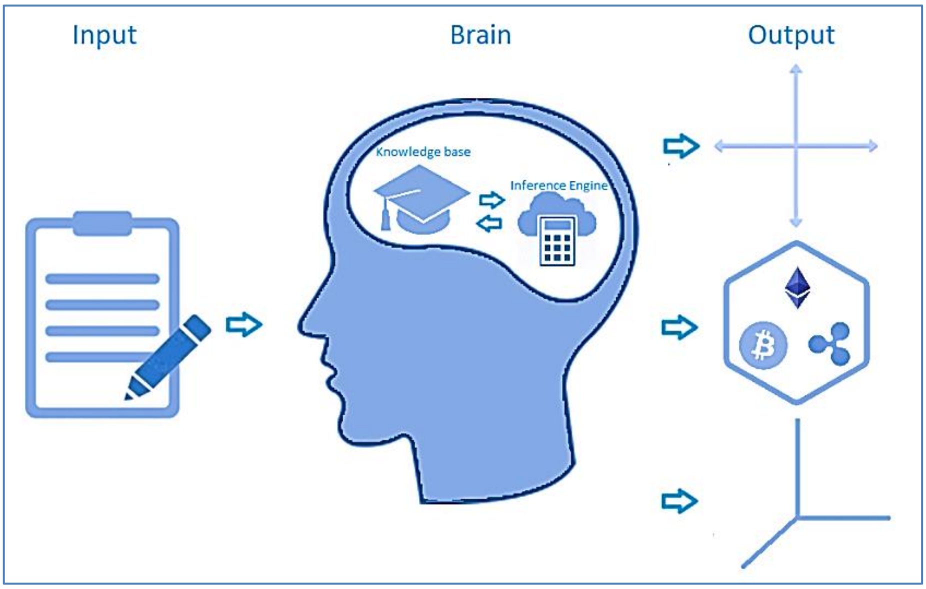

Figure 5.1: Artefact overview

5.1 Input

The input is a questionnaire containing twenty questions with a Likert-scale for weighted variables, implying a range of strongly agree to strongly disagree. The remaining four questions include a Boolean measure for categorical variables, implying a yes or no. This questionnaire is added as figure E.1 and E.2.

Design Choice 3: The input is obtained through a questionnaire

This is an easy and understandable mean of interaction. It is all in service of the conversation that takes place between researchers and respondents (Krosnick & Presser, 2010).

This questionnaire is academically researched through the best practices of two articles (Krosnick & Presser, 2010; Lietz, 2010) as discussed in chapter 4.

Design Choice 4: The Likert-scale is chosen for weighted variables

This scale is chosen because of the two following recommendations: 'A number of authors … report that between 5-point and 7-point scale response options are the most commonly used, with Dawes (2008) finding that 5- and 7-point scales can easily be rescaled to facilitate comparisons' (Lietz, 2010) and 'Many closed attitude measures are modelled after Likert's technique' (Krosnick & Presser, 2010).

Design Choice 5: A Boolean measure is chosen for categorical variables

A scale containing only yes and no is chosen for questions concerning categorical variables. This is chosen because there are no in between possibilities for the answers to these questions. Every answer excludes a possibility for categorisation.

Design Choice 6: The business unit with several use cases that needs an objective advice on selecting the best applicable use case for Blockchain, is the user group that provides the input

The business unit is selected because the business unit wants to get involved in this technological opportunity but needs help in selecting the best application for their business needs. This knowledge gap is also established in the systematic literature review.

5.2 Brain

The brain consists of two parts that are the knowledge base and the inference engine which define the core of the expert system (Hendriks & Vriens, 1999).

5.2.1 Knowledge base

The knowledge base is ´an active database with some form of ´formal knowledge´ about how the data may be used in practice' (Hendriks & Vriens, 1999). An overview of all constructs and components can be found in table 5.1. A class diagram is added in figure E.3. The top level is the academic framework, followed by the domains, constructs, components and the business factors.

Assumption 1: The systematic literature review contains all relevant constructs and components of the knowledge base besides the components of the business domain

Design Choice 7: The components of the business domain are derived from a document analysis

Design Choice 8: The level of analysis is set on the components

This level is set to reduce the complexity for data generation and the complexity of the research had to be restrained due to the six-month' time limit. Data collection was generally performed in a qualitative manner and in an early stage of the technology.

Assumption 3: To delve deeper into the antecedents of the components would not lead to better results due to the high uncertainty presented by the two given reasons described before.

Knowledge base		
Domain	**Construct**	**Component**
Technology	Trust	Trustworthiness
		Immutability
Business	Efficiency	Consolidation
		Flow transactions
		Single source of truth
Architecture	Openness	Public permissionless
		Public permissioned
		Private permissioned
	Generation	Blockchain 1.0
		Blockchain 2.0
Expert advisory	Technology Acceptance Model	Perceived usefulness
		Perceived ease-of-use
	Platform	Bitcoin
		Ethereum
		Ripple
	Business clustering strength	Consolidation
		Flow transactions
		Single source of truth

Table 5.1: Overview constructs and components

The constructs are derived from the BOAT-model or linked to expert advisory.

Design Choice 9: The BOAT-model is used to include all relevant aspects to research the strengths and weaknesses of Blockchain

Design Choice 10: The organisation domain is left out of the scope of this research

The business domain was not thoroughly researched in academic literature and the organisation domain was barely mentioned. Due to the six-month' restriction to this research, it is not feasible to thoroughly research both domains. Because Blockchain is a technology-push, the business domain is the logical next step to explore besides technology and architecture. Therefore, it is chosen to exclude the organisation domain from the scope.

5.2.1.1 Technology

According to academic literature, there are constructs related to technology. Table 5.2 provides these together with their components and in-/exclusion explanation.

Design Choice 11: Components related to the architecture are not considered in this construct

Blockchain in academic literature is defined as a public permissionless type. The other two types, public permissioned and private permissioned, are called distributed ledgers. To include all types, certain technological features are architectural related rather than technological related

Design Choice 12: The construct usability is not considered in this domain, because it differs per platform and is taken into consideration in the expert advisory domain

Each platform, thus Bitcoin, Ethereum, Ripple, has its own specifications regarding some technological features.

Design Choice 13: For the analysis of the best suited use case for Blockchain, factors that only regard the business case in terms of profit are not considered

Technology knowledge base			
Construct	**Components**	**Included**	**Additional explanation**
Trust	Trustworthiness	**Yes**	-
	Transparency	*No*	*Design Choice 11*
	Immutability	**Yes**	-
Security	-	*No*	*Design Choice 11*
Usability	*Latency*	*No*	*Design Choice 12*
	Throughput	*No*	*Design Choice 12*
	Wasted resources	*No*	*Design Choice 13*
	Scalability	*No*	*Design Choice 11*
	Interoperability	*No*	*Design Choice 11*
Privacy	-	*No*	*Design Choice 11*

Table 5.2: Technology knowledge base

5.2.1.2 Business

The constructs derived from the systematic literature review and related to business are listed in table 5.3. Efficiency is divided into consolidation, flow transactions and single source of truth.

Business knowledge base			
Construct	**Components**	**Included**	**Additional explanation**
Efficiency	Consolidation	**Yes**	-
	Flow transactions	**Yes**	-
	Single source of truth	**Yes**	-
Intermediary	*Replacement*	*No*	*Design Choice 14*
	Supervision	*No*	*Design Choice 14*
Cost saving	-	*No*	*Design Choice 13*
Regulation	-	*No*	*Design Choice 10*
Other threats	*Limits competitiveness*	*No*	*Design Choice 15*
	Illegal activities	*No*	*Design Choice 15*

Table 5.3: Business knowledge base

Design Choice 14: The construct of the business domain 'role of the intermediary' is excluded from the knowledge base

During the research, there has been numerous discussion about this role. Proponents of replacement argue that Blockchain eventually will replace third parties. Opponents argue that some form of third party will always reside perhaps with a smaller role. Therefore, this is excluded.

Cost saving is related to the business case and therefore not considered.

Assumption 4: Regulation is related to the organisation rather than the business domain and therefore not considered in accordance with Design Choice 10

Regulation is nation-specific, industry-specific and company-specific and therefore a part of the organisation domain.

Assumption 5: Constructs related to national concerns are not relevant for the chosen user group of this artefact, that is the business unit

Design Choice 15: In accordance with assumption 5, the construct of the business domain 'other threats' is excluded from the knowledge base

The limitation of competition or the possibility of illegal activities are concerns of national and international institutions rather than private companies.

5.2.1.3 Architecture

Table 5.4 represents the constructs related to the architectural domain. The first construct includes openness, also known as the type of Blockchain. Secondly, generation is included whereas Blockchain 1.0 regards the transactional use of Blockchain like Bitcoin. Blockchain 2.0 represents the inclusion of smart contracts and Blockchain 3.0 represents the path towards a new digital society.

Design Choice 16: The components 'Blockchain 1.0' and 'Blockchain 2.0' are included whereas the component 'Blockchain 3.0' is excluded

Blockchain 1.0 and Blockchain 2.0 are concrete uses for Blockchain with its own different kinds of platforms, involved communities and differences in functionalities. Blockchain 3.0 is a vision of the direction Blockchain can take place soon. Therefore, it is not applicable now and not considered.

At the time of writing it is not possible to choose the consensus protocol because this is dependent on the choice of platform. Therefore, Design Choice 12 is applied.

Architecture knowledge base			
Construct	**Components**	**Included**	**Additional explanation**
Openness	Public permissionless	**Yes**	-
	Public permissioned	**Yes**	-
	Private permissioned	**Yes**	-
Generation	Blockchain 1.0	**Yes**	-
	Blockchain 2.0	**Yes**	-
	Blockchain 3.0	*No*	*Design Choice 13*
Consensus protocol	*Proof-of-Work*	*No*	*Design Choice 12*
	Proof-of-Stake	*No*	*Design Choice 12*

Table 5.4: Architecture knowledge base

5.2.1.4 Expert advisory

This domain has several constructs.

Design Choice 17: The Technology Acceptance Model is chosen to evaluate the use cases based on academic terminology

This choice is further elaborated upon in Chapter 4.

Design Choice 18: The construct 'platform' is included in the knowledge base as part of the expert advisory domain

An often-mentioned knowledge gap exists between the business unit and the IT department, according to the respondents. To help translate the wishes of the business unit towards a technological decision, an automated technological advice on platform is included into the expert system.

Platforms, sometimes referred to as protocols, are defined as the chosen set of rules which reflects the user requirements the best. A simplified overview of the main platforms is provided in table 5.5.

Platform overview				
		Bitcoin	**Ethereum**	**Ripple**
Usability	Latency	600 seconds	7 seconds	>4 seconds
	Throughput	3 transactions per second	15 transactions per second	1000 transactions per second
Architecture	Openness	Public	Public & private	Private
	Generation	Blockchain 1.0	Blockchain 2.0	Blockchain 1.0

Table 5.5: Platform overview

Assumption 6: Only platforms that apply a cryptocurrency are regarded as Blockchain platforms

Cryptocurrency is a key characteristic of Blockchain as discussed in the systematic literature review. Without a cryptocurrency, it is impossible to be developed into a decentralised ledger because an entity is then in charge of (certain functionalities of) the Blockchain records. This is also regularly mentioned by the respondents. Platforms that have no possibility to be interoperable to a public Blockchain because it is not a decentralised ledger are therefore excluded, like IBM Hyperledger, Corda or R3.

Design Choice 19: The included platforms are Bitcoin, Ethereum and Ripple

This selection is made because they are the three biggest platforms that entail all the possibilities with regards to the constructs of the architecture domain.

Table 5.5 shows the most important features of the platform and figure 5.2 represents the market cap of the top 5 platforms (Van Hemelen & Winderickx, 2016; Ethereum Stackexchange, 2017; Bitcoin Stackexchange, 2017; Ripple, 2017). There are at the time of writing over 800 cryptocurrencies and the chosen three platforms have a total market cap of over 75 percent.

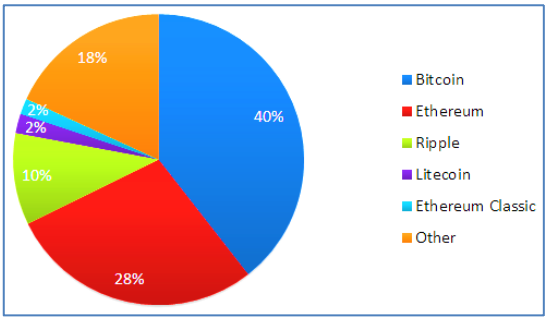

Figure 5.2: Overview top 5 platforms according to their market gap

Assumption 7: The type of Blockchain and the use of Blockchain are the most important characteristics and therefore other platform characteristics like latency and throughput are excluded

Design Choice 20: The construct 'business clustering strength' is included in the knowledge base as part of the expert advisory domain

Business clustering strength is defined as the relative strength of the use case according to the three given clusters of the preliminary use case analysis. These are named consolidation, flow transactions and single source of truth. This expert advisory construct delivers a business advice

5.2.2 Inference engine

The inference engine defines the ways in which the knowledge base may be used (Hendriks & Vriens, 1999). All the constants, variables and formulas are listed as an overview in figure E.4.

Design Choice 21: The inference engines are split in three distinct parts related to the three constructs of the expert advisory domain

The Technology Acceptance Model helps answering the question which use case should be selected. Platform and business clustering strength provide deeper insight into the use case in terms of recommendation of where to build it and what the added value of the use case is to the business unit. Because these three constructs all help the business unit in a different way, it is chosen to split up the inference engines related to these three constructs.

Assumption 8: If an expert system provides additional knowledge concerning the use case, the trust in the outcome for the selection of the use case is enhanced

The part concerning the construct TAM answers the described problem statement. The parts concerning platform and business clustering strength are both complementary. These help the business unit which platform to select, thus reduces the knowledge gap between the business unit and the IT department as discussed before. Also, it improves the understanding of the added value of the use case for Blockchain when giving the business clustering strength.

To make the relations more focused on insurance, several measures are taken.

Assumption 9: A sample size of 33 participants during data collection of which one-third worked in the insurance sector is sufficient to withdraw insurance-specific data for the expert system

Design Choice 22: The data collected for the constructs trust, openness and generation do not receive a correction to make the model more specific for the insurance branch

Approximately 33 percent of the 33 respondents is working in the insurance branch and most of the other respondents is working cross-sectorial. Since the respondents working in the insurance sector are highly represented in the respondents' size and the respondents' size is not big enough to properly analyse the difference between insurance and non-insurance respondents, it is chosen that an insurance-specific correction factor does not enhance the model for the constructs trust, openness and generation.

Assumption 10: A sample size of over 100 use cases of which 25 percent was related to the insurance sector is not sufficed to establish an expert system for the insurance sector

Design Choice 23: The data collected for the construct efficiency do receive a correction to make the model more specific for the insurance branch

In the construct efficiency, it is possible to derive an insurance-specific correction factor that improves the model. This is mainly because the sample size, which is over 100 use cases, is large enough to analyse differences.

5.2.2.1 Technology Acceptance Model

The relations with the TAM are represented by table 5.6 and figure E.5 represents a drawn overview. A positive relation is visualised by a plus in table 5.6, whereas a plus/minus represents a neutral relation and a minus represents a negative relation between the constructs. The effect of trust, openness and generation on the Technology Acceptance Model are derived from the interview. For instance, the higher the components of trust are applied to the use case, the higher the score on perceived usefulness is but it has no effect on the perceived ease-of-use. The first is explained through the full usage of the technological advantages of trustworthiness and immutability, leading to a higher perceived usefulness. There is no effect on perceived ease-of-use because Blockchain always consists of these advantages, if you use it, does not affect the perceived ease-of-use. Because the components of efficiency were not established by then, these relations are derived from the expert analysis.

Technology Acceptance Model			
		Perceived usefulness	**Perceived ease-of-use**
Trust	*Trustworthiness*	+	**No effect**
	Immutability	+	**No effect**
Efficiency	*Consolidation*	+	+/-
	Flow transactions	+/-	-
	Single source of truth	+	+
Openness	*Public permissionless*	+/-	-
	Public permissioned	+/-	+
	Private permissioned	-	+
Generation	*Blockchain 1.0*	+/-	+
	Blockchain 2.0	+	-

Table 5.6: Technology Acceptance Model inference engine

The weights of these relations are derived from the expert analysis where the weights of the different domains are discussed as well as the underlying constructs. Table 5.7 provides an overview of these weights. Since trust has no effect on perceived ease-of-use, the other weights are altered. These weights are used to determine the maximum range of the score of each construct. Furthermore, it provides a deeper insight in the importance of each construct on the variables of the TAM.

Weights constructs				
	Technology	**Business**	**Architecture**	
Expert analysis	24.6%	50%	25.4%	
Rough estimate	25%	50%	25%	
Constructs	*Trust*	*Efficiency*	*Openness*	*Generation*
Weights in general	25%	50%	15%	10%
Weights PU	25%	50%	15%	10%
Weights PEOU	0%	67%	20%	13%

Table 5.7: Weights constructs

Table E.4 represents the business logic for trust on perceived usefulness and perceived ease-of-use. Both technological components are weighted equally within the construct and have a scale ranging from 1 to 5 whereas 1 represents a weak relation and 5 a strong one in accordance with the chosen Likert-scale in the input. Figure E.6 represent the calculative rules of trust.

To evaluate the efficiency construct on perceived usefulness and perceived ease-of-use, first the effect is analysed using the data of all industries. As discussed earlier, after this, it is corrected through an insurance-specific factor.

Assumption 11: To assess the strength of each business factor underlying the efficiency components, their predictor importance is used

Starting with all industries, the predictor importance on the factors within each component, acquired by the cluster analysis, is used to classify the strength of each component. These strengths per component are related to perceived usefulness and perceived ease-of-use, acquired through the expert analysis. Table E.6 provides an overview of the strength of each factor on the component and table E.7 provides an overview of the strength of each component on perceived usefulness and perceived ease-of-use.

The strength of each factor must be corrected for the insurance sector. The difference between sectors is corrected by applying an insurance-specific correction of table E.9. The relative strength is used to ensure that the boundaries on perceived usefulness and ease-of-use are maintained. For consolidation, the summarised effect is 0.99 instead of 1.

Design Choice 24: If the summarised effect of consolidation is 0.99 instead of 1 through a rounding error, it is not corrected

It is a design choice not the correct it by adding 0.01 to one factor. This is chosen since the factors still have a summarised strength within the boundaries and adding 0.01 to any factor decreases the model's effectiveness.

Table E.10 represents the aggregated effect of the three components on perceived usefulness and perceived ease-of-use. The calculative rules are put in figure E.7. The relation between openness and the two variables of the TAM are easier to describe since it is a classification instead of a weighted value. Table E.11 shows the reasoning behind the values and table E.12 provides an overview. The relation regarding generation is comparable to openness, because it is also a classification category. Table E.13 shows the reasoning whereas table E.14 provides the overview.

5.2.2.2 Platform

This inference engine looks at the relations between the architecture domain and the platform, thus the constructs openness, generation and platform. Table 5.8 represents the schematic overview whereas figure E.8 represents a drawn overview. These relations are based on table 5.5.

Inference engine 2				
		Platform		
		Bitcoin	*Ethereum*	*Ripple*
Openness	*Public permissionless*	**X**	**X**	
	Public permissioned	**X**	**X**	
	Private permissioned		**X**	**X**
Generation	*Blockchain 1.0*	**X**		**X**
	Blockchain 2.0		**X**	

Table 5.8: Inference engine 2

As can be seen in table 5.8, the constructs openness and generation are of a classifying nature. This means that every use case falls into one of the three categories of openness and one of the two of generation. Table E.15 translates the previous table into business logic.

5.2.2.3 Business clustering strength

The third engine represents the relation between efficiency and business clustering strength. This is a direct effect between the three components of each. Table 5.9 represents the schematic overview whereas the drawn overview is added in figure E.9.

Inference engine 3				
		Business clustering strength		
		Consolidation	*Flow transactions*	*Single source of truth*
Efficiency	*Consolidation*	**X**		
	Flow transactions		**X**	
	Single source of truth			**X**

Table 5.9: Inference engine 3

In general, the formula to calculate the strength of each of the three components of business clustering strengths is to be seen in figure E.10 and figure E.11.

5.3 Output

There are three different outputs represented each according to their inference engine.

Design Choice 25: The outputs are represented in three distinct parts each showing a result of a different inference engine

As said before, the three distinct inference engines all answer a different question. Therefore, this information is provided separately. Another remark is that the output is a required visualisation that suits the user the best. Therefore, this is also chosen in accordance with the respondents.

In this chapter, the three outputs relative to their inference engine are discussed. Figure 5.3 shows a possible sketch of the three different outputs. All outputs are chosen through consideration of experts and users.

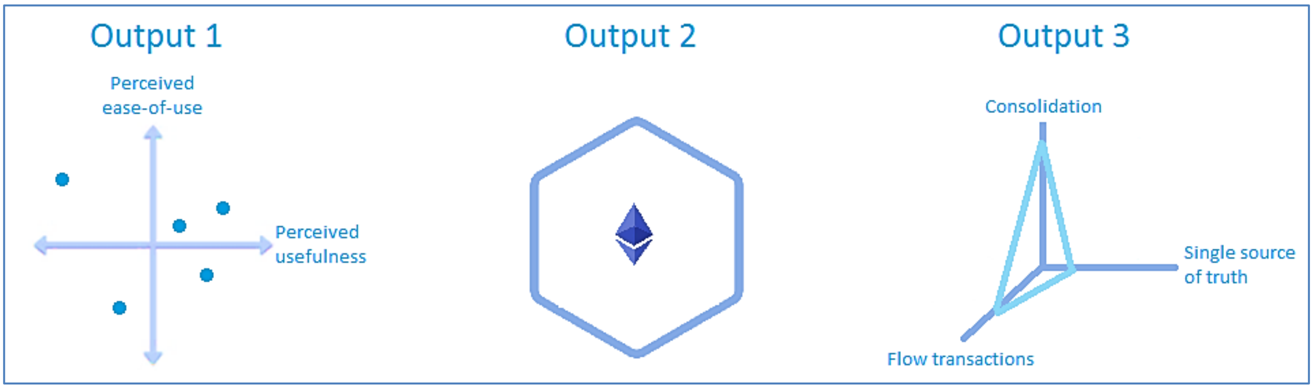

Figure 5.3: Overview outputs

5.3.1 Output 1

It is chosen to represent the values of the Technology Acceptance Model along two axes on a two-dimensional classification scheme.

Design Choice 26: The first output is represented on a two-dimensional classification scheme with the two variables of TAM on the two axes

The respondents which represent possible users preferred this type of visualisation of the results.

The output values represent a point on the two axes. The technology is in an early stage, subject to high uncertainty concerning the successfulness of use cases. Therefore, it is an advice to use the tool to assess the relative perceived usefulness and relative perceived ease-of-use of multiple use cases. Therefore, it is chosen in figure 5.3 to represents several points indicating several use cases.

5.3.2 Output 2

Output 2 is related to table E.7 where a technological advice concerning the platform is given as output. As said earlier, only Bitcoin, Ethereum and Ripple are considered and in this example, the advice is Ethereum. This means that the use case is a Blockchain 2.0 type. This is the advice for a single use case and the three different representations of the platforms are listed below in figure 5.4.

Design Choice 27: The second output is represented by an image that represents the given output

The respondents which represent possible users preferred this type of visualisation of the results.

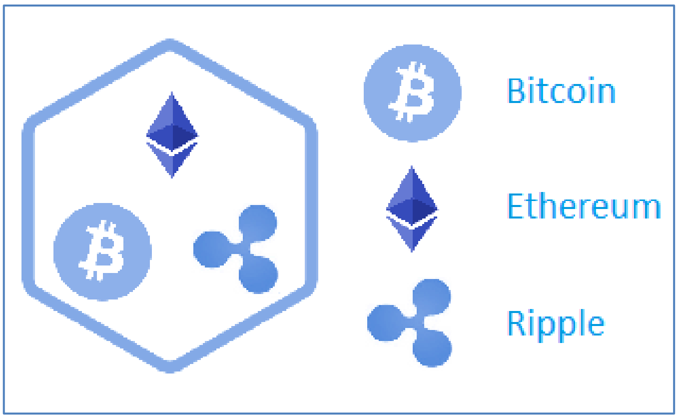

Figure 5.4: Platform overview

5.3.3 Output 3

Output 3 is related to table E.8 where the business advice concerning the business clustering strength is given as an output, specified per component. The components are consolidation, flow transactions and single source of truth. This strength is represented in a three-dimensional graph.

Design Choice 28: The third output is represented by a three-dimensional graph containing the three components on the axes

The respondents which represent possible users preferred this type of visualisation of the results.

5.4 Summary

This chapter described the artefact as a product. The three separate parts of the artefact are discussed that are the input, the brain and the output. All relevant design choices and assumptions are provided and explained. Furthermore, the most important parts of the brain are thoroughly discussed that are the information in the knowledge base and the relations between them. The next chapter provides information concerning a first verification and validation on the artefact.

6. Artefact validation

In this chapter, the artefact is checked in terms of verification and validation. As described in Chapter 4, two methods are chosen to research these areas. Anomalies are investigated for verification purposes and case testing is applied for validation purposes. There are three different outputs generated as explained in chapter 5. It is assumed that the validation of the second and third output is already established because the relations of the second output are withdrawn from academic literature & industry research and the relations of the third output are directly interacting in a 1:1 relation as shown in figure E.9. Therefore, these relations are only verified and not validated. Furthermore, in general, each section follows the same order. It stars by describing the goal, followed by the plan and concluded with the findings.

6.1 Verification

'Verification is building the system right' (O'Keefe et al., 1987). Therefore, the goal of verification is aimed at eliminating errors in the system. The errors are already defined as anomalies, which can be conflicts, redundancies and deficiencies. The plan is to check every possibility as an input to the expert system and analyse the given range of results. This should lead to the discovery of possible anomalies and the range can be compared to the range of the formulas, as written down in Chapter 5. The first twenty input questions are calculative which implies that they provide a numerical range of output independently from other input. Besides, these questions all relate to the technology and business domain. The last four input questions are rule-based which implies that they act as certain scenarios depending on input of multiple questions. Also, these questions all relate to the architecture domain. Because these inputs have a different way of calculating, a slightly altered manner of verification is needed. The overall verification phase entails the overview of all the constructs.

6.1.1 Calculative

The calculative input of the first twenty questions, as can be found in figure E.1, is explored by checking the range of possibilities per question on the two variables of the Technology Acceptance Model. These are then aggregated to the level of the components.

The values containing the range of the calculative questions are shown in table F.2. Figure F.1 shows the output per question on perceived usefulness and perceived ease-of-use. In general, the range should be equally distributed around the zero with an equally low minimum as high maximum. As figure F.1 shows, this can be verified. The first seven question entail the trust domain of which formula 1 of figure E.4 encloses the according formula and table E.5 represents an overview. This formula is set on the component level and the total range of the first four questions should be twice the range of the formula. This is because the business domain has two components each with the range belonging to formula 1 of figure E.4. Thus, the range of the first seven questions should be between the -12.5 and 12.5 on the perceived usefulness and a zero range on perceived ease-of-use. This is correct; thus, these seven questions are verified. The sequential 13 questions are derived from the relations between the business domain and the TAM. This should be in accordance with formula 2 of figure E.4 and table E.10 represents the overview. The formula is set on the factor level and can be verified per question. The ranges of question 13 to 20 shown in table F.2 are in accordance with the ranges of table E.10, therefore these questions can also be verified.

These questions are aggregated in table F.3 and figure F.2. First verification is that the range should be equally distributed which it is. Second verification is that the aggregated minimum and maximum should comply with the rules of Chapter 5. Table E.5 shows the overview of the trust-related components and table E.7 shows the overview of the business-related components. These are verified although some minor differences exist between the produced output and the theoretical output. However, this difference is 1 percent or lower, which can be explained by rounding inaccuracies.

6.1.2 Rule-based

The rule-based input of the last four questions, as can be found in figure E.2, is explored by checking the range of possibilities per scenario on the two variables of the Technology Acceptance Model. These are then aggregated to the level of the components.

Question 21 & question 22 are interdependent and questions 23 & question 24 are interdependent. The input is Boolean; therefore, two times four scenarios exist in this expert system. Question 21 & question 22 both comprises the component openness whereas question 23 & question 24 concern the component generation of the architecture domain.

Table F.4 represents the overview of the scenarios which implies the input of which question whereas table F.5 represents the according values to perceived usefulness and perceived ease-of-use. These are also shown in figure F.3 as a graph. The values of the first four scenarios must be in the range predetermined by table E.11 and the values of the second four scenarios must be in the range predetermined by table E.12. They both apply to this condition; therefore, the range is verified. However, an important anomaly is discovered. Question 23 is considered a redundancy, this implies that it ‘refers to the presence within the system of logically-unnecessary structures which never affect the relationship between the input and output of the system’ (O'Keefe & Preece, 1996). Whatever input is provided for question 23, the output is not affected. This is a chosen anomaly because it has a psychological effect on the input rather than a numerical effect. The question is put in place to clarify the difference between question 23 and question 24 without giving question 23 meaning in the expert system. Because this goal is still considered useful, it is chosen not to remove this redundancy.

The scenarios are aggregated into the five components related to the architecture domain. The range of each scenario is already verified. Each component is derived from one or two scenarios, implying that the range of each component is also verified. Table F.6 represents an overview of the effect of each component on the two variables of the TAM whereas figure F.4 shows a graphical overview. The values are in accordance with table E.11 and table E.12, therefore, these values can be verified.

6.1.3 Overall

First, the aggregated results of the relations between the constructs and the two variables of the TAM are provided. Thereafter, the overall verification with regards to the second and third output are discussed.

F.6 represents the numerical overview of the constructs on perceived usefulness and perceived ease-of-use whereas figure F.5 represents a graphical overview. An overview of the ranges according to the weights given in Chapter 5 is presented in table 6.1. The first three rows are derived from table 5.7. The actual ranges are derived from table F.7. Then the weights are adjusted to compare the actual ranges to the predetermined weights. At the level of perceived usefulness, in general, the trust construct has a much higher influence than predetermined whereas the constructs openness and generation has a much lower influence. At the level of perceived ease-of-use, the construct efficiency has a much lower influence than predetermined whereas the constructs openness and generation has a much higher influence. Overall, the differences are much smaller between the predetermined weight and the actual range. The construct trust has had a bit less influence than predetermined and the constructs openness & generation had a bit higher influence.

Verification, weights of constructs				
	Construct			
	Trust	*Efficiency*	*Openness*	*Generation*
Predetermined range overall	25	50	15	10
Predetermined range PU	25	50	15	10
Predetermined range PEOU	0	67	20	13
Actual range PU	25	33.15	3.75	2.5
Actual range PEOU	0	22.24	15	10
Actual range overall	12.50	27.70	9.38	6.25
Actual range PU %	38.82	51.48	5.82	3.89
Actual range PEOU %	0	47.08	31.75	21.17
Actual range overall %	19.41	49.28	18.79	12.53
Difference PU	+13.82	-1.48	-9.18	-6.11
Difference PEOU	0	-19.92	+11.75	+8.17
Difference overall	**-5.59/5,59%**	**-0.72/0,72%**	**+3.79/3,79%**	**+2.53/2,53%**

Table 6.1: Verification, weights of constructs

Output two is only affected by the rule-based questions, the last four. Table F.8 represents the sixteen scenarios whereas table F.9 compares the predicted versus the actual outcome. As table F.9 shows, all possible scenarios comply with the predetermined output of chapter five. In summary, if question 24 is yes then we need Blockchain 2.0, then Ethereum is advised. If question 24 is no, then it depends if we want a private Blockchain or a public permissioned/permissionless which depends on question 21. Thus, if question 24 is no and question 21 is yes, then Ripple is advised. Otherwise, Bitcoin is advised. Concluding, the relations underlying output two are verified.

Output three reflects the relation between the construct efficiency and the business clustering strength. The model should provide a summarised maximum effect of 1 on each business cluster that is consolidation, flow transactions and single source of truth. The added effect of each input related to the construct efficiency should be in accordance with table E.9. Table F.10 shows the numerical overview of this verification whereas figure F.6 provides us with a graphical overview. Table F.10 is in accordance with table E.9 therefore, this last part of the model is verified.

6.2 Validation

'Validation is building the right system' (O'Keefe et al., 1987). Therefore, it is concerned with the quality of the system, 'the extent to which it performs its tasks, the degree of accuracy, and the observed robustness' (O'Keefe & Preece, 1996).

The stakeholder goal of the tool should be validated in this section. It should guide client of CGI to start with Blockchain. As described in the problem context, the decision-making on the selection of the best possible Blockchain use case is the main hurdle for the clients to start with Blockchain. Therefore, it should be validated that the score of the use case provides a valid advice. The score is determined through the two axes of the TAM. Both academic literature as discussions with the stakeholders determined that the two axes, perceived usefulness and perceived ease-of-use, are the two main variables to decide to start with a Blockchain use case.

As suggested, the most prevalent method of validation is case testing. Therefore, for perceived usefulness, the use cases of the Blockchain Innovation Conference are measured against a random set of other use cases. As for perceived ease-of-use, the set of use cases from the Blockchain Innovation Conference and the random set of other use cases are rearranged in terms of perceived ease-of-use beforehand and compared with the system.

6.2.1 Perceived usefulness

The use cases from the Blockchain Innovation Conference 2017 are chosen as the successful use cases for case testing. An equal set of random use cases is generated from the use cases derived during the document analysis iteration. A short summary of each use case is provided in table F.11. To decrease the threats of validity, the use cases are entered into the system by two experts. The average is chosen as means of comparison. It is concluded that this phase of validation seems to give a satisfying outcome and that success is mostly determined through the use cases' reliance on the technological features of Blockchain. Furthermore, the abbreviations of platform E, R, and B are respectively Ethereum, Ripple and Bitcoin. Other abbreviations can be found in figure E.4.

As figure F.7 shows, the expert set seems to show a significant difference with the random set in terms of perceived usefulness. None of the use cases of the expert set are below zero in perceived usefulness whereas more than a quarter of the use cases of the random set is. Furthermore, more than a quarter of the use cases of the expert set has a higher perceived usefulness than the best use case of the random set. The average of the expert set is almost at the level of the use case of the random set with the highest perceived usefulness. To delve into more details, table 6.2 summarises the averages of the two sets whereas table F.12 shows the details per use case.

Validation perceived usefulness, average results				
	Expert set	**Random set**	**Absolute difference**	**Difference on total range**
Perceived usefulness	14.63	5.45	9.18	14.25%
Trust	6.28	0.55	5.73	22.92%
Trustworthiness	3.04	0.43	2.61	20.88%
Immutability	3.24	0.12	3.12	24.96%
Efficiency	8.77	5.87	2.89	8.72%
Consolidation	0.79	0.74	0.05	5.00%
Flow transactions	0.64	0.54	0.09	9.00%
Single source of truth	0.74	0.61	0.12	12.00%
Openness	56% Pr; 22% PPs; 22% PPd	78% Pr; 22% PPs	-22% Pr; 22% PPd	-22% Pr; 22% PPd
Generation	67% B2.0	78% B2.0	11% B2.0	11% B2.0
Platform	67% E; 33% R	78% E; 11% R; 11% B	-11% E; 22% R; -11% B	-11% E; 22% R; -11% B

Table 6.2: Validation perceived usefulness, average results

The average score of each set is provided in table 6.2. The absolute difference between the two sets is 9.18 in perceived usefulness, which can be translated to a difference of 14.25 percent on the total range. In general, the expert set scores a bit higher in the categories of efficiency but in openness and generation, the score is roughly equal. The most interesting finding of this validation phase, is that the expert set consists of use cases that are far more applicable to the technological features of Blockchain. Both on the constructs trustworthiness as immutability, the expert set scored over 20 percent difference on perceived usefulness. However, it is only a small sample size and thorough statistical advice is not feasible. This merely provides directions of further research.

6.2.2 Perceived ease-of-use

Two experts with hands-on experience on a Blockchain platform are asked to categorise the use cases and subdivide it into two sets of use cases in terms of difficulty. These two sets are compared to validate the perceived usefulness with an overview of the two sets in table F.13. Concluding, this phase of validation seems to give a satisfying outcome and that ease-of-use is mostly determined by the architectural aspects of Blockchain like openness and generation. As figure F.8 shows, the difficult set seems to show a significant difference with the easy set in terms of perceived ease-of-use. Half of the use cases of the difficult set has a lower score in perceived ease-of-use than the use case of the easy set with the lowest score in perceived ease-of-use. Also, over half of the use cases of the easy set have a higher score in perceived ease-of-use than the use case of the difficult set with the highest score in perceived ease-of-use.

Validation perceived ease-of-use, average results				
	Difficult set	**Easy set**	**Absolute difference**	**Difference on total range**
Perceived ease-of-use	-0.92	13.17	-14.09	-29.78%
Trust	0	0	0	0%
Trustworthiness	0	0	0	0%
Immutability	0	0	0	0%
Efficiency	-0.18	2.06	-2.24	-10.07%
Consolidation	0.81	0.72	0.09	9.00%
Flow transactions	0.66	0.52	0.14	14.00%
Single source of truth	0.64	0.71	-0.06	-6.00%
Openness	44% PPs; 33% PPd; 22% Pr	100% Private	44% PPs; 33% PPd; -77% Pr	44% PPs; 33% PPd; -77% Pr
Generation	89% B2.0; 11% B1.0	56% B2.0; 44% B1.0	33% B2.0; -33% B1.0	33% B2.0; -33% B1.0
Platform	89% E; 11% B	67% E; 33% R	22% E; -22% R	22% E; -22% R

Table 6.3: Validation perceived ease-of-use, average results

To delve into more details, table 6.3 summarises the averages of the two sets whereas table F.14 shows the details per use case. There is a difference of almost 30 percent of the total range between the difficult and the easy set. One could argue that use cases in the cluster flow transactions could lead to a lower perceived ease-of-use but this would remain a hypothesis. An important difference is in the construct openness. The difficult use cases often needed a PPs Blockchain whereas an easy use case would be best in a Pr environment. This could indicate that the construct openness was considered important to determine perceived ease-of-use. The difficult cases were almost always B2.0. The easy use cases were far more diverse. This also seems to show that B2.0 is associated with more difficult use cases whereas B1.0 are more associated with easy use cases.

6.3 Summary

The model has been verified and only one anomaly has been found, which is placed there for a reason. Furthermore, it seems to be that the model shows a significant difference in the validation phase between the expert set and the random set, but also between the difficult and the easy set, relatively in terms of perceived usefulness and perceived ease-of-use. However, more validation is recommended.

7. Conclusions

This chapter contains the most important findings for this research. The research questions are answered, followed by a reflection on the work, and concluded with the limitations and recommendations.

7.1 Research questions

The research questions are derived from the design problem:

'Improve the decision-making on Blockchain use cases for the insurance branch by developing an intelligent tool such that it can provide an objective analysis of possible use cases to help understand the factors underlying the appropriateness of Blockchain and to help guide clients of CGI in starting a Blockchain project'

A designed artefact had to be made, in this case, an expert system is chosen as an intelligent tool. The next section provides answers to the two research questions to help build this artefact.

7.1.1 Research question 1

The research question includes the following:

What are the factors that determine the appropriateness of a Blockchain use case?

Table 5.1 provides an overview of the variables in the knowledge base, thus an overview of the contributing factors. The domains are derived from the BOAT-model or the expert advisory domain.

Technology consists of the construct trust, which can be further divided into trustworthiness and immutability. Business consists of the construct efficiency, which is categorised into three clusters that are consolidation, flow transactions and single source of truth. Architecture consists of openness and generation. The first includes the components public permissionless, public permissioned and private permissioned. The second includes Blockchain 1.0 and Blockchain 2.0 as its components. The organisation domain is excluded from the research scope.

The expert advisory consists of the constructs Technology Acceptance Model, platform and business clustering strength. The first is measured through two components that are perceived usefulness and perceived ease-of-use. The second is a technological advice that includes Bitcoin, Ethereum and Ripple as its components. The third is a business advice that consists of the same components as the efficiency construct, which are consolidation, flow transactions and single source of truth.

In general, the answer to the question is mainly answered using the BOAT-model without including the organisation domain and the TAM. Some components of the domains are not included due to design choices or assumptions listed in Chapter 5. To delve deeper in the fourth domain and to include more components both in the three domains as the antecedents of the TAM is recommended.

7.1.2 Research question 2

The research question includes the following:

What are the relations between the factors that determine the appropriateness of a Blockchain use case?

Table 5.6 provides an overview of the relations between the BOAT-model and the TAM. The constructs of the BOAT-model are relatively positively related to the perceived usefulness. Trust had no relation with perceived ease-of-use, whereas efficiency, openness and generation depend on its components.

Also, there is a relation between the architecture domain that are the constructs openness and generation, and platform, to be found in table 5.8. These relations are not weighted but categorical. If the generation component is Blockchain 2.0, then Ethereum is related. If Blockchain 1.0 is the generation component and private permissioned is the openness component, then Ripple is related. To the other possibilities is Bitcoin related.

Furthermore, the relation between the efficiency construct and the business clustering strength construct can be found in table 5.9. The relations between the components are also categorical in which consolidation is related to consolidation, flow transactions is related to flow transactions and single source of truth is related to single source of truth, with the first component of the efficiency construct and the second component of the business clustering strength construct.

In general, all relations between the factors are assessed and determined. However, this is mainly done through qualitative methods, which could lead to imprecise relations. Quantitative methods and thoroughly testing would lead to better results and is recommended.

7.2 Method and process review

In this section, a reflection is given to discuss the differences between the proposed plan and the actual outcome. In terms of chapters, this is the comparison of Chapter 3 to Chapter 4. The outline of this section is comparable to Chapter 4. First, a general evaluation is given about the used frameworks. Secondly, the foundations of this research are discussed. Thirdly, the tools of the research are discussed together with its environment.

7.2.1 General method

In general, the chosen frameworks of Chapter 3 are not only successful but even necessary to create a thoroughly designed research. These frameworks are successful as it forced the researcher to clearly establish a research approach with the required business needs and foundations of each iteration beforehand. This led to a structured approach in the collection of data that can be used for the designed artefact. The combination of these two frameworks is recommended to be used in other research.

Two frameworks are used to obtain a structural plan for this design research which are the design cycle and the IS Research Framework (Wieringa, 2009). The first is used to provide a thorough understanding of the progress of the designed artefact. To further zoom into the different aspects needed during those phases, the IS Research Framework is used. In this framework, the chosen environment and knowledge base influencing the IS Research provides a solid understanding of the business needs and applicable knowledge needed to build a successful artefact. By describing the differences at each phase and applying it to the design cycle, it provides an understanding in what is needed and how it can be obtained. This structured process with different levels of zooming in and out, is proved to be highly successful to determine a thorough research plan. Combining the two frameworks has been successful and can be recommended.

However, this structured plan of the IS Research Framework to be found in figure 3.3, was created after the interviews. It was not possible to create this structured plan earlier to guarantee an open vision in this research project. This input together with the input of the stakeholders was required to establish the designed artefact and a structured plan towards it.

Also, another part is advised to look after at an earlier stage. At the second iteration, the first foundation concerning expert systems was derived, due to the slight delay in the structured plan together with this relatively late knowledge acquisition concerning expert systems, figures D.1, D.3 and D.4. To show the progress of the entire project at each iteration phase in the parts of an expert system as seen in the figures mentioned earlier, it provides a reminder of the missing parts of the artefact. If established earlier, it would be easy to see that the efficiency construct had delay compared to the other constructs. If noted, it could be caught up, leaving more room for deeper insights in the correlations or more time for the artefact validation.

7.2.2 Foundations

It is evaluated that a structured approach provides detailed insights, which can be missed using a semi-structured approach. This is not only caused through the exclusion of relevant articles, but a structured approach also provides detailed insights, which are regarded to be not relevant at that given point in time but are considered relevant at a later stage. In this retrospective, a structured approach on Blockchain was highly necessary to successfully build the artefact. Basically, it laid the foundation of the entire expert system. However, the most important area of interest on the output side is regarded to be the Technology Acceptance Model. Although there are many factors in favour of using this model for the given situation, I would prefer to do a structured literature review on TAM and comparable models. This could provide deeper insights in the reason why TAM is the best model, could suggest looking at antecedents of the given variables or even could suggest an adaptation of the model that fits better. Therefore, a structured approach for TAM and comparable models would improve this research.

However, the fields concerning prototyping, the Design Science Cycle, expert systems and questionnaires, are researched thoroughly enough by using a semi-structured approach. This only supplied applicable knowledge to certain fields surrounding the research rather than delivering an important part of the results. It is also assumed that the knowledge found in these areas of interest was sufficient for this research since there were no indications of lack of knowledge in these areas influencing the research.

7.2.3 Tools

All the criteria that are written down in Chapter 3 are satisfied. In general, this implies that the difference between the plan and the actual outcome has been small and the data collection is a success. However, the ranged criteria were often met by minima or just above minima. Also, a part of the validation phase is less strong. Therefore, some weaknesses are still present in this research. Besides, it is assumed that almost all people with considerable Blockchain knowledge have participated in this research. A method to increase the pool of participants is to organise workshops. However, this is deemed to be not feasible due to time limitations.

Three requirements were set for the interviews and two for the document analysis, to be found in table 4.2. All the requirements are fulfilled. However, the number of insurance employees is small at this stage and only covered 30 percent, of which half works at the same company. These limited variety of perspectives is a threat to this research. For the document analysis, the number of use cases should range between the 100 and 200 of which 25 to 50 use cases should be applicable to the insurance sector. In total, there were 117 use cases of which 27 use cases applied to the insurance sector. Although these requirements are fulfilled, both the total number of use cases as the insurance's share in it, are small. Therefore, it is a weakness in this research.

Three requirements were set for the focus group, to be found in table 4.5. All the requirements are fulfilled. However, the group only consisted of six people which was the minimum. This happened through late cancellations in the days before the event. The event was planned several weeks in advance with twelve people who said to be available. Half the respondents had cancelled of which a quarter at the last day. Therefore, it is wise to have more than double of the minimum people available on a given day.

Three requirements were set for the expert analysis and two for the simulation testing, to be found in table 4.7. All the requirements are fulfilled. Only the ratio IT and business is somewhat weak. This ratio has been in general 1:2 which is sufficient when considering the number of IT people involved in Blockchain and the number of business people. However, the ratio during the expert analysis was a weak 1:3. The requirements for the simulation testing can be considered broad rather than in-depth, therefore, the requirements are fulfilled. The verification should be done through anomalies testing and the validation through case testing. The verification part should be successful where all possibilities were analysed. The validation part was weaker since only two persons with hands-on experience oversaw the case testing on perceived ease-of-use. The recommendation is that the criteria for the selected experts as well as the amount of the experts should be reconsidered for the next validation iteration. The other validation measures are successful.

In general, 33 persons have participated, working at 15 different companies, of which 6 are insurance companies. This number and diversity of participants is decent for data collection. Only people with considerable Blockchain knowledge were invited to participate in this research. It is assumed that almost all those people are reached and have participated in this research. Therefore, an interesting method to acquire more people would be to set up workshops for the insurance companies. Then more insurance companies could be taken as participants of this research. Due to the time limit of this research, this is not considered to be feasible.

7.2.4 Other reflective remarks

As described above, both parts of the IS Research Framework could be applied more thoroughly in this research. However, the foundations on which this research is built, are more out of balance then the business needs. Not only a deeper dive into foundations concerning the Technology Acceptance Model or comparable models is a strong recommendation, also the areas that entail inter-organisational collaboration, regulation or new technology implementation are highly relevant. Maybe the most important area which is not discussed yet, is the area of Distributed Ledger Technology. This could provide a more critical look at the Blockchain technology and put it into perspective with comparable Distributed Ledger Technologies.

Another reflective remark concerns the number of iterations. Because the area of research was not yet thoroughly discovered, numerous iterations concerned the finding of factors and their relations. This led to only one small phase of validation. To have a successful artefact, this validation phase should be much longer and more thoroughly. This could be done with several focus groups evaluating different use cases in the system or by prototyping several use cases and evaluating its results with the expert system.

From the perspective of the participants and the stakeholders, the decision that the organisation domain had to be left outside the scope, was an important imperfection of the model. The exploration of the factors and their relations could have been rougher to have more time to enclose all domains in the model. Also, the lack of prototypes of at least a single use case to show its clients, was regrettable.

However, all stakeholders agreed that this model could provide more added value to its clients than a prototype of a single use case.

7.3 Limitations

This section reflects on the research and discusses its limitations. Some of the limitations are suggested to further explore in the following section.

7.3.1 Threats to internal validity

Internal validity describes the extent to which the collected data enables researches to draw conclusions in a valid manner (Creswell, 2003). The most important threat to internal validity is the fact that this research is conducted by one person. This implies that all data collection is performed by a biased researcher.

Also, the amount of use cases for the document analysis was 117, which is considered low to perform statistical analysis upon. Nevertheless, this is performed and the data has an influence on the artefact.

Furthermore, the validation phase of the artefact is performed by testing the relations on perceived usefulness and perceived ease-of-use. Especially the validation on the relation on perceived ease-of-use is a threat to validity because this is performed by only two random experts with hands-on experience on a Blockchain platform. This should be done through a selection procedure leading to several experts testing the relation.

7.3.2 Threats to external validity

External validity describes the extent to which the findings can be generalized (Creswell, 2003). The most important is the way the artefact is made specific for the insurance sector while gathering data from multiple sectors.

For the document analysis, it is a threat to validity that only 27 use cases were derived from the insurance sector and an insurance-specific correction factor is established on the differences between those use cases and the other 90.

Besides, the insurance-specific correction factor is not applied to the technology and architecture domain. These are derived during the interviews, focus group and expert analysis. The number of participants ranging from six to twenty was too small to spot significant differences. Therefore, the only way of getting more insurance-related data was to establish an insurance:cross-industry/consultancy rate of 1:2. This is also an important threat to external validity.

7.3.3 Other limitations

Other limitations concern the design choices and the maturity of the artefact. It is chosen to use the TAM rather than the extended versions of TAM2 or TAM3. Through this choice, the antecedents and determinants of the two variables of the TAM are not researched.

Also, the advice concerning the platforms is limited to the three biggest platforms. This is enough to include the range of possibilities of the expert system but limits it substantially.

Since no research had been conducted in this field of factors contributing to the appropriateness of a Blockchain use case, a blueprint is made in this research. However, this ‘brain’ is still infantile, thus, far from mature. For instance, it is made using data from Western society whereas African or Asian society could benefit from other factors of Blockchain. Also, only relative scores of use cases are given rather than absolute scores, which prevents a certain baseline. Finally, the organisation domain of the BOAT-model is not taken into consideration due to time limits.

7.4 Implications for future research

Starting this research, there was a research gap in the several domains of Blockchain, especially concerning the business domain. Also, the link between the characteristics of Blockchain and the usability of a use case has not yet been established. I added an academic model that assesses the relation between three different domains of Blockchain, which are technology, business and architecture, and the appropriateness of a Blockchain use case. To establish this first model, several design choices have been made as to be seen in table E.4, leading to an artefact that is not yet fully mature. This section reflects on the implications for future research and makes some recommendations.

7.4.1 Artefact

The most important recommendation is to include the organisation domain into the expert system. The organisation domain is often mentioned to be important since Blockchain requires cross-sectorial collaboration. Topics like culture, politics or legislation are important constructs of this domain. Legislation in terms of digital signatures, archiving or smart contracts is all in a very low stage of maturity and should be discussed together with regulators to move forward with Blockchain.

Not only the addition of the organisation domain should be considered. The lower levels of the used components should be investigated further to enhance the artefact. Now, the level of analysis is on the level of the components. For instance, antecedents and determinants of the two variables of the TAM can be researched. But also, the levels of platform can be better assessed in terms of privacy, security, latency, throughput, scalability and other features.

Also, as suggested in 7.2.2, a structured literature research is proposed towards Distributed Ledger Technologies and the Technology Acceptance Model & other comparable models. Although, the TAM could suffice for this type of research, it is interesting to compare it with other models or even switch to alternatives.

Furthermore, as already mentioned in section 7.3.1, the validation phase of this artefact was short and only a first validation phase is used to evaluate the model. It is recommended that this model should be validated by using more measures and more use cases. Especially the relation between perceived ease-of-use and the components of the BOAT-model should be tested more thoroughly.

7.4.2 Other recommendations

The artefact should be developed and tested even further. Maybe, this could lead to a general blueprint of use case testing for Blockchain but numerous research is still needed to achieve this goal. However, not only the further development of the artefact is recommended, also some additions are recommended to fully understand the technology and to apply it to your business processes.

The most often mentioned addition that could help the discussion of using Blockchain for a specific use case, is a technological substitution list. This could be limited by specifying the technological features that underlie Blockchain and compare it to other technologies which could deliver those same features. This could be done to weigh several technologies for a given use case. The list could even be extended by making a cost-benefit model of comparison of different technologies where the domains of several technologies are compared to their own perceived usefulness and ease-of-use.

Another addition could be to include the aspects of a business case. Currently, the cost aspects versus the benefits aspects are not considered. This is the next step when one or a few use cases are selected due to their fit to Blockchain. This is becoming increasingly important because the transaction costs of the cryptocurrencies underlying the Blockchain platforms are rising substantially. Therefore, this impacts the choice of developing a certain use case for Blockchain.

Another important recommendation concerns the ecosystem. This research is only a small part to determine if an organisation should implement Blockchain for a given use case. As said before, it is a tool for discussion and a first blueprint. To have a complete image of implementing Blockchain for a given use case in a certain organisation, one should consider the change of communities helping the Blockchain platform, how to get a semantic standardised database, the role of the regulation & its according legislation and the role of the intermediary in this technology. During this entire research, people have suggested a variety of possibilities concerning these topics but all have suggested that it should be important to considerate. Therefore, it is suggested to consider these areas to create the bigger picture.

Furthermore, the academic world has also progressed in the domains of Blockchain and insurance. Two articles I want to mention that can broaden the mind of the researcher are Blockchain or not blockchain, that is the question of the insurance and other sectors (Lamberti et al., 2017), and Blockchain and Smart Contracts: Disruptive Technologies for the Insurance Market (Hans et al., 2017). Both articles are published in the last months and they provide interesting perspectives and additional information that may influence the maturity of this research field.

7.5 Recommendation CGI

A short word of advice is provided for the company involved. Since the start of this research, several improvements have already been made. The most important improvement is the start of a Blockchain community that meets several times a year, discusses the new developments around Blockchain and communicates the new projects or clients' interests in Blockchain. It is advised to discuss this framework in terms of contributing factors for the selection of a use case. By iteratively reviewing the factors of this framework, the framework can be extended to provide a more thorough understanding on the decision-making. This could also lead to an inclusion of the organisation domain.

Furthermore, it is advised that the expert system is used in preliminary conversations with clients. By applying this tool, it cannot only help select the most appropriate use case for Blockchain but it can also guide the discussion in possible use cases based on the factors of a Blockchain. It is even possible to put this tool online to interest customers into the opportunities Blockchain offers for a specific use case. After using the tool, the client is advised to make a free appointment to discuss the possibilities in a more thorough manner.

In general, it is very important that an IT consultancy should provide an immediate answer to questions surrounding new technology and the impact it can have on the organisations of their clients. Therefore, it is advised that the developments of Blockchain and other technologies should be structurally tracked through experts working horizontally across departments.

To improve the usability of this report for CGI, the three most occurring use cases for the insurance branch, which are fraud prevention, peer-to-peer insurance and claims handling, are explored through the model and added in the appendix G. The overall score of these three use cases are provided, the score on each domain of the BOAT-model and the overall conclusion is graphically depicted. Fraud prevention is medium useful and has a high ease-of-use, peer-to-peer insurance is highly useful but is low in ease-of-use and claims handling is medium-high is useful and medium-high in ease-of-use. It is advised to take these three use cases to the insurance clients, discuss possibilities and create a fruitful discussion for further collaboration.

7.6 Summary

The first research question is mainly answered using the BOAT-model and the TAM. The most important deficiencies are the exclusion of the organisation domain in the scope and the exclusion of both some components of each domain as the antecedents of the TAM. The second question is mainly answered by providing the relations between the factors. The most important deficiencies are the use of qualitative methods rather than quantitative methods and the lack of multiple test rounds.

As a reflection on the method and process, the used frameworks are vital to the success of this research but could have been developed one iteration phase earlier. The business needs are thoroughly explored by including 33 participants. However, the IT-business ratio and the insurance-consultancy ratio were considered weak with a relative ratio of both 1:3. The foundations are considered sufficient. The most important recommendations are a structured literature review in TAM and comparable models, and in Distributed Ledger Technologies. Also, more emphasis may be placed on the validation phase by adding multiple rounds of testing.

The limitations of this research include several aspects on the threats to internal validity and external validity like the number of persons involved in this research for data collection or validation is low and the number of persons involved in this research for data generation is considered low to be specifically aimed at a given sector that is the insurance branch. Other limitations include the expansion of the TAM, the number of platforms and the maturity of the brain.

Some implications for future research are also mentioned to increase the brain's maturity like including the organisation domain, the lower levels of used components, more structured literature research in the previous mentioned areas of interest and more validation rounds. Other recommendations are made concerning the addition of a technological substitution list, the inclusion of business case aspects and other elements of the Blockchain ecosystem.

Some words of advice are given to the company involved, CGI. The company should discuss the factors that influence the decision-making of a Blockchain use case on a regular basis. It is advised that this discussion should be held on each meeting of the Blockchain community to extend and evaluate the underlying factors. Also, the expert system should be used in preliminary conversations with clients such that it can help with an objective analysis and can guide the discussion on the selection. It is a possibility to put this tool online to attract the interest of clients. Furthermore, it is advised that the company should assign experts to Blockchain and other technologies to track the developments. Also, three use cases for the insurance branch are added in appendix G.

8. Bibliography

Aboulafia, M. (1991). *Philosophy, Social Theory, and the Thought of George Herbert Mead.* Albany: SUNY Press.

Abraham, A. (2005). Rule-Based expert systems. In P. H. Sydenham, & R. Thorn, *Handbook of measuring system design* (pp. 909-919). Hoboken: John Wiley and Sons.

Adams, D. A., Nelson, R. R., & Todd, P. A. (1992). Perceived usefulness, ease of use, and usage of information technology: A replication. *MIS Quarterly*, *16*(2), 227-247.

Alavi, M., & Wetherbe, J. C. (1991). Mixing prototyping and data modeling for information system design. *IEEE Software, 8*(3), 86-91.

Ali, M., Nelson, J., Shea, R., & Freedman, M. J. (2016). Blockstack: A Global Naming and Storage System Secured by Blockchains. *USENIX Annual Technical Conference*, 181-194.

Angelov, S., & Grefen, P. (2008). An E-contracting Reference Architecture. *Journal of Systems and Software, 81*(11), 1816-1844.

Azaria, A., Ekblaw, A., Vieira, T., & Lippman, A. (2016). MedRec: Using Blockchain for Medical Data Access and Permission Management. *International Conference on Open and Big Data (OBD)*, 25-30.

Bacher, J., Wenzig, K., & Vogler, M. (2004). SPSS TwoStep Cluster- a first evaluation. *Arbeits- und Diskussionspapiere*, *2*(2), 1-23.

Back, A. (2002). *A Denial of Service Counter-Measure*. Retrieved from Hashcash: http://www.hashcash.org/papers/hashcash.pdf

Barber, B. (1983). *The Logic and Limits of Trust.* New Rutgers University Press: Brunswick.

Beck, R., Czepluch, J. S., Lollike, N., & Malone, S. (2016). Blockchain–The Gateway to Trust-Free Cryptographic Transactions. *ECIS 2016 Proceedings*, 1-14.

Bitcoin Stackexchange. (2017). *Stackexchange*. Retrieved from Bitcoin: https//bitcoin.stackexchange.com

Bitcoinwiki. (2017). *Weaknesses*. Retrieved from Bitcoinwiki: https://en.bitcoin.it/wiki/Weaknesses

Booth, C. J., & Kurpis, G. P. (1993). *The New IEEE Standard Dictionary of Electrical and Electronics Terms.* New York: IEEE.

Bradbury, D. (2016). Blockchain's big deal. *Engineering & Technology*, *11*(10), 44-48.

Buldas, A., Kroonmaa, A., & Laanoja, R. (2013). Keyless signatures' infrastructure: How to build global distributed hash-trees. *Nordic Conference on Secure IT Systems*, 313-320.

Caes, N., Williams, R., Duggar, E. H., & Bauer, G. W. (2016). *Credit Strategy - Blockchain Technology: Robust, Cost-effective Applications Key to Unlocking Blockchain's Potential Credit Benefits.* New York: Moody's Investors Service.

Carnevale, D. G., & Wechsler, B. (1992). Trust in the public sector: Individual and organizational determinants. *Administration & Society, 23*(4), 471-494.

CGI. (2016). *2016 Annual Report.* Montreal: CGI Group Inc.

CGI. (2016). *Digital Strategy and Roadmap.* Montreal: CGI Group Inc.

CGI. (2017). *The CGI Constitution*. Retrieved from CGI.com: https://www.cgi.com/en/overview/constitution

Chiu, T., Fang, D., Chen, J., Wang, Y., & Jeris, C. (2001). A Robust and Scalable Clustering Algorithm for Mixed Type Attributes in Large Database Environment. *Proceedings of the 7th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 263-268.

Cohen, L., Manion, L., & Morrison, K. (2007). Interviews. In *Research Methods in Education* (pp. 349-383). New York: Routledge.

Collomb, A., & Sok, K. (2016). Blockchain / Distributed Ledger Technology (DLT): What Impact on the Financial Sector? *Digiworld Economic Journal, 103*, 93-111.

Creswell, J. W. (2003). *Research Design: Qualitative, Quantitative, and Mixed Method approaches.* California: Sage Publications: Thousand Oaks.

Culubas. (2011). *Timejacking & Bitcoin*. Retrieved from Culubas.blogspot.com: http://culubas.blogspot.nl/2011/05/timejacking-bitcoin_802.html

Davis, A. M. (1992). Operational Prototyping: A New Development Approach. *IEEE Software, 9*(5), 70-78.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science, 35*(8), 982-1003.

Denning, P. J. (1997). A New Social Contract for Research. *Communications of the ACM, 40*(2), 132-134.

Denzin, N. K. (1994). *The Research Act.* New York: McGraw-Hill.

Emmadi, N., & Narumanchi, H. (2017). Reinforcing Immutability of Permissioned Blockchains with Keyless Signatures' Infrastructure. *Proceedings of the 18th International Conference on Distributed Computing and Networking*, 46-51.

Eskandari, S., Barrera, D., Stobert, E., & Clark, J. (2015). A first look at the usability of bitcoin key management. *Workshop on Usable Security*, 1-12.

Ethereum Stackexchange. (2017). *Stackexchange*. Retrieved from Ethereum: https://ethereum.stackexchange.com

Fanning, K., & Centers, D. P. (2016). Blockchain and its Coming Impact on Financial Services. *Journal of Corporate Accounting & Finance, 27*(5), 53-57.

Federal Advisory Committee on Insurance. (2017). *Blockchain Technology in the Insurance Sector.* New York: McKinsey&Company.

Fishbein, M., & Ajzen, I. (1975). *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research.* Reading: Addison-Wesley.

Frambach, R. T., & Schillewaert, N. (2002). Organizational innovation adoption: A multi-level framework of determinants and opportunities for future research. *Journal of Business Research, 55*(2), 163-176.

Galliers, R. D., & Baets, W. R. (1998). *Information Technology And Organizational Transformation: Innovation For The 21st Century Organization.* Chichester: John Wiley.

Gartner. (2016). *Gartner's 2016 Hype Cycle for Emerging Technologies Identifies Three Key Trends That Organizations Must Track to Gain Competitive Advantage.* Retrieved from Gartner.com: http://www.gartner.com/newsroom/id/3412017

Gasser, U., & Palfrey, J. G. (2007). Breaking down digital barriers: When and how ICT interoperability drives innovation. *Berkman Center Research Publication, 8,* 1-28.

Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: interviews and focus groups. *British Dental Journal, 20*(4), 291-295.

Global Agenda Council on the Future of Software & Society. (2015). *Deep Shift: Technology Tipping Points and Societal Impact.* Geneva: World Economic Forum.

Gordon, V. S., & Bieman, J. M. (1995). Rapid Prototyping: Lessons Learned. *IEEE Software, 12*(1), 85-95.

Grefen, P. (2015). *Beyond E-Business: Towards Networked Structures.* New York: Routledge.

Grefen, P. (2016). *Business Information System Architecture.* Eindhoven: University of Technology.

Grewal-Carr, V., & Marshall, S. (2016). *Blockchain: Enigma. Paradox. Opportunity.* London: Deloitte LLP.

Guo, Y., & Liang, C. (2016). Blockchain application and outlook in the banking industry. *Financial Innovation, 2*(24), 1-12.

Hans, R., Zuber, H., Rizk, A., & Steinmetz, R. (2017). Blockchain and Smart Contracts: Disruptive Technologies for the Insurance Market. *E-Business and E-Commerce Digital Commerce*, 1-14.

Hendriks, P. H., & Vriens, D. J. (1999). Knowledge-based systems and knowledge management. *Information & Management, 35*, 113-125.

Hevner, A. R. (2007). A three cycle view of design science research. *Scandinavian journal of information systems, 19*(2), 87-92.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly, 28*(1), 75-105.

Hoogervorst, J. (2004). Enterprise Architecture: Enabling Integration, Agility and Change. *International Journal of Cooperative Information Systems, 13*(3), 1-20.

Iansiti, M., & Lakhani, K. R. (2017). The Truth About Blockchain. *Harvard Business Review, 95*(1), 118-127.

Jick, T. D. (1979). Mixing Qualitative and Quantitative Methods: Triangulation in Action. *Administrative Science Quarterly, 24*(4), 602-611.

Kanter, R. M. (2001). *Evolve!: Succeeding in the Digital Culture of Tomorrow.* Boston: Harvard Business School Press.

Karame, G. O. (2016). On the Security and Scalability of Bitcoin's Blockchain. *Proceedings of the 2016 ACM SIGSAC Conference on Computer and Communications Security*, 1861-1862.

King, S., & Nadal, S. (2012). *Peer-to-Peer Crypto-Currency with Proof-of-Stake.* Retrieved from PPCoin: https://peercoin.net/assets/paper/peercoin-paper.pdf

Kitchenham, B., & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering. *EBSE Technical Report, 2007*(1), 1-57.

Koetsier, M., Grefen, P., & Vonk, J. (2000). Contracts for Cross-Organizational Workflow Management. *Proceedings 1st International Conference on Electronic Commerce and Web Technologies*, 110-121.

Konstantinos, C., & Devetsikiotis, M. (2016). Blockchains and Smart Contracts for the Internet of Things. *IEEE Access, 4,* 2292-2303.

Kordon, F. (2002). An Introduction to Rapid System Prototyping. *IEEE Transactions on Software Engineering, 28*(9), 817-821.

Krosnick, J. A., & Presser, S. (2010). Question and Questionnaire Design. In P. V. Marsden, & J. D. Wright, *Handbook of Survey Research* (pp. 263-313). Bingley: Emerald Publishing Group Ltd.

Kypriotaki, K. N., Zamani, E. D., & Giaglis, G. M. (2015). From Bitcoin to Decentralized Autonomous Corporations: Extending the Application Scope of Decentralized Peer-to-Peer Networks and Blockchains. *18th International Conference on Enterprise Information Systems*, 1-7.

Lamberti, F., Gatteschi, V., Demartini, C., Pranteda, C., & Santamaria, V. (2017). Blockchain or not blockchain, that is the question of the insurance and other sectors. *IT Professional, 99*, 1-12.

Lee, A. S. (1999). Rigor and Relevance in MIS Research: Beyond the Approach of Positivism Alone. *MIS Quarterly, 23*(1), 29-34.

Lemieux, V. L. (2016). Trusting records: is Blockchain technology the answer? *Records Management Journal, 26*(2), 110-139.

Liao, S. (2005). Expert system methodologies and applications - a decade review from 1995 to 2004. *Expert Systems with Applications, 28*(1), 93-103.

Lietz, P. (2010). Research into questionnaire design: A summary of the literature. *International Journal of Market Research, 52*(2), 249-272.

Lorenz, J., Münstermann, B., Higginson, M., Olesen, P. B., Bohlken, N., & Ricciardi, V. (2016). *Blockchain in insurance - opportunity or threat?* New York: McKinsey&Company.

March, J. G. (1994). *A Primer on Decision-Making.* New York: Free Press.

March, S. T., & Smith, G. (1995). Design and Natural Science Research on Information Technology. *Decision Support Systems, 15*(4), 251-266.

Marino, B., & Juels, A. (2016). Setting Standards for Altering and Undoing Smart Contracts. *International Symposium on Rules and Rule Markup Languages for the Semantic Web*, 151-166.

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *Academic Management Review, 20*(3), 709-734.

McWaters, J. R., Bruno, G., Galaski, R., & Chatterjee, S. (2016). *The future of financial infrastructure: An amibitious look at how blockchain can reshape financial services.* Cologny: World Economic Forum.

Merriam-Webster. (2017). *Dictionary*. Retrieved from Merriam-Webster.com: https://www.merriam-webster.com/

Mianelli, M., & Manson, B. (2016). *Chain Reaction: How Blockchain Technology Might Transform Wholesale Insurance.* London: Z/Yen Group Limited.

Mingers, J. (2001). Combining IS Research Methods: Towards a Pluralist Methodology. *Information Systems Research, 12*(3), 240-259.

Moore, G. C., & Benbasat, I. (1996). Integrating Diffusion of Innovations and Theory of Reasoned Action Models to Predict Utilization of Information Technology by End-Users. In K. Kautz, & J. Pries-Hege, *Diffusion and Adoption of Information Technology* (pp. 132-146). London: Chapman and Hall.

Nakamoto, S. (2008). *A peer-to-peer electronic cash system*. Retrieved from Bitcoin: https://bitcoin.org/bitcoin.pdf

Narayanan, A., Bonneau, J., Felten, E., Miller, A., Goldfeder, S., & Clark, J. (2016). *Bitcoin and Cryptocurrency Technologies.* Princeton, New Jersey: Princeton University Press.

Nguyen, Q. K. (2016). Blockchain - A Financial Technology For Future Sustainable Development. *International Conference on Green Technology and Sustainable Development*, 51-54.

OECD. (2016). *Case Study: Blockchain Voting for Peace - Colombia.* Paris: OECD.

O'Keefe, R. M., & Preece, A. D. (1996). The development, validation and implementation of knowledge-based systems. *European Journal of Operational Research, 92*(3), 458-473.

O'Keefe, R. M., Balci, O., & Smith, E. P. (1987). Validating expert system performance. *IEEE Expert, 2*(4), 81-90.

Panetta, K. (2017). *Top Trends in the Gartner Hype Cycle for Emerging Technologies, 2017*. Retrieved from Gartner.com: http://www.gartner.com/smarterwithgartner/top-trends-in-the-gartner-hype-cycle-for-emerging-technologies-2017/

Pomp, M., & Hartog, K. (2016). *Resultaten Blockchainpilots juni - november 2016.* Amsterdam: BlockchainPilots.

Preece, A. D., Shinghal, R., & Batarekh, A. (1992). Principles and practice in verifying rule-based systems. *Knowledge Engineering Review, 7*(2), 115-141.

PwC. (2015). Money is no object: Understanding the evolving cryptocurrency market. *PwC's Financial Services Institute*, 1-17.

PwC. (2016). *Blockchain in the insurance sector*. London: PwC LLP.

Ream, J., Chu, Y., & Schatsky, D. (2016). *Upgrading blockchains: Smart contract use cases in industry.* London: Deloitte LLP.

Reichardt, C. S., & Rallis, S. F. (1994). *The Qualitative-Quantitative Debate: New Perspectives.* San Francisco: Jossey-Bass.

Reinecke, J. A. (1984). *Introduction to Business: A Contemporary View*. Boston: Allyn & Bacon.

Ripple. (2017). *Ripple.com*. Retrieved from Technology: https://www.ripple.com

Robey, D. (1996). Diversity in Information Systems Research: Threat, Promise, and Repsonsibility. *Information Systems Research, 7*(4), 400-408.

Rogers, E. M. (1995). *Diffusion of Innovations.* Simon & Schuster Inc.: New York.

Rousseau, D. M., Sitkin, S. B., Burt, R. S., & Camerer, C. (1998). Not so different after all: A cross-discipline view of trust. *Academic Management Review, 23*(3), 393-404.

Schollmeier, R. (2001). A definition of peer-to-peer networking for the classification of peer-to-peer architectures and applications. *First International Conference on Peer-to-Peer Computing*, 101-102.

Seidman, I. (2006). *Interviewing as Qualitative Research: A Guide for Researchers in Education and the Social Sciences.* New York: Teachers College.

Shapiro, S. P. (1987). The social control of impersonal trust. *American Journal of Sociology, 93*(3), 623-658.

Sidorova, A., Evangelopoulos, N., Valacich, J. S., & Ramakrishnan, T. (2008). Uncovering the Intellectual Core of the Information Systems Discipline. *MIS Quarterly, 32*(3), 467-482.

Silver, M. S., Markus, M. L., & Beath, C. M. (1995). The Information Technology Interaction Model: A Foundation for the MBA Core Course. *MIS Quarterly, 19*(3), 87-113.

Simon, H. A. (1955). A behavioral model of rational choice. *Quarterly Journal of Economics, 69*(1), 99-118.

Simon, H. A. (1996). *The Sciences of the Artificial.* Cambridge: MIT Press.

Stewart, D. W., Shamdasani, P. N., & Rook, D. W. (2007). *Focus Groups: Theory and Practice.* Newbury Park: Sage Publications.

Sundararajan, A. (2016). *The Sharing Economy: The End of Employment and the Rise of Crowd-Based Capitalism.* Cambridge: The MIT Press.

Sydenham, P., & Thorn, R. (2005). *Handbook of Measuring System Desgin.* Hoboken: John Wiley & Sons.

Szabo, N. (1997). Formalizing and securing relationships on public networks. *First Monday, 2*(9).

Taylor, S., & Todd, P. A. (1995). Understanding information technology usage: A test of competing models. *Information systems research, 6*(2), 144-176.

Thesaurus. (2017). *Browse*. Retrieved from Thesaurus.com: http://www.thesaurus.com/

Thompson, R. L., Higgins, C. A., & Howell, J. M. (1991). Personal computing: Toward a conceptual model of utilization. *MIS Quarterly, 15*(1), 124-143.

Tomatzky, L. G., & Klein, K. J. (1982). Innovation Characteristics and Innovation Adoption-Implementation: A Meta-Analysis of Findings. *IEEE Transactions on Engineering Management, 29*(1), 28-45.

Tremblay, M. C., Hevner, A. R., & Berndt, D. J. (2010). Focus groups for artifact refinement and evaluation in design research. *CAIS, 26*(27), 599-618.

Tsai, W., Blower, R., Zhu, Y., & Yu, L. (2016). A System View of Financial Blockchains. *2016 IEEE Symposium on Service-Oriented System Engineering*, 450-457.

Tsichritzis, D. (1998). The Dynamics of Innovation. In P. J. Denning, & R. M. Metcalfe, *Beyond Calculation: The Next Fifty Years of Computing* (pp. 259-265). New York: Copernicus Books.

Ufacik, E. (2016). *Making Blockchain Real for Business: Use Cases.* Singapore: IBM Corporation.

UK Government Chief Scientific Adviser. (2016). *Distributed Ledger Technology: beyond block chain.* London: Government Office for Science.

Underwood, S. (2016). Blockchain Beyond Bitcoin. *Communications of the ACM, 59*(11), 15-17.

Van Aken, J. E., Berends, H., & Van der Bij, H. (2007). *Problem Solving in Organizations: A Methodological Handbook for Business Students.* Cambridge: Cambridge University Press.

Van de Wall, J. P., & Razavian , M. (2017). A systematic literature review on Blockchain and its application in the industry. *Working paper*, 1-45.

Van Hemelen, J., & Winderickx, K. (2016). *Blockchain: Defining the possibilities and the value of Smart Contracts.* Faculty of Engineering Technology. Leuven: KU Leuven.

Van Mullem, B., & Vierendeels, K. (2016). *KBC's Digital Trade Chain.* Brussels: KBC Group N.V.

Van Strien, P. J. (1997). Towards a methodology of psychological practice: The regulative cycle. *Theory & Psychology, 7*(5), 683-700.

Venkatesh, V. (2000). Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model. *Information Systems Research*, *11*(4), 342-365.

Venkatesh, V., & Bala, H. (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decision Sciences, 39*(2), 273-315.

Venkatesh, V., & Davis, F. D. (1996). A Model of the Antecedents of Perceived Ease of Use: Development and Test. *Decision Sciences, 27*(3), 451-481.

Venkatesh, V., Brown, S. A., & Bala, H. (2013). Bridging the Qualitative-Quantitative Divide: Guidelines for Conducting Mixed Methods Research in Information Systems. *MIS Quarterly, 37*(1), 21-54.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly, 27*(3), 425-478.

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS Quarterly, 36*(1), 157-178.

Volosovich, S. (2016). InsurTech: Challenges and Development Perspectives. *International Journal of Innovative Technologies in Economy, 3*(5), 39-42.

Walker, M. J., Burton, B., & Cantara, M. (2016). *Hype Cycle for Emerging Technologies, 2016*. Retrieved from Gartner.com: https://www.gartner.com/doc/3383817

Walls, J. G., Widmeyer, G. R., & El Sawy, O. A. (1992). Building an Information System Design Theory for Vigilant EIS. *Information Systems Research*, *3*(1), 36-59.

Wang, H., Chen, K., & Xu, D. (2016). A maturity model for blockchain adoption. *Financial Innovation*, *2*(12), 1-5.

Watanabe, H. e. (2016). Blockchain Contract: A Complete Consensus using Blockchain. *IEEE 4th Global Conference on Consumer Electronics*, 577-578.

Watanabe, H. e. (2016). Blockchain contract: Securing a blockchain applied to smart contracts. *IEEE International Conference on Consumer Electronics (ICCE)*, 467-468.

Weber, I. e. (2016). Untrusted Business Process Monitoring and Execution Using Blockchain. *International Conference on Business Process Management*, 329-347.

Wieringa, R. (2009). Design Science as Nested Problem Solving. *Proceedings of the 4th international conference on design science research in information systems and technology*, 8-20.

Wieringa, R. (2014). *Design Science Methodology for Information Systems and Software Engineering.* New York: Springer.

Witte, J. H. (2016). *The Blockchain: A Gentle Four Page Introduction.* Retrieved from SSRN: https://ssrn.com/abstract=2887567

Xu, J. J. (2016). Are blockchains immune to all malicious attacks? *Financial Innovations, 25*, 1-9.

Yli-Huumo, J., Ko, D., Choi, S., Park, S., & Smolander, K. (2016). Where Is Current Research on Blockchain Technology? - A Systematic Review. *PLoS ONE, 11*(10), 1-27.

Zhao, J. L., Fan, S., & Yan, J. (2016). Overview of business innovations and research opportunities in blockchain and introduction to the special issue. *Financial Innovation, 2*(28), 28-35.

Appendix A: Additional tables and figures, Chapter 1 Introduction

This appendix encloses all the additional figures of the first chapter of the report, Introduction. The first figures clarify the link between Blockchain and the involved company whereas the last figures clarify the current and future path of Blockchain. Table A.1 presents an overview of the cross-reference.

Cross-reference, appendix A				
	No.	**Explanation**	**Ref. page**	**Page**
Figure	A.1	The top 5 of the global industry trends according to the clients of CGI	15	75
	A.2	The top 5 of the global business and IT priorities according to the clients of CGI	15	75
	A.3	The roadmap of CGI that goes towards Digital Business in 2021	15	76
	A.4	A comparison of the trend line of the academic papers used versus the trend line of the Gartner Hype Cycle	16	76
	A.5	The phases of Blockchain over time according to McKinsey	16, 126	76

Table A.1: Cross-reference, appendix A

Figure A.1: Top 5 Global industry trends (CGI, 2016)

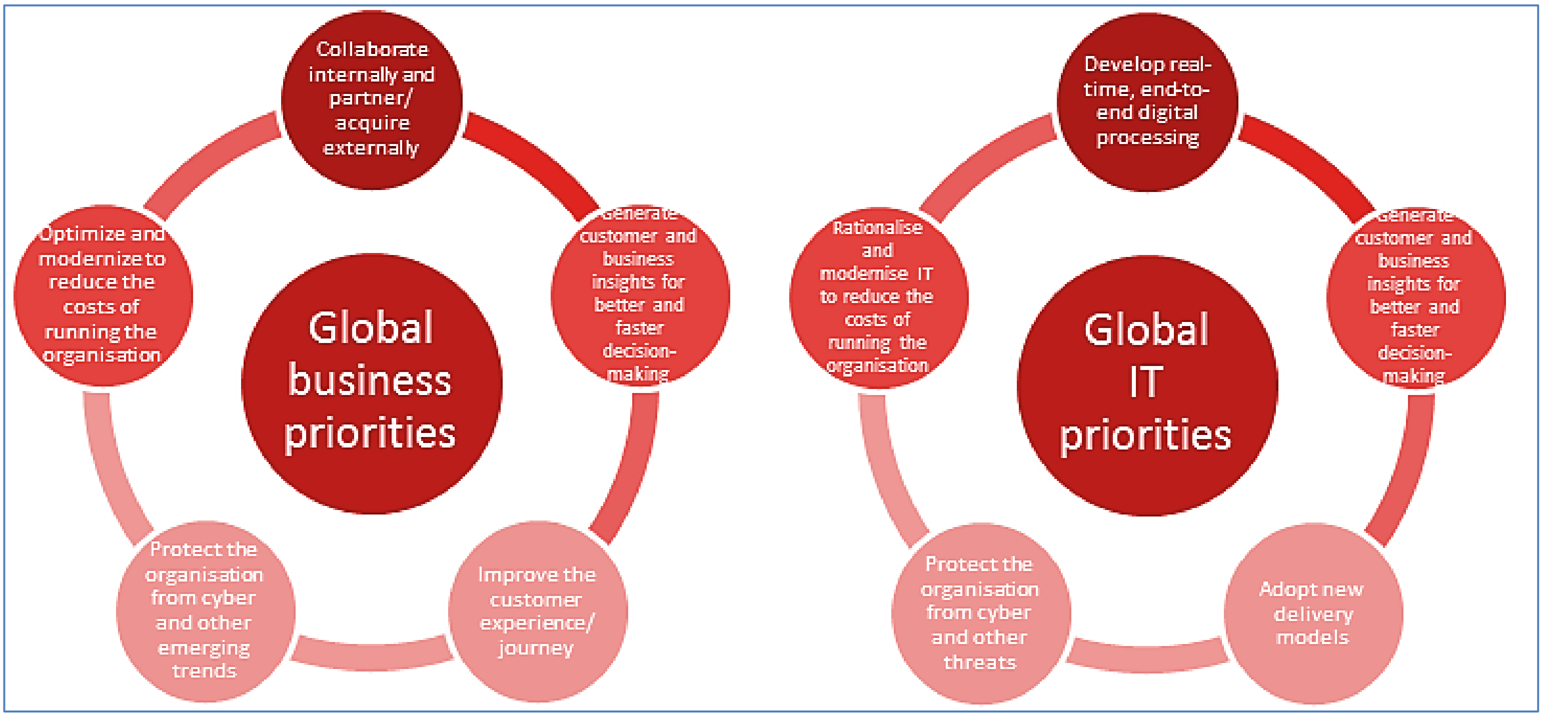

Figure A.2: Top 5 Global business and IT priorities (CGI, 2016)

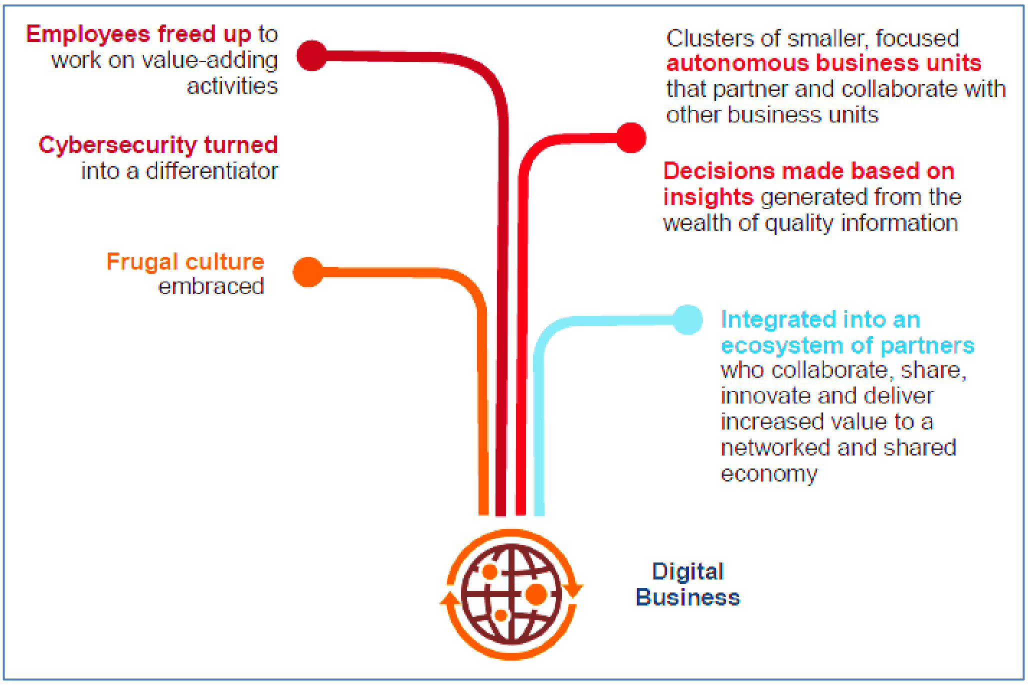

Figure A.3: CGI Roadmap Towards Digital Business 2021 (CGI, 2016)

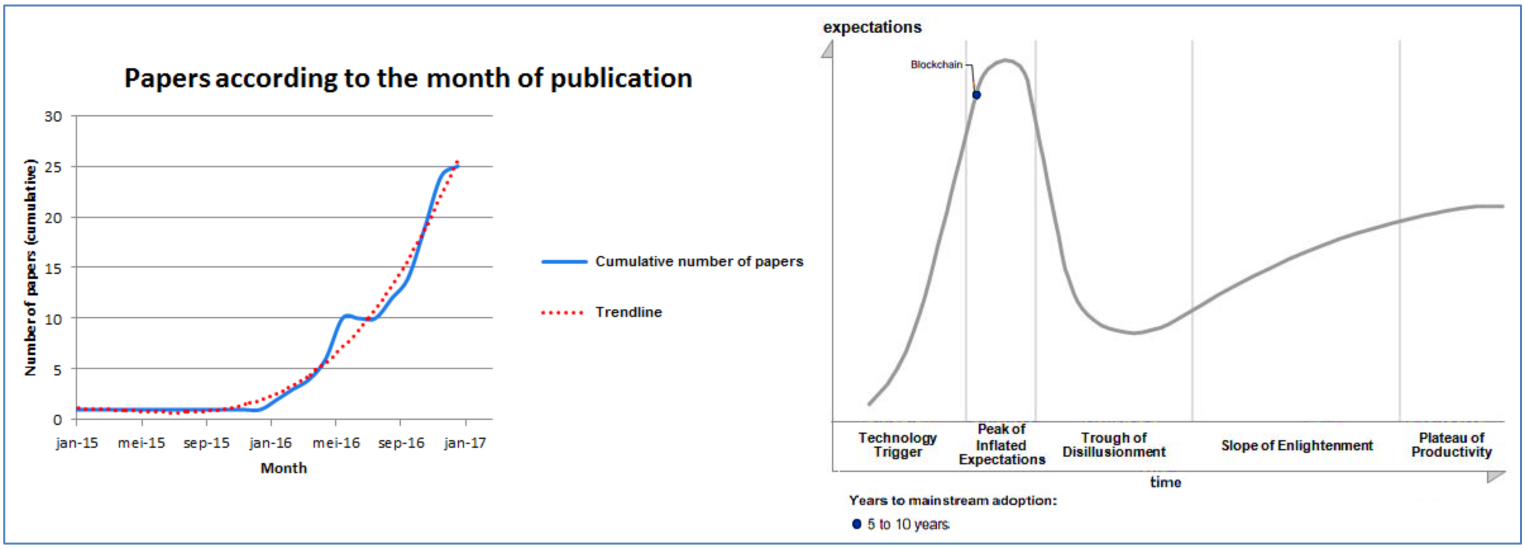

Figure A.4: Trend line of academic papers versus trend line of Gartner Hype Cycle

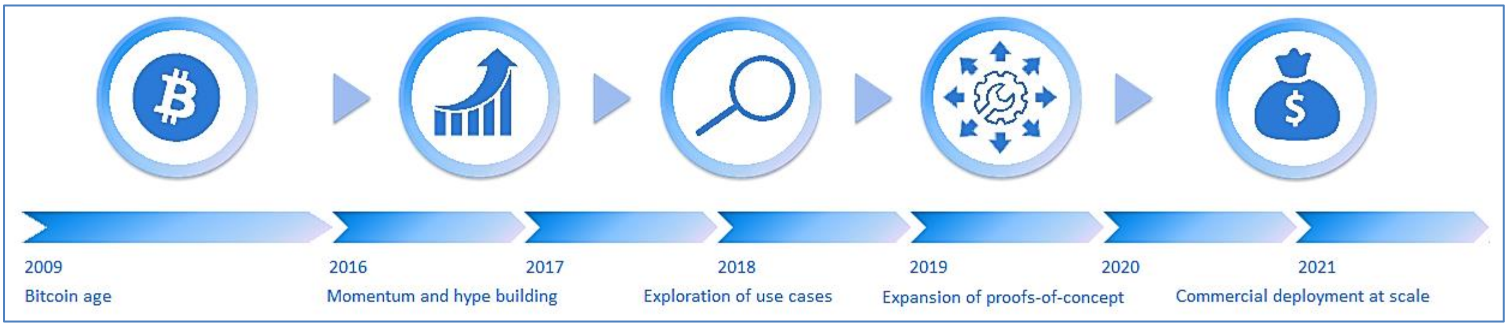

Figure A.5: Ages of Blockchain over time (Federal Advisory Committee on Insurance, 2017)

Appendix B: Additional tables and figures, Chapter 2 State-of-the-Art, Blockchain

This appendix encloses the additional figure of the second chapter of the report, State-of-the-Art, Blockchain. It shows the BOAT-model by Grefen from the perspective of a technology-push. Table B.1 presents an overview of the cross-reference.

Cross-reference, appendix B				
	No.	**Explanation**	**Ref. page**	**Page**
Figure	B.1	Grefen's BOAT-framework with the domains of Business, Organisation, Architecture and Technology, from a technology-push perspective	18	78

Table B.1: Cross-reference, appendix B

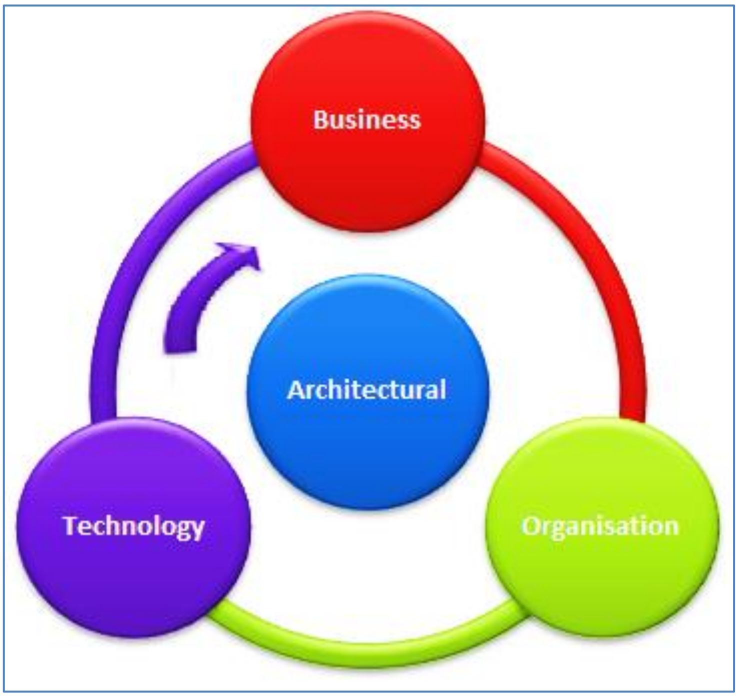

Figure B.1: BOAT framework, technology-push perspective (Grefen, 2015)

Appendix C: Additional tables and figures, Chapter 3 Methodology

This appendix encloses all the additional figures of the third chapter of the report, Methodology. The first figures show the frameworks used for the methodology whereas the last figures show them applied to this research. Table C.1 presents an overview of the cross-reference.

Cross-reference, appendix C				
	No.	**Explanation**	**Ref. page**	**Page**
Figure	C.1	Hevner's Information Systems Research Framework	24	80
	C.2	Wieringa's Regulative cycle, adapted to a design-science research perspective	24	80

Table C.1: Cross-reference, appendix C

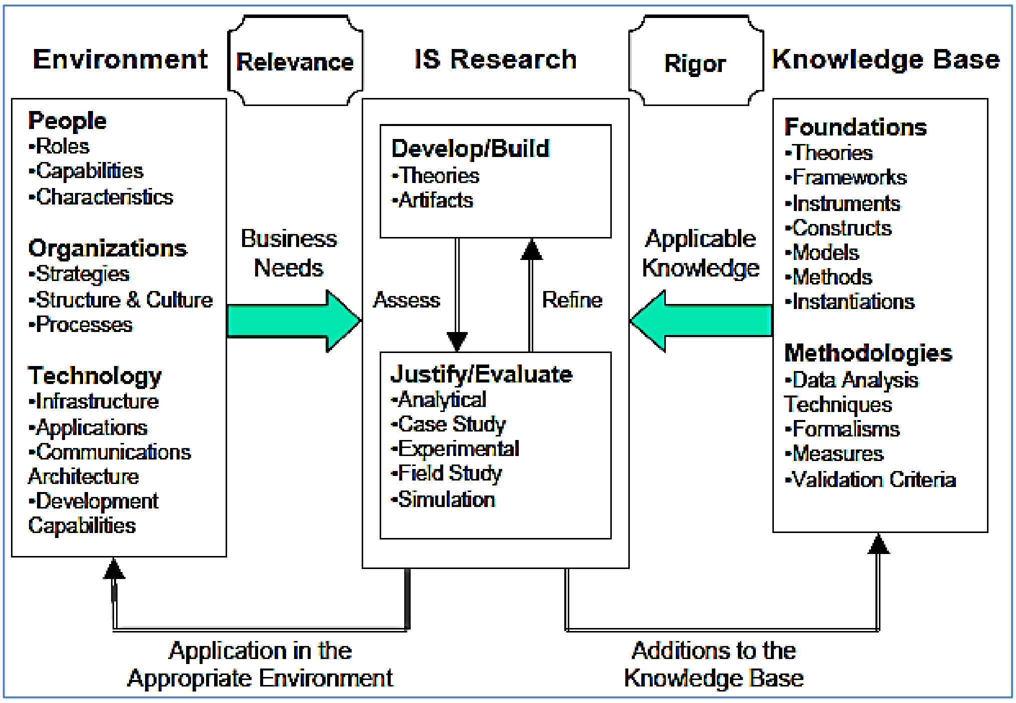

Figure C.1: Information Systems Research Framework (Hevner et al., 2004)

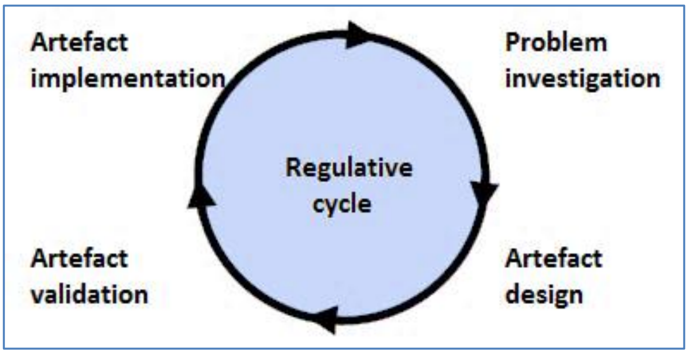

Figure C.2: Regulative cycle, adapted for design science research (Wieringa, 2009)

Appendix D: Additional tables and figures, Chapter 4 Artefact design, iterative process

This appendix encloses all the additional figures and tables of the fourth chapter of the report, Artefact design, iterative process. The figures explain the general actions per iteration whereas the tables provide more detailed information of these iterations. Table D.1 presents an overview of the cross-reference.

Cross-reference, appendix D				
	No.	**Explanation**	**Ref. page**	**Page**
Table	D.2	An overview of the interviewees together with their index number, department and kind of company	33	82
	D.3	The aggregated results of the interviews on the technology and business domain	33	82
	D.4	The aggregated results of the interviews on the architecture domain	33	83
	D.5	The aggregated results of the interviews as other remarks	33	83
	D.6	List of all the articles used in the document analysis	34	84
	D.7	The aggregated results of the document analysis	34	85
	D.8	The first scenario of business factors through a TwoStep cluster analysis	34, 39	85
	D.9	The second scenario of business factors through a TwoStep cluster analysis	35, 39	86
	D.10	The third scenario of business factors through a TwoStep cluster analysis	35	86
	D.11	The fourth scenario of business factors through a TwoStep cluster analysis	35	87
	D.12	An overview of the participants of the focus group together with their index number, department and kind of company	37	87
	D.13	The aggregated results of the focus group	37	88
	D.14	The best practices of creating a questionnaire	39	89
	D.15	An overview of the experts together with their index number, department and kind of company	39	90
	D.16	The aggregated results of the expert analysis on the business domain	39	90
	D.17	The aggregated results of the expert analysis on the weights of each domain	39	90
	D.18	An overview of all participants together with their index number, department, kind of company and participation	40	91
Figure	D.1	The first iteration on the artefact	35	92
	D.2	Davis' Technology Acceptance Model	36	92
	D.3	The second iteration on the artefact	38	93
	D.4	The third iteration on the artefact	40	94

Table D.1: Cross-reference, appendix D

Interview, overview of participants		
Index number	**Department**	**Kind of company**
I1	Business	Consultancy 1
I2	Business	Consultancy 1
I3	Business	Consultancy 1
I4	Business	Consultancy 1
I5	Business	Consultancy 1
I6	Business	Consultancy 1
I7	IT	Consultancy 1
I8	IT	Consultancy 1
I9	IT	Consultancy 1
I10	Business	Consultancy 2
I11	Business	Consultancy 3
I12	Business	Consultancy 4
I13	IT	Consultancy 5
I14	IT	Consultancy 6
I15	Business	Insurance 1
I16	Business	Insurance 2
I17	IT	Insurance 2
I18	IT	Insurance 2
I19	Business	Insurance 3
I20	Business	Insurance 4

Table D.1: Interview, overview of participants

Interviews, aggregated results on technology and business		
Domain	**Finding**	**Percentage**
Technology	Immutability is an important consideration	80
	Trustworthiness is an important consideration	70
	Security is an important consideration	65
	Scalability is an important consideration	55
	Transparency is an important consideration	50
	Privacy is an important consideration	20
Business	Multiple parties are an important consideration	90
	Efficiency through streamlining databases is an important consideration	70
	No fraud/tampering is an important consideration	55
	Decreased settlement time is an important consideration	55
	Provenance is an important consideration	45
	Paper-based processes are an important consideration	45
	Real-time visibility is an important consideration	40
	Upfront control is an important consideration	25
	Need-to-know base is an important consideration	25
	Simplification of processes is an important consideration	25
	Interdependent transactions are an important consideration	25
	Microtransactions are an important consideration	20
	Connected to an IoT device is an important consideration	5

Table D.2: Interviews, aggregated results on technology and business

Interviews, aggregated results on architecture						
Period	**Indicator**	**Public permissionless**	**Public permissioned**	**Private permissioned**	**Blockchain 1.0**	**Blockchain 2.0**
Short-term	*Usefulness*	Low	Medium	Medium	Medium	Medium
	Ease-of-use	Low	Medium	High	High	Low
Long-term	*Usefulness*	High	Medium	Low	Medium	High
	Ease-of-use	Medium	High	High	High	Medium
Average	*Usefulness*	Medium	Medium	Medium-Low	Medium	Medium-High
	Ease-of-use	Low-Medium	Medium-High	High	High	Low-Medium

Table D.3: Interviews, aggregated results on architecture

Interviews, other remarks	
Remark	**Percentage**
Learning is the most important step now	75
Verification is the first step before starting with Blockchain	55
Role of regulators and regulation are unclear at the moment	55
Security of Blockchain can be established through Private Permissioned Blockchains	55
One should start with the question if someone needs a Blockchain	55
An academic tool that objectively analyses a use case is very useful	55
Internal Blockchains are only good for experimentation	50
The IT challenges and the lack of expertise is a main hurdle	50
Business and IT should better work together	50
(Cross-sectorial) collaboration is the most important factor	45
Organisational challenges and the lack of infrastructure is a main hurdle	40
Tools of the platform are important for implementation possibilities	40
Smart contracts are the most important feature to the insurance branch	35
Semantic standardised database is needed to let Blockchain work	35
Disruption will not happen on the short-term	35
Exploration of use cases is the most important step at the moment	30
Blockchain is a disruptive technology	30
Blockchain is merely the next phase of automation	25
One should consider that it will still be a garbage-in garbage-out principle	20

Table D.4: Interviews, other remarks

Overview of the articles containing use cases for the document analysis	
Citation	**Branch**
Caes, N., Williams, R., Duggar, E. H., & Bauer, G. W. (2016). *Credit Strategy - Blockchain Technology: Robust, Cost-effective Applications Key to Unlocking Blockchain's Potential Credit Benefits.* New York: Moody's Investors Service.	Cross-sectorial
Grewal-Carr, V., & Marshall, S. (2016). *Blockchain: Enigma. Paradox. Opportunity.* London: Deloitte LLP.	Cross-sectorial
Ream, J., Chu, Y., & Schatsky, D. (2016). *Upgrading blockchains: Smart contract use cases in industry.* London: Deloitte LLP.	Cross-sectorial
Ufacik, E. (2016). *Making Blockchain Real for Business: Use Cases.* Singapore: IBM Corporation.	Cross-sectorial
Lorenz, J., Münstermann, B., Higginson, M., Olesen, P. B., Bohlken, N., & Ricciardi, V. (2016). *Blockchain in insurance - opportunity or threat?* New York: McKinsey&Company.	Insurance
Mianelli, M., & Manson, B. (2016). *Chain Reaction: How Blockchain Technology Might Transform Wholesale Insurance.* London: Z/Yen Group Limited.	Insurance
PwC. (2016). *Blockchain in the insurance sector.* London: PwC LLP.	Insurance
McWaters, J. R., Bruno, G., Galaski, R., & Chatterjee, S. (2016). *The future of financial infrastructure: An ambitious look at how blockchain can reshape financial services.* Cologny: World Economic Forum.	Banking & Insurance
Federal Advisory Committee on Insurance. (2017). *Blockchain Technology in the Insurance Sector.* New York: McKinsey&Company.	Banking
Van Mullem, B., & Vierendeels, K. (2016). *KBC's Digital Trade Chain.* Brussels: KBC Group N.V.	Banking
OECD. (2016). *Case Study: Blockchain Voting for Peace - Colombia.* Paris: OECD.	Government
Pomp, M., & Hartog, K. (2016). *Resultaten Blockchainpilots juni - november 2016.* Amsterdam: BlockchainPilots.	Government

Table D.5: Overview of the articles containing use cases for the document analysis

Document analysis, aggregated results		
Area of interest	**Finding**	**Percentage**
Technology	Immutability is important	50
	Trustworthiness is important	37
	Security is important	31
	Transparency is important	23
	Privacy is important	10
Business	Multiple parties are important	59
	Efficiency through streamlining databases is important	35
	Real-time visibility is important	32
	Decreased settlement time is important	30
	No fraud/tampering is important	30
	Provenance is important	27
	Upfront control is important	26
	Need-to-know base is important	20
	Simplification of processes is important	18
	Interdependent transactions are important	15
	Connected to an IoT device is important	8
	Paper-based processes are important	7
	Microtransactions are important	5
Industry sector	Cross-industry	36
	Insurance	23
	Banking	21
	Government	20

Table D.6: Document analysis, aggregated results

TwoStep cluster analysis, first scenario		
Cluster	**Business factor**	**Predictor Importance**
Cluster 1	Decreased settlement time	1
	Multiple parties	0.98
	Efficiency through streamlining databases	0.98
	Interdependent transactions	0.30
	Paper-based processes	0.28
	Simplification of processes	0.28
	Real-time visibility	0.06
	Upfront control	0.02
Cluster 2	Provenance	0.31
	Need-to-know	0.05
	Connected to an IoT device	0.03
	Microtransactions	0.02
	No fraud/tampering	0.01

Table D.7: TwoStep cluster analysis, first scenario

TwoStep cluster analysis, second scenario		
Cluster	**Business factor**	**Predictor Importance**
Cluster 1	Decreased settlement time	1
	Multiple parties	0.98
	Efficiency through streamlining databases	0.98
	Interdependent transactions	0.30
	Paper-based processes	0.28
	Simplification of processes	0.28
	Real-time visibility	0.06
	Upfront control	0.02
Cluster 2.1	Real-time visibility	1
	Need-to-know base	0.80
	No fraud/tampering	0.42
	Provenance	0.32
	Multiple parties	0.29
	Decreased settlement time	0.23
	Interdependent transactions	0.04
Cluster 2.2	Microtransactions	0.22
	Connected to an IoT device	0.16
	Efficiency through streamlining databases	0.16
	Simplification of processes	0.12
	Upfront control	0.09

Table D.8: TwoStep cluster analysis, second scenario

TwoStep cluster analysis, third scenario		
Cluster	**Business factor**	**Predictor Importance**
Cluster 1.1	Upfront control	1
	Need-to-know base	0.52
	Efficiency through streamlining databases	0.51
	Simplification of processes	0.47
	Connected to an IoT device	0.31
	Interdependent transactions	0.31
	Multiple parties	0.22
	No fraud/tampering	0.19
	Provenance	0.16
	Real-time visibility	0.12
	Paper-based processes	0.05
Cluster 1.2	Decreased settlement time	0.07
Cluster 2	Provenance	0.31
	Need-to-know base	0.05
	Connected to an IoT device	0.03
	Microtransactions	0.02
	No fraud/tampering	0.01

Table D.9: TwoStep cluster analysis, third scenario

TwoStep cluster analysis, fourth scenario		
Cluster	**Business factor**	**Predictor Importance**
Cluster 1.1	Upfront control	1
	Need-to-know base	0.52
	Efficiency through streamlining databases	0.51
	Simplification of processes	0.47
	Connected to an IoT device	0.31
	Interdependent transactions	0.31
	Multiple parties	0.22
	No fraud/tampering	0.19
	Provenance	0.16
	Real-time visibility	0.12
	Paper-based processes	0.05
Cluster 1.2	Decreased settlement time	0.07
Cluster 2.1	Real-time visibility	1
	Need-to-know base	0.80
	No fraud/tampering	0.42
	Provenance	0.32
	Multiple parties	0.29
	Decreased settlement time	0.23
	Interdependent transactions	0.04
Cluster 2.2	Microtransactions	0.22
	Connected to an IoT device	0.16
	Efficiency through streamlining databases	0.16
	Simplification of processes	0.12
	Upfront control	0.09

Table D.10: TwoStep cluster analysis, fourth scenario

Focus group, overview of participants		
Index number	**Department**	**Kind of company**
F1	Business	Consultancy 1
F2	Business	Consultancy 1
F3	Business	Insurance 1
F4	IT	Insurance 1
F5	Business	Insurance 2
F6	IT	Insurance 2

Table D.11: Focus group, overview of participants

Focus group, findings	
Topic	**Finding**
Input	Make a short questionnaire as an input
	Try to use as simple words and phrases as possible in the questionnaire
	The questionnaire should be designed for the business and should contain enough recommendations for the IT department to get started
Expert system – Technology	The more unique technological components are used in the use case, the more appropriate the use case is
	All components of the technology domain are trust-related
	The main components of the technology domain are immutability and trustworthiness
Expert system – Business	The business domain is the least researched domain at the moment, therefore most interesting how the processes can be improved, thus efficiency enhancement
Expert system – Architecture	The main constructs of the architecture domain are openness and generation
Expert system – Domains	The expert system should involve the interaction between technology, business and architecture
Expert system – Expert advisory	You should have a platform advice but only include the ones with a large community
	Ease-of-use is hard at the moment, especially for smart contracts, due to technological immaturity
	The advice should consist advantage and complexity as variables
Output	Platform advice should be one of the outputs
	The business clusters should be one of the outputs, perhaps visualised with a spider web
	The two axes should be represented in a two-dimensional scheme with an advice of each quadrant
	The advice in total should help people getting started to experiment
Other remarks	The interplay of IT and business is important
	A technological substitution list should be helpful to determine if the use case is applicable for Blockchain
	The expert system is only applicable to the Western society because it requires other factors in other societies
	The expert system should be a tool for discussion
	The business case should be discussed hereafter
	The long-term implications should not be considered due to high uncertainty in this early phase
	The number of involved parties is an important factor but should be more thoroughly assessed in the organisation domain
	It should help the business unit with selecting the best possible use case from several possibilities, thus providing a portfolio of appropriate use cases

Table D.12: Focus group, findings

Questionnaire, best practices			
Design	**Kosnick & Presser AND Lietz**	**Kosnick & Presser**	**Lietz**
Question design	Use simple, familiar words	Make response options exhaustive and mutually exclusive	Should employ active rather than passive voice
	Use simple syntax	Avoid leading or loaded questions	Maximum of 16 words per question
	Avoid ambiguous words		Repeat nouns instead of using pronouns
	Strive for specific, concrete wording		Provide behavioural illustration of concepts
	Avoid double-barrelled questions		Use specific quantifiers rather than adverbs
	Avoid single/double negation		
Questionnaire design	Questions on the same topic grouped together	Filter questions should be included	Filter questions are not necessary
	Questions on same topic from general to specific	Early questions should be easy and pleasant	16-64 words introduction before grouped questions
	Sensitive questions at the end	Beginning should explicitly address topic	
	Warning of fatigue at the end		
Response design	5- or 7-point scale best used approach	Should cover entire measurement continuum	
	Liker-scale most used approach	Ordinal points without overlap	
	Verbal rather than numerical labels	Respondents must have a relatively precise, stable understanding of scale	
	Start with options that convey less socially desirable responses	All respondents must agree on the interpretation	
	Include midpoint		

Table D.13: Questionnaire, best practices

Expert analysis, overview of participants		
Index number	**Department**	**Kind of company**
E1	Business	Consultancy 1
E2	Business	Consultancy 1
E3	Business	Consultancy 1
E4	Business	Consultancy 1
E5	IT	Consultancy 1
E6	Business	Consultancy 2
E7	Business	Consultancy 3
E8	IT	Consultancy 3
E9	IT	Consultancy 4
E10	Business	Consultancy 5
E11	Business	Insurance 1
E12	Business	Insurance 2
E13	IT	Insurance 3
E14	Business	Insurance 4
E15	Business	Insurance 4
E16	Business	Insurance 5
E17	Business	Insurance 5

Table D.14: Expert analysis, overview of participants

Expert analysis, aggregated results on business				
Period	**Indicator**	**Cluster 1**	**Cluster 2.1**	**Cluster 2.2**
		Consolidation	*Single source of truth*	*Flow transactions*
Short-term	*Usefulness*	High	High	Medium
	Ease-of-use	Medium	Medium	Low
Long-term	*Usefulness*	High	High	Medium
	Ease-of-use	Medium	High	Medium
Average	*Usefulness*	High	High	Medium
	Ease-of-use	Medium	Medium-High	Low-Medium

Table D.15: Expert analysis, aggregated results on business

Expert analysis, weight of each domain			
	Technology	**Business**	**Architecture**
Expert analysis	24.6%	50%	25.4%
Rough estimate	25%	50%	25%

Table D.16: Expert analysis, weight of each domain

Overview of all participants					
Index number	**Department**	**Kind of company**	**Interviews**	**Focus group**	**Expert analysis**
P1	Business	Consultancy 1	X		
P2	Business	Consultancy 1	X		
P3	Business	Consultancy 1	X		X
P4	Business	Consultancy 1	X		X
P5	Business	Consultancy 1	X		X
P6	Business	Consultancy 1	X	X	
P7	Business	Consultancy 1		X	
P8	Business	Consultancy 1			X
P9	IT	Consultancy 1	X		
P10	IT	Consultancy 1	X		
P11	IT	Consultancy 1	X		X
P12	Business	Consultancy 2	X		X
P13	Business	Consultancy 3	X		
P14	Business	Consultancy 4	X		
P15	IT	Consultancy 5	X		
P16	IT	Consultancy 6	X		
P17	Business	Consultancy 7			X
P18	Business	Consultancy 8			X
P19	IT	Consultancy 8			X
P20	IT	Consultancy 9			X
P21	Business	Insurance 1	X	X	
P22	IT	Insurance 1		X	
P23	Business	Insurance 2	X	X	
P24	IT	Insurance 2	X	X	
P25	IT	Insurance 2	X		
P26	Business	Insurance 2			X
P27	Business	Insurance 3	X		X
P28	Business	Insurance 4	X		
P29	Business	Insurance 4			X
P30	Business	Insurance 4			X
P31	IT	Insurance 5			X
P32	Business	Insurance 6			X
P33	Business	Insurance 6			X

Table D.17: Overview all participants

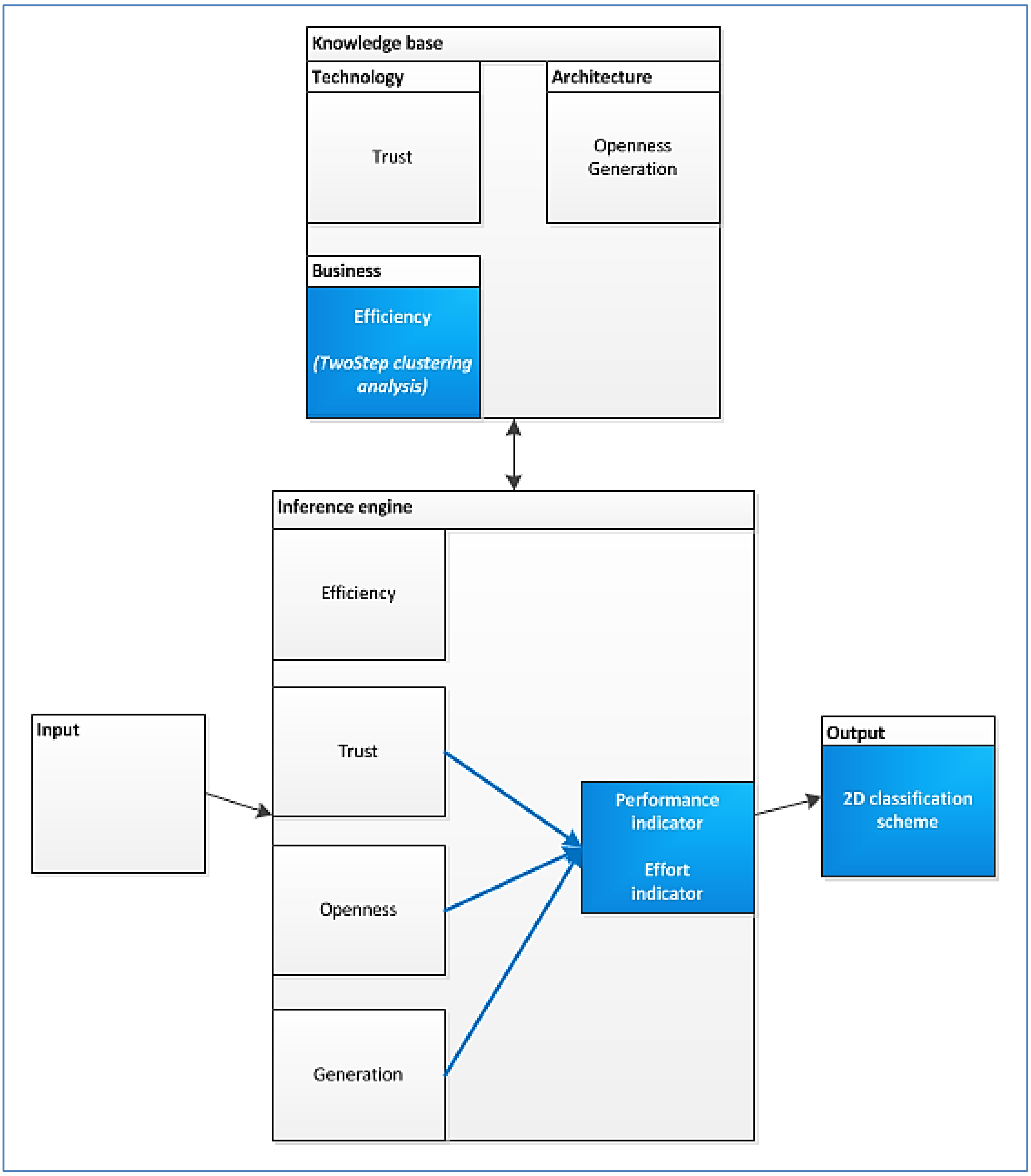

Figure D.1: Artefact, first iteration

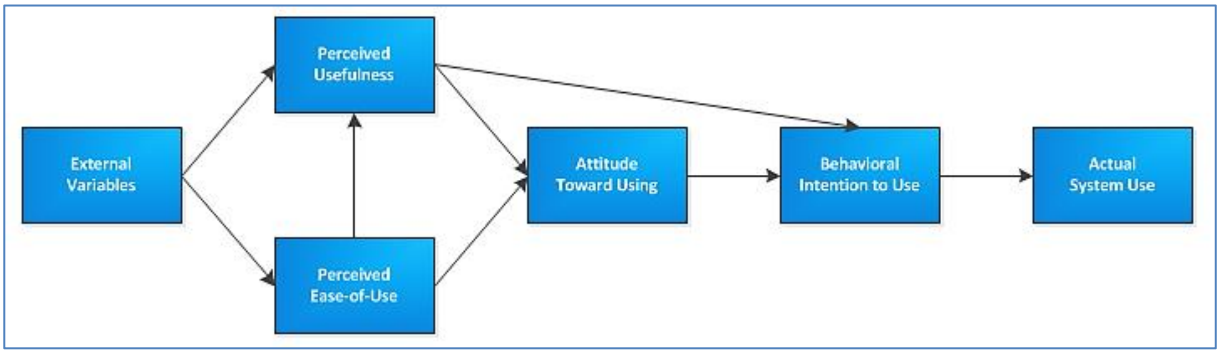

Figure D.2: Technology Acceptance Model (Davis et al., 1989)

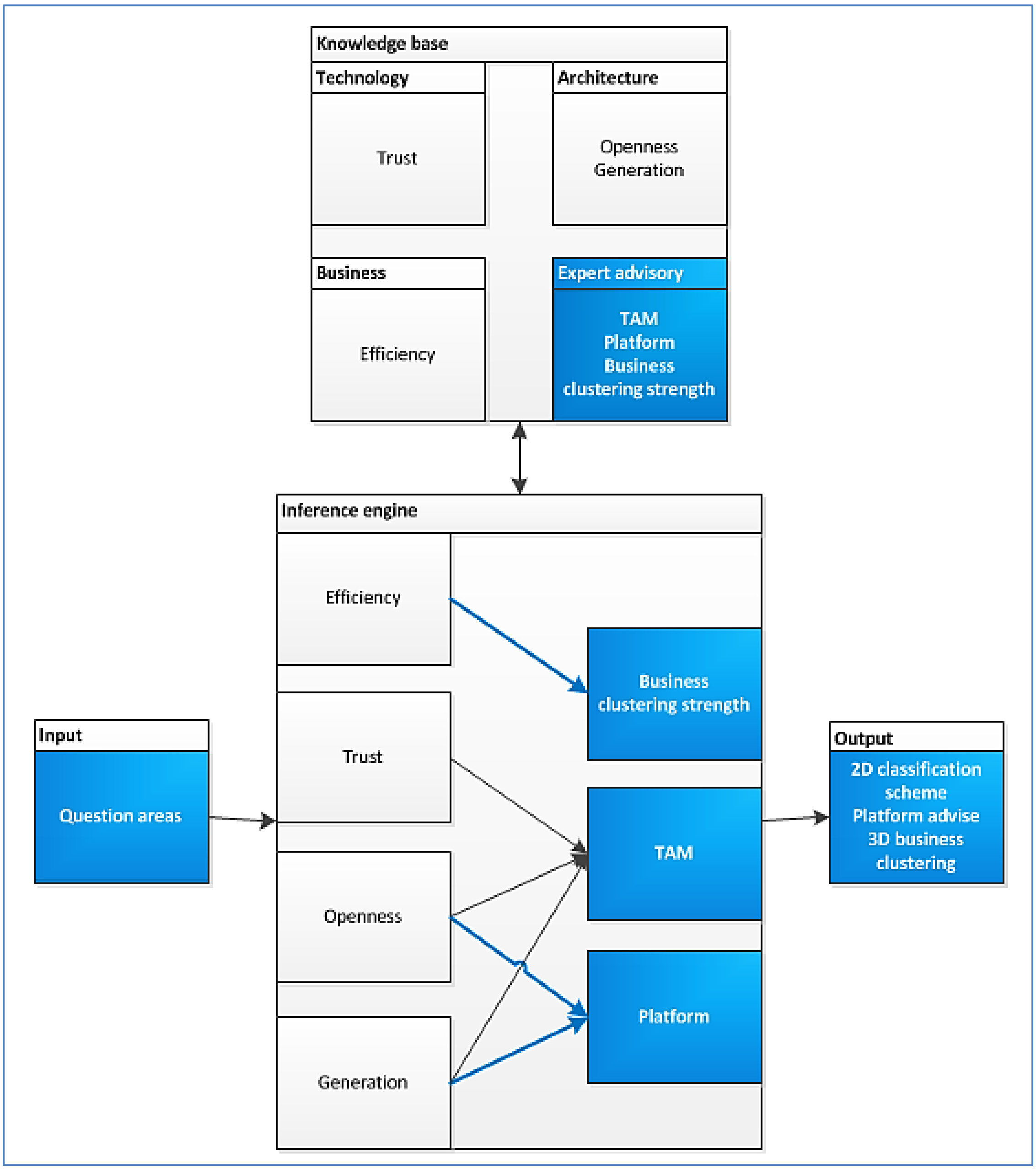

Figure D.3: Artefact, second iteration

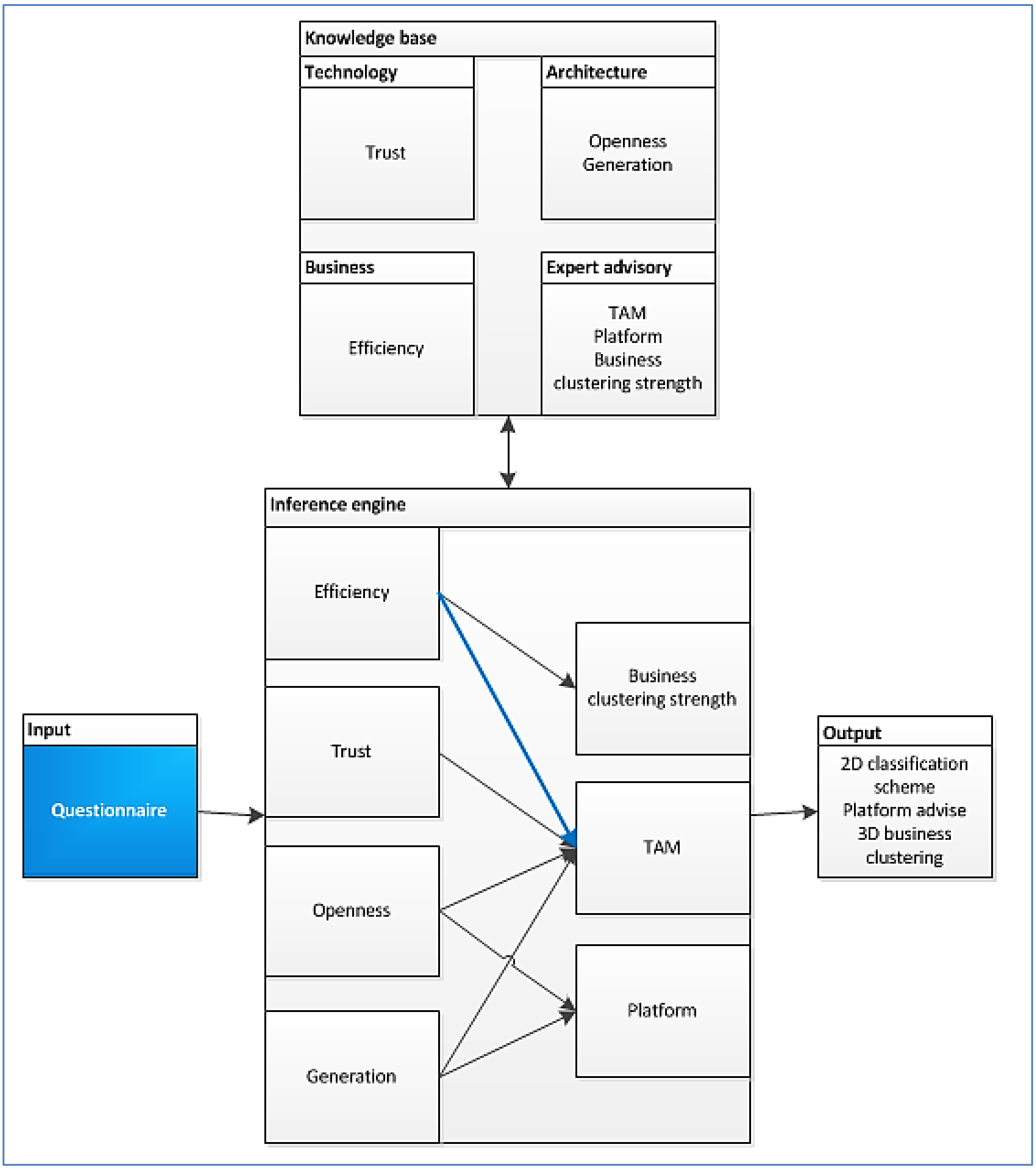

Figure D.4: Artefact, third iteration

Appendix E: Additional tables and figures, Chapter 5 Artefact design, product description

This appendix encloses all the additional figures and tables of the fifth chapter of the report, Artefact design, product description. The first figures show some additional information on the artefact whereas the latter provide some causal diagrams of the model. For the tables, the first ones provide an overview of the requirements, assumptions and design choices whereas the latter show some additional information concerning the calculative rules. Table E.1 presents an overview of the cross-reference.

Cross-reference, appendix E				
	No.	**Explanation**	**Ref. page**	**Page**
Table	E.2	The requirements of the designed artefact	41	96
	E.3	The assumptions of the designed artefact	41	96
	E.4	The design choices of the designed artefact	41, 62	97
	E.5	The calculative rules of the trust construct	48, 52	98
	E.6	The strength of each business factor	49	98
	E.7	The strength of the efficiency components	49, 51, 52	99
	E.8	The factor importance score of each business factor	49, 51	99
	E.9	The strength of each business factor, applied to insurance	49, 54	99
	E.10	The calculative rules of the efficiency construct	49, 52	100
	E.11	The weights of the openness construct	49, 53	100
	E.12	The business logic of the openness construct	49, 53	100
	E.13	The weights of the generation construct	49	101
	E.14	The business logic of the generation construct	49	101
	E.15	The business logic of the platform component	49	101
Figure	E.1	The first (calculative) part of the questionnaire	42, 52	102
	E.2	The second (rule-based) part of the questionnaire	42, 53	103
	E.3	The class diagram of the domains, constructs and components	42	104
	E.4	The constants, variables and formulas used in the artefact	47, 52, 55	105
	E.5	The causal diagram of the BOAT components on the Technology-Acceptance-Model component	48	106
	E.6	The calculative rules of the trust construct	48	106
	E.7	The calculative rules of the efficiency construct	49	107
	E.8	The causal diagram of the BOAT components on the platform component	49	107
	E.9	The causal diagram of the BOAT components on the business-clustering-strength component	50, 52	107
	E.10	The first part of the calculative rules of the business-clustering-strength component	50	108
	E.11	The second part of the calculative rules of the business-clustering-strength component	50	108

Table E.1: Cross-reference, appendix E

Artefact design, requirements		
Requirements	*Functional requirements*	The designed artefact should provide an advice on the appropriateness of a given use case
		The designed artefact should provide an advice on the platform choice of a given use case
		The designed artefact should provide information on the business clustering strength of a given use case
	User requirements	The designed artefact should be made user-friendly in such a way the business unit can easily work with it
		The designed artefact should be made user-friendly in such a way that the business unit can easily understand it
		The designed artefact should be according to the style of the stakeholder
	Boundary conditions	The designed artefact should be specifically aimed at the insurance branch
		The designed artefact should be specifically aimed at the Western society
		The designed artefact should comply with the culture and policies of CGI
	Design restrictions	The designed artefact should be applicable to all use cases of the insurance branch
		The designed artefact should be useable on short-term notice

Table E.1: Artefact design, requirements

Artefact design, assumptions	
1	The systematic literature review contains all relevant constructs and components of the knowledge base besides the components of the business domain
2	The components of the business domain were not thoroughly researched in academic literature. These are therefore derived from a document analysis
3	To delve deeper into the antecedents of the components would not lead to better results due to the high uncertainty presented by the two given reasons described before.
4	Regulation is related to the organisation rather than the business domain and therefore not considered in accordance with Design Choice 9
5	Constructs related to national concerns are not relevant for the chosen user group of this artefact, that is the business unit
6	Only platforms that apply a cryptocurrency are regarded as Blockchain platforms
7	The type of Blockchain and the use of Blockchain are the most important characteristics and therefore other platform characteristics like latency and throughput are excluded
8	If an expert system provides additional knowledge concerning the use case, the trust in the outcome for the selection of the use case is enhanced
9	A sample size of 33 participants during data collection of which one-third worked in the insurance sector is sufficient to withdraw insurance-specific data for the expert system
10	A sample size of over 100 use cases of which 25 percent was related to the insurance sector is not sufficed to establish an expert system for the insurance sector
11	To assess the strength of each business factor underlying the efficiency components, their predictor importance is used

Table E.2: Artefact design, assumptions

Artefact design, design choices	
1	The expert system is partly calculative and partly rule-based
2	The artefact can be subdivided into three distinct parts: being the input, 'brain' and the output
3	The input is obtained through a questionnaire
4	The Likert-scale is chosen for weighted variables
5	A Boolean measure is chosen for categorical variables
6	The business unit with several use cases that needs an objective advice on selecting the best applicable use case for Blockchain, is the user group that provides the input
7	The components of the business domain are derived from a document analysis
8	The level of analysis is set on the components
9	The BOAT-model is used to include all relevant aspects to research the strengths and weaknesses of Blockchain
10	The organisation domain is left out of the scope of this research
11	Components related to the architecture are not considered in this construct
12	The construct usability is not considered in this domain, because it differs per platform and is taken into consideration in the expert advisory domain
13	For the analysis of the best suited use case for Blockchain, factors that only regard the business case in terms of profit are not considered
14	The construct of the business domain 'role of the intermediary' is excluded from the knowledge base
15	In accordance with assumption 5, the construct of the business domain 'other threats' is excluded from the knowledge base
16	The components 'Blockchain 1.0' and 'Blockchain 2.0' are included whereas the component 'Blockchain 3.0' is excluded
17	The Technology Acceptance Model is chosen to evaluate the use cases based on academic terminology
18	The construct 'platform' is included in the knowledge base as part of the expert advisory domain
19	The included platforms are Bitcoin, Ethereum and Ripple
20	The construct 'business clustering strength' is included in the knowledge base as part of the expert advisory domain
21	The inference engines are split in three distinct parts related to the three constructs of the expert advisory domain
22	The data collected for the constructs trust, openness and generation do not receive a correction to make the model more specific for the insurance branch
23	The data collected for the construct efficiency do receive a correction to make the model more specific for the insurance branch
24	If the summarised effect of consolidation is 0.99 instead of 1 through a rounding error, it is not corrected
25	The outputs are represented in three distinct parts each showing a result of a different inference engine
26	The first output is represented on a two-dimensional classification scheme with the two variables of TAM on the two axes
27	The second output is represented by an image that represents the given output
28	The third output is represented by a three-dimensional graph containing the three components on the axes

Table E.3: Artefact design, design choices

Trust, calculative rules			
		Perceived usefulness	**Perceived ease-of-use**
	IF	**THEN**	**THEN**
Trustworthiness	$k = I$	$\frac{3-k}{2} * 6.25$	0
Immutability	$k = I$	$\frac{3-k}{2} * 6.25$	*0*
Total range		$\mathbf{-12.5 < PU < 12.5}$	$\mathbf{PEOU = 0}$

Table E.4: Trust, calculative rules

All industries factor strength							
		Efficiency					
		Consolidation		Flow transactions		Single source of truth	
		Absolute	*Relative*	*Absolute*	*Relative*	*Absolute*	*Relative*
Efficiency1	Decreased settlement time	1	**0.26**	0	**0**	0.23	**0.07**
Efficiency2	Multiple parties	0.98	**0.25**	0	**0**	0.29	**0.09**
Efficiency3	Efficiency through streamlining databases	0.98	**0.25**	0.16	**0.21**	0	**0**
Efficiency4	Interdependent transactions	0.30	**0.08**	0	**0**	0.04	**0.01**
Efficiency5	Paper-based processes	0.28	**0.07**	0	**0**	0	**0**
Efficiency6	Microtransactions	0.02	**0.01**	0.22	**0.29**	0	**0**
Efficiency7	Connected to an IoT device	0	**0**	0.16	**0.21**	0	**0**
Efficiency8	Simplification of processes	0.28	**0.07**	0.12	**0.16**	0	**0**
Efficiency9	Upfront control	0.02	**0.01**	0.09	**0.12**	0	**0**
Efficiency10	Real-time visibility	0.06	**0.02**	0	**0**	1	**0.32**
Efficiency11	Need-to-know base	0	**0**	0	**0**	0.80	**0.26**
Efficiency12	No fraud/tampering	0	**0**	0	**0**	0.42	**0.14**
Efficiency13	Provenance	0	**0**	0	**0**	0.32	**0.10**
Efficiency	Total	3.92	**1.02**	0.75	**0.99**	3.1	**0.99**

Table E.5: All industries factor strength

Components strength				
		Efficiency		
		Consolidation	*Flow transactions*	*Single source of truth*
Perceived usefulness	*Weights range*	(-8.33, 8.33)	(-8.33, 8.33)	(-8.33, 8.33)
	Expert analysis	High	Medium	High
	Numerical	5	3	5
	Weight	**8.33**	**0**	**8.33**
Perceived ease-of-use	*Weights range*	(-11.11, 11.11)	(-11.11, 11.11)	(-11.11, 11.11)
	Expert analysis	Medium	Low-Medium	Medium-High
	Numerical	3	2	4
	Weight	**0**	**-5.56**	**5.56**

Table E.6: Components strength

Factor importance			
Factor	**All industries**	**Insurance-specific**	**Difference**
Efficiency1	31.6	40.7	1.288
Efficiency2	59	63	1.068
Efficiency3	35	40.7	1.163
Efficiency4	14.5	14.8	1.021
Efficiency5	6.8	7.4	1.088
Efficiency6	5.1	11.1	2.176
Efficiency7	7.7	14.8	1.922
Efficiency8	17.9	25.9	1.447
Efficiency9	26.5	29.6	1.117
Efficiency10	32.5	25.9	0.797
Efficiency11	19.7	22.2	1.127
Efficiency12	29.9	33.3	1.114
Efficiency13	27.4	33.3	1.215

Table E.7: Factor importance

Insurance Factor strength							
	Efficiency						
		Consolidation		Flow transactions		Single source of truth	
	Insurance	*All industries*	IF_{i1}	*All industries*	IF_{i2}	*All industries*	IF_{i3}
Efficiency1	1.288	0.26	**0.28**	0	**0**	0.07	**0.09**
Efficiency2	1.068	0.25	**0.22**	0	**0**	0.09	**0.09**
Efficiency3	1.163	0.25	**0.24**	0.21	**0.15**	0	**0**
Efficiency4	1.021	0.08	**0.07**	0	**0**	0.01	**0.01**
Efficiency5	1.088	0.07	**0.06**	0	**0**	0	**0**
Efficiency6	2.176	0.01	**0.02**	0.29	**0.38**	0	**0**
Efficiency7	1.922	0	**0**	0.21	**0.25**	0	**0**
Efficiency8	1.447	0.07	**0.08**	0.16	**0.14**	0	**0**
Efficiency9	1.117	0.01	**0.01**	0.12	**0.08**	0	**0**
Efficiency10	0.797	0.02	**0.01**	0	**0**	0.32	**0.25**
Efficiency11	1.127	0	**0**	0	**0**	0.26	**0.29**
Efficiency12	1.114	0	**0**	0	**0**	0.14	**0.15**
Efficiency13	1.215	0	**0**	0	**0**	0.10	**0.12**
Efficiency		1.02	**0.99**	0.99	**1**	0.99	**1**

Table E.8: Insurance Factor strength

Efficiency, calculative rules			
		Perceived usefulness	Perceived ease-of-use
	IF	THEN	THEN
Efficiency1	$Ef_1 = I$	$\frac{3 - Ef_1}{2} * (0.28 * 8.33 + 0.09 * 8.33)$	$\frac{3 - Ef_1}{2} * (0.09 * 5.56)$
Efficiency2	$Ef_2 = I$	$\frac{3 - Ef_2}{2} * (0.22 * 8.33 + 0.09 * 8.33)$	$\frac{3 - Ef_2}{2} * (0.09 * 5.56)$
Efficiency3	$Ef_3 = I$	$\frac{3 - Ef_3}{2} * (0.24 * 8.33)$	$\frac{3 - Ef_3}{2} * (0.15 * -5.56)$
Efficiency4	$Ef_4 = I$	$\frac{3 - Ef_4}{2} * (0.07 * 8.33 + 0.01 * 8.33)$	$\frac{3 - Ef_4}{2} * (0.01 * 5.56)$
Efficiency5	$Ef_5 = I$	$\frac{3 - Ef_5}{2} * (0.06 * 8.33)$	*0*
Efficiency6	$Ef_6 = I$	$\frac{3 - Ef_6}{2} * (0.02 * 8.33)$	$\frac{3 - Ef_6}{2} * (0.38 * -5.56)$
Efficiency7	$Ef_7 = I$	*0*	$\frac{3 - Ef_7}{2} * (0.25 * -5.56)$
Efficiency8	$Ef_8 = I$	$\frac{3 - Ef_8}{2} * (0.08 * 8.33)$	$\frac{3 - Ef_8}{2} * (0.14 * -5.56)$
Efficiency9	$Ef_9 = I$	$\frac{3 - Ef_9}{2} * (0.01 * 8.33)$	$\frac{3 - Ef_9}{2} * (0.08 * -5.56)$
Efficiency10	$Ef_{10} = I$	$\frac{3 - Ef_{10}}{2} * (0.01 * 8.33 + 0.25 * 8.33)$	$\frac{3 - Ef_{10}}{2} * (0.25 * 5.56)$
Efficiency11	$Ef_{11} = I$	$\frac{3 - Ef_{11}}{2} * (0.29 * 8.33)$	$\frac{3 - Ef_{11}}{2} * (0.29 * 5.56)$
Efficiency12	$Ef_{12} = I$	$\frac{3 - Ef_{12}}{2} * (0.15 * 8.33)$	$\frac{3 - Ef_{12}}{2} * (0.15 * 5.56)$
Efficiency13	$Ef_{13} = I$	$\frac{3 - Ef_{13}}{2} * (0.12 * 8.33)$	$\frac{3 - Ef_{13}}{2} * (0.12 * 5.56)$

Table E.9: Efficiency, calculative rules

Openness				
		Public permissionless	*Public permissioned*	*Private permissioned*
Perceived usefulness	*Weights range*	(-7.5, 7.5)	(-7.5, 7.5)	(-7.5, 7.5)
	Expert analysis	Medium	Medium	Low-Medium
	Numerical	3	3	2
	Weight	**0**	**0**	**-3.75**
Perceived ease-of-use	*Weights range*	(-10, 10)	(-10, 10)	(-10, 10)
	Expert analysis	Low-Medium	Medium-High	High
	Numerical	2	4	5
	Weight	**-5**	**5**	**10**

Table E.10: Openness

Openness business logic		
	Perceived usefulness	Perceived ease-of-use
Public permissionless	0	-5
Public permissioned	0	5
Private permissioned	-3.75	10

Table E.11: Openness, business logic

Generation			
		Blockchain 1.0	**Blockchain 2.0**
Perceived usefulness	*Weights range*	(-5, 5)	(-5, 5)
	Expert analysis	Medium	Medium-High
	Numerical	3	4
	Weight	**0**	**2.5**
Perceived ease-of-use	*Weights range*	(-6.67, 6.67)	(-6.67, 6.67)
	Expert analysis	High	Low-Medium
	Numerical	5	2
	Weight	**6.67**	**-3.33**

Table E.12: Generation

Generation business logic		
	Perceived usefulness	**Perceived ease-of-use**
Blockchain 1.0	0	6.67
Blockchain 2.0	2.5	-3.33

Table E.13: Generation, business logic

Platform			
	IF	$THEN$	$ELSE$
Bitcoin	$(PPs = YES\ AND\ B1.0 = YES)\ OR\ (PPd = YES\ AND\ B1.0 = YES)$	$Bitcoin = YES$	$Bitcoin = NO$
Ethereum	$B2.0 = YES$	$Ethereum = YES$	$Ethereum = NO$
Ripple	$Pr = YES\ AND\ B1.0 = YES$	$Ripple = YES$	$Ripple = NO$

Table E.14: Platform

Questionnaire – Questions

The following questionnaire is advised to be used for the business unit of a(n) (insurance) company. For a thorough analysis, it is advised that the business unit should comprise different perspectives and therefore be filled in at a managerial level. Every time the word database or ledger is used, it is an explanation of what is Blockchain more or less represent. Every time the word data or asset is used, this is also called information or a digitalised reference of an asset. Furthermore, all answers can be given on the answer sheet in which the first 20 questions have a Likert-scale range due to its weighted nature implying a the following range, strongly agree-agree-neutral-disagree-strongly disagree. The last four questions can only be filled in with yes or no due to its classifying nature. The answers should be given by placing an X in the corresponding response.

The first questions relate to the technological features Blockchain comprises. These features try to establish trust which in the current situation is often guaranteed by a third independent party. Blockchain aims at delivering that same trust through technology. There are up- and downsides to this, therefore you should think carefully about the following statements:

1. It is important that trust in a database will be guaranteed through a technological solution
2. Currently, trust in data, assets or transactions can be guaranteed by a third party
3. It is important that the origin of data or assets can be traced back
4. It is important that alterations to data or assets can be traced back to an entity
5. It is important that all alterations and transactions will be stored permanently
6. It is important that past data or transactions can be erased
7. It is important that past data or transactions can be altered rather than mere updated

The following statements can apply to your use case. Think carefully about the goals and desired benefits the use case should deliver. It is unlikely that all aspects can be beneficial to a specific use case and this could add complexity to the usage.

8. It is important that the settlement time of processes will be improved
9. It is important that multiple parties are involved in the shared ledger
10. It is important that multiple databases on multiple locations are streamlined
11. The transactions or the processes are interdependent
12. The documentation of the current process is paper-based
13. The amount of data per transaction is very small
14. It is important that Internet-of-Things devices are linked to the database
15. It is important that the processes will be simplified
16. It is important to establish upfront control in terms of process automation
17. It is important that the visibility of data, assets or transactions are real-time
18. It is important that involved parties have different rights in terms of data visibility
19. It is important that the data can prevent fraud through its immutability
20. It is important that the provenance of data or assets is included

When using a distributed ledger or database there could be some ground rules in terms of the openness and transparency of using this. You should keep some features in mind before answering the following questions.

Figure E.1: Questionnaire, part one

- All transactions are cryptographically concealed and the specific content can only be seen by the parties that interact in that transaction.
- Involved parties in the database could be concealed to their true entity if chosen.
- All participants that enter the database are able to see (concealed) transactions between (concealed) parties.

21. Should there be control of who can enter the database?
22. Should there be control of who can perform a transaction?
23. Should the database be able to perform standard data procedures (perform transactions, update information, show data et cetera)?
24. Should the database be able to perform self-executing business logic (complex automated logic like IF THEN ELSE)?

Figure E.2: Questionnaire, part two

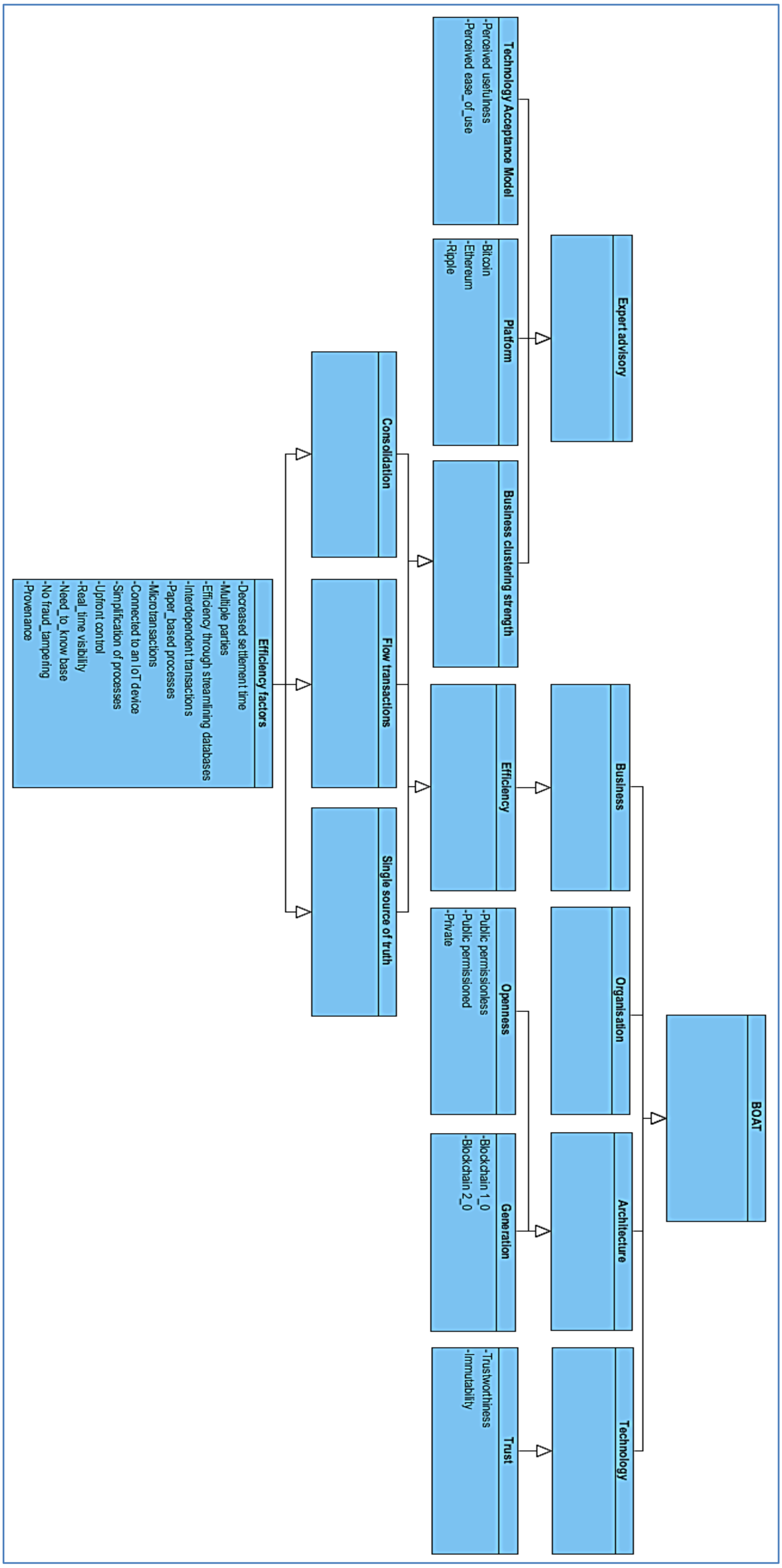

Figure E.3: Class diagram

Constants, variables & formulas

Constants

$$B1.0 = Blockchain\ 1.0;$$

$$B2.0 = Blockchain\ 2.0;$$

$$C = Component\ strength;$$

$$i = Number\ of\ input;$$

$$IF = Insurance\ Factor;$$

$$PPd = Public\ Permissioned;$$

$$PPs = Public\ Permissionless;$$

$$Pr = \ Private;$$

Variables

$$BCS = Business\ clustering\ strength;$$

$$Ef = Efficiency;$$

$$I = Input\ strength$$

$$= (strongly\ agree, agree, neutral, disagree, strongly\ disagree) = (1, 2, 3, 4, 5);$$

$$j = Number\ of\ component$$

$$= (consolidation, flow\ transactions, single\ source\ of\ truth) = (1, 2, 3);$$

$$Tr = Trust$$

Formulas

$$IF\ k = I\ THEN\ \frac{3-k}{2} * 6.25 \tag{1}$$

$$WITH\ k = \textstyle\sum_1^i \frac{I}{i}$$

$$IF\ Ef_i = I\ THEN\ \frac{3-Ef_i}{2} * \textstyle\sum_1^i IF_{ij} * C_j \tag{2}$$

$$IF\ Ef_i = I\ THEN\ BCS_j = \ \textstyle\sum_1^i \frac{Ef_i-1}{4} * F_{ij} \tag{3}$$

Figure E.4: Constants, variables & formulas

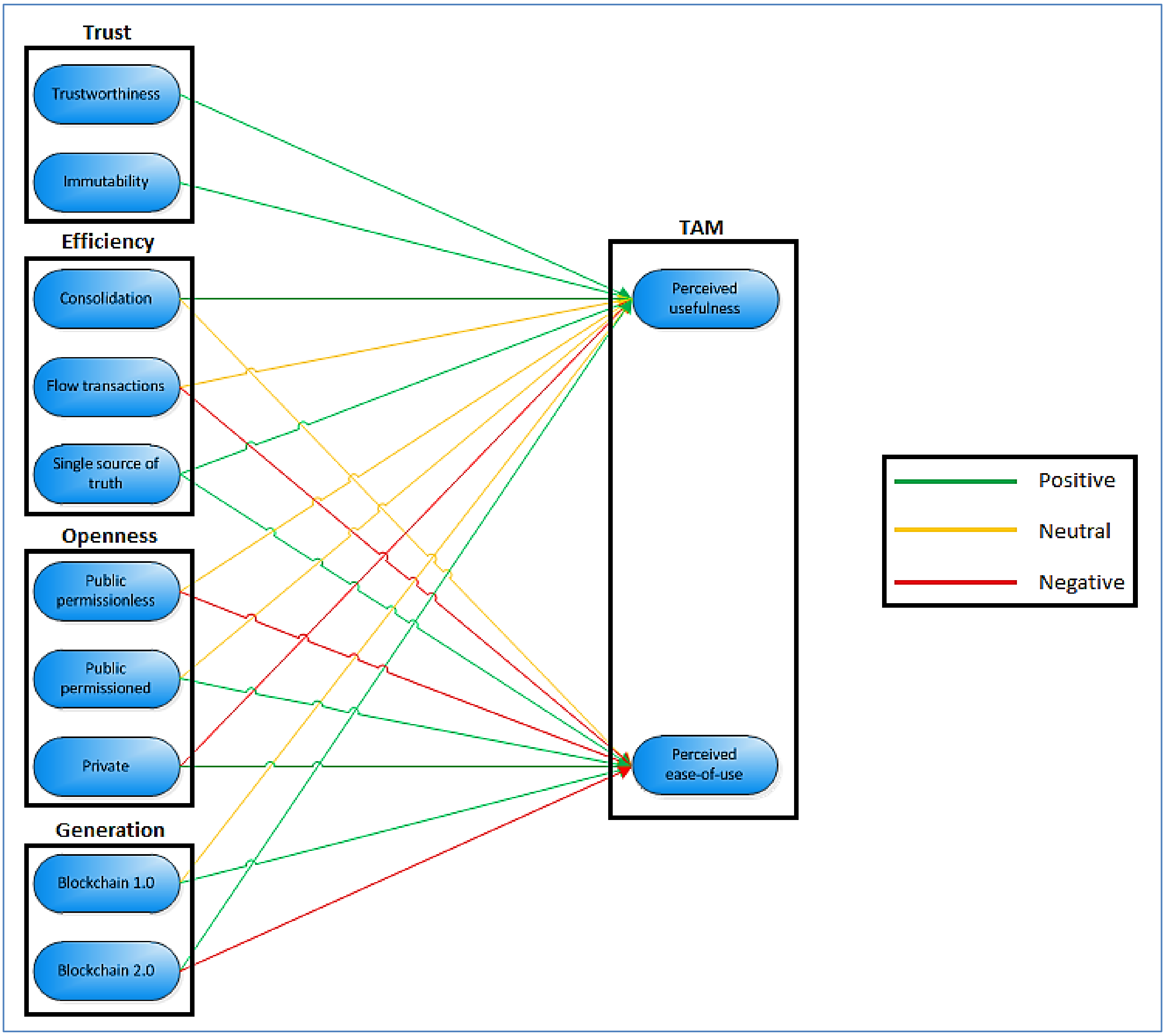

Figure E.5: Technology Acceptance Model, causal diagram

$$IF\ k = I\ THEN\ k = \sum_{1}^{i} \frac{I}{Tr_i}$$

$$where\ I = input\ strength = (1, 2, 3, 4, 5);$$

$$Tr_i = Trust\ i;$$

$$i = Number\ of\ input$$

Figure E.6: Trust, calculative rules

$$FOR\ Ef_1 = I\ THEN\ \frac{3 - Ef_i}{2} * \sum_{1}^{i} IF_{ij} * C_j$$

$$with\ Ef_i = Efficiency\ i;$$

$$IF_{ij} = Insurance\ Factor\ strength\ i\ of\ component\ j;$$

$$C_j = Component\ strength\ j;$$

$$j = Number\ of\ component = (1, 2, 3)$$

$$= (consolidation, flow\ transactions, single\ source\ of\ truth)$$

Figure E.7: Efficiency, calculative rules

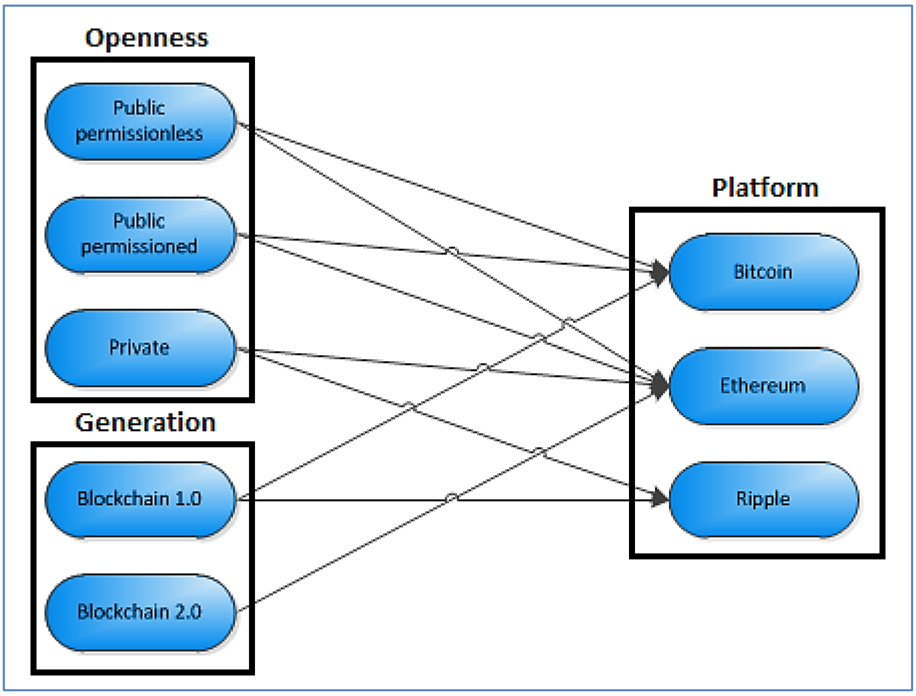

Figure E.8: Platform, causal diagram

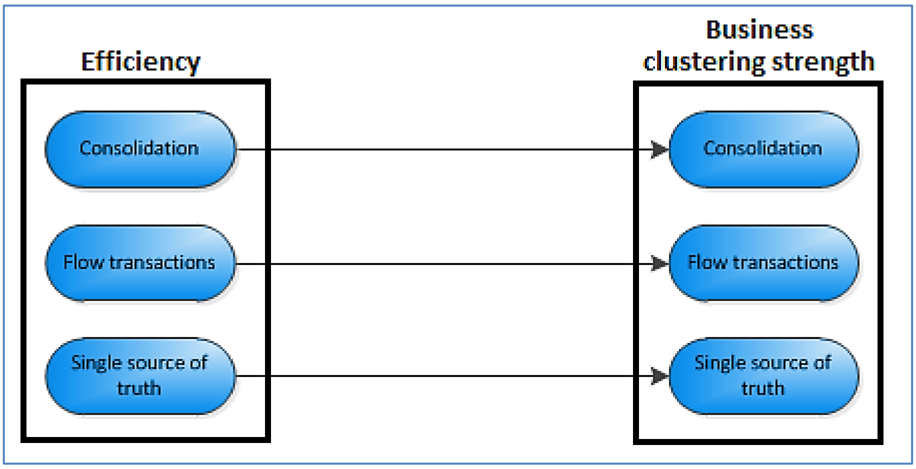

Figure E.9: Business clustering strength, causal diagram

$$BCS_j = \sum_{1}^{i} \frac{5 - Ef_i}{4} * IF_{ij}$$

$$with\ BCS_j = Business\ clustering\ strength\ of\ component\ j$$

Figure E.10: Business clustering strength, calculative rules, part one

$$Consolidation = \frac{5 - Ef_1}{4} * 0.28 + \frac{5 - Ef_2}{4} * 0.22 + \frac{5 - Ef_3}{4} * 0.24 + \frac{5 - Ef_4}{4} * 0.07 + \frac{5 - Ef_5}{4} * 0.06 + \frac{5 - Ef_6}{4} * 0.02 + \frac{5 - Ef_8}{4} * 0.08 + \frac{5 - Ef_9}{4} * 0.01 + \frac{5 - Ef_{10}}{4} * 0.01$$

$$Flow\ transactions = \frac{5 - Ef_3}{4} * 0.15 + \frac{5 - Ef_6}{4} * 0.38 + \frac{5 - Ef_7}{4} * 0.25 + \frac{5 - Ef_8}{4} * 0.14 + \frac{5 - Eff_9}{4} * 0.08$$

$$Single\ source\ of\ truth = \frac{5 - Ef_1}{4} * 0.09 + \frac{5 - Ef_2}{4} * 0.09 + \frac{5 - Ef_4}{4} * 0.01 + \frac{5 - Ef_{10}}{4} * 0.25 + \frac{5 - Ef_{11}}{4} * 0.29 + \frac{5 - Ef_{12}}{4} * 0.15 + \frac{5 - Ef_{13}}{4} * 0.12$$

Figure E.11: Business clustering strength, calculative rules, part two

Appendix F: Additional tables and figures, Chapter 6 Artefact validation

This appendix encloses all the additional figures and tables of the sixth chapter of the report, Artefact validation. The figures and tables provide information on a lower level of the model than the highest aggregated one described in Chapter 6. Table F.1 presents an overview of the cross-reference.

Cross-reference, appendix F				
	No.	**Explanation**	**Ref. page**	**Page**
Table	F.2	The range of scores of the calculative questions	52	110
	F.3	The range of scores of the calculative questions, aggregated to the component level	52	110
	F.4	The scenario explanation of the rule-based questions, relevant to the first output	53	110
	F.5	The scores of the rule-based scenarios	53	111
	F.6	The scores of the rule-based scenarios, aggregated to the component level	53	111
	F.7	The range of scores of the calculative questions and the rule-based scenarios, aggregated to the construct level	53	111
	F.8	The scenarios explanation of the rule-based questions, relevant to the second output	54	111
	F.9	The scenarios of the rule-based questions, relevant to the second output	54	112
	F.10	The range of scores of the (business-related) calculative questions, relevant to the third output	54	112
	F.11	The use cases for validation purposes together with their index number, use-case title, a short description and a first subdivision	55	113
	F.12	The results of the validation on perceived usefulness	55	114
	F.13	The use cases for validation purposes together with their index number, use-case title and a second subdivision	56	114
	F.14	The results of the validation on perceived ease-of-use	56	115
Figure	F.1	The range of scores of the calculative questions	52	116
	F.2	The range of scores of the calculative questions, aggregated to the component level	52	116
	F.3	The scores of the rule-based scenarios	53	116
	F.4	The scores of the rule-based scenarios, aggregated to the component level	53	116
	F.5	The range of scores of the calculative questions and the rule-based scenarios, aggregated to the construct level	53	117
	F.6	The range of scores of the (business-related) calculative questions, relevant to the third output	54	117
	F.7	A boxplot of the validation on perceived usefulness	55	118
	F.8	A boxplot of the validation on perceived ease-of-use	56	118

Table F.1: Cross-reference, appendix F

Calculative, question				
	Perceived usefulness		Perceived ease-of-use	
Question	*Minimum*	*Maximum*	*Minimum*	*Maximum*
1	-1.5625	1.5625	0	0
2	-1.5625	1.5625	0	0
3	-1.5625	1.5625	0	0
4	-1.5625	1.5625	0	0
5	-2.0833	2.0833	0	0
6	-2.0833	2.0833	0	0
7	-2.0833	2.0833	0	0
8	-3.0821	3.0821	-0.5004	0.5004
9	-2.5823	2.5823	-0.5004	0.5004
10	-1.9992	1.9992	-0.8340	0.8340
11	-0.6664	0.6664	-0.0556	0.0556
12	-0.4998	0.4998	0	0
13	-0.1666	0.1666	-2.1128	2.1128
14	0	0	-1.3900	1.3900
15	-0.6664	0.6664	-0.7784	0.7784
16	-0.0833	0.0833	-0.4445	0.4445
17	-2.1658	2.1658	-1.3900	1.3900
18	-2.4157	2.4157	-1.6124	1.6124
19	-1.2495	1.2495	-0.8340	0.8340
20	-0.9996	0.9996	-0.6672	0.6672

Table F.1: Calculative, question

Calculative, component				
	Perceived usefulness		Perceived ease-of-use	
Component	*Minimum*	*Maximum*	*Minimum*	*Maximum*
Trustworthiness	-6.2500	6.2500	0	0
Immutability	-6.2499	-6.2499	0	0
Consolidation	-8.2467	8.2467	0	0
Flow transactions	0	0	-5.5597	5.5597
Single source of truth	-8.3300	8.3300	-5.5600	5.5600

Table F.2: Calculative, component

Rule-based, scenario explanation				
	Question			
Scenario	*21*	*22*	*23*	*24*
1	Yes	Yes	-	-
2	Yes	No	-	-
3	No	Yes	-	-
4	No	No	-	-
5	-	-	Yes	Yes
6	-	-	Yes	No
7	-	-	No	Yes
8	-	-	No	No

Table F.3: Rule-based, scenario explanation

Rule-based, scenarios		
Scenario	**Perceived usefulness**	**Perceived ease-of-use**
1	-3.75	10
2	-3.75	10
3	0	5
4	0	-5
5	2.50	-3.33
6	0	6.67
7	2.50	-3.33
8	0	6.67

Table F.4: Rule-based, scenarios

Rule-based, component		
Component	**Perceived usefulness**	**Perceived ease-of-use**
Public permissionless	0	-5
Public permissioned	0	5
Private permissioned	-3.75	10
Blockchain 1.0	0	6.67
Blockchain 2.0	2.50	-3.33

Table F.5: Rule-based, component

All constructs				
	Perceived usefulness		**Perceived ease-of-use**	
Construct	*Minimum*	*Maximum*	*Minimum*	*Maximum*
Trust	-12.4999	12.4999	0	0
Efficiency	-16.5767	16.5767	-11.1197	11.1197
Openness	-3.75	0	-5	10
Generation	0	2.5	-3.33	6.67

Table F.6: All constructs

Output two, scenario explanation				
	Question			
Scenario	*21*	*22*	*23*	*24*
1	Yes	Yes	Yes	Yes
2	Yes	Yes	Yes	No
3	Yes	Yes	No	Yes
4	Yes	Yes	No	No
5	Yes	No	Yes	Yes
6	Yes	No	Yes	No
7	Yes	No	No	Yes
8	Yes	No	No	No
9	No	Yes	Yes	Yes
10	No	Yes	Yes	No
11	No	Yes	No	Yes
12	No	Yes	No	No
13	No	No	Yes	Yes
14	No	No	Yes	No
15	No	No	No	Yes
16	No	No	No	No

Table F.7: Output two, scenario explanation

Output two, scenarios		
Scenario	**Predetermined output**	**Actual output**
1	Ethereum	Ethereum
2	Ripple	Ripple
3	Ethereum	Ethereum
4	Ripple	Ripple
5	Ethereum	Ethereum
6	Ripple	Ripple
7	Ethereum	Ethereum
8	Ripple	Ripple
9	Ethereum	Ethereum
10	Bitcoin	Bitcoin
11	Ethereum	Ethereum
12	Bitcoin	Bitcoin
13	Ethereum	Ethereum
14	Bitcoin	Bitcoin
15	Ethereum	Ethereum
16	Bitcoin	Bitcoin

Table F.8: Output two, scenarios

Output three, actual output						
	Consolidation		**Flow transactions**		**Single source of truth**	
Question	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
8	0	0.28	0	0	0	0.09
9	0	0.22	0	0	0	0.09
10	0	0.24	0	0.15	0	0
11	0	0.07	0	0	0	0.01
12	0	0.06	0	0	0	0
13	0	0.02	0	0.38	0	0
14	0	0	0	0.25	0	0
15	0	0.08	0	0.14	0	0
16	0	0.01	0	0.08	0	0
17	0	0.01	0	0	0	0.25
18	0	0	0	0	0	0.29
19	0	0	0	0	0	0.15
20	0	0	0	0	0	0.12

Table F.9: Output three, actual output

Use cases for validation		
Successful use cases		
Index No.	**Use case**	**Short description**
[1.1]	PGB	Streamlining the different databases dealing with PGB
[1.2]	Pay-per-Use	Very small payments through IoT-connected devices
[1.3]	P2P Electricity Trade	Streamlining lots of small energy suppliers and users
[1.4]	Fraud Prevention	Immutable history to tackle fraud
[1.5]	CC Payments	Improve settlement time of CC payments
[1.6]	Medical Records	Automated diagnosis through an IoT-connected device
[1.7]	Real Estate Data Management	Streamlining the different databases dealing with real estate
[1.8]	Easy Trading Connect	Streamlining databases and improve settlement time of trades
[1.9]	P2P Lending Platform	Streamlining lots of small lenders and suppliers
Random set of use cases		
Index No.	**Use case**	**Short description**
[2.1]	Trade Clearing & Settlement	Streamlining the different databases dealing with trade
[2.2]	Supply Chain	Streamlining the processes of interdependent stakeholders
[2.3]	HALT Punishment	Ownership of information at the user
[2.4]	Flash Foundation	Automated building of foundations
[2.5]	Shipping	Streamlining interdependent partners on a network
[2.6]	Syndicated Loans	Streamlining several lenders on a network
[2.7]	Voting	Creating a trustworthy voting system
[2.8]	Claims Management	Automating the claims management process and prevent fraud
[2.9]	P2P Insurance	Automated small groups of insurance

Table F.10: Use cases for validation

Validation perceived usefulness, score per use case									
	Index no. of successful use cases								
	[1.1]	[1.2]	[1.3]	[1.4]	[1.5]	[1.6]	[1.7]	[1.8]	[1.9]
Perceived usefulness	10.22	7.40	22.20	9.77	23.41	3.36	15.79	17.81	21.74
Trust	3.38	3.64	6.26	6.77	8.34	1.82	8.34	7.82	10.16
Trustworthiness	2.34	1.56	3.13	4.69	3.13	0.78	3.13	4.69	3.91
Immutability	1.04	2.08	3.13	2.08	5.21	1.04	5.21	3.13	6.25
Efficiency	8.08	1.25	13.45	6.75	12.56	2.79	11.20	13.74	9.08
Consolidation	0.92	0.56	0.94	0.63	0.95	0.54	0.83	0.96	0.78
Flow transactions	0.57	0.82	0.92	0.43	0.60	0.74	0.47	0.63	0.55
Single source of truth	0.57	0.51	0.86	0.77	0.81	0.63	0.84	0.87	0.76
Openness	Pr	PPd	PPd	Pr	PPs	Pr	Pr	Pr	PPs
Generation	B2.0	B2.0	B2.0	B1.0	B2.0	B2.0	B1.0	B1.0	B2.0
Platform	Ethereum	Ethereum	Ethereum	Ripple	Ethereum	Ethereum	Ripple	Ripple	Ethereum
	Index no. of random use cases								
	[2.1]	[2.2]	[2.3]	[2.4]	[2.5]	[2.6]	[2.7]	[2.8]	[2.9]
Perceived usefulness	4.38	6.74	-1.55	-10.63	10.94	-0.82	10.59	11.88	17.52
Trust	0.26	0.78	-9.38	-2.34	1.82	2.35	2.34	1.30	7.82
Trustworthiness	-0.78	0.78	-3.13	-2.34	0.78	-0.78	2.34	2.34	4.69
Immutability	1.04	0	-6.25	0	1.04	3.13	0	-1.04	3.13
Efficiency	4.12	7.21	9.08	-7.04	10.37	0.58	9.50	11.83	7.21
Consolidation	0.93	0.92	0.78	0.44	0.96	0.30	0.71	0.90	0.70
Flow transactions	0.41	0.32	0.32	0.73	0.71	0.49	0.40	0.64	0.86
Single source of truth	0.31	0.51	0.77	0.13	0.66	0.73	0.86	0.81	0.73
Openness	PPs	Pr	Pr	Pr	Pr	Pr	Pr	Pr	PPs
Generation	B1.0	B2.0	B2.0	B2.0	B2.0	B1.0	B2.0	B2.0	B2.0
Platform	Bitcoin	Ethereum	Ethereum	Ethereum	Ethereum	Ripple	Ethereum	Ethereum	Ethereum

Table F.11: Validation perceived usefulness, score per use case

Subdivision, validation of perceived ease-of-use			
Difficult use cases		Easy use cases	
Index no.	**Title**	**Index no.**	**Title**
[1.2]	Pay-per-Use	**[1.1]**	PGB
[1.3]	P2P Electricity Trade	**[1.4]**	Fraud Prevention
[1.5]	CC Payments	**[1.7]**	Real Estate Data Management
[1.6]	Medical Records	**[1.8]**	Easy Trading Connect
[1.9]	P2P Lending Platform	**[2.3]**	HALT Punishment
[2.1]	Trade Clearing & Settlement	**[2.4]**	Flash Foundation
[2.2]	Supply Chain	**[2.6]**	Syndicated Loans
[2.5]	Shipping	**[2.7]**	Voting
[2.9]	P2P Insurance	**[2.8]**	Claims Management

Table F.12: Subdivision, validation of perceived ease-of-use

Validation perceived ease-of-use, score per use case									
	Index no. of difficult use cases								
	[1.2]	[1.3]	[1.5]	[1.6]	[1.9]	[2.1]	[2.2]	[2.5]	[2.9]
Perceived ease-of-use	-1.72	1.06	-6.08	-1.22	-5.99	0.59	8.78	6.06	-9.78
Trust	0	0	0	0	0	0	0	0	0
Trustworthiness	0	0	0	0	0	0	0	0	0
Immutability	0	0	0	0	0	0	0	0	0
Efficiency	-3.39	-0.61	2.25	-1.22	2.34	-1.08	2.11	-0.61	-1.45
Consolidation	0.56	0.94	0.95	0.54	0.78	0.93	0.93	0.96	0.70
Flow transactions	0.82	0.92	0.60	0.74	0.55	0.41	0.32	0.71	0.86
Single source of truth	0.51	0.86	0.81	0.63	0.76	0.31	0.51	0.66	0.73
Openness	PPd	PPd	PPs	Pr	PPs	PPs	Pr	Pr	PPs
Generation	B2.0	B2.0	B2.0	B2.0	B2.0	B1.0	B2.0	B2.0	B2.0
Platform	Ethereum	Ethereum	Ethereum	Ethereum	Ethereum	Bitcoin	Ethereum	Ethereum	Ethereum
	Index no. of easy use cases								
	[1.1]	[1.4]	[1.7]	[1.8]	[2.3]	[2.4]	[2.6]	[2.7]	[2.8]
Perceived ease-of-use	6.61	20.42	20.81	19.28	11.65	0.03	19.39	11.81	8.53
Trust	0	0	0	0	0	0	0	0	0
Trustworthiness	0	0	0	0	0	0	0	0	0
Immutability	0	0	0	0	0	0	0	0	0
Efficiency	-0.06	3.75	4.14	2.61	4.98	-6.64	2.72	5.14	1.86
Consolidation	0.92	0.63	0.83	0.96	0.78	0.44	0.30	0.71	0.90
Flow transactions	0.57	0.43	0.47	0.63	0.32	0.73	0.49	0.40	0.64
Single source of truth	0.57	0.77	0.84	0.87	0.77	0.13	0.73	0.86	0.81
Openness	Pr	Pr	Pr	Pr	Pr	Pr	Pr	Pr	Pr
Generation	B2.0	B1.0	B1.0	B1.0	B2.0	B2.0	B1.0	B2.0	B2.0
Platform	Ethereum	Ripple	Ripple	Ripple	Ethereum	Ethereum	Ripple	Ethereum	Ethereum

Table F.13: Validation perceived ease-of-use, score per use case

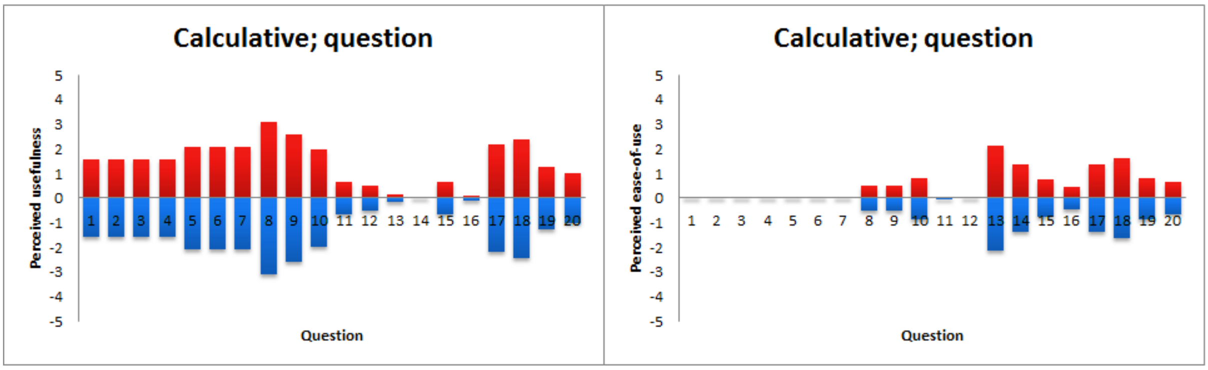

Figure F.1: Calculative, question

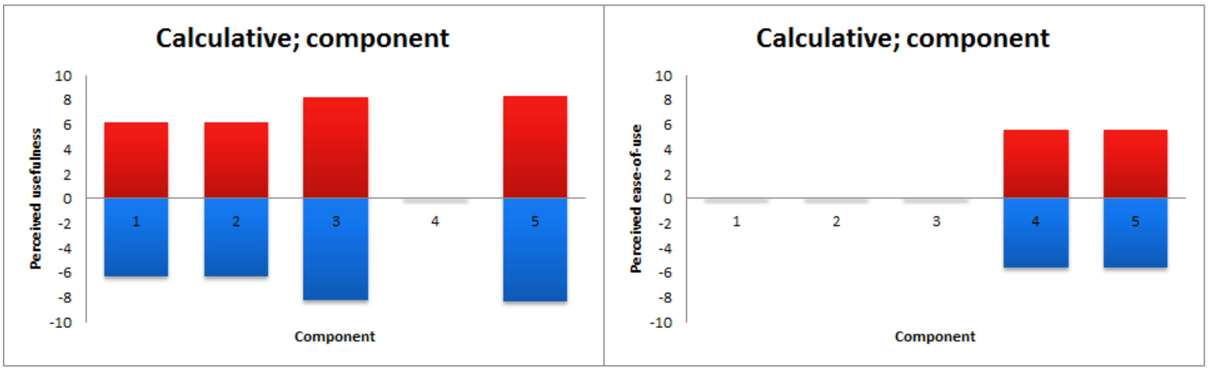

Figure F.2: Calculative, component
1: Trustworthiness; 2: Immutability; 3: Consolidation; 4: Flow transactions; 5: Single source of truth

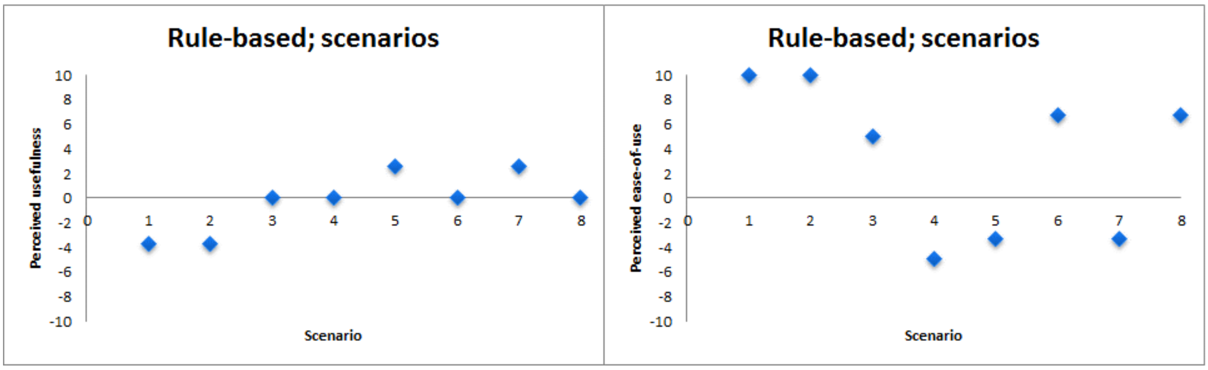

Figure F.3: Rule-based, scenarios

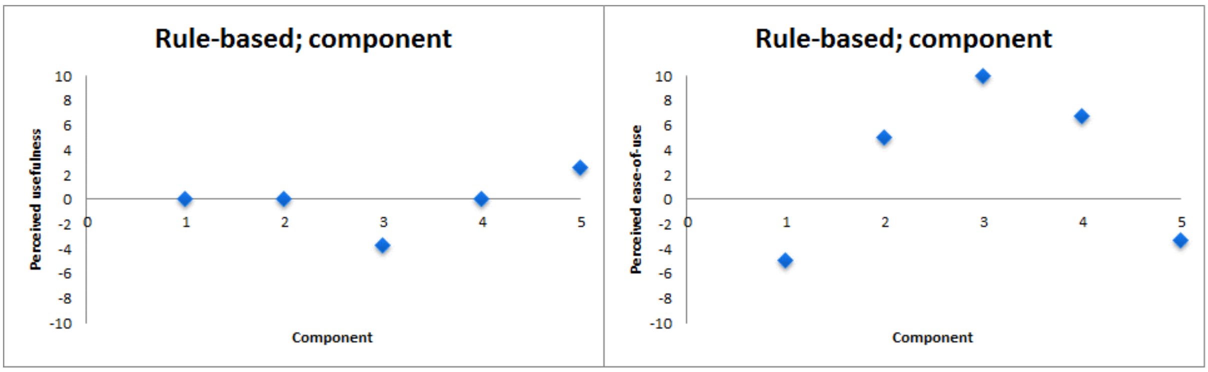

Figure F.4: Rule-based, component
1: Public permissionless; 2: Public permissioned; 3: Private; 4: Blockchain 1.0; 5: Blockchain 2.0

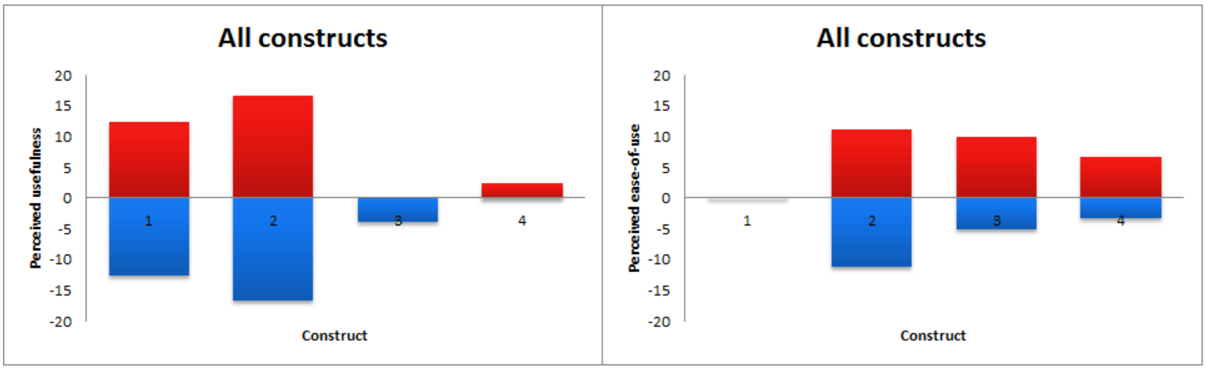

Figure F.5: All constructs
1: Trust; 2: Efficiency; 3: Openness; 4: Generation

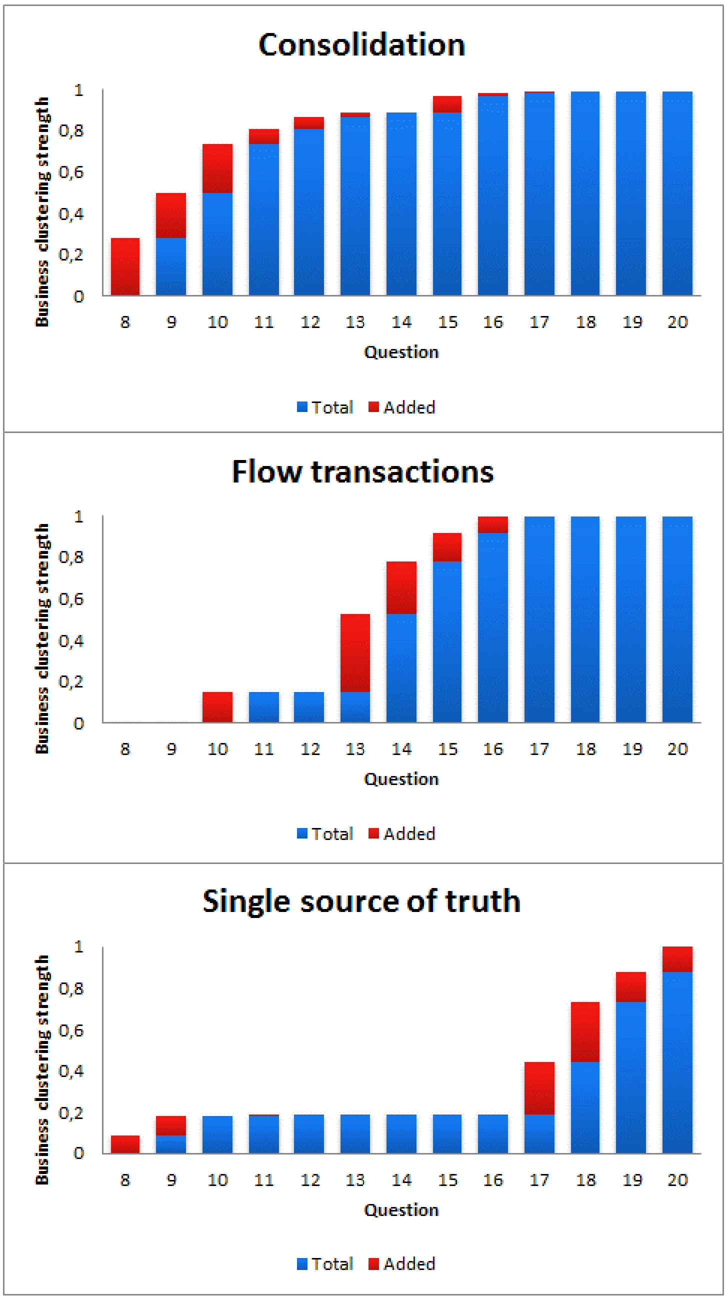

Figure F.6: Output three, actual output

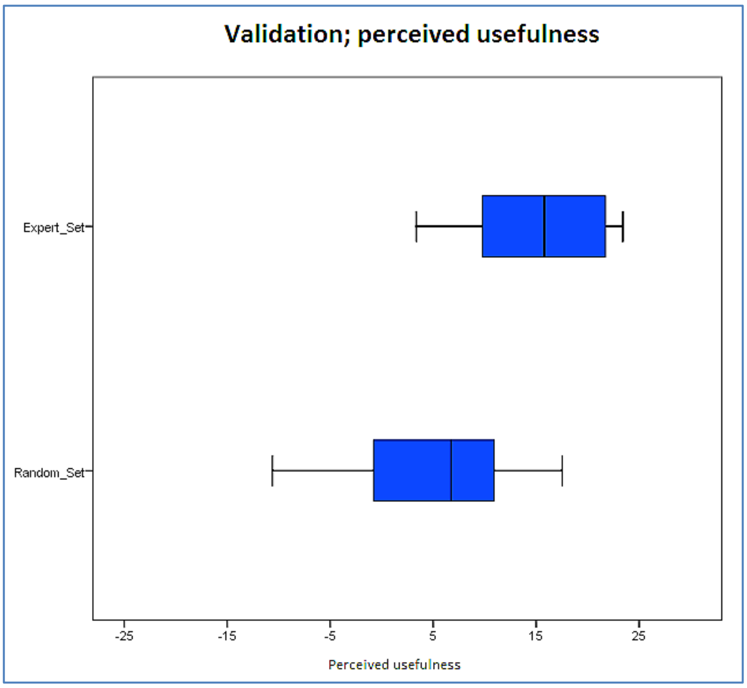

Figure F.7: Boxplot validation; perceived usefulness

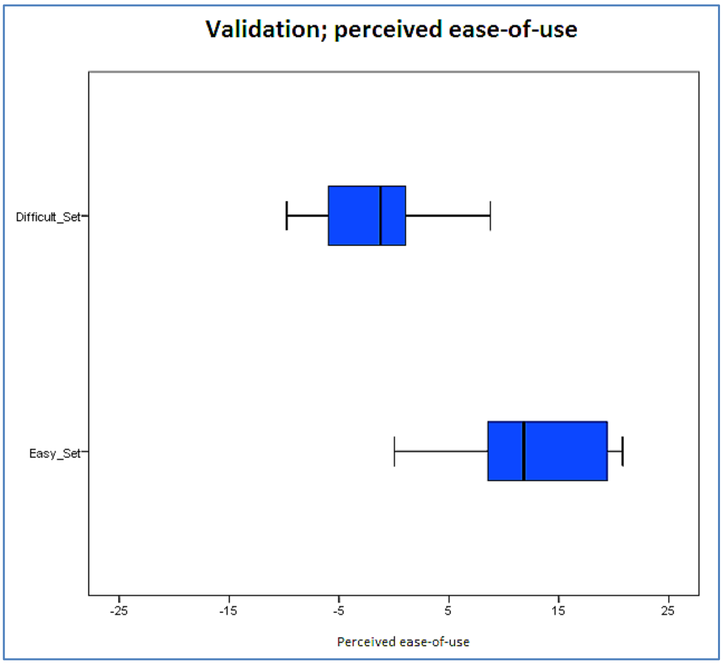

Figure F.8: Boxplot validation; perceived ease-of-use

Appendix G: Additional tables and figures, Chapter 7 Conclusions

This appendix encloses all the additional figures and tables of the seventh chapter of the report, Conclusions. The figures all show the result of three use cases that are tested in the expert system. The use cases are fraud prevention, peer-to-peer insurance and claims handling. First, the domains are provided, followed by the overall score and a simplistic overview. Table G.1 presents an overview of the cross-reference.

Cross-reference, appendix G				
	No.	**Explanation**	**Ref. page**	**Page**
Figure	G.1	The scores of three insurance use cases, based on the technology domain	4, 63, 64	120
	G.2	The scores of three insurance use cases, based on the business domain	4, 63, 64	120
	G.3	The scores of three insurance use cases, based on the architecture domain	4, 63, 64	120
	G.4	The scores of three insurance use cases	4, 63, 64	121
	G.5	The scores of three insurance use cases, simplistic presented	4, 63, 64	121

Table G.1: Cross-reference, appendix G

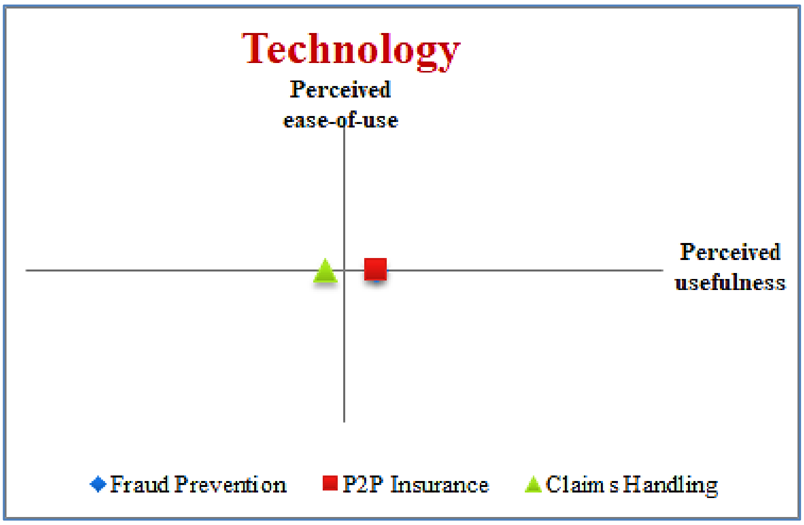

Figure G.1: Insurance use cases, technology domain

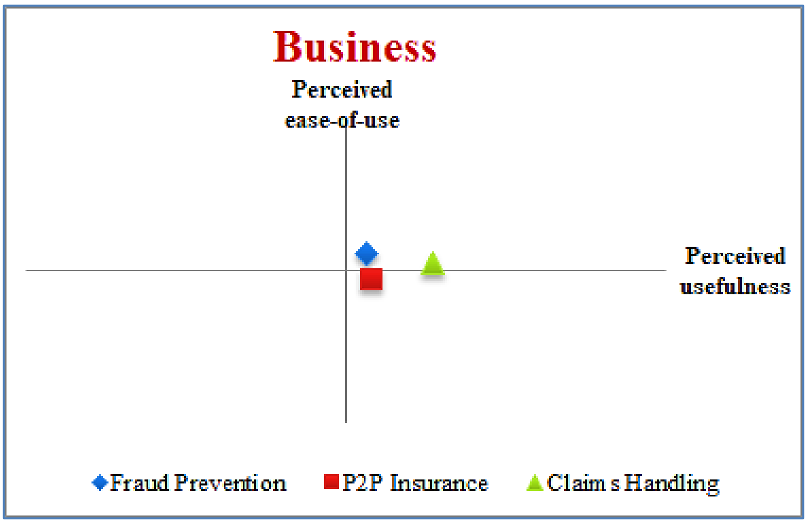

Figure G.2: Insurance use cases, business domain

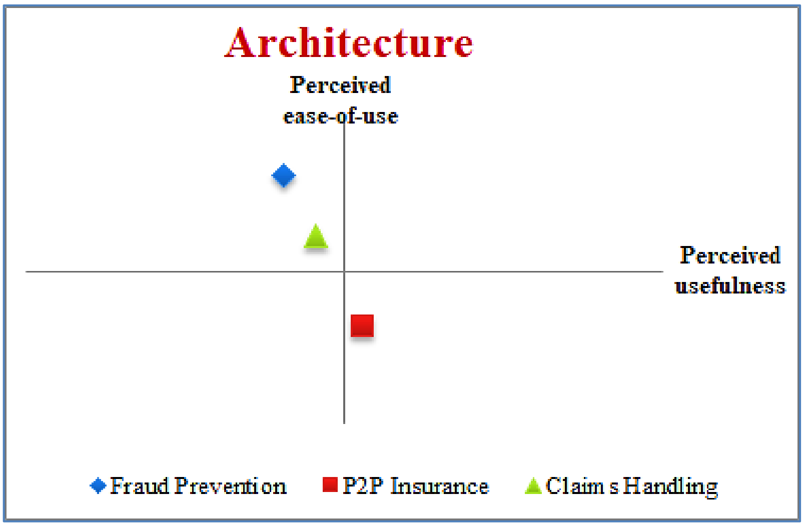

Figure G.3: Insurance use cases, architecture domain

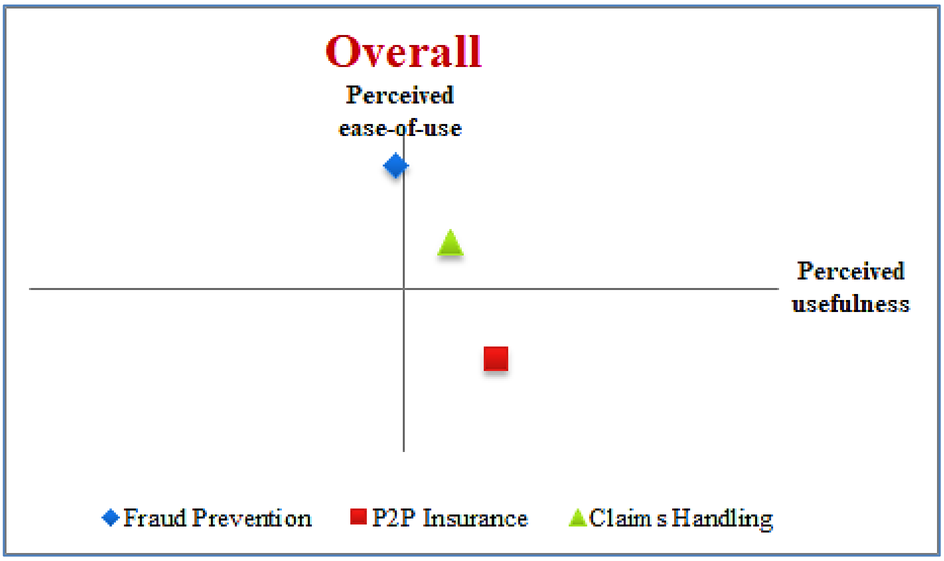

Figure G.4: Insurance use cases, overall

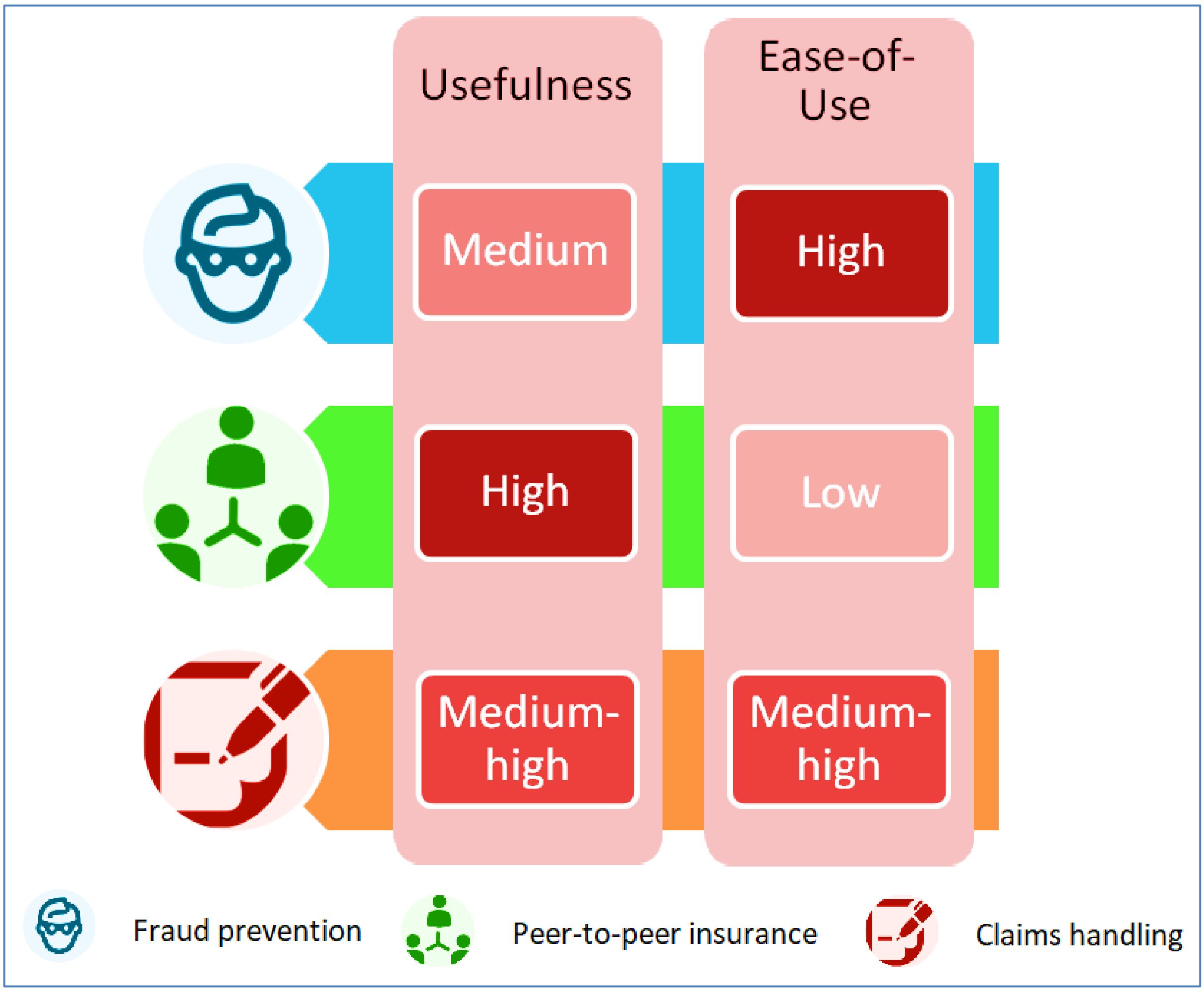

Figure G.5: Simplistic overview of insurance use cases

Appendix H: Blockchain, unique characteristic

Cryptography

Cryptography is applied in two ways, hashing and keys. Hashing is the process of converting a document or transaction into a fixed length digest that is associated with time (Buldas et al., 2013). The hashing method used in Blockchain is called SHA-256 which implies that it produces a 256-bit, or 32 bytes, hash value. This is a one-way method implying that it is not an encryption method, due to the impossibility of decryption. To explain this, a single syllable is made into a 256-bit hash value but also an entire library full of books can be made into a 256-bit hash value. Given the example of the library full of books another characteristic of a hash value can be explained. If one letter of one book of the entire library is changed, the hash value will be completely different, therefore any alteration can be noticed. The function of hash values is that they uniquely identify their hashed content, therefore, can detect data corruption like alterations or duplications. However, there are only 2^256 possibilities a hash value can have. Therefore, there are almost always possible alterations without changing the hash value. Because this is completely random and the search space is big enough, the assumption is made that an alteration is visible at most times. To quickly see alterations without checking each hash value of each transaction, the blocks are given a hash value that is made using all hash values of the transactions in that block. The creation of this block hash value is made through a method called the Merkle tree. 'A Merkle tree is an optimised hashchain and is constructed by hashing pairs of leaves until a single hash remains, the Merkle root' (Emmadi & Narumanchi, 2017). There are three stages in this Merkle tree that are hashing, aggregation and publication (Buldas et al., 2013). Figure H.1 shows an overview of the three stages linked to Blockchain. The first stage is hashing of each transaction as discussed earlier. The aggregation stage hashes two hashes together until a final hash value is produced, called the Merkle root. This Merkle root is published in the block. This hash value guarantees the notice of data corruption of the containing transactions. The block also contains the hash value of the previous block, a nonce and the hash value of these three combined. The nonce is discussed at the paragraph concerning the consensus protocol but for now, let's say it is a random value. Hashing the previous block and the Merkle root together 'chains' the Blockchain records, thus any alteration in a previous block will lead to an inconsistency in all the ones to come. Figure H.2 shows what happens if a transaction is altered.

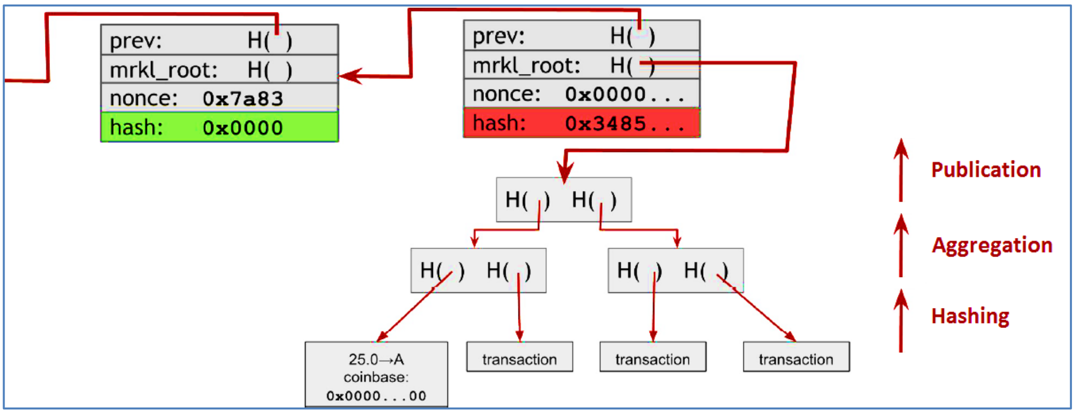

Figure H.1: Blockchain with a Merkle root detailed (Narayanan et al., 2016)

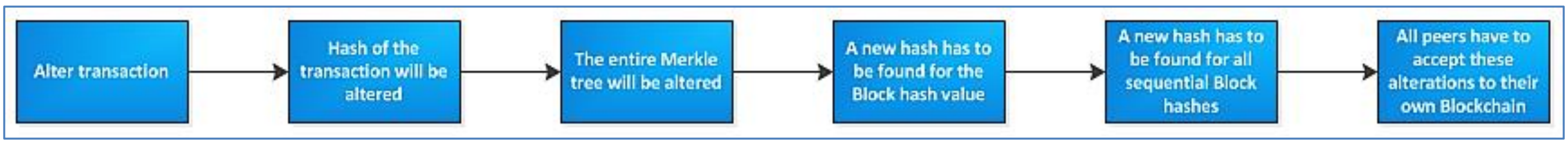

Figure H.2: Steps to make an alteration

Within a chain, everything must be altered to erase inconsistencies. Due to the distributed nature of Blockchain, every participant must have the same alterations to their Blockchain. Changing a transaction without people accepting it, means that the hacking of all those hashes at all chains should be done within a time limit that nobody notices it, therefore it is said that it can't be hacked.

Keys are another form of cryptography used in Blockchain. The Public Key Infrastructure relies on the use of a public and a private key for every participant (Witte, 2016). The private key is only known to the participant but the public key is known to everyone. There are two functions these keys possess. When executing transactions on Blockchain, it must be certain that the righteous parties are performing these transactions. Therefore, these parties must digitally sign the transactions to legitimate such a transaction. If a person signs with its private key, the other participants or peers can verify using the public key which peer signed the transaction and verify that it is the right one. This digital signature gives the recipient reason to believe that the message is authentic, non-repudiable and it has integrity (Lemieux, 2016). Also, the PKI signatures are protected by timestamps (Buldas et al., 2013). Another possibility is the sending of messages. The private key of the signed party together with the public key of the recipient party is used so that only the recipient party can decrypt the transaction but all participants can authorise it (Witte, 2016). Thus, if person A wants to send a message that only person B should be able to read, person A must encrypt the message using the public key of person B so that person B can use its private key to decrypt this message. This type of cryptography is called asymmetric ciphers but is more commonly known in the community as public key cryptography.

Consensus protocol

A consensus must be reached between the participants in the network before a block, a set of transactions, can be approved and added to the Blockchain records (Van Hemelen & Winderickx, 2016). Since there is no central authority or even a difference in power between all participants, a specific consensus protocol is put in place to assure objective verification of made transactions. How can it be ensured that every transaction is verified and added to the Blockchain records where every participant should have equal power and false transactions are easily found?

The most common used is Proof of Work, hereafter called PoW. The PoW mechanism is first introduced in a white paper in 2002 (Back, 2002). It is a mechanism that ensures reliability of the added record. Every peer can make a transaction and every peer can add that transaction to a block, finally adding this block to the chain. If it is easy to add new transactions to the Blockchain records, there is a possibility everyone will keep adding transactions, even if they are false, and there will be no time to check them properly. Requiring effort is the basis for each type of consensus protocol that is currently developed of which PoW is the only one tested and operational on a large scale. This consensus protocol ensures that a certain amount of work is needed to add new blocks, thus new bundles of transactions. Therefore, it is called Proof-of-Work, thus one needs to deliver a proof that a certain amount of work is made to add the block to the Blockchain records. Every peer can participate in this process and select transactions to be bundled in a block. To achieve this PoW, a computationally heavy puzzle must be solved (Watanabe et al., 2016). Looking back at figure H.1, a hash must be determined for the block. This hash value is the hash of the nonce, the previous hash and the Merkle root. To ensure the difficulty of adding a block, a target area is given in which the hash value should fall. Remember that a hash has 256 bits of zeros and ones. The difficulty is determined by demanding a requisite number of leading 0 bits and is regulated each time a new block is found (Beck et al., 2016). If the hash value should start with only one 0 and the rest can be random, the chances to find a hash value that will fulfil this condition will be far easier than when a hash value should start with 50 zeros. For instance, for Bitcoin the difficulty of finding a hash value for the new block is set on a target area that requires on average ten minutes to be solved by the entire community. Remember also that a hash is generated randomly so that it is not possible to logically find the hash other than just trying. Therefore, every peer has an equal chance at finding the hash value but more computational power results in more guesses in the same amount of time. Therefore, the chances of a peer of finding a hash value for a new Bitcoin block is defined by the following formula (Narayanan et al., 2016):

$$mean\ time\ to\ next\ block = \frac{10\ minutes}{fraction\ of\ hash\ power}$$

The nonce is the only value which is not given and contains 256 bits. So, the formula that is used to fulfil the PoW is (Narayanan et al., 2016):

$$H(nonce \mid prev_{hash} \mid mrkl_{root}) < target$$
$$with\ nonce = 256\ bit\ unknown\ value;$$
$$prev_{hash} = \ hash\ of\ the\ previous\ block;$$
$$mrkl_{root} = final\ hash\ of\ the\ hashed\ transactions$$
$$target = hash\ value\ with\ predefined\ number\ of\ leading\ zeros$$

This process can be compared with the opening of a number lock. To unravel the number lock, one must try lots of different combinations but to verify the code, that's easy for everyone. It is computational difficult to find the nonce that is suited for the target area. However, it is easy for the community to check whether the found nonce is leading to a hash within the target area.

There are two incentives to participate in this consensus protocol. The first incentive is that each transaction encloses a bit of extra cryptocurrency for the peer that adds it to the Blockchain records. Therefore, participants are eager to enclose more transactions in a block. Furthermore, each block that is added to the Blockchain records, thus when the peers accepted the new block, the block reward is given to the participant. This is newly generated money and is currently set on 12.5 Bitcoin. Because new money is created in the network as a block reward, participating in the consensus protocol is known as mining and the participants are called miners. Their goal is to enhance their computational power if the mining reward is bigger than the cost. The following formula can be derived for the miner that must be optimised when participating in the consensus protocol (Narayanan et al., 2016):

$$miner\ profits = mining\ rewards - mining\ costs$$
$$miner\ profits = (block\ reward + tx\ fees) -$$
$$\big(hardware\ cost + operating\ costs\ (electricity, cooling, etc.)\big)$$

The block reward is cut in half every four years leading to a limit in total supply of bitcoins of 21 million.

Smart contracts

The usage of smart contracts is a possible extension of Blockchain. The concept was firstly introduced in 1994, published in 1997 and defined as 'a computerized transaction protocol that executes the terms of a contract' (Szabo, 1997). According to Szabo, the key is translating contractual clauses into code and embedding them into property, hardware or software, that can self-enforce them, to maximize trust without intermediaries (Konstantinos & Devetsikiotis, 2016). However, it is need merely the translation of physical contracts into digital contracts which can be automatically triggered. As Konstantinos & Devetsikiotis explain, smart contracts are simply scripts stored in

Blockchain, each with a unique address that can be triggered by addressing a transaction to it. 'It then executes independently and automatically in a prescribed manner on every node in the network, according to the data that was included in the triggering transaction' (Konstantinos & Devetsikiotis, 2016). Thus, it is a form of smart business logic which is in the network that can be triggered so that it automates the written script. The upcoming of smart contracts is discussed together with its dangers.

It started in 2009 with Bitcoin which is a way of interacting peer-to-peer with one another by making transactions. At that time, there was some business logic already available to use. For instance, some transactions must be authorised by some specific peers. This creates possibilities that, for instance, 80 percent of the network must authorise a transaction before it is transferred or that an escrow account is created that acts like a third-party to hold the money until involved parties agree on the performed transaction. Other business logic entails time bound transactions. This implies that after a certain amount of time a certain transaction will take place, providing time and certainty for the involved parties. Literature suggests calling this way of using Blockchain, Blockchain 1.0 for digital currency (Van Hemelen & Winderickx, 2016; Zhao et al., 2016).

More and more peers were arguing that the amount of possibilities of business logic was too narrow. This led to a proposal by Vitalik Buterin for Ethereum which was funded halfway 2014 and went live a year later. The possibilities for smart business logic was huge and automated scripts can be written down. For comprehensibility reasons, imagine it to be like every possible IF THEN ELSE combination which automatically can be triggered and the action will be performed as written down. Such a script could make calculations, execute transfers and keep the ownership records automatically (Bradbury, 2016). It could automatically enforce agreed protocols (Marino & Juels, 2016), allowing participants to automate complex multi-step processes (Konstantinos & Devetsikiotis, 2016). Nguyen argues that smart contracts therefore increases the efficiency of transactions and payments in, for instance, the stock market (Nguyen, 2016). Also, through this complex multi-step process that can be automated, a smart-contract solution can 'govern all phases of a typical trade agreement from order, shipment and invoice to final payment' (Collomb & Sok, 2016).

However, when enhancing the complexity of a network, there is also a trade-off in terms of usability. An important lesson was learned in 2016 when applying smart contracts to achieve a decentralised autonomous organisation. Over 150 million dollars was invested in this application through crowdfunding via Blockchain. However, an attacker spotted a bug in a smart contract governing that decentralised autonomous organisation and used it to extract all that money (Bradbury, 2016). Because everything is automated and there is no central control, the attacker can get all the money if the smart contract 'allows' it. Therefore, a perfect bug-free system is necessary. However, if you want to secure the contracts against disruption for breach, this often means that you must secure it against disruption of any sort (Marino & Juels, 2016). Therefore, it is very costly, if not impossible (Beck et al., 2016), to alter smart contracts. This way of using Blockchain is called Blockchain 2.0 for digital finance or smart contracts (Zhao et al., 2016)

Appendix I: Blockchain, long-term vision

McKinsey

Figure A.5 graphically represents an overview of the steps of McKinsey. According to McKinsey, the momentum and hype building started in 2016. More than a year later, the exploration of use cases should start. The initial hurdles would be threefold. First, the view on potential benefits of use cases, also in terms of money. Secondly, the relevance to, and severity of, current pain points and proof that Blockchain is the best solution. Thirdly, the critical number of players willing to move.

A year later the age of expansions of proofs-of-concept will start, followed by the start of having commercial deployments at scale from halfway 2020 on forward. The main hurdles dealing with the two latter stages would also be threefold. First, establishment of legal/regulatory framework. Secondly, the viability of business cases including justifying costs of implementation. Thirdly, agreement on key standards and active collaboration across all required players.

At the start of this research, we just entered the age of use cases' exploration, which will last until somewhere at the end of 2018. According to McKinsey, this is their focus established together with experts in the field of financial services. The question remains what kind of use cases do we have to look at and which different kinds are there?